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CLIMATE CHANGE IMPACTS, VULNERABILITY, AND ADAPTATION FOR FOOD AND LIVELIHOOD SECURITY

A case study of Maharashtra

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4.1 Introduction

In India, 69% of the population lives in rural areas, and 55% of the total workforce is engaged in agriculture (Census of India, 2011). Women account for 37% of this agricultural workforce, playing a major role in agricultural production. The agriculture sector contributes 12% of the country's gross domestic product (GDP) (Government of India, 2016). Despite its declining share in the nation's GDP, it remains the backbone of the Indian economy, since it is the major source of food and livelihood security for the vast majority of the country's rural poor, women and men alike.

The government of India, recognising the importance of this sector to the livelihood security of millions of people, developed various programmes to strengthen the sector. The initiative to 'double farmers' income' (Chand, 2017) underlines its commitment to make farming a viable livelihood option. Agricultural performance and growth are imperative to ensure food and livelihood security. In consequence, any assessment of this security calls for an in-depth analysis of the vulnerability of the agriculture sector as such.

Climate change predictions of extreme events – such as those regarding frequency and intensity of droughts, floods, and erratic rains – are expected to have a great impact on agriculture as also on the food and livelihood security of millions of resource-poor rural populations (World Bank, 2012; IPCC, 2023). A vulnerability assessment of the agricultural sector will give insights into the capacity of agricultural systems to adapt to climate change.

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It is widely recognised that climate change has differential impacts on countries, regions, and even sectors and geographies. Also, sectors vary widely in their degree of vulnerability to climate change. It is further recognised that 'even within regions [. . .] impacts, adaptive capacity and vulnerability will vary' (IPCC, 2001, p. 15). The differential impacts are mainly because changes in climatic patterns are not evenly distributed across geographies.

India has a wide range of climatic conditions, from the Himalayan winters to the tropical climate of the southern peninsula. The 28 states and 8 union territories in the country and the 707 districts within the states fall under different agroecological and agroclimatic regions (Gajbhiye & Mandal, 2000). They also have very different natural resource endowments and are at different levels of socio-economic development. They are bound to experience a disproportionate impact on the food and livelihood security of their populations. Their ability to cope with climate vulnerabilities also differs widely.

Household vulnerability is largely an outcome and consequence of macro- (country-level) and meso- (state- and district-level) vulnerability. Understanding macro- and meso-vulnerability at the national, state, and district levels is key to designing development and adaptation plans. Climate change adaptation plans in India should consider the regional and state-level differences in impacts and coping capacities. A sound strategic adaptation plan needs to be based on a disaggregated and detailed analysis of vulnerabilities across the states with sensitivity to spatial scale. This chapter is an attempt to have a meso-level disaggregated vulnerability analysis for the state of Maharashtra. The analysis has been carried out across all its districts.

4.2 Methodology

The Intergovernmental Panel on Climate Change (IPCC, 2001) described three dimensions of vulnerability: (1) sensitivity, (2) adaptive capacity, and (3) exposure. *Sensitivity* is defined as the degree to which a system is affected by disaster, *adaptive capacity* is the system's ability to resist and absorb disaster, and *exposure* is the magnitude and duration to which a population is exposed to disaster (Ebi et al., 2006).

$$\text{vulnerability (V)} = f(\text{sensitivity, adaptive capacity, exposure}) \qquad (1)$$

IPCC came up with a framework that forms the basis of a Livelihood Vulnerability Index (LVI) proposed by Hahn et al. (2009). They calculated a new variable, LVI-IPCC. This takes into consideration IPCC's definition of *vulnerability*. Here, instead of putting all the major components together in equation 1, the major components are first combined according to three categories, namely, exposure, sensitivity, and adaptive capacity, as in equation 2:

$$CF_d = \frac{\sum_{i=1}^{n} w_{Mi} M_{di}}{\sum_{i=1}^{n} w_{Mi}} \quad (2)$$

Where:

CF_d = IPCC-defined contributing factors (exposure, sensitivity, or adaptive capacity) for district *d*

M_{di} = major components for district *d* indexed by *i*

w_{Mi} = weight of each major component

n = number of major components in each contributing factor

After these factors are calculated separately, they are combined as in equation 3:

$$LVI - IPCC_d = (e_d - a_d) \times s_d \quad (3)$$

Where:

$LVI - IPCC_d$ = the LVI for district *d* expressed using the IPCC vulnerability framework

e_d = is the calculated exposure score for district *d* (weighted average of the climate variability and exposed population and area)

a_d = the calculated adaptive capacity for district *d* (weighted average of livelihood capacity, socio-demographic capacity, economic capacity, infrastructure capacity, and resource capacity)

s_d = the calculated sensitivity score for district *d* (weighted average of system sensitivity, human sensitivity, and ecological sensitivity)

The LVI-IPCC is scaled from –1 (least vulnerable) to 1 (most vulnerable).

The preceding methodology is adapted from Hahn et al. (2009, p. 76).

4.2.1 Ranking and sub-categorisation

Districts were ranked on the basis of the index values following Shukla et al.'s (2016) methodology, as in Table 4.1. The vulnerability indexes (VI) of

TABLE 4.1 Classified ranking of vulnerability index values

Vulnerability index value > (M + SD)	Highly vulnerable
(M + SD) > **vulnerability index value** > (M)	Moderately vulnerable
(M) > **vulnerability index value** > (M – SD)	Less vulnerable
Vulnerability index value < (M – SD)	Extremely less vulnerable or non-vulnerable

Source: Shukla (2016).

Note: M = mean; *SD* = standard deviation.

districts were ranked from lower to higher order according to an index value. Thereafter, districts were classified into four different groups with the help of mean (M) and standard deviation (SD):

1 Districts with a VI value higher than M plus SD are considered highly vulnerable.
2 Districts with a VI value less than M plus SD but more than M are moderately vulnerable.
3 Districts with a VI value less than M but more than M minus SD are less vulnerable.
4 Districts with a VI value less than M minus SD are considered extremely less vulnerable.

4.2.2 Data

Table 4.2 gives details of the sub-components used to construct the Livelihood Vulnerability Index (LVI) and the contributing factors in the LVI-IPCC framework.

TABLE 4.2 Components used to construct the Livelihood Vulnerability Index (LVI) and the contributing factors in the LVI-IPCC framework

Component	*Input profile*	*Indicators*
Exposure	Climate variability	Coefficient of variation (COV) of south-west rainfall deviation
		COV of north-east rainfall deviation
		COV of max temperature
		COV of min temperature
	Exposed population	% rural population
	Exposed area	% rain-fed area
Sensitivity	System sensitivity	% area under food grain to total cropped area (TCA)
		Average size of operational holding
		% net sown area to total geographical area
	Human sensitivity	% labour force in agriculture
		% marginal and smallholders
	Ecological sensitivity	% of blocks over-exploited in terms of groundwater extraction

(*Continued*)

TABLE 4.2 (Continued)

Component	*Input profile*	*Indicators*
Adaptive capacity	Economic capacity	% share of non-agriculture sector to NDDP
	Livelihood capacity	% non-agriculture labour force
		Livestock population
	Socio-demographic capacity	% of technical diploma and graduate and above-level holder by operational holders
		% rural literacy rate
	Infrastructure capacity	% rural population served by transport, communication
		% rural population served by pucca road
	Resource capacity	% rural population served by agricultural credit societies
		Crop intensity
		Fertiliser consumption per hectare
		% electric consumption for agriculture to total electricity consumption

Source: Census of India (2011), GoI (2021), and GoI (2016).

4.3 Description of study areas

The state of Maharashtra accounts for 12% of India's net sown area (NSA) and contributes 8% of India's agricultural gross value added (GVA). The gross domestic product (GDP) for agriculture Maharashtra amounted to Rs 2.28 trillion in the financial year 2024. The sector accounts for 50% of the state's working population and provides a total monthly income of Rs 11,492 (GoI, 2021). The average outstanding loan per agricultural household in the state is Rs 82,085, with about 54% of agricultural households reporting indebtedness. Climate change, in the form of fluctuations in temperature and rainfall patterns, is predicted to have detrimental impact on the major crops in the state, like wheat, gram, soybean, and cotton (Sen et al., 2021). This has impact on farmers as income from crops accounts for a major share of the farmers' income (IPCC, 2023; Bawne & Patil, 2024). Table 4.3 gives a basic profile of the state of Maharashtra compared to the overall situation in India.

The proportion of the state's rural population is 52%. Of its total workforce, 53% are engaged in agriculture. The contribution of this sector to the state's economy is significant, with crop production alone accounting for 6% of its gross domestic product. The state is vulnerable to climate

TABLE 4.3 Basic profile of Maharashtra compared to India

Data	*Maharashtra*	*India*	*Data reference year*
Total population	112,374,333	1,210,854,977	2011
Proportion of rural population (in %)	55	69	2011
Total workers	49,427,878	481,888,868	2011
Proportion of agricultural workforce (in %)	53	55	2011
Proportion of small- and marginal operational holdings (OHs) to total operational holdings of land (proportion in bracket)	10,761,351 (79)	117,605,129 (85)	2011
Proportion of small- and marginal operational holding of land (proportion in bracket)	8,924,981 (45)	71,152,325 (45)	2011
Gross cropped area (GCA)	24,069,231	193,759,280	2011
Proportion of gross irrigated area to GCA (in %)	20	45	2011
Proportion of area under food grains to GCA (in %)	49.1	62.2	2013–2014
Frequency of drought in the last five years (2010 to 2015)	4		2010–2015
State net domestic product at constant prices (year)	132,930,760		
% contribution of agriculture (crop production alone) to NSDP (net state domestic product)	6		

Source: Census of India (2011), GoI (2021), and GoI (2016).

change, which is evident by the increase in frequency of extreme events in the last decade. In Annexure 1 is a detailed socio-economic profile of its 33 districts.

4.4 Results and discussion

4.4.1 Description of sub-component indices

The climate variability index ranges from 0.14 to 0.76 (Table 4.4). A high level of climate variability was reported in Ahmednagar, Gondia, Pune, and Wardha, while Nashik, Ratnagiri, Sangli, and Sindhudurg showed very low levels of climate variability. Among the climate variables, the south-west monsoon showed the highest variability, followed by the north-east monsoon.

TABLE 4.4 IPCC contributing factors to vulnerability major components, Maharashtra districts

District	*Exposure*		*Sensitivity*			*Adaptive capacity*				
	Climatic variability	*Exposed population*	*System sensitivity*	*Human sensitivity*	*Ecological sensitivity*	*Economic capacity*	*Socio-demography*	*Infrastructure capacity*	*Livelihood strategy*	*Resource capacity*
Ahmednagar	0.68	0.86	0.55	0.73	0.00	0.63	0.66	0.89	0.49	0.55
Akola	0.41	0.57	0.62	0.59	–0.33	0.61	0.77	0.51	0.29	0.37
Amravati	0.57	0.62	0.50	0.62	1.00	0.62	0.98	0.57	0.31	0.33
Aurangabad	0.52	0.50	0.45	0.67	–0.33	0.74	0.40	0.84	0.53	0.48
Beed	0.47	0.87	0.54	0.78	–0.33	0.36	0.67	0.88	0.45	0.69
Bhandara	0.57	0.87	0.58	0.88	–0.33	0.71	0.78	0.63	0.52	0.39
Buldhana	0.59	0.85	0.53	0.70	0.03	0.51	0.62	0.52	0.28	0.43
Chandrapur	0.51	0.63	0.51	0.50	–0.33	0.81	0.40	0.37	0.51	0.37
Dhule	0.25	0.74	0.65	0.57	–0.33	0.48	0.36	0.69	0.52	0.59
Gadchiroli	0.54	1.00	0.50	0.68	–0.33	0.60	0.17	0.00	0.52	0.30
Gondia	0.68	0.91	0.44	0.88	–0.33	0.78	0.63	0.69	0.59	0.34
Hingoli	0.39	0.94	0.59	0.68	–0.33	0.29	0.46	0.86	0.34	0.77
Jalgaon	0.45	0.69	0.55	0.58	0.29	0.59	0.60	0.60	0.37	0.64
Jalna	0.47	0.87	0.52	0.73	–0.33	0.28	0.36	0.91	0.45	0.55
Kolhapur	0.30	0.69	0.23	0.78	–0.33	0.67	0.68	0.91	0.61	0.59
Latur	0.28	0.78	0.62	0.62	–0.33	0.41	0.66	0.96	0.47	0.68
Nagpur	0.57	0.13	0.57	0.25	–0.33	0.93	0.68	0.57	0.38	0.21
Nanded	0.56	0.75	0.50	0.70	–0.33	0.57	0.34	0.46	0.41	0.46
Nandurbar	0.49	0.91	0.57	0.56	–0.33	0.45	–0.07	0.68	0.39	0.47
Nasik	0.28	0.52	0.55	0.58	–0.33	0.54	0.38	0.90	0.53	0.52
Osmanabad	0.42	0.91	0.70	0.56	–0.33	0.25	0.73	0.94	0.33	0.76
Parabhani	0.49	0.70	0.65	0.64	–0.33	0.35	0.42	0.89	0.22	0.75

(Continued)

TABLE 4.4 (Continued)

District	*Exposure*		*Sensitivity*			*Adaptive capacity*				
	Climatic variability	*Exposed population*	*System sensitivity*	*Human sensitivity*	*Ecological sensitivity*	*Economic capacity*	*Socio-demography*	*Infrastructure capacity*	*Livelihood strategy*	*Resource capacity*
Pune	0.67	0.24	0.44	0.42	–0.33	0.88	0.60	0.86	0.79	0.47
Raigadh	0.40	0.61	0.38	0.55	–0.33	0.95	0.44	0.70	0.78	0.21
Ratnagiri	0.14	0.92	0.26	0.69	–0.33	0.85	0.40	0.84	0.63	0.16
Sangli	0.14	0.78	0.56	0.69	–0.33	0.44	0.58	0.94	0.51	0.53
Satara	0.52	0.88	0.34	0.86	–0.33	0.61	0.58	0.85	0.54	0.50
Sindhudurg	0.17	0.98	0.27	0.74	–0.33	0.63	0.63	0.86	0.66	0.25
Solapur	0.38	0.68	0.68	0.45	0.09	0.66	0.33	0.91	0.53	0.58
Thane	0.29	0.00	0.45	0.31	–0.33	1.00	0.28	0.85	0.69	0.22
Wardha	0.76	0.67	0.56	0.39	–0.33	0.63	0.76	0.68	0.47	0.25
Washim	0.49	0.90	0.64	0.64	–0.33	0.00	0.65	0.67	0.21	0.49
Yavatmal	0.48	0.84	0.58	0.47	–0.33	0.54	0.76	0.48	0.35	0.30

Source: Authors' estimation.

The coefficient of variation (COV) of the south-west rainfall ranged from 57 to 263%, with the lowest values in the districts of Bhandara, Nagpur, Sindhudurg, and Thane. The Ahmednagar, Nasik, Pune, and Satara districts reported a COV in the range of 115–263%, the last reported for Pune. The COV of the north-east rainfall ranged from 55 to 106%, with the lowest in Beed, Hingoli, Latur, and Sangli. The districts of Amravati, Buldhana, Nanded, and Wardha reported the highest rainfall, with 106% given for Wardha.

As rainfall in both seasons is directly related to rain-fed-based production, its variation has implications for both food production and livelihoods. The variance in minimum temperature was in the range of 1.3% in Sindhudurg to 2.4% in Wardha. A variance of more than 2% in minimum temperatures showed up in 18 out of 33 districts. This can have serious consequences for agriculture and food production in Maharashtra, as fluctuation or increase in night temperatures was already estimated to have a detrimental effect on the yield of rice and wheat in India in 2003 (Pathak et al., 2003). Rice yield is estimated to decline by 10% for each 1°C increase in minimum temperature during the growing season (Peng et al., 2004). The maximum temperature shows relatively low variance, with values ranging from as low as 0.7% in Sangli, Sindhudurg, Kolhapur, and Ratnagiri and as high as 1.2% in Gondia, Parbhani, Nagpur, and Wardha.

The districts of Ahmednagar, Beed, Bhandara, Jalna, Satara, Washim, Gondia, Osmanabad, Nandurbar, Ratnagiri, Hingoli, Sindhudurg, and Gadchiroli have an index value above 0.85 of the exposed population. This indicates their susceptibility to risk due to climate variability and impacts on agriculture and rural livelihoods.

The variable proportion of rain-fed area was dropped from the subcomponent ‘exposed area’ since Thane, a predominantly urban district, showed the highest percentage of rain-fed area, and this could, in a way, affect the outcomes of the vulnerability calculation. The lowest values of the exposed population were reported in Thane, Nagpur, and Pune, as expected, while Gondia, Osmanabad, Nandurbar, Ratnagiri, Hingoli, Sindhudurg, and Gadchiroli have very high values for the exposed population index.

System sensitivity values ranged from 0.23 to 0.70. Kohlapur, Ratnagiri, and Sindhudurg have very low system sensitivity values, while Parabhani, Solapur, and Osmanabad have a very high system sensitivity index. The proportion of net sown area to geographical area ranges from 12 to 80%, with Akola reporting the highest proportion. The Gadchiroli, Thane, Raigad, Sindhudurg, Ratnagiri, Gondia, Chandrapur, and Nandurbar districts have less than 50% of their geographical area under crops. The average size of landholding is also very small, with 2.4 ha the largest, in Wardha district. Less than 0.85 ha are reported from Satara and Kolhapur.

The districts with very high human sensitivity values are Beed, Satara, Gondia, and Bhandara, because they have a very high proportion of marginal and smallholder farmers, and a high proportion of their total workforce is engaged in agriculture. Farmers in districts across Maharashtra are predominantly marginal and smallholders. Particularly in Gadchiroli, Buldhana, Nadurbar, Hingoli, and Washim, many are working in agriculture. So this is an important means of livelihood for the rural population in these districts.

The districts reporting high ecological index values are Amravati, Jalgaon, and Solapur. They have taluks with over-exploited blocks in terms of groundwater extraction. The maximum is in Amravati, where 28% of taluks report groundwater exploitation. Ahmednagar and Buldhana also show some level of stress in this regard.

In all the 33 districts considered in the analysis, sectors other than agriculture contribute more than 70% of the net domestic product of a district. The districts with a very low economic capacity are Osmanabad, Jalna, Hingoli, Parabhani, Beed, and Washim. These have relatively low contributions from non-agricultural sectors to the district's domestic product. Not surprisingly, those with a higher share of the non-agricultural sector to the district domestic product, like Thane, Nagpur, Pune, Raigad, and Ratnagiri, come out high on the economic capacity index.

Variables used to measure socio-demographic capacity were the proportion of farmers with some technical education or higher level, and rural literacy. Akola, Bhandara, and Amaravati had high values for socio-demographic capacity, in contrast with Gadchiroli, Thane, and Nandurbar. In these last three districts, less than 3% of farmers have an academic and/or technical education. They also show relatively low values for rural literacy, with a count of few farmers with a high technical level of education or beyond. Very low rural literacy was particularly reported in Nandhurbar, Dhule, Jalna, and Parbhani, while Wardha, Sindhudurg, Amravati, and Akola had high levels of rural literacy.

The resource capacity index was measured in terms of fertiliser and electricity use in agriculture, cropping intensity, and coverage by agricultural credit societies. Thane, Nagpur, Raigadh, and Ratnagiri come low in this index. They have a low cropping intensity and also report very little electricity consumption for agriculture. The districts that give high resource capacity values are Beed, Parabhani, Osmanabad, and Hingoli. They report an electricity consumption for agriculture of 70% and above. They also have a high cropping intensity and high level of fertiliser consumption, as well as an extensive coverage by agricultural credit societies. Aurangabad, Amravati, Akola, Ahmednagar, Yavatmal, Wardha, and Thane use relatively very little fertiliser, less than 10,000 t (metric tonnes) per year. On the other hand, Gadchiroli, Dhule, Jalgaon, and Chandrapur use annually more than 5 lakh metric tonnes of fertiliser.

On the whole, agriculture appears to account for more than 50% of electricity consumption in 12 out of 33 districts in Maharashtra. Less than 5% consumption of electricity for agriculture was reported from Ratnagiri, Raigad, and Thane.

Infrastructure capacity was measured in terms of the extent of coverage by pucca roads, transport facilities, and communication. Gadchiroli, Chandrapur, Nanded, and Yavatmal have very low infrastructure capacity index values, while Sangli, Osmanabad, and Latur have very high values in this regard.

The percentage of the rural population served by agricultural credit societies ranges from 34% in Gadchiroli to 97% in Solapur. The proportion served by pucca roads in rural areas ranges from 76% in Gadchiroli to 99% in Ratnagiri. Coverage by communication and transport is 99.7% in Solapur and Sangli, while it is 76.7% in Gadchiroli.

Livestock is an integral and important component in the farming systems in Maharashtra, with all 33 districts reporting more than 90% livestock population; only Nagpur had about 88%. The indicator driving the values of the livelihood strategy index was the proportion of the non-agricultural labour force. Districts with high levels of urbanisation – Pune, Thane, and Raigadh – come out high on this index, while those with a predominantly high proportion of agricultural labour force have a low livelihood strategy index.

4.4.2 Livelihood Vulnerability Index (LVI)

The sub-components of the LVI are aggregated to arrive at the IPCC dimensions of vulnerability, namely, exposure, sensitivity, and adaptive capacity (Table 4.5). Further, using the IPCC vulnerability framework, the dimensions of vulnerability or, alternately, the contributing factors are combined to arrive at composite LVI-IPCC index values of vulnerability. The index value of the individual indicators used to calculate the exposure index is given in Annexure 2.

The overall exposure index for Maharashtra ranges from 0.23 in Thane to 0.75 in Wardha (Figure 4.1). Nanded, Bhandara, Gadchiroli, Buldhana, Ahmednagar, Gondia, and Wardha show exposure index values of 0.60 to 0.75.

Six indicators were used to estimate the sensitivity index. The index value of the individual indicators used to calculate the sensitivity index is given in Annexure 3.

The overall sensitivity index takes values in the range of 0.27 in Thane to 0.62 in Amravati (Figure 4.2). Buldhana, Solapur, Jalgaon, Ahmednagar, Bhandara, and Amravati show values of more than 0.50. Thane, Pune, Ratnagiri, and Nagpur report very low values, in contrast.

The index value of the individual indicators used to calculate the adaptive capacity index is given in Annexure 4. The adaptive capacity index ranges from 0.29 in Gadchiroli to 0.68 in Kolhapur (Figure 4.3). The districts with less than 0.50 values are Gadchiroli, Nandurbar, Nanded, Chandrapur, Washim, Nagpur, Yavatmal, Buldhana, Akola, Ratnagiri, and Wardha.

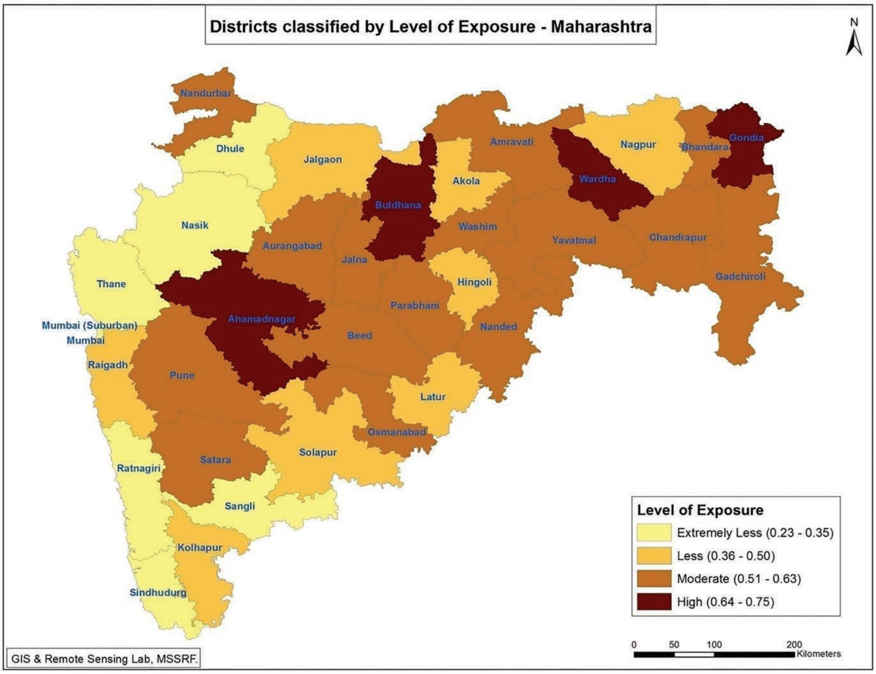

FIGURE 4.1 Districts classified by level of exposure of vulnerability – Maharashtra.

Source: Authors' estimation.

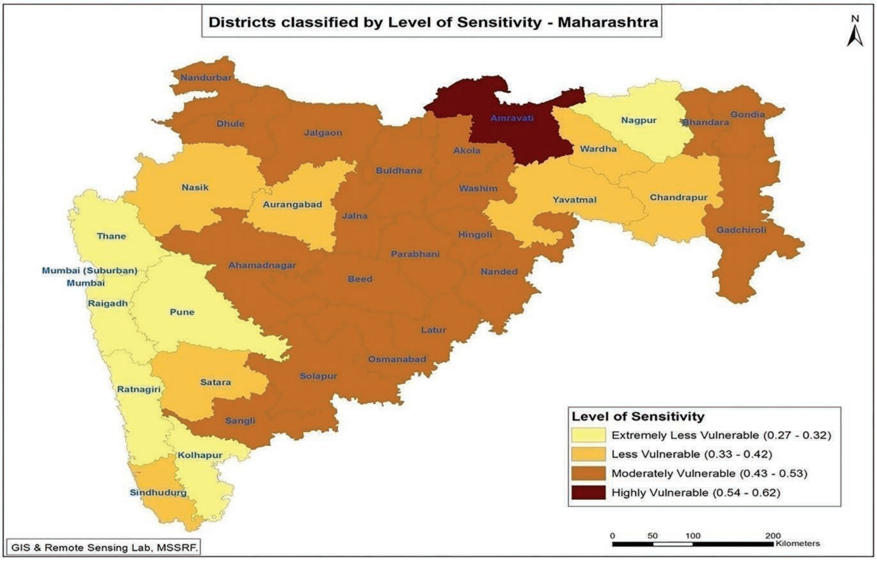

FIGURE 4.2 Districts classified by the level of sensitivity of vulnerability – Maharashtra.

Source: Authors' estimation.

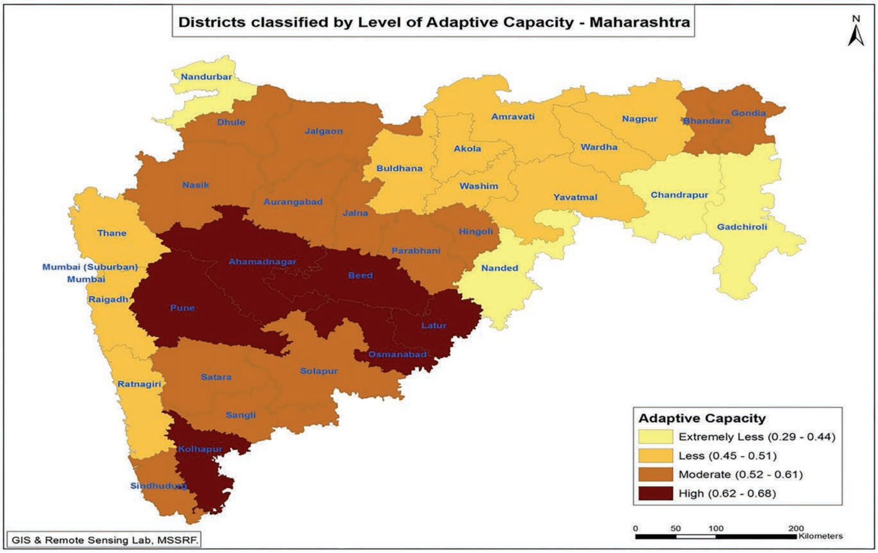

FIGURE 4.3 Districts classified by level of adaptive capacity – Maharashtra.

Source: Authors' estimation.

The LVI-IPCC index takes values from –1 to +1, with –1 being least vulnerable and +1 being the most vulnerable. The districts that appear 'extremely low' vulnerable here are Sangli, Latur, Nasik, Kolhapur, and Dhule (Figure 4.4). Washim, Nanded, Nandurbar, Gondia, Wardha, Buldhana, and Gadchiroli are in the 'highly' vulnerable category. Values of 'low' vulnerability show up for Solapur, Thane, Osmanabad, Sindhudurg, Ratnagiri, Hingoli, Beed, Jalgaon, Parabhani, Pune, Raigadh, Aurangabad, and Akola. Satara, Jalna, Nagpur, Chandrapur, Bhandara, Yavatmal, Amravati, and Ahmednagar report 'moderate' vulnerability.

4.4.3 Ranking and vulnerability sub-categorisation

Adopting the methodology used by Shukla (2016), the districts were categorised by extent of vulnerability. Table 4.6 shows the ranking and categorisation of districts according to the extent of vulnerability across the two methods of integrated vulnerability assessment.

Sangli, Latur, Nasik, Kolhapur, and Dhule fall in the 'extremely low vulnerability' category. Washim, Nanded, Nandurbar, Gondia, Wardha, Buldhana, and Gadchiroli are 'highly vulnerable'. The results of the study, with a couple of exceptions, are mostly in conformity to a socio-economic vulnerability analysis carried out by Adhav et al. (2021).

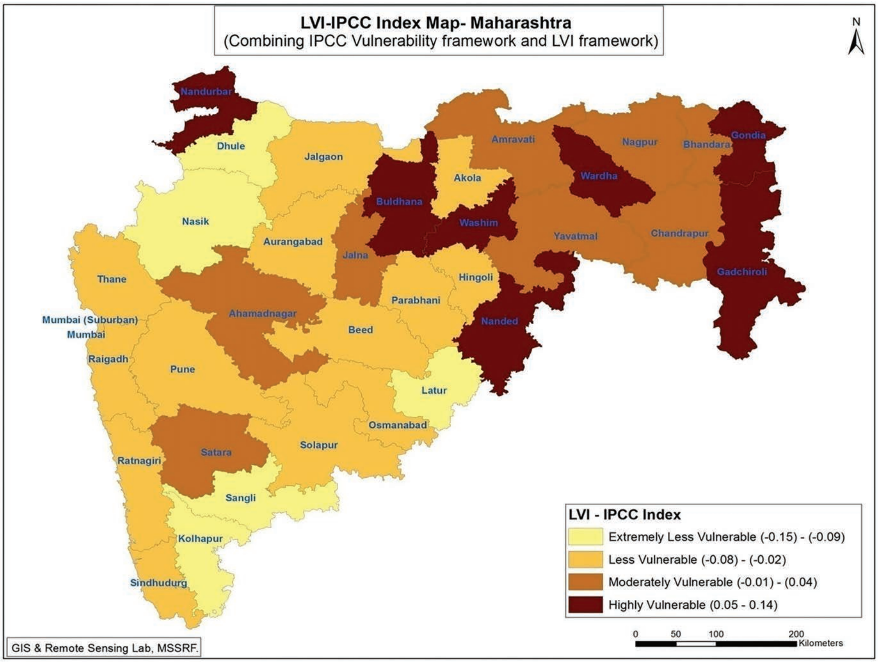

FIGURE 4.4 LVI-IPCC index – Maharashtra.

Source: Authors' estimation.

TABLE 4.5 Major component index contributing to LVI-IPCC index in Maharashtra districts

District	*Exposure index*	*Sensitivity index*	*Adaptive capacity index*	*LVI – IPCC index*
Sangli	0.27	0.46	0.60	–0.15
Latur	0.38	0.46	0.66	–0.13
Nasik	0.33	0.42	0.57	–0.10
Kolhapur	0.38	0.32	0.68	–0.09
Dhule	0.35	0.46	0.54	–0.09
Solapur	0.44	0.50	0.59	–0.08
Thane	0.23	0.27	0.50	–0.07
Osmanabad	0.51	0.48	0.66	–0.07
Sindhudurg	0.33	0.32	0.54	–0.07
Ratnagiri	0.29	0.31	0.48	–0.06
Hingoli	0.50	0.47	0.61	–0.05
Beed	0.55	0.47	0.65	–0.05
Jalgaon	0.49	0.52	0.57	–0.04
Parabhani	0.53	0.48	0.58	–0.02

(*Continued*)

TABLE 4.5 (Continued)

District	*Exposure index*	*Sensitivity index*	*Adaptive capacity index*	*LVI – IPCC index*
Pune	0.58	0.31	0.66	–0.02
Raigadh	0.44	0.32	0.51	–0.02
Aurangabad	0.52	0.39	0.56	–0.02
Akola	0.44	0.45	0.48	–0.02
Satara	0.59	0.40	0.59	0.00
Jalna	0.55	0.45	0.54	0.01
Nagpur	0.48	0.31	0.46	0.01
Chandrapur	0.53	0.37	0.44	0.04
Bhandara	0.63	0.53	0.56	0.04
Yavatmal	0.55	0.39	0.45	0.04
Amravati	0.58	0.62	0.51	0.04
Ahamadnagar	0.71	0.52	0.63	0.04
Washim	0.57	0.48	0.46	0.06
Nanded	0.60	0.43	0.44	0.07
Nandurbar	0.58	0.42	0.39	0.08
Gondia	0.72	0.46	0.54	0.08
Wardha	0.75	0.36	0.49	0.09
Buldhana	0.65	0.50	0.46	0.09
Gadchiroli	0.63	0.42	0.29	0.14

Source: Authors' estimation.

TABLE 4.6 Categorical ranking of LVI-IPCC index for Maharashtra districts

District	*LVI-IPCC*	*Ranking*
Sangli	–0.15	**Hardly vulnerable** (districts with vulnerability index value lower than M – SD)
Latur	–0.13	
Nasik	–0.10	
Kolhapur	–0.09	
Dhule	–0.09	
Solapur	–0.08	**Less vulnerable** (districts with vulnerability index value higher than M but less than M + SD)
Thane	–0.07	
Osmanabad	–0.07	
Sindhudurg	–0.07	
Ratnagiri	–0.06	
Hingoli	–0.05	
Beed	–0.05	
Jalgaon	–0.04	
Parabhani	–0.02	
Pune	–0.02	
Raigadh	–0.02	
Aurangabad	–0.02	
Akola	–0.02	

TABLE 4.6 (Continued)

District	*LVI-IPCC*	*Ranking*
Satara	0.00	**Moderately vulnerable** (districts with vulnerability index value higher than M but less than M + SD)
Jalna	0.01	
Nagpur	0.01	
Chandrapur	0.04	
Bhandara	0.04	
Yavatmal	0.04	
Amravati	0.04	
Ahamadnagar	0.04	
Washim	0.06	**Highly vulnerable** (districts with vulnerability index values higher than M + SD)
Nanded	0.07	
Nandurbar	0.08	
Gondia	0.08	
Wardha	0.09	
Buldhana	0.09	
Gadchiroli	0.14	

Source: Authors' estimation.

Table 4.7 gives the sub-categorisation of districts by individual dimensions of vulnerability as also the integrated vulnerability indices. Washim, Nanded, Nandurbar, Gondia, Wardha, Buldhana, and Gadchiroli districts fall in the 'highly vulnerable' category. This result, to an extent, is in contrast to those reported by Swami and Parthasarathy (2020), where Gadchiroli and Gondia came out as least agriculturally vulnerable.

Three out of the seven 'highly vulnerable' districts, Gondia, Wardha, and Buldhana, reported 'high vulnerability' on the exposure index, indicating a high climate vulnerability in these districts. Gondia and Buldhana report 'moderate vulnerability' on the sensitivity index and 'moderate' and 'low' adaptive capacity. These make them vulnerable to climate change. Districts with 'extremely low' vulnerability are Sangli, Nasik, Latur, Kolhapur, and Dhule. They also have 'extremely low' to 'low' climate variability. Sangli, Nasik, and Dhule have moderate adaptive capacity, in contrast to Latur and Kolhapur with high adaptive capacity.

4.4.4 Adaptation strategies to reduce vulnerability of agriculture to climate change – Maharashtra

Washim, Nanded, Nandurbar, Gondia, Wardha, Buldhana, Gadchiroli, Amravati, Ahmednagar, Beed, and Osmanabad report a 'high vulnerability' of agriculture to climate change. Policies and programmes aimed at strengthening the agriculture sector and reducing its vulnerability to climate change should consider the individual contributing factors for vulnerability in these districts and design interventions that would help address this vulnerability.

TABLE 4.7 Sub-categorisation of districts in Maharashtra by dimensions of vulnerability and integrated vulnerability indices

District	*Exposure index*	*Sensitivity index*	*Adaptive capacity index*	*LVI-IPCC index*
Sangli	EL	M	M	EL
Latur	L	M	H	EL
Nasik	EL	L	M	EL
Kolhapur	L	EL	H	EL
Dhule	EL	M	M	EL
Washim	M	M	L	H
Nanded	M	M	EL	H
Nandurbar	M	L	EL	H
Gondia	H	M	M	H
Wardha	H	L	L	H
Buldhana	H	M	L	H
Gadchiroli	M	L	EL	H

Source: Authors' estimation.

Note: *EL* = extremely low; *L* = low; *M* = moderate; *H* = high. Districts included in the table are those that reported either 'extremely low' or 'high' vulnerability in any of the integrated vulnerability assessment methods.

A major factor contributing to the vulnerability of agriculture to climate change in Gadchiroli, Nanded, Bhandara, Amravati, Bhuldana, Ahmednagar, Gondia, and Wardha is a high climate variability. The findings conform to other climate modelling results projecting a rise in temperature and rainfall across the state with regional variations (TERI, 2014).

Strengthening the natural resource base through soil and water conservation and rainwater harvesting, adopting water-efficient micro-irrigation technologies, and adopting climate-resilient agronomic practices would help address issues of climate variability in these districts. Temperature and rainfall fluctuations are bound to have serious implications for soybean, cotton, wheat, and gram, which are major crops in most parts of Maharashtra. Also, jowar, bajra, and pulses are projected to decline due to temperature variability, a phenomenon that is only going to aggravate. Experience has taught us that weather-based agromet advisory services contribute to strengthening on-farm capacity to deal with climate-related risks (Lobo et al., 2017).

High system sensitivity is prevalent in Wardha, Nandurbar, Bhandara, Washim, and Osmanabad. High human sensitivity occurs in Amravati, Washim, Gadchiroli, Buldhana, Nanded, Ahmednagar, Beed, Gondia, and Bhandara. These are districts with a high proportion of marginal and smallholders and agricultural labour force. Institutional initiatives aimed at collectivising marginal and smallholders would reduce the vulnerability of these districts to human sensitivity.

High ecological sensitivity is reported in Beed, Gondia, Bhandara, Ahmednagar, Buldhana, and Amravati. Almost 87% of the area in Ahmednagar is prone to extreme groundwater vulnerability (Thomas & Duraisamy, 2018). The most affected are small and marginal farmers, because they end up taking loans at high interest rates from private moneylenders (Kuchimanchi et al., 2018).

Technological interventions aimed at groundwater augmentation and recharge would reduce the vulnerability to ecological sensitivity of these districts (Srinidhi & D'Souza, 2018). Also, watershed development programmes help build overall capacities of farming communities, but its sustenance is dependent on the intensity of social capital availability (Singh et al., 2018, 2019).

The Maharashtra government has been encouraging the use of drip and sprinkler irrigation by providing subsidies. These techniques can help address many issues related to water availability, especially in the drylands of the Marathwada region. This is in keeping with the goal of increasing water efficiency by 20% under the National Water Mission (TERI, 2014).

Livelihood diversification and promotion of off-farm and non-farm enterprises would strengthen the economic capacity in Washim, Osmanabad, Beed, Buldhana, and Nandurbar. Increasing the technical capacity of the rural population, especially the smallholders, would improve the sociodemographic capacity in Nandurbar, Gadchiroli, and Nanded. Improving and strengthening rural infrastructure in Gadchiroli, Nanded, Buldhana, and Amravati is important to deal with the vulnerability of these districts. Facilitating access to institutional credit, improving irrigation capacity, and facilitating access to agricultural inputs would reduce the vulnerability of Washim, Buldhana, Amaravati, Osmanabad, Nandurbar, Nanded, Beed, Wardha, and Ahmednagar.

The Maharashtra State Action Plan for Climate Change (MSAPCC) aims at making rain-fed and dryland agriculture more productive. The development of drought- and pest-resistant crop varieties, adopting resource-conserving technologies, providing institutional support to farmers, and capacity building of stakeholders to realise the potential of dryland agriculture are all interventions designed to build the general and specific capacities of specific communities and ecosystems. The state could draw lessons from the drought mitigation and water conservation efforts in other, similar agroecology areas and have a combination of measures for the protection as well as recovery from drought (Bandyopadhyay et al., 2020).

Apart from dryland farming, measures to enhance agricultural productivity through customised interventions such as biotechnology to develop improved varieties of crops and livestock, promoting efficient irrigation systems, demonstration of appropriate technology, capacity building, and skill development are also thrust areas in the MSAPCC. There is mention of efforts at promoting citizens' and state actions for water conservation, augmentation, and preservation. The plan has provisions to empower and involve the Panchayati Raj, water users' associations, and primary stakeholders. Other than this, the largely rain-fed nature of the water resources of the state mandates the conservation of water for consumption and irrigation purposes.

District-level analysis gives insight into vulnerabilities in a more disaggregated form. Complementing this with an analysis at lower spatial scales, differentiated by communities, gender, and size, would be helpful in designing adaptation strategies that are inclusive and robust. Participatory approaches, like a community-based vulnerability evaluation, are also useful tools that help assess and map vulnerabilities at village, landscape, and community levels (Kuchimanchi et al., 2019).

4.5 Conclusion and the way forward

The study attempted to obtain a disaggregated understanding of the nature of the livelihood vulnerability faced by the districts of Maharashtra. The LVI-IPCC method helps classify the districts into high-, moderate-, and low-vulnerability categories. Interestingly, districts reporting low to extremely low vulnerability on the exposure index showed overall livelihood vulnerability. This indicates the importance of climate variables in determining livelihood vulnerabilities. Districts with the highest vulnerability to climate variables are Amravati, Bhandara, Buldhana, Gadchiroli Gondia, Nanded, and Wardha. High system sensitivity is experienced in Wardha, Nandurbar, Bhandara, Washim, and Osmanabad. Districts with very high system sensitivity report high dependence on agriculture and have a large number of marginal and smallholder farmers. Districts with high ecological sensitivity had a large majority of taluks reporting severe groundwater exploitation.

Strengthening the natural resource base through soil and water conservation and rainwater harvesting efforts, adopting water-efficient micro-irrigation technologies, and adopting climate-resilient agronomic practices are suggested as ways to address climate variability. Institutional initiatives aimed at collectivising marginal and smallholders, livelihood diversification and promotion of off-farm and non-farm enterprises, facilitating access to institutional credit, improving irrigation capacity, and facilitating access to agricultural inputs are other suggestions to build the capacities of districts to cope with the vulnerability of farmers and the farming community to climate change. The district-level analysis needs to be complemented with an analysis at lower spatial scales, differentiated by communities, gender, and size. Such a cross-sectional and finer analysis would contribute to design adaptation strategies that are inclusive and robust.

ANNEXURES

Annexure 1

TABLE 4.8 Maharashtra socio-economic profile

Districts	*Total population person (2011–2012)*	*Total rural population person (2011–2012)*	*% rural population (2011–2012)*	*Total worker population person (2011–2012)*	*% agri labour force (2011–2012)*	*Proportion of marginal and smallholders to overall holders (2011–2012)*	*TCA (2015–2016) (in 00' HA)*	*% area under total food grain to TCA (2015–2016)*	*Total NDDP (2013–2014) (in cr.)*	*NDDP (agriculture, 2013–2014) (in cr.)*	*% NDDP (agriculture, 2013–2014)*	*% of total irrigated area to gross cropped area (2015–2016)*	*% net sown area to gross total geographical area (2015–2016)*
Ahmednagar	4,543,159	3,630,542	80	2,204,590	71	82	14,202	62	22,811	2,609	11	31	61
Akola	1,813,906	1,094,165	60	768,154	67	74	6,761	30	9,189	1,125	12	14	79
Amravati	2,888,445	1,851,158	64	1,236,322	70	75	9,838	37	13,548	1,541	11	13	61
Aurangabad	3,701,282	2,081,112	56	1,575,079	60	83	10,760	50	21,423	2,133	10	14	66
Beed	2,585,049	2,070,751	80	1,255,548	78	81	10,408	64	8,709	1,698	19	6	73
Bhandara	1,200,334	966,503	81	597,305	73	91	2,531	93	5,397	423	8	36	52
Buldana	2,586,258	2,037,398	79	1,219,641	81	75	9,215	32	9,403	1,454	15	14	68
Chandrapur	2,204,307	1,428,929	65	1,058,172	66	69	5,338	49	12,805	809	6	26	42
Dhule	2,050,862	1,479,826	72	936,370	71	71	5,419	71	9,693	1,548	16	33	59
Gadchiroli	1,072,942	954,909	89	584,237	81	73	2,108	84	3,096	253	8	33	12
Gondia	1,322,507	1,096,577	83	665,419	70	92	2,405	88	5,266	250	5	32	31
Hingoli	1,177,345	998,612	85	569,182	82	72	5,762	45	3,173	537	17	1	71
Jalgaon	4,229,917	2,887,206	68	1,863,571	71	72	11,629	36	20,369	2,765	14	29	73
Jalna	1,959,046	1,581,617	81	930,886	77	78	8,755	40	7,245	1,630	22	9	74
Kolhapur	3,876,001	2,645,992	68	1,704,054	54	93	5,918	30	29,789	2,717	9	34	56
Latur	2,454,196	1,829,216	75	1,046,857	71	74	7,218	52	9,959	1,919	19	3	75
Mumbai	3,085,411	0	0	1,284,396	1				189,159	1,041	1		#DIV/0!
Mumbai – Suburban	9,356,962	0	0	3,735,021	1							0	0

(Continued)

TABLE 4.8 (Continued)

Districts	*Total population person (2011–2012)*	*Total rural population person (2011–2012)*	*% rural population (2011–2012)*	*Total worker population person (2011–2012)*	*% agri labour force (2011–2012)*	*Proportion of marginal and smallholders to overall holders (2011–2012)*	*TCA (2015–2016) (in 00' HA)*	*% area under total food grain to TCA (2015–2016)*	*Total NDDP (2013–2014) (in cr.)*	*NDDP (agriculture, 2013–2014) (in cr.)*	*% NDDP (agriculture, 2013–2014)*	*% of total irrigated area to gross cropped area (2015–2016)*	*% net sown area to gross total geographical area (2015–2016)*
Nagpur	4,653,570	1,474,811	32	1,868,560	34	68	6,498	50	38,703	706	2	23	56
Nanded	3,361,292	2,447,394	73	1,493,953	72	79	8,595	39	11,988	1,516	13	0	68
Nandurbar	1,648,295	1,372,821	83	792,065	82	65	3,662	49	4,601	633	14	17	42
Nashik	6,107,187	3,509,814	57	2,763,328	61	77	9,946	54	36,568	5,621	15	42	55
Osmanabad	1,657,576	1,376,519	83	773,916	77	68	7,748	45	6,341	1,515	24	13	56
Parbhani	1,836,086	1,266,280	69	822,797	74	74	8,254	49	6,861	1,426	21	1	76
Pune	9,429,408	3,678,226	39	4,048,993	32	81	11,212	50	91,241	3,500	4	28	55
Raigarh	2,634,200	1,664,005	63	1,072,969	37	87	2,155	65	19,887	275	1	59	27
Ratnagiri	1,615,069	1,351,346	84	714,076	63	83	2,625	35	10,236	365	4	53	31
Sangli	2,822,143	2,102,786	75	1,215,104	63	83	7,653	50	18,153	2,735	15	46	69
Satara	3,003,741	2,433,363	81	1,354,947	65	93	6,611	67	17,295	2,145	12	33	51
Sindhudurg	849,651	742,645	87	347,178	60	88	1,592	47	5,442	454	8	0	28
Solapur	4,317,756	2,918,665	68	1,898,395	63	67	11,594	70	23,726	2,127	9	36	67
Thane	11,060,148	2,545,470	23	4,492,767	17	80	2,420	26	111,238	359	0	1	25
Wardha	1,300,774	877,474	67	608,235	68	61	4,625	27	7,182	696	10	7	58
Washim	1,197,160	985,747	82	569,792	84	70	5,249	31	4,643	1,285	28	2	73
Yavatmal	2,772,348	2,174,195	78	1,355,999	79	60	9,926	30	10,456	1,155	11	14	63
Maharashtra	**112,374,333**	**61,556,074**	**55**	**49,427,878**	**53**		**22,8632**	**49**	**805,593**	**50,965**	**6**	**20**	**56**
Sources:	Census of India (2011)	Census of India (2011)	Census of India (2011)	Census of India (2011)	Census of India (2011)	Agriculture Census database, district table	Dept. of Agriculture, Govt. of Maharashtra	Dept. of Agriculture, Govt. of Maharashtra	Directorate of Economics and Statistics	Directorate of Economics and Statistics	Directorate of Economics and Statistics	Dept. of Agriculture, Govt. of Maharashtra	Dept. of Agriculture, Govt. of Maharashtra

Annexure 2

TABLE 4.9 Indicators used to build exposure index – Maharashtra districts

District	*COV south-west monsoon deviation*	*COV north-east monsoon deviation*	*COV temperature max*	*COV temperature min*	*% rural population*
Ahamadnagar	0.40	0.72	0.81	0.77	0.86
Akola	0.04	0.21	0.77	0.61	0.57
Amravati	0.06	0.73	0.94	0.55	0.62
Aurangabad	0.08	0.72	0.52	0.76	0.50
Beed	0.10	0.07	0.73	0.97	0.87
Bhandara	0.04	0.32	0.99	0.91	0.87
Buldhana	0.07	0.84	0.77	0.70	0.85
Chandrapur	0.11	0.38	0.90	0.65	0.63
Dhule	0.05	0.11	0.27	0.56	0.74
Gadchiroli	0.08	0.47	0.90	0.70	1.00
Gondia	0.12	0.73	0.99	0.87	0.91
Hingoli	0.09	0.01	0.86	0.60	0.94
Jalgaon	0.15	0.29	0.67	0.68	0.69
Jalna	0.08	0.24	0.71	0.83	0.87
Kolhapur	0.27	0.59	0.16	0.18	0.69
Latur	0.07	0.02	0.61	0.43	0.78
Nagpur	0.00	0.43	0.99	0.86	0.13
Nanded	0.22	0.91	0.86	0.24	0.75
Nandurbar	0.11	0.58	0.65	0.64	0.91
Nasik	0.28	0.20	0.29	0.35	0.52
Osmanabad	0.04	0.57	0.48	0.57	0.91
Parabhani	0.08	0.39	0.99	0.52	0.70
Pune	1.00	0.37	0.66	0.63	0.24
Raigadh	0.10	0.47	0.65	0.37	0.61
Ratnagiri	0.06	0.15	0.16	0.18	0.92
Sangli	0.21	0.08	0.01	0.28	0.78
Satara	0.62	0.64	0.49	0.32	0.88
Sindhudurg	0.00	0.57	0.09	0.00	0.98
Solapur	0.06	0.39	0.48	0.58	0.68
Thane	0.04	0.46	0.29	0.36	0.00
Wardha	0.05	1.01	0.99	1.00	0.67
Washim	0.06	0.44	0.86	0.60	0.90
Yavatmal	0.04	0.40	0.96	0.52	0.84

Source: Authors' estimation.

Annexure 3

TABLE 4.10 Indicators used to build sensitivity index – Maharashtra districts

Districts	*% area under food grain to TCA*	*% net sown area to total geographical area*	*Average size of land-holding*	*Proportion of marginal and smallholders to overall holders*	*Agriculture labour force*	*% taluks over-exploited in terms of ground-water extraction*
Ahmednagar	0.49	0.77	0.39	0.65	0.82	0.00
Akola	0.20	1.00	0.66	0.42	0.76	–0.33
Amravati	0.10	0.73	0.66	0.45	0.80	1.00
Aurangabad	0.14	0.83	0.39	0.69	0.65	–0.33
Beed	0.35	0.86	0.40	0.64	0.92	–0.33
Bhandara	1.00	0.59	0.15	0.92	0.84	–0.33
Buldhana	0.15	0.84	0.59	0.44	0.96	0.03
Chandrapur	0.40	0.44	0.70	0.27	0.73	–0.33
Dhule	0.55	0.69	0.70	0.33	0.82	–0.33
Gadchiroli	0.87	0.01	0.61	0.39	0.96	–0.33
Gondia	0.94	0.28	0.10	0.96	0.80	–0.33
Hingoli	0.29	0.86	0.63	0.37	0.98	–0.33
Jalgaon	0.07	0.90	0.69	0.35	0.81	0.29
Jalna	0.18	0.91	0.47	0.54	0.91	–0.33
Kolhapur	0.04	0.64	0.00	1.00	0.56	–0.33
Latur	0.36	0.89	0.61	0.43	0.82	–0.33
Nagpur	0.30	0.64	0.78	0.25	0.25	–0.33
Nanded	0.20	0.83	0.46	0.57	0.83	–0.33
Nandurbar	0.43	0.44	0.85	0.15	0.98	–0.33
Nasik	0.48	0.65	0.53	0.50	0.67	–0.33
Osmanabad	0.54	0.76	0.80	0.22	0.90	–0.33
Parbhani	0.40	0.95	0.60	0.41	0.86	–0.33
Pune	0.22	0.69	0.42	0.62	0.23	–0.33
Raigadh	0.66	0.23	0.24	0.81	0.30	–0.33
Ratnagiri	0.17	0.28	0.34	0.69	0.69	–0.33
Sangli	0.51	0.82	0.35	0.69	0.70	–0.33
Satara	0.44	0.57	0.02	1.00	0.72	–0.33
Sindhudurg	0.39	0.23	0.18	0.83	0.64	–0.33
Solapur	0.44	0.83	0.77	0.21	0.69	0.09
Thane	0.68	0.21	0.45	0.61	0.00	–0.33
Wardha	0.01	0.67	1.00	0.01	0.77	–0.33
Washim	0.23	0.91	0.78	0.28	1.00	–0.33
Yavatmal	–0.01	0.75	0.98	0.00	0.93	–0.33

Source: Authors' estimation.

Annexure 4

TABLE 4.11 Indicators used to build adaptive capacity index – Maharashtra districts

	% share of non-agri sectors in NDDP	*% of technical diploma and graduate and above to overall education done by operational holders*	*% non-agri labour force*	*Rural literacy rate*	*% of rural livestock population*	*% of rural population served by different amenities (agri credit society)*	*% of rural population served by different amenities (pucca road)*	*% of rural population served by different amenities, 2011 (transport communi-cation)*	*Crop intensity*	*Consumption of chemical fertilisers (in Mt)*	*% electricity consumption for Agri (in MWh)*
Ahmednagar	0.63	0.78	0.18	0.55	0.79	0.96	0.78	1.00	0.34	0.05	0.88
Akola	0.61	0.54	0.24	1.00	0.35	0.55	0.30	0.73	0.53	0.02	0.37
Amravati	0.62	1.00	0.20	0.96	0.42	0.49	0.45	0.68	0.32	0.00	0.52
Aurangabad	0.74	0.46	0.35	0.35	0.71	0.86	0.78	0.90	0.72	0.00	0.35
Beed	0.36	0.90	0.08	0.44	0.81	0.84	0.81	0.94	0.37	0.67	0.90
Bhandara	0.71	0.75	0.16	0.81	0.87	0.55	0.58	0.68	0.44	0.27	0.30
Buldhana	0.51	0.44	0.04	0.80	0.52	0.51	0.23	0.81	0.42	0.20	0.57
Chandrapur	0.81	0.31	0.27	0.48	0.74	0.23	0.24	0.49	0.17	1.00	0.07
Dhule	0.48	0.65	0.18	0.08	0.87	0.74	0.41	0.96	0.23	0.77	0.60
Gadchiroli	0.60	0.00	0.04	0.34	1.00	0.00	0.00	0.00	0.24	0.77	0.21
Gondia	0.78	0.38	0.20	0.88	0.99	0.38	0.73	0.66	0.32	0.40	0.26
Hingoli	0.29	0.37	0.02	0.55	0.66	0.87	0.79	0.92	0.69	0.53	1.00
Jalgaon	0.59	0.76	0.19	0.45	0.54	0.69	0.21	0.99	0.38	0.80	0.68
Jalna	0.28	0.55	0.09	0.17	0.80	0.91	0.85	0.96	0.40	0.56	0.31

(Continued)

TABLE 4.11 (Continued)

	% share of non-agri sectors in NDDP	*% of technical diploma and graduate and above to overall education done by operational holders*	*% non-agri labour force*	*Rural literacy rate*	*% of rural livestock population*	*% of rural population served by different amenities (agri credit society)*	*% of rural population served by different amenities (pucca road)*	*% of rural population served by different amenities, 2011 (transport communi-cation)*	*Crop intensity*	*Consumption of chemical fertilisers (in Mt)*	*% electricity consumption for Agri (in MWh)*
Kolhapur	0.67	0.74	0.44	0.62	0.79	0.93	0.86	0.96	0.54	0.70	0.20
Latur	0.41	0.85	0.18	0.46	0.75	0.92	0.95	0.97	0.51	0.51	0.76
Nagpur	0.93	0.57	0.75	0.80	0.00	0.33	0.63	0.51	0.16	0.26	0.09
Nanded	0.57	0.33	0.17	0.34	0.64	0.59	0.05	0.87	0.35	0.19	0.70
Nandurbar	0.45	0.16	0.02	–0.30	0.75	0.34	0.50	0.87	0.23	0.45	0.85
Nashik	0.54	0.20	0.33	0.57	0.73	0.88	0.83	0.96	0.12	0.70	0.40
Osmanabad	0.25	0.91	0.10	0.55	0.57	0.91	0.90	0.97	1.00	0.18	0.94
Parbhani	0.35	0.62	0.14	0.22	0.31	0.86	0.87	0.91	0.90	0.34	0.90
Pune	0.88	0.45	0.77	0.75	0.80	0.89	0.80	0.92	0.28	0.53	0.17
Raigad	0.95	0.24	0.70	0.65	0.85	0.48	0.80	0.60	0.13	0.22	0.01
Ratnagiri	0.85	0.09	0.31	0.71	0.96	0.47	1.00	0.68	0.03	0.14	0.02
Sangli	0.44	0.46	0.30	0.70	0.73	0.98	0.88	1.00	0.16	0.32	0.65
Satara	0.61	0.39	0.28	0.78	0.81	0.78	0.87	0.83	0.20	0.51	0.50
Sindhudurg	0.63	0.33	0.36	0.93	0.95	0.56	0.97	0.76	0.12	0.25	0.07
Solapur	0.66	0.25	0.31	0.41	0.75	1.00	0.82	1.00	0.13	0.32	0.86
Thane	1.00	0.32	1.00	0.24	0.39	0.77	0.79	0.91	0.00	0.10	0.00
Wardha	0.63	0.59	0.23	0.92	0.71	0.45	0.67	0.70	0.30	0.08	0.16
Washim	0.00	0.50	0.00	0.81	0.43	0.56	0.51	0.83	0.43	0.20	0.76
Yavatmal	0.54	0.78	0.07	0.73	0.64	0.35	0.26	0.69	0.16	0.07	0.60

Source: Authors' estimation.

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