Measuring Disaster Risks and Resilience at Sub-National Level in India

Dr. P.G.Dhar Chakrabarti[1]

[1] Author is the Team Leader of this study undertaken at the behest of Ministry of Home Affairs, Government of India, and supported by UNDP. The author had earlier headed India's National Institute of Disaster Management and was the founding Director of SAARC Disaster Management Centre. He also served as Secretary of National Disaster Management Authority. The author was also involved with the Expert Groups of UNISDR for development of indicators under Hyogo Framework and Sendai Framework for Disaster Risk Reduction.

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Abstract: The paper is based on a yearlong study conducted by the author to develop a Disaster Score Card that would rank 640 districts of India in disaster risks and 29 States and 7 Union Territories in both disaster risks and resilience. Data on multiple parameters of 14 hazards, 14 vulnerabilities and 2 exposures were collected from primary sources and methodologies were developed for measuring risks through combination of different weights on these parameters. Districts, States and Union Territories were ranked on each hazard, vulnerability and exposure as well as composite risks of disasters. Resilience of the State Governments and Union Territory Administration were measured through 7 generic indicators each having 10 indicators, based on global and national frameworks for reducing risks and building resilience to disasters. In the absence of any database on resilience a comprehensive set of questionnaires was developed for collecting information from the State governments and Union Territory administration. Quantitative norms for evaluation were developed and statistical techniques were applied for measuring progress on each indicator as well as on composite resilience index. This is a pioneering study on measuring risks and resilience in India, and probably the first study of its kind globally.

Introduction

During the past decade and half (2002-2017) disaster management system of India has undergone a paradigm shift from humanitarian relief and rehabilitation of the victims to holistic management of disasters that include pre-disaster prevention, mitigation and preparedness as well as post-disaster response, recovery and reconstruction. This shift was ushered through the Disaster Management Act 2005, institutionalized with the setting up of the disaster management authorities at national, state and district levels, guided by the National Policy on Disaster Management 2009, and operationalised through a series of guidelines, plans, procedures, programmes and projects at national, state and local levels.

The cumulative impacts of all these initiatives are clearly visible in advanced early warning of hydro-meteorological disasters, coordinated response to actual and impending disasters, drastic reduction in human and animal mortalities in disasters, and general increase in education and awareness about disasters at all levels. The impacts are not so visible in comprehensive assessment of hazards, vulnerabilities and risks of disasters at different levels, prevention of creation of new risks and mitigation of the existing risks of disasters, and mainstreaming disaster risk reduction across different sectors of development.

The progress achieved has also not been uniform throughout the country. A few States that encountered mega disasters have learnt from the catastrophes and developed systems and processes to deal with the disasters, but a few States that faced major disasters have not been so proactive in transforming the challenges into opportunities. Many States are in the process of improving their systems of disaster management, but the majority of States have remained largely complacent, irrespective of whether they faced major or minor disasters. Even the States that have done relatively better have not done so uniformly in every aspect of disaster risk management - performance has been typically better in post-disaster response-relief-reconstruction than in pre-disaster prevention-mitigation-preparedness.

At the national level, Government of India had been reviewing biennial progress of the implementation of the Hyogo Framework of Action and would be doing similar exercise for the successor Sendai Framework for Disaster Risk Reduction, but such reviews do not always address the national priorities of disaster management as enshrined in our national legislations, policies and programmes, nor do these cover the relative progress achieved at the sub-national level. Finance Commission has been reviewing the financial needs of the States for disaster response and relief on a five-yearly basis, but this does not involve performance review of the States. To a limited extent Comptroller and Auditor General conducted performance audit of a few State governments, but typically these are limited to government expenditure. Standing Committee of Parliament has been reviewing management of specific aspects and events of disasters, but these are not systematic reviews of progress of the entire gamut of disaster risk management.

In the federal system of governance of India the State governments have the primary responsibilities of disaster management while the Central government plays largely a supporting role. State governments, district administration and the local authorities have been dealing with disasters on a daily basis, but as yet no scientific system or tool is available to the State governments and their agencies either to benchmark the performance or to measure the progress achieved on different aspects and issues of disaster management on a scientific basis. Sometimes legislative scrutiny, financial audit, media analysis, and academic research have been helpful in identifying the constraints and challenges, but such exercises have focused more on management of specific events of disasters than on the entire cycle of disaster risk management.

Therefore, in order to assist the State governments to benchmark the performance on different aspects of disaster risk management and to measure the progress achieved in building disaster resilience of the rural and urban communities, the Ministry of Home Affairs, with support from the United Nations Development Programme and in consultation with the State governments, came up with the initiative to develop a system of Disaster Score Card for the country.

II

Methodology

The methodology of Disaster Score Card was developed through a consultative process, involving Government of India, its concerned scientific and technical agencies, State governments and Union Territory administrations.[3] A general consensus was developed that Disaster Score Card shall be developed through two different but interrelated scorecards –

[3] At the apex level an Advisory Committee was constituted by Ministry of Home Affairs (nodal Ministry on disaster management in India) that included representatives of National Disaster Management Authority, State Governments and experts. Three expert Working Groups on Hazards, Vulnerabilities and Computation of Risks and Resilience were constituted involving various scientific and technical agencies of Government of India and State Governments and academic institutions.

disaster risk scorecards and disaster resilience scorecards. These are worked out on the basis of two different sets of indexes: Disaster Risk Index (DRisI) and Disaster Resilience Index (DResI). DRisI captures the risks of disasters at the level of districts, which are further aggregated at the level of States and Union Territories.[4] In the absence of any data on resilience at district level, DResI measures the level of resilience to disasters only at the level of States and UTs.

A. Disaster Risk Index (DRisI)

The methodology developed for calculating Disaster Risk Index has several components. These are explained in sequential manner as under.

a) What constitutes risks of disasters

A general consensus was developed on what constitutes risks of disasters. This is presented in the following equation

$$R= \{(h \times v) \times e\} \div c$$

when '*R*' denotes risks of disasters; 'h' the hazards or the potentials of a physical event that may cause loss of life or property; 'v' the vulnerabilities or the factors or processes - physical, social, economic, and environmental - which increase susceptibility of an area or a community to impact of hazards; '*e*' exposures of vulnerable population and assets to hazards; and '*c*' or capacities or resources available within a community, society or organization that can reduce the level of risk, or the effects of disasters.

This equation is aligned with globally accepted definition of risks of disasters.[5]

b) Selection of indicators on hazards, vulnerabilities and exposures

It was agreed that indicators on hazards, vulnerabilities and exposures shall be selected on the basis of importance of the indicators in specific contexts of India as well as availability of data in uniform format throughout the country. Robust data sets on some of the indicators, such as lightning, coastal erosion, fire, industrial hazards etc are not available, but considering their importance these were selected and available datasets were used to the best possible extent.

The final list indicators selected for hazards, vulnerabilities and exposures are as follows:

Table-1.1: Indicators selected for Disaster Risk Index

[4] India is a federal country with 29 States, each having its legislature, executive and judiciary. In addition there are 7 Union Territories (UT) that are administered by the Central Government. Some of the States of India are larger than many countries. Uttar Pradesh with population of more than 200 million is larger than Brazil, the fifth largest country of the world. In fact, 18 States of India are larger in population than 75 percent countries of the world. Each State and UT is administratively divided in districts which are the basic administrative units of the country. There are 640 districts of the country at the time last decennial census of the country was conducted in 2011. More than 50 new districts have been created since then by way of bifurcation of existing districts or merger of parts of two or more districts. Since comprehensive database on the newly created districts are not available the study was restricted to 640 census districts of the country.

[5] This was separately studied in a separate Technical Paper that made a comprehensive survey of literature on methodology on disaster risks.

	Hazards	Vulnerabilities	Exposures
1.	Earthquake	Unsafe buildings	Population
2.	Cyclone	Social Infrastructure	GDP
3.	Flood	Physical Infrastructure	
4.	Drought	Net cropped area	
5.	Landslide	Livestock population	
6.	Tsunami	Industries	
7.	Avalanche	Vulnerable women	
8.	Heat Wave	Vulnerable children	
9.	Cold Wave	Disabled people	
10.	Coastal Erosion	Aged people	
11.	Coastal Erosion	Rural/Urban poor	
12.	Forest Fire	Deforestation	
13.	Fire	Depletion of Mangrove	
14.	Industrial Hazards	Water stress	

c) Parameters on indicators and weights on parameters

Each of these 14 hazards, 14 vulnerabilities and 2 exposures has several parameters. Based on the availability of datasets throughout the country on uniform formats several parameters were selected for development of indexes on the hazards, vulnerabilities and exposures.

Not all the parameters of hazards, vulnerabilities and exposures are equally important. Based on the importance of the parameters and as agreed during consultation workshops with experts, differential weights have been assigned on various parameters of hazard and vulnerabilities. The parameters of 14 indicators of hazards and weights on parameters are detailed in Annexure 2.1, while the parameters of 14 indicators of vulnerabilities and weights on these parameters are detailed in Annexure 2.2. For exposures equal weights are given on the twin indicators of population and GDP

d) Hazard specific vulnerabilities

Every indicator of vulnerability is not relevant for every hazard. For example, vulnerable building and infrastructure are extremely relevant for earthquake and landslide, but these are not relevant for drought. Similarly water stress is very relevant for drought, but it may not be relevant for earthquake. Therefore, depending on the relevance of vulnerabilities for specific types of hazards, a hazard-vulnerability matrix has been developed for measuring risks. This is shown in the table below.

Table-1.2: Hazard-Vulnerability Matrix on Risks of Disasters

HAZARD MATRIX	VULNERABILITY MATRIX			
	Built Environment	Production System	Vulnerable socio-economic conditions	Vulnerable environment

	Buildings	Social Infrastructure	Physical Infrastructure	Agriculture	Livestock	Industries	Poverty	Women	Children	Disabled	Elderly	Forest cover	Mangrove cover	Water Stress
Earthquake	√	√	√	√	√	√	√	√	√	√	√			
Landslide	√	√	√	√	√	√	√	√	√	√	√	√		
Tsunami	√	√	√	√	√	√	√	√	√	√	√		√	√
Drought				√	√	√	√	√	√	√	√	√		√
Flood	√	√	√	√	√	√	√	√	√	√	√	√		√
Cyclone	√	√	√	√	√	√	√	√	√	√	√		√	√
Heat Wave							√	√	√	√	√	√		
Cold Wave							√	√	√	√	√			
Avalanche	√	√	√				√	√	√	√	√	√		
Lightning							√	√	√	√	√			
Coastal erosion	√	√	√	√			√	√	√	√	√		√	
Forest Fire	√	√	√	√	√		√	√	√	√	√	√	√	√
Fire	√	√			√	√	√	√	√	√	√			√
Industrial Hazard						√	√	√	√	√	√			√

√ denotes the vulnerabilities in horizontal matrix that are relevant to the hazards in vertical matrix

e) Relative weights on indicators on hazards and vulnerabilities

Every hazard and every indicator on vulnerability do not create the same magnitude of risks. For example, an earthquake would create much more intense risks of disasters than landslide or forest fire. Similarly, every vulnerable condition may not create the same level of risks of disasters. For example, vulnerable physical conditions of houses and infrastructure may cause more deaths, injuries and economic losses than vulnerable human conditions of poverty or gender discriminations. In the absence of any robust time series data sets on disasters and its impacts, existing datasets of disaster damage and losses have been used to develop relative weights on hazards and vulnerabilities for measuring composite risks of disasters. These have been further refined based on the feedbacks received during the process of consultations.

Four major hazards of India – earthquake, cyclone, flood and drought – have been given equal weights of 15 percent, landslide is weighed 7 percent, while heat wave and landslides are assigned weights of 6 percent each, considering number of deaths caused by these hazards. Remaining hazards are given equal weights of 3 percent each.

Human vulnerabilities are given highest weights of 38 percent (poverty 10%, vulnerable women and children 8% each, disabled and aged 6% each), followed up built up environment 25 percent (vulnerable buildings 15%, social infrastructure 5% and physical infrastructure 5%), production systems 22 percent (agriculture 10%, livestock 6%, and industries 6%), and environmental vulnerabilities 15 percent (depletion of forest cover, mangrove cover and water stress 5% each). Two indicators of exposures are given equal weights of 50 percent. The relative weights given on the indicators of hazards, vulnerabilities and exposures are explained in the table below.

Table-1.3: Weights on indicators of Hazards, Vulnerabilities, Exposures

HAZARDS		VULNERABILITIES		EXPOSURES	
Hazards	Weights	Vulnerabilities	Weights	Exposure	Weights

Earthquake	15%	Unsafe Buildings	15%	Population	50%
Cyclone	15%	Social Infrastructure	5%	Economy	50%
Flood	15%	Physical Infrastructure	5%		
Drought	15%	Cropped Area	10%		
Landslide	7%	Livestock	6%		
Heat Wave	6%	Industries	6%		
Lightning	6%	Poverty	10%		
Tsunami	3%	Vulnerable Women	8%		
Cold Wave	3%	Vulnerable Children	8%		
Avalanche	3%	Disabled People	6%		
Coastal erosion	3%	Aged People	6%		
Forest Fire	3%	Deforestation	5%		
Fire	3%	Mangrove Depletion	5%		
Industrial hazard	3%	Water Stress	5%		

f) Relative weights on hazards, vulnerabilities and exposures

Equal weights on hazards, vulnerabilities and exposures would magnify the risk level of districts with high density of population and GDP. Since hazards are the primary triggers of risks of disasters it was decided that relative weights of H, V and E shall be given in the ratio of 4:2:1.

g) Measuring composite Disaster Risk Index

Based on hazard, vulnerability and exposure index, hazard specific vulnerabilities, relative weights on indicators on hazards, vulnerabilities and exposures, and relative weights on hazard, vulnerability and exposure, a composite Disaster Risk Index has been developed for each of 640 census districts of the country. Districts have been ranked at national and state levels according to their risk scores.

B. Disaster Resilience Index (DResI)

UNISDR has defined resilience as '*the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner*',[6] but there is no consensus among experts regarding what constitutes such abilities.

Broadly, there are three layers of resilience: first the societal layer which include capacities of individuals, families, neighbourhood, communities and the culture that have developed through experiences and wisdom over generations; second, is the layer of governance which consists of institutions, systems, regulations, processes, programmes, and activities which support and strengthen societal layer; and the third layer is the support system when the capacity of the government is overwhelmed by the magnitude of the disasters. Such support systems may be available either from the national government or international agencies. In the context of large federal country like India the support system is very crucial for the constituent States and UTs.

In this study we are essentially looking at the second layer - the systems, institutions, processes, programmes and activities of the state governments and UT Administration in building resilience as per the national and global frameworks of disaster risk management.

[6] UNISDR Terminology on Disaster Risk Reduction 2017

The study does not examine resilience at level of society not does it look at the support system of central government or regional and international organizations.

The systems, institutions, processes, programmes and activities expected to be taken up at the sub-national level have been compiled and catalogued from 3 global and 3 national frameworks on building resilience to disasters. Three global frameworks include: (a) Sendai Framework for Disaster Risk Reduction, with specific reference to the activities proposed at national and local level under the four priorities of action; (b) Sustainable Development Goals, with particular reference to the goals that have specific targets and indicators that are directly or implicitly related to disaster risk reduction, such as goals, 1, 2, 3, 4, 9, 11, 13, 14 and 15; and (c) Paris Agreement on Climate Change, with reference to article 8 of the agreement that outlines 8 specific action areas for enhancing 'understanding, action and support' for disaster risk reduction. A total of 72 activities were catalogued under these three global frameworks.[7]

Three national frameworks on disaster management analysed for classifying the activities proposed to be taken up at sub-national level are: (a) Disaster Management Act 2005; (b) National Policy on Disaster Management 2009; and (c) National Plan on Disaster Management 2016. A total of 335 activities were catalogued under these three national frameworks.[8]

Activities that are not relevant in Indian contexts and activities that have recurrence in different frameworks were removed and the residual activities were classified and clubbed together to master catalogue of activities expected to be performed by sub-national governments in the specific contexts of India. A clear consensus emerged during the process of consultations in expert working groups and regional workshops that these activities may be grouped in 7 generic indicators, based on the cycle of disaster risk management. These are: (a) Risk Assessment; (b) Risk Prevention and Mitigation; (c) Risk Governance; (d) Disaster Preparedness; (e) Disaster Response; (f) Disaster Relief and Rehabilitation; and (g) Disaster Reconstruction. These are very well aligned with the national and global frameworks on disaster risk management.

There was further consensus that each of these 7 generic indicators shall be further disaggregated in 10 indicators, making a total of 70 indicators on disaster risk resilience at the level of the States and UTs. These indicators were cross-checked with the master catalogue of activities to confirm that none of the activities have been left out from the set of 7 x 10 indicators. The list of these indicators is provided in the table below.

Table-1.4: Indicators of Disaster Resilience Index

Generic Indicator	Specific Indicators
1. Risk Assessment	1. Hazard Vulnerability Risk Assessment

[7] This includes 59 activities to be taken at national and local levels under Sendai Framework, 15 activities under SDGs and 8 under Paris Agreement.

[8] This includes 72 activities under Disaster Management Act, 43 activities under National Disaster Management Policy, and 270 activities under National Plan on Disaster Management.

	2. Digital Risk Mapping in Public Domain 3. Real Time Data on Risks and Disasters 4. Micro Zonation of Earthquake Risks 5. Flood Risk Assessment 6. Drought Risk Assessment 7. Dissemination of Risk Information to People 8. Assessing Traditional and Local Knowledge 9. Assessing Patterns of Emerging Risks 10. Developing Database on Disasters
2. Risk Prevention & Mitigation	1. Disaster Risk Mitigation Projects 2. Mainstreaming DRR in Development 3. State and Disaster Risk Mitigation Fund 4. Safety standards for construction/ land use plans 5. Safety audit/ retrofitting of life line structures 6. Construction of cyclone/ flood shelters 7. Eco System Approach for Disaster Risk reduction 8. Social Safety Net for Poor and Vulnerable 9. Mitigating risks of heritage 10. Integration of climate change adaptation with DRR
3. Risk Governance	1. Institutional mechanisms for risk governance 2. Disaster Management Policy and Plans 3. Disaster Management Manuals and Procedures 4. Decentralisation and Devolution of Functions 5. Community Involvement and Participation 6. Multi-Stakeholder Platform 7. Training and Capacity Development 8. Enforcement and Compliance 9. Transparency and Accountability 10. Monitoring and Evaluation System
4. Disaster Preparedness	1. End-to-End Early Warning Systems 2. Emergency Operation Centres 3. Disaster Communication System 4. Emergency Medical Preparedness 5. Scenario Building, Simulation and Mock Drills 6. Contingency Plans, SOPs, Manuals 7. Community Based Disaster Preparedness 8. Awareness Generation 9. Resource Inventory 10. Media Partnership
5. Disaster Response	1. State agencies for disaster response 2. Incident Response System 3. Coordination with GOI, NDRF, Armed Forces 4. Evacuation, Search and Rescue 5. Emergency Medical Response 6. Emergency Support Functions 7. Protection of Women and Children 8. Disposal of dead bodies 9. Disposal of Animal Carcasses 10. Disposal of Debris
6. Disaster Relief & Rehabilitation	1. Minimum Standard of Relief 2. Ex-gratia Relief 3. Relief Logistics and Supply Chain Management 4. Food and Essential Supplies 5. Drinking Water, Dewatering and Sanitation 6. Health and Mental Health Care 7. Management of Relief Camps 8. Veterinary Care 9. Relief Employment 10. Temporary and Intermediary Shelters
7. Disaster Reconstruction	1. Damage and Loss Assessment

	2. Post Disaster Need Assessment 3. Financing Reconstruction 4. Institutional mechanisms for reconstruction 5. Building Back Better 6. Reconstruction of houses 7. Reconstruction of infrastructure 8. Regeneration of ecology and environment 9. Livelihood Reconstruction 10. Learning from reconstruction and recovery

As all the 7 aggregate indicators are not equally important for building resilience to disasters it was imperative that relative weights on these indicators are decided through a consultative process. A consensus emerged on the following relative weights on 7 aggregate indicators.

Table-1.5: Weights on Indicators on Disaster Resilience

No.	Aggregate Indicators	Weights
1.	Risk Assessment Risk Assessment	10%
2.	Risk Prevention & Mitigation	20%
3.	Risk Governance	20%
4.	Disaster Preparedness	20%
5.	Disaster Response	10%
6.	Disaster Relief & Rehabilitation	15%
7.	Disaster Reconstruction	5%

There is hardly any database on the initiatives of the States/UTs in building resilience to disasters. Therefore, this database had to be got constructed on the basis of information to be collected from the State Governments and UT Administration through a comprehensive set of questionnaire on different aspects of disaster risk management.

The questionnaire was carefully designed and structured to obtain maximum possible information in both qualitative and quantitative terms on the systems, institutions, processes, programmes and activities taken up at the level of State Governments and UT Administration for reducing risks and building resilience to disasters. The first question asked on an indicator is in binary format (yes-no), followed by a more probing question on the details of activities undertaken, and finally a question on the means of verification, asking for documentary evidence of the activities. Under each generic question an open-ended question was asked to cover activities and initiatives that are not captured under specific questions.

Each of 29 States and 7 UTs submitted their response to the questionnaire supported by voluminous documents as evidences of action taken by them. These were carefully examined to assess both the veracity and quality of action actually undertaken on the ground. Quantitative norms for assessing the performance of the States and UTs against each question were developed. [9]

III

[9] Copies of the Questionnaire on Disaster Resilience and Quantitative Norms for Evaluation of Performance of States/ UTs on 70 indicators of disaster resilience can be accessed in Ministry of Home website where the study report in 3 volumes was uploaded. http://www.ndmindia.nic.in/important-letters

Disaster Risk Index

Data collected, collated and compiled on each of the 14 selected indicators on hazard and their parameters as detailed in Annexure-2.1 were tabulated for each of 640 districts of the country, on the basis of statistical computation formula, as explained below.

a) Earthquake

Earthquake Hazard Index has been calculated as the weighted average of the prescribed values of the seismic hazard zones, where the weights are the percentage of area falling within a particular zone. Here X_1= 0, X_2= 4, X_3= 6, X_4= 8, X_5= 10 is the intensity of the i-th hazard zone, w_i's are percentage of area of district in the i-th hazard zone, i = 1, …, 5.

$$\mathrm{I} = \frac{\sum_{i=1}^{5} w_i \times X_i}{\sum w_i}$$

b) Landslide

Landslide Hazard Indexhas been calculated as the weighted average of the prescribed values of the landslide hazard zones, where the weights are the percentage of area falling within a particular zone. Here X_1= 0, X_2= 4, X_3= 6, X_4= 8, X_5= 10 is the intensity of the i-th hazard zone, w_i's are percentage of area of district in the i-th hazard zone.

$$\mathrm{I} = \frac{\sum_{i=1}^{5} w_i \times X_i}{\sum w_i}$$

c) Flood

The index has been calculatedas the weighted average of the three prescribed indicators which are the values of the percentage of flood prone are according to the mapping by BMTPC(2006), standardized by formula (I) and NRSC(2017), standardized by formula (II) where w's denote the percentage of flood area in the risk zone and Y's denote the pre-specified score of the zones, as well as total number of Flood prone cities in the district with population greater than 1 Million and 10 Million, standardized by formula (III), where the weights had been pre-specified as 60%, 20% and 20%.

$$X_1^* = (X_1)/(10) \ldots\ldots\ldots (I)$$

$$X_2^* = \frac{\sum_{i=1}^{5} w_i \times Y_i}{\sum w_i} \ldots\ldots\ldots (II)$$

$$X_3^* = 10 * (X_3)/\left(max(X_3)\right) \ldots\ldots\ldots (III)$$

$$\mathrm{I} = \frac{\sum_{i=1}^{3} w_i \times X_i^*}{\sum w_i}$$

d) Drought

Drought Hazard Indexhas been calculated as the average of the normalised scores of the parameters. For (a), Negative of the moisture index has been normalised to a range of 0 to 10 according to formula (I) such that the higher the value of this normalised value, the more intense the hazard. For (b) the percentages have been divided by 100 to normalise from 0 to 10. (c) and (d) has been normalised through dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10.Then a simple average of all these parameters had been taken since equal weights had been pre-specified.

$$X_1^* = 10 * (max\ (X_1) - X_1)/(max(X_1) - \min(X_1)) \ldots\ldots\ldots.(I)$$
$$X_2^* = (X_2)/(100) \ldots\ldots\ldots.(II)$$
$$X_3^* = 10 * (X_3)/(max(X_3)) \ldots\ldots\ldots.(III)$$
$$X_4^* = 10 * (X_4)/(max(X_4)) \ldots\ldots\ldots.(IV)$$
$$I = mean\ (X_i^*)$$

e) Cyclone

For calculating Cyclone Hazard Index parameters (a), (b), (c), (d), (e), as shown in the table have been normalized by dividing by the maximum value and multiplying by 10 to get on scale of 0 to 10 according to formula (I).For (f) an ad hoc score has been developed which follows the following properties: (i) Score (yes) > Score (no) (ii) The mean of all scores = (0+10)/2 = 5. Out of several possible choices, the middle point has been chosen which gives the values: Score (yes) = 5.85, Score (no) = 2.49. The score has been assigned corresponding to the responses Yes and No.Then a weighted average of all these parameters had been taken where the weights had been pre specified.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right) \ldots\ldots\ldots.(I)$$

$$X_6^* = \begin{cases} 5.85\ if\ X_6 = yes \\ 2.49\ if\ X_6 = no \end{cases}$$

$$I = mean\ (X_i^*)$$

f) Tsunami

For Tsunami Hazard Index 3 parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10 according to formula (I).Then a weighted average of all these parameters had been taken where the weights had been pre specified.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right) \ldots\ldots\ldots.(I)$$

$$\mathrm{I} = \frac{\sum_{i=1}^{3} w_i \times X_i^*}{\sum w_i}$$

g) Avalanche

Avalanche Hazard Index has been calculated as the weighted average of the prescribed values of the seismic hazard zones, where the weights are the percentage of area falling within a particular zone. Here X_1= 0, X_2= 4, X_3= 6, X_4= 8, X_5= 10 is the intensity of the i-th hazard zone, w_i's are percentage of area of district in the i-th hazard zone.

$$\mathrm{I} = \frac{\sum_{i=1}^{5} w_i \times X_i}{\sum w_i}$$

h) Heat Wave

The first 3 parameters(annual average of the number of hot days, number of heat waves and length of longest heat wave) have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10 according to formula (I). The average heat index during the heat waves is normalised according to formula (II).Then a simple average of all these parameters had been taken to get the index since equal weights had been pre specified. Since there were extensive cases of missing data for several districts due to non existence of weather stations etc, the missing values have been imputed with data from the geographically closest district in order to compute the index.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right) \dots\dots\dots.(I)$$
$$X_4^* = 10 * (X_4 - 54)/(max(X_4) - 54) \dots\dots\dots.(II)$$
$$I = mean\ (X_i^*)$$

i) Cold Wave

All 3 parameters (the proportion out of total days in the three zones on basis of severity of cold day) have been normalized by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10.Then a simple average of all these parameters had been taken to get the index since equal weights had been pre specified. Since there were extensive cases of missing data for several districts due to non-existence of weather stations etc., the missing values have been imputed with data from the geographically closest district in order to compute the index.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right)$$
$$I = mean\ (X_i^*)$$

j) Coastal Erosion

For Coastal Erosion Hazard Index 3 parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. Then a simple average of all these parameters had been taken since equal weights had been pre specified.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right)$$
$$I = mean\ (X_i^*)$$

k) Lightning

The average annual deaths has been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. Since, the data has been compiled at the state level, an assumption has been made that the incidence is equally likely across all districts, hence the districts with more population would be at a higher risk.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right)$$
$$I = mean\ (X_i^*)$$

l) Forest Fire

We obtain a multiplier which has been defined as the weighted average of proportions of "very dense", "dense" and "open" forest cover in the district (area of forest category in district divided by total forest cover in district) where the weights had been pre specified. The multiplier is strictly between 0 and 1.Then this multiplier is multiplied to the pre-assigned score associated with the risk category of the district to get the hazard index.

m) Fire

All 3 parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. Then a simple average of all these parameters had been taken since equal weights had been pre specified. Since, the data has been compiled at the state level, an assumption has been made that the incidence is equally likely across all districts, hence the districts with more population would be at a higher risk.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right)$$
$$I = mean\ (X_i^*)$$

a) Industrial Hazards

The first 2 parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. The CEPI has been rescaled on a scale of 10, which is 10 for CEPI>80, 8 for CEPI>70, 60 for CEPI>60, 4 for CEPI>50, 2 for CEPI<50. Then a weighted average of all these parameters had been taken where the weights had been pre specified as 50%:25%:25%.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right)$$
$$\mathrm{I} = \frac{\sum_i^3 w_i \times X_i^*}{\sum w_i}$$

Composite Hazard Index

Hazard Indexes of 14 hazards were aggregated on the basis of relative weights on hazards to compute the Composite Hazard Index of districts. These were further aggregated to work out the Composite Hazard Index of States and UTs, which is provided in Annexure-2.3.

Computation of Vulnerability Index

Data collected, collated and compiled on each of the 14 selected indicators on vulnerabilities and their specific parameters as stated in Table were tabulated for each of 640 districts of the country. Vulnerability Index of each vulnerability was worked out for each district based on the statistical computation formula as explained below.

a) Buildings-Walls

In order to capture the effect each particular hazard has on each particular type of roof, the following coding has been used: X:{VH = 10, H = 8, M = 6, L = 4, VL = 2} and each hazard index has been categorized according to 5 risk zones A weighted average of these has been taken where the weights are proportion of a particular roof type in all houses of the district.

b) Buildings-Roofs

In order to capture the effect each particular hazard has on each particular type of wall, the following coding has been used: X:{VH = 10, H = 8, M = 6, L = 4, VL = 2} and each hazard index has been categorized according to 5 risk zones A weighted average of these has been taken where the weights are proportion of a particular wall type in all houses of the district.

c) Agriculture and Livestock

For agriculture, the net non-irrigated cropped area (total cropped area–irrigated area) and irrigated area has been normalized by dividing by the total area of the district and multiplying by 10 to put on scale of 0 to 10. Then a weighted average of all these parameters had been taken where the weights had been pre specified as 80% on former and 20% on latter. (X_c : Cropped area, X_i : Irrigated area, X_t : Total area)

$$I_a = 0.8 * (X_c - X_i)/X_t + 0.2 * X_i/X_t$$

For livestock, the number of bovine animals and other animals has been normalized by dividing by the total number of the district and multiplying by 10 to put on scale of 0 to 10. Then a weighted average of all these parameters had been taken where the weights had been pre specified as 75% on former and 25% on latter. (X_b : No. of bovine animals, X_o : No. of other animals, X_t : Total No. of animals)

$$I_l = 0.75 * (X_b)/X_t + 0.25 * (X_o)/X_t$$

d) Industries

The total number of industries, industrial clusters and SEZs have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. Then a weighted average of all these parameters had been taken where the weights had been pre specified as 40%:40%:20%.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right)$$

$$\mathrm{I} = \frac{\sum_i^3 w_i \times X_i^*}{\sum w_i}$$

e) Physical Infrastructure

All parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. Then a simple average of groups of these parameters (Road & Rail Connectivity, Sea and Air Connectivity, Dams & Reservoirs and Power Plants) had been taken since equal weights had been pre specified. Within each group, simple average of each of the parameter in the group has been taken.

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right)$$

$$Y_j = mean\ (X_i : X_i \,\epsilon\, j - th\ group)$$

$$I = mean\ (Y_j)$$

f) Social Infrastructure

All parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. Then a simple average of groups of sub-groups of these parameters (Educational Institutions and Health Institutions) had been taken since equal weights had been pre specified. Within each group, simple average of each of the sub-group of parameters in the group has been taken. Within each sub-group, simple average of each of the parameter in the sub-group has been taken.

$$Y_j = mean\ (X_i : X_i \epsilon\ j - th\ subgroup)$$
$$Z_j = mean\ (Y_i : Y_i \epsilon\ j - th\ group)$$
$$I = mean\ (Z_j)$$

g) Poverty

All parameters (rural and urban BPL and Homeless population) have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10. Then a simple average of all these parameters had been taken, since equal weights had been pre specified

$$X_i^* = 10 * (X_i)/\left(max(X_i)\right)$$
$$I = mean\ (X_i^*)$$

h) Women

All parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10 according to Formula (I). Then a simple average of all these parameters had been taken, since equal weights had been pre specified

$$X_i^* = 10 * \ (X_i - min(X_i))/(max(X_i) - \min(X_i)) \dots \dots \dots . (I)$$
$$I = mean\ (X_i^*)$$

i) Children

All parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10 according to Formula (I). Then a simple average of groups of these parameters had been taken since equal weights had been pre specified. Within each group, weighted average of each of the parameter in the group has been taken where the weights had been pre specified. This has been done twice, once using absolute numbers and once using percentages. Then a geometric mean of both these indexes have been taken to obtain final index

$$X_i^* = 10 * \ (X_i - min(X_i))/(max(X_i) - min(X_i)) \dots \dots \dots . (I)$$
$$I_1 = mean\ (X_i^*)$$
$$I_2 = mean\ (X_i^*)$$
$$I = geomean\ (I_1, I_2)$$

j) Disability

All parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10 according to Formula (I). Then a simple average of all these parameters had been taken since equal weights had been pre specified. This has been done twice, once using absolute numbers and once using percentages. Then a geometric mean of both these indexes have been taken to represent final index.

$$X_i^* = 10 * \ (X_i - min(X_i))/(max(X_i) - min(X_i)) \dots \dots \dots . (I)$$
$$I_1 = mean\ (X_i^*)$$
$$I_2 = mean\ (X_i^*)$$
$$I = geomean\ (I_1, I_2)$$

k) Elderly

All parameters have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10 according to Formula (I). Then a simple average of all these parameters had been taken since equal weights had been pre specified. This has been done twice, once using absolute numbers and once using percentages. Then a geometric mean of both these indexes has been taken to represent final index.

$$X_i^* = 10 * (X_i - min(X_i))/(max(X_i) - min(X_i)) \dots\dots\dots (I)$$
$$I_1 = mean\ (X_i^*)$$
$$I_2 = mean\ (X_i^*)$$
$$I = geomean\ (I_1, I_2)$$

l) Depleting Forest Cover

All parameters of change (dense & open) have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10 according to Formula (I). Then a simple average of all these parameters had been taken, since equal weights had been pre specified.

$$X_i^* = 10 * (X_i - min(X_i))/(max(X_i) - \min(X_i)) \dots\dots\dots (I)$$
$$I = mean(X_i^*)$$

m) Depleting Mangroves

All parameters of change (dense & open) have been normalised by dividing by the maximum value and multiplying by 10 to put on scale of 0 to 10 according to Formula (I). Then a simple average of all these parameters had been taken, since equal weights had been pre specified.

$$X_i^* = 10 * (X_i - min(X_i))/(max(X_i) - \min(X_i)) \dots\dots\dots (I)$$
$$I = mean(X_i^*)$$

n) Water Stress

All parameters of change have been on scale of 0 to 10 according to Formula (I), (II) and (III). Then a simple average of all these parameters had been taken, since equal weights had been pre specified.

$$X_1^* = 10 * (max\ (X_1) - X_1)/(max(X_1) - \min(X_1)) \dots\dots\dots (I)$$

$$X_2^* = (100 - X_2)/(100) \dots\dots\dots (II)$$

$$X_3^* = \frac{\sum_i^3 w_i \times X_i}{\sum w_i} \dots\dots\dots (III)$$
$$I = mean(X_i^*)$$

Composite Vulnerability Index

Vulnerability Indexes of 14 vulnerabilities were aggregated on the basis of relative weights on vulnerabilities to compute the Composite Vulnerability Index of districts. These were further aggregated to work out the Composite Vulnerability Index of States and UTs. The detail of Composite Vulnerability Index is provided in Annexure- 2.4.

Exposure Index

Exposures of districts to the hazards have been measured on the basis of two indicators – density of population and per capita GDP, with equal weights. District wise exposure index is computed and these are aggregated to work out exposure Index of States and UTs, as detailed in Annexure- 2.5.

Capacity Index

In the absence of any nation-wide data on capacities, Disaster Resilience Index of the States/ UTs – as presented in Table-1.7 is taken as proxy indicator on capacities. This reflects the capacity of the State Governments and UT Administration for disaster risk management, measured on a set of 70 indicators.

Disaster Risk Index

Hazard, vulnerability and exposure indexes have been compounded and further discounted by capacities for calculating the overall Disaster Risk Index applying the basic equation of {(h x v) x e} ÷ c. The resultant Disaster Risk Index of States/ UTs is presented below.

Table-1.6: Disaster Risk Index of States and Union Territories

	STATES / UINION TERRITORIES	Hazard	Vulnerability	Exposure	Hazard* Vulnerability* Exposure	Capacity	Risk	Disaster Risk Index	Rank
		(Scale of 10)						(Scale of 100)	
	1	2	3	4	5	6	7	8	9
1	Andhra Pradesh	4.25	3.03	3.17	1.97	3.70	2.76	27.58	8
2	Arunachal Pradesh	2.76	1.67	0.52	1.17	2.26	1.56	15.63	21
3	Assam	3.03	2.53	2.05	2.14	4.19	2.87	28.75	7
4	Bihar	3.13	3.15	3.31	1.80	4.12	2.50	24.99	10
5	Chhattisgarh	2.25	2.39	2.03	1.13	2.34	1.42	14.20	26
6	Goa	1.96	1.38	0.90	1.06	2.56	1.03	10.35	29
7	Gujarat	3.66	3.82	4.05	2.10	4.93	2.74	27.44	9
8	Haryana	2.26	2.46	2.86	1.17	3.46	1.48	14.76	23
9	Himachal Pradesh	3.03	2.02	1.28	1.21	3.97	1.56	15.63	22
10	Jammu and Kashmir	2.26	2.06	1.35	1.15	2.73	1.46	14.56	25
11	Jharkhand	2.46	2.34	2.09	1.20	1.71	1.70	17.03	16
12	Karnataka	2.78	3.60	4.03	2.11	3.29	2.98	29.82	6
13	Kerala	2.97	2.26	3.20	1.14	4.19	1.37	13.75	27
14	Madhya Pradesh	2.81	3.86	2.96	2.16	3.10	3.08	30.79	4
15	Maharashtra	4.07	4.75	5.67	5.69	4.43	5.48	54.75	1
16	Manipur	2.96	1.62	0.55	1.18	2.10	1.61	16.11	17

17	Meghalaya	2.65	1.53	0.63	1.20	3.00	1.59	15.88	20
18	Mizoram	3.06	1.47	0.46	1.16	2.96	1.47	14.71	24
19	Nagaland	2.82	1.67	0.55	1.18	2.12	1.59	15.92	19
20	Odisha	3.80	2.80	2.42	1.63	4.17	2.27	22.68	11
21	Punjab	2.67	2.45	2.62	1.46	3.06	2.13	21.29	13
22	Rajasthan	2.29	4.34	3.29	2.22	3.91	3.00	30.04	5
23	Sikkim	2.12	1.33	0.48	1.07	3.23	1.11	11.11	28
24	Tamil Nadu	2.84	3.34	4.47	1.64	4.63	2.24	22.36	12
25	Telangana	2.00	2.63	3.01	1.30	3.04	1.82	18.25	14
26	Tripura	2.81	1.64	0.77	1.23	4.08	1.60	15.99	18
27	Uttar Pradesh	2.62	5.41	5.09	3.29	3.03	4.22	42.24	3
28	Uttarakhand	3.38	2.07	1.63	1.32	3.65	1.82	18.16	15
29	West Bengal	4.31	3.40	4.62	4.81	3.64	5.18	51.78	2
	UNION TERRITORIES								
1	Andaman and Nicobar Islands	3.15	1.85	0.29	1.11	2.81	1.32	13.23	2
2	Chandigarh	1.50	1.00	0.93	1.07	3.06	1.09	10.94	3
3	Dadra and Nagar Haveli	1.85	1.09	0.23	1.06	2.20	0.99	9.91	6
4	Daman and Diu	2.16	1.26	0.19	1.06	1.89	1.02	10.20	5
5	Delhi	1.85	1.46	4.07	1.16	3.57	1.44	14.43	1
6	Lakshadweep	1.58	0.99	0.11	1.06	1.86	0.97	9.72	7
7	Puducherry	1.99	1.17	0.74	1.06	2.85	1.04	10.41	4

Maharashtra has the highest Disaster Risk Index of 54.75 in a scale of 100, followed by West Bengal (51.78), Uttar Pradesh (42.24), Madhya Pradesh (30.79), Rajasthan (30.04), Karnataka (29.82), Assam (28.75), Andhra Pradesh (27.58), Gujarat (27.44), and Bihar (24.99).

It would be useful to read the Disaster Risk Index of States/ UTs in conjunction with that of Hazard, Vulnerability and Capacity Index of the States/ UTs. Some of the States with high index of hazards like Andhra Pradesh, Himachal Pradesh, Uttarakhand and North Eastern States have relatively low risk index as the level of vulnerabilities and exposures in these States are comparatively low. States like Gujarat, Tamil Nadu, Assam, Tripura, Himachal Pradesh have higher index of capacity which have discounted the net risk of disasters in these States. States like Uttar Pradesh, Madhya Pradesh, Rajasthan have high risk index despite having lower hazard index due to high vulnerability, high exposure and low capacity index.

District level hazard, vulnerability, exposure and risk index are not shown in this paper as these are huge data sheets in excel files that are difficult to be annexed to this paper.[10] Wealth of data generated through the study can be used to determine the inter se position of districts in the country and within each State in respect of each hazard, vulnerability, exposure and risks. Various permutations and combination of data can be made to compute risks of individual hazard such as earthquake, flood, drought, landslide etc. or a group of hazards like geological hazards, hydro-meteorological hazards, climate related hazards etc. Vulnerability index of group of vulnerabilities, such as built environment, natural environment, production systems and human vulnerabilities can be worked separately and in relation to each hazard to develop scenarios of risks in different situations. Similarly, regional pattern of hazards,

[10] These can be accessed in Ministry of Home website where the study report in 3 volumes was uploaded. http://www.ndmindia.nic.in/important-letters

vulnerabilities, exposures and risks can be worked out to highlight levels of risks in various regions of the country and within different regions in large States.

The data can be visualized in GIS platform to generate hazard, vulnerability, exposure and risk maps of States/ UTs, districts and regions on each indicator. Risks can be measured, compared and ranked in dashboards. This can be powerful tool to policy makers, administrators, practitioners and researchers. National Remote Sensing Centre (NRSC) of Indian Space Research Organization has agreed to develop a portal for visualization of the data through interactive maps and dashboards.

IV

Disaster Resilience Index

Based on information collected from State governments and UT administration and the quantitative norms for evaluation, as detailed in Annexure-I and Annexure-II, the performance of the States/ UTs in reducing risks and building resilience to disasters are measured on each of the 10 specific indicators under each of 7 generic indicators of resilience: risk assessment, risk prevention and mitigation, risk governance, disaster preparedness, disaster response, disaster relief and rehabilitation, and disaster reconstruction. The resilience score cards of States/ UTs are provided in Annexure Tables 2.7 To 2.12.

The resilience score cards on 7 generic indicators are aggregated on the basis of weights, as stated in Table- 1.5. The resultant Disaster Resilience Index of States/ UTs is worked out as shown in the table below.

Table-1.7: Disaster Resilience Index of States and UTs (Scale of 100)

	STATES / UNION TERRITORIES	Risk Assessment	Risk Prevention & Mitigation	Risk Governance	Disaster Preparedness	Disaster Response	Disaster Relief & Rehabilitation	Disaster Reconstruction	Disaster Resilience Index	Rank
1	2	3	4	5	6	7	8	9	10	11
	STATES									
1	Andhra Pradesh	44.0	24.0	37.0	39.0	44.0	41.0	41.0	37.0	11
2	Arunachal Pradesh	14.0	16.0	25.0	23.0	30.0	30.0	17.0	22.6	26
3	Assam	50.0	27.0	54.0	46.0	42.0	39.0	29.0	41.9	4
4	Bihar	34.0	40.0	48.0	39.0	38.0	44.0	39.0	41.2	7
5	Chattisgarh	16.0	12.0	28.0	28.0	25.0	31.0	20.0	23.4	25
6	Goa	18.0	21.0	23.0	27.0	33.0	35.0	20.0	25.6	24
7	Gujarat	48.0	45.0	53.0	54.0	50.0	44.0	50.0	49.3	1
18	Haryana	24.0	28.0	40.0	39.0	41.0	38.0	19.0	34.6	14
9	Himachal Pradesh	51.0	26.0	52.0	46.0	34.0	36.0	20.0	39.7	9
10	Jammu & Kashmir	18.0	18.0	28.0	24.0	42.0	39.0	28.0	27.3	23

11	Jharkhand	13.0	9.0	20.0	15.0	18.0	29.0	16.0	17.1	29
12	Karnataka	40.0	21.0	34.0	36.0	39.0	36.0	27.0	32.9	15
13	Kerala	32.0	38.0	42.0	49.0	44.0	45.0	35.0	41.9	5
14	Madhya Pradesh	19.0	18.0	40.0	33.0	41.0	37.0	24.0	31.0	17
15	Maharashtra	33.0	31.0	50.0	55.0	51.0	45.0	38.0	44.3	3
16	Manipur	16.0	9.0	21.0	22.0	31.0	33.0	18.0	21.0	28
17	Meghalaya	18.0	20.0	37.0	33.0	36.0	36.0	24.0	30.0	21
18	Mizoram	16.0	20.0	40.0	33.0	34.0	33.0	20.0	29.6	22
19	Nagaland	13.0	9.0	29.0	21.0	30.0	28.0	17.0	21.2	27
20	Odisha	36.0	29.0	52.0	44.0	44.0	44.0	42.0	41.7	6
21	Punjab	18.0	17.0	32.0	36.0	43.0	43.0	21.0	30.6	18
22	Rajasthan	34.0	28.0	50.0	37.0	40.0	49.0	26.0	39.1	10
23	Sikkim	31.0	28.0	38.0	32.0	34.0	33.0	24.0	32.3	16
24	Tamil Nadu	44.0	47.0	39.0	49.0	49.0	52.0	44.0	46.3	2
25	Telangana	25.0	21.0	36.0	26.0	41.0	40.0	24.0	30.4	19
26	Tripura	43.0	32.0	54.0	45.0	36.0	38.0	20.0	40.8	8
27	Uttar Pradesh	18.0	25.0	33.0	33.0	31.0	40.0	24.0	30.3	20
28	Uttarakhand	34.0	24.0	41.0	39.0	46.0	39.0	37.0	36.5	12
29	West Bengal	21.0	30.0	43.0	39.0	46.0	37.0	35.0	36.4	13
	State Average	27.1	24.0	37.0	35.7	38.7	38.6	26.5	33.6	
	Union Territories									
1	Andaman & Nicobar Islands	17.0	14.0	33.0	41.0	34.0	28.0	24.0	28.1	4
2	Chandigarh	20.0	15.0	19.0	49.0	40.0	46.0	22.0	30.6	2
3	Dadra & Nagar Haveli	15.0	10.0	15.0	34.0	28.0	34.0	16.0	22.0	5
4	Daman & Diu	14.0	10.0	16.0	22.0	26.0	30.0	16.0	18.9	7
5	Delhi	34.0	21.0	29.0	50.0	48.0	41.0	26.0	35.7	1
6	Lakshadweep	13.0	11.0	23.0	19.0	28.0	21.0	14.0	18.6	6
7	Pondicherry	19.0	16.0	21.0	42.0	36.0	40.0	23.0	28.5	3
	Ut Average	18.8	13.8	22.3	36.7	34.3	34.3	20.1	26.0	
	National Average	25.7	21.7	34.6	35.6	37.2	37.4	25.3	32.1	

Gujarat tops the list of States in disaster risk resilience with overall Disaster Risk Resilience Index of 49.3 in a scale of 100 followed by Tamil Nadu (46.3), Maharashtra (44.3), Assam and Kerala (41.9), Odisha (41.7), Bihar (41.2) and Tripura (40.8). Among the Union Territories Delhi tops with a score of 35.7.

The national average score of disaster resilience is 32.17, with State average of 33.6 and UT average of 32.1. 13 States (Arunachal Pradesh, Chhattisgarh, Goa, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Punjab, Telangana, and Uttar Pradesh) and 6 Union Territories (Andaman & Nicobar Islands, Chandigarh, Dadra & Nagar Haveli, Daman & Diu, Lakshadweep, and Puducherry) score less than national average. None of the States has scored the level of 50% in disaster resilience.

The study shows that level of resilience to disasters in States and Union Territories is low and requires considerable improvements. Most of the existing level of resilience has been developed during the past decade and half and it may be expected impacts of these initiatives would be felt in the years ahead.

However, as already explained in the section on methodology, this index captures the progress achieved by the State Governments and Union Territory Administrations in the implementation of national and global frameworks for building resilience to disasters. It neither factors the inherent societal or community resilience not does it reflect on the national capacity for resilience. The national level capacities on disaster management, developed over the years, provide tremendous support to the States/ UTs, particularly during major disasters. These have not been measured in this study.

2.1: Parameters and Weights on Hazards

	Hazards	Parameters on hazards	Weights on parameters
1.	Earthquake	Seismic hazard zonation: Zone-V, IV, III and II.	Zone-V: 10, Zone-IV: 6, Zone-III: 4, Zone-II: 2
2.	Landslide	Landslide hazard zonation: Zone- IV, III, II and I	Zone-IV: 10, Zone-III: 8, Zone-II: 4, Zone-I: 0
3.	Flood	a) CWC data on flood prone areas in States b) Flood Vulnerability Index of NRSC c) Flood prone cities with population above 100,000+ and million+ population	a) 80% b) 20% c) 20% (10% each)
4.	Drought	a) Moisture Index b) Unirrigated cropped area c) Drought Prone Area d) Number of drought years	Equal weights
5.	Cyclone	a) Number of cyclones b) Number of severe cyclones c) Probable maximum wind speed d) Probable maximum precipitation e) Probable maximum rainfall f) Whether area is flood prone	a) Equal weights of 15% for (a) and (c) to (e) b) 25% weights for (b)
6.	Tsunami	a) Length of coastline b) Population living within ½ km of coasts c) Average height of tsunami wave	a) 25% b) 25% c) 50%
7.	Avalanche	Avalanche hazard zonation: Zone- V, IV, III, II and I	Zone-IV: 10, Zone-III: 8, Zone-II: 4, Zone-I: 0
8.	Heat Wave	a) Average Heat Index based on NOAA methodology b) No of days with heat index above 54 c) No of heat wave (temperature above 40°C for 5+ days) d) Longest duration of heat wave	Equal weights
9.	Cold Wave		
10.	Coastal Erosion	a) Length of coastline b) Coastal length (km) under erosion c) Coastal area (sq. km)under erosion	Equal weights
11.	Lightning	Normalized annual average lightning mortality in districts	Mortality Index scaled 0 to 10
12.	Forest Fire	Forest fire zonation in very dense, dense and open forests a) High risk zone b) Moderate risk zone c) No risk zone	Values of 10, 5 and 0 for three risk zones with weights 50%, 30% and 20% on three types of forests
13.	Fire	Normalized fire index of districts based on average annual a) Number of accidents of fire b) Number of deaths c) Number of injuries	Equal weights
14.	Industrial Hazards	a) MAH industries b) MPI industries c) CEPI index	a) 50% b) 25% c) 25%

2.2: Parameters and Weights on Vulnerabilities

	Vulnerabilities	Parameters on vulnerabilities	Weights on parameters
1.	Unsafe buildings	Number of buildings constructed with predominant materials used for construction of roofs and walls and classified as Very High, High, Moderate, Low and Very Low risks in earthquake, landslide, flood and cyclone	VH:10, H:8, M: 6, L:4, VL: 2, as classified by Committee of Experts
2.	Social Infrastructure	Number of educational and health institutions in the district	a) 40% weights on primary educational institutions b) 10% weights on higher educational institutions c) 25% weights on primary health institutions d) 25% weights on hospitals
3.	Physical Infrastructure	a) Length of roadways b) Length of railways c) Number of airports and seaports d) Number of large dams and reservoirs e) Number of hydel, thermal and nuclear power stations	Equal weights of each indicator and further equal weights on sub-indicators within each indicator
4.	Net cropped area	a) Cropped area b) Irrigated area	a) 80% b) 20%
5.	Livestock population	Number of livestock in district a) Bovine animals b) Other animals	a) 80% b) 20%
6.	Industries	a) Number of MSME in districts b) Number of industrial clusters c) Number of SEZ	a) 40% b) 40% c) 20%
7.	Vulnerable women	a) Sex ratio b) Illiteracy c) MMR d) WHH e) WPR f) VAW	Equal weights
8.	Vulnerable children	a) Age group 0-6 and 7-18 b) Non-school going children c) Working children d) IMR	Equal weights
9.	Disabled people	Types of disability a) Visual b) Physical c) Mental	Equal weights
10.	Aged people	a) Age group 60+ b) Age group 80+ c) Dependency Ratio	Equal weights
11.	Rural/Urban poor	a) BPL population (rural and urban) b) Homeless population	Equal weights on both with further equal weights on rural and urban BPL and Homeless
12.	Deforestation	Change of forests cover (positive, negative, overall) during 2001-2015 a) Dense forests b) Open Forests	Equal weights
13.	Depletion of Mangrove	Change of mangrove cover (positive, negative, overall) during 2001-2015	Equal weights

		a) Dense mangrove b) Open mangrove	
14.	Water stress	a) Terrestrial water as captured in moisture index b) Surface water as captured in area under irrigation c) Sub-surface area as reflected CWGB data on	Equal weights

2.3: Composite Hazard Index of States/ UTs (scale of 10)

	STATES / UNION TERRITORIES	Earthquake	Landslide	Flood	Drought	Cyclone	Tsunami	Avalanche	Heat Wave	Cold Wave	Coastal Erosion	Lightning	Forest Fire	Fire	Industrial Hazards	Composite Hazard Index	Rank
	Weights for Hazard Index (%)	15%	7%	15%	15%	15%	3%	3%	6%	3%	3%	6%	3%	3%	3%		
1	ANDHRA PRADESH	2.67	1.65	4.49	6.80	6.34	5.29	-	5.77	0.00	3.68	2.34	2.04	1.89	1.29	4.25	2
2	ARUNACHAL PRADESH	10.00	6.70	1.38	1.82	-	-	-	1.65	0.58	-	0.01	2.92	0.01	0.50	2.76	18
3	ASSAM	10.00	1.29	3.84	3.03	-	-	-	2.96	0.96	-	0.28	1.95	0.07	0.59	3.03	9
4	BIHAR	6.35	0.21	6.04	4.05	-	-	-	4.64	3.27	-	0.84	0.49	0.20	0.55	3.13	7
5	CHATTISGARH	2.31	2.37	1.50	4.56	-	-	-	3.20	0.83	-	3.49	2.37	0.62	0.86	2.25	26
6	GOA	4.00	3.04	1.70	2.29	2.37	1.18	-	1.52	0.00	0.29	0.04	0.59	0.31	1.02	1.96	29
7	GUJARAT	5.39	0.41	3.18	4.63	4.90	2.78	-	3.07	0.70	3.88	0.67	0.65	1.37	1.73	3.66	5
8	HARYANA	4.56	0.25	4.16	2.77	-	-	-	3.56	3.75	-	0.11	0.08	0.23	0.92	2.26	24
9	HIMACHAL PRADESH	7.41	7.55	2.55	3.80	-	-	2.26	1.15	6.59	-	0.09	0.71	0.08	0.82	3.03	9
10	JAMMU &KASHMIR	6.39	5.30	1.40	2.77	-	-	1.51	0.31	7.59	-	0.04	0.25	0.03	0.57	2.26	25
11	JHARKHAND	3.20	1.90	1.58	5.98	-	-	-	4.89	1.47	-	1.43	1.44	0.17	0.94	2.46	22
12	KARNATAKA	2.27	1.46	1.59	7.05	2.72	1.71	-	2.21	0.13	0.79	1.08	0.95	0.69	1.00	2.78	17
13	KERALA	3.96	4.22	3.88	3.96	2.54	3.49	-	2.64	0.34	1.43	0.76	0.73	0.29	0.88	2.97	11
14	MADHYA PRADESH	2.72	0.98	1.90	5.30	-	-	-	3.99	3.74	-	2.04	1.77	0.74	0.76	2.81	15
15	MAHARASHTRA	3.21	1.65	1.83	7.23	3.22	3.90	-	4.07	0.78	2.25	2.51	1.30	2.90	1.63	4.07	3
16	MANIPUR	10.00	7.57	1.10	3.09	-	-	-	1.34	2.50	-	0.01	2.03	0.00	0.51	2.96	12
17	MEGHALAYA	10.00	5.11	1.62	1.30	-	-	-	1.73	2.32	-	0.14	2.64	0.03	0.56	2.65	20
18	MIZORAM	10.00	8.15	1.99	2.49	-	-	-	2.45	0.36	-	0.01	2.33	0.01	0.50	3.06	8
19	NAGALAND	10.00	7.41	0.56	2.92	-	-	-	1.63	0.19	-	0.01	2.67	0.00	0.51	2.82	14
20	ODISHA	2.28	1.96	2.73	4.34	6.87	3.49	-	6.95	1.10	1.44	2.71	0.99	0.21	0.76	3.80	4
21	PUNJAB	5.02	0.16	6.67	1.95	-	-	-	4.23	3.80	-	0.97	0.28	0.24	1.05	2.67	19
22	RAJASTHAN	2.69	0.51	1.65	6.67	-	-	-	3.46	4.33	-	0.59	0.09	0.36	0.90	2.29	23

23	SIKKIM	6.00	7.78	1.77	1.88	-	-	-	1.64	0.08	-	0.11	0.16	0.02	0.52	2.12	27
24	TAMIL NADU	2.56	0.67	1.89	3.66	5.77	5.45	-	6.13	0.31	2.13	0.79	0.39	0.89	1.10	2.84	13
25	TELANGANA	2.59	1.20	1.57	5.85	-	-	-	3.17	0.06	-	2.95	1.26	2.45	1.76	2.00	28
26	TRIPURA	10.00	3.54	2.46	3.16	-	-	-	1.92	0.09	-	0.58	2.64	0.08	0.61	2.81	15
27	UTTAR PRADESH	4.20	0.12	4.76	3.83	-	-	-	6.16	3.13	-	0.80	0.48	0.26	0.88	2.62	21
28	UTTARAKHAND	7.64	7.74	1.11	5.74	-	-	1.79	2.28	4.09	-	0.08	1.94	0.11	0.87	3.38	6
29	WEST BENGAL	4.61	0.22	6.43	3.10	8.88	1.98	-	5.43	0.11	0.98	2.17	0.43	0.70	1.17	4.31	1
	UNION TERRITORIES																
1	ANDAMAN & NICOBAR ISLANDS	10.00	0.00	0.11	2.85	3.06	7.67	-	2.40	0.00	9.91					3.15	1
2	CHANDIGARH	6.00	0.00	1.53	1.52	-	-	-	1.45	0.05	-	0.03	0.92	0.08	0.54	1.50	7
3	DADRA & NAGAR HAVELI	4.00	1.95	0.89	2.71	2.58	-	-	2.29	0.00	-	0.04	0.56	0.29	0.50	1.85	4
4	DAMAN & DIU	4.00	0.00	1.32	4.35	3.45	0.98	-	1.79	0.11	0.09	0.14	0.48	0.13	0.50	2.16	2
5	DELHI	6.00	0.00	2.74	1.60	-	-	-	3.13	1.02	-	0.02	0.50	0.07	0.50	1.85	5
6	LAKSHADEEP	4.00	0.00	0.00	2.86	2.36	1.35	-	1.60	0.00	0.40	0.02	0.00	0.67	0.77	1.58	6
7	PONDICHERRY	2.16	0.04	1.24	2.35	4.08	3.99	-	5.66	0.10	0.16	0.00	0.53	0.01	0.50	1.99	3

Composite Vulnerability Index of States and Union Territories (scale of 10)

	STATES / UNION TERRITORIES	Buildings: Walls	Buildings: Roofs	Agriculture & Livestock		Industries	Physical Infrastructure	Social Infrastructure	Poverty	Women	Children	Disability	Elderly People	Depletion of Forest Cover	Depletion of Mangrove	Water Stress	Composite Vulnerability Index	Rank
	Weights (%)	**15%**		**10%**	**6%**	**6%**	**5%**	**5%**	**10%**	**8%**	**8%**	**6%**	**6%**	**5%**	**5%**	**5%**		
1	ANDHRA PRADESH	3.04	2.67	2.96	3.41	2.64	5.27	2.27	1.33	5.38	3.83	3.56	3.40	0.31	0.86	4.89	3.03	10
2	ARUNACHAL PRADESH	4.68	4.27	0.15	2.12	0.00	0.54	0.12	0.06	4.46	2.36	0.42	1.31	2.39		2.05	1.67	22
3	ASSAM	3.91	3.42	2.06	3.39	0.35	2.23	1.56	0.88	6.29	4.03	1.91	2.20	1.80		2.88	2.53	13
4	BIHAR	2.34	2.43	2.84	4.41	0.38	2.58	3.27	3.15	6.56	5.35	4.18	3.53	0.25		3.70	3.15	9
5	CHATTISGARH	2.57	1.80	2.65	3.43	0.53	2.04	1.80	1.16	4.80	3.52	2.83	2.50	0.73		4.78	2.39	16
6	GOA	3.15	2.42	0.91	2.15	0.28	0.76	0.10	0.06	3.51	1.13	0.52	2.75	0.00	0.00	2.40	1.38	28
7	GUJARAT	2.60	2.16	4.52	4.37	6.28	8.31	2.54	3.11	5.46	4.01	3.51	2.97	2.15	0.08	5.50	3.82	5
8	HARYANA	2.01	1.98	2.14	3.15	2.46	2.06	1.34	1.09	5.83	2.99	2.14	2.76	2.15		4.67	2.46	14
9	HIMACHAL PRADESH	5.84	3.64	0.45	2.45	0.37	2.74	1.19	0.10	3.50	2.14	1.19	2.78	0.56		3.97	2.02	21
10	JAMMU &KASHMIR	4.78	3.86	0.44	2.40	0.25	2.17	0.84	0.40	5.55	2.30	1.70	2.22	0.47		3.07	2.06	20
11	JHARKHAND	2.44	1.81	0.98	3.29	0.53	2.52	2.12	1.32	5.38	3.14	2.75	2.46	2.45		4.40	2.34	17
12	KARNATAKA	2.33	1.92	4.38	3.74	4.56	7.49	4.49	2.42	4.93	3.66	3.61	3.50	2.32	0.42	5.44	3.60	6
13	KERALA	3.31	2.72	2.14	2.21	2.23	4.86	1.92	0.43	2.95	1.48	3.35	4.10	0.00	0.00	3.13	2.26	18
14	MADHYA PRADESH	2.02	1.48	6.23	5.10	1.94	5.37	3.51	4.14	7.12	5.06	3.99	3.24	0.76		5.28	3.86	4
15	MAHARASHTRA	2.37	2.13	7.51	4.53	6.41	9.44	6.78	4.97	6.28	3.87	4.92	4.43	0.74	0.00	6.09	4.75	2
16	MANIPUR	6.11	4.22	0.34	2.03	0.04	0.35	0.16	0.15	3.52	1.21	0.81	1.82	0.34		3.12	1.62	25
17	MEGHALAYA	5.02	4.01	0.40	2.08	0.03	0.72	0.26	0.05	3.46	3.10	0.55	1.36	0.62		0.63	1.53	26
18	MIZORAM	5.79	4.39	0.26	1.38	0.01	0.14	0.17	0.02	3.18	2.42	0.39	1.65	0.16		2.30	1.47	27
19	NAGALAND	5.21	4.39	0.73	1.80	0.07	0.24	0.40	0.05	3.88	1.43	0.39	1.44	2.31		2.97	1.67	23
20	ODISHA	2.65	2.61	2.13	3.50	1.16	4.51	2.61	1.44	5.57	4.06	3.66	3.26	0.46	0.42	4.06	2.80	11
21	PUNJAB	2.00	2.39	2.07	3.14	2.21	2.32	2.11	1.00	5.28	2.50	2.30	3.26	2.49		4.04	2.45	15

22	RAJASTHAN	2.03	1.44	7.18	5.62	2.41	5.18	6.78	3.65	7.48	4.79	4.31	3.06	2.16		7.91	4.34	3
23	SIKKIM	3.22	3.67	0.19	2.02	0.00	0.25	0.17	0.01	4.48	1.59	0.28	1.63	0.00		1.80	1.33	29
24	TAMIL NADU	2.33	1.93	2.33	3.31	7.87	9.29	4.79	1.53	4.25	2.75	3.38	3.92	0.38	0.14	5.16	3.34	8
25	TELANGANA	2.11	1.69	2.37	3.35	2.83	2.73	1.54	1.56	4.99	3.24	3.03	3.09	2.37		4.96	2.63	12
26	TRIPURA	5.33	3.93	0.39	2.03	0.01	0.59	0.21	0.09	3.85	1.83	0.78	2.02	0.89		2.10	1.64	24
27	UTTAR PRADESH	1.81	1.95	6.52	7.26	5.36	6.69	6.96	9.91	8.39	7.28	5.22	4.62	0.40		3.97	5.41	1
28	UTTARAKHAND	5.31	3.36	0.51	2.49	0.30	2.00	1.25	0.29	4.63	2.64	1.28	2.59	0.42		3.83	2.07	19
29	WEST BENGAL	2.40	3.12	2.91	4.16	2.47	4.10	4.46	3.57	6.73	3.90	4.40	3.54	0.00	0.89	3.10	3.40	7
	UNION TERRITORIES																	
1	ANDAMAN & NICOBAR ISLANDS	5.91	3.38	0.08	1.78	0.00	0.90	0.03	0.00	3.57	1.66	0.27	1.70	2.64	3.81	2.71	1.85	1
2	CHANDIGARH	2.02	1.64	0.00	2.46	0.01	0.12	0.07	0.11	4.07	1.79	0.41	1.53	0.00		4.98	1.00	6
3	DADRA & NAGAR HAVELI	3.08	3.14	1.03	2.44	0.01	0.01	0.01	0.03	4.02	2.01	0.16	1.01	2.58		3.13	1.09	5
4	DAMAN & DIU	2.73	2.36	0.85	2.06	0.00	0.15	0.01	0.01	5.97	2.10	0.18	1.36	0.00	0.58	5.57	1.26	4
5	DELHI	2.05	1.58	0.00	2.25	1.09	0.72	0.08	0.99	5.29	1.88	1.68	1.93	0.00		6.70	1.46	2
6	LAKSHADEEP	2.69	1.47	1.88	1.18	0.00	0.32	0.01	0.00	1.87	1.55	0.15	2.00	2.58		3.71	0.99	7
7	PONDICHERRY	2.70	1.82	0.39	2.03	3.61	0.21	0.15	0.04	2.83	1.14	0.60	2.47	0.00	1.20	4.17	1.17	3

2.5: Composite Exposure Index of States/ UTs (scale of 10)

	State/UTs	Population	GDP (2015-16) (Rs. Cr.)	Population Density (sq. km)	GDP Per Capita (Rs.)	Level of exposure (scale of 10)			Rank
						Population	GDP	Composite Exposure Index	
	STATES								
1	Andhra Pradesh	49386799	609934	308	108163	0.820	5.518	3.169	10
2	Arunachal Pradesh	1383727	20294	17	122466	0.032	1.007	0.519	27
3	Assam	31205576	226276	397	60526	0.741	3.361	2.051	17
4	Bihar	104099452	381501	1,102	31454	2.256	4.364	3.310	7
5	Chhattisgarh	25545198	260776	189	84767	0.462	3.608	2.035	18
6	Goa	1458545	54275	394	327059	0.159	1.646	0.903	22
7	Gujarat	60439692	1033791	308	141504	0.907	7.184	4.045	5
8	Haryana	25351462	485184	573	162034	0.802	4.921	2.862	13
9	Himachal Pradesh	6864602	112852	123	134376	0.193	2.374	1.283	21
10	Jammu & Kashmir	12541302	119093	124	74653	0.262	2.438	1.350	20
11	Jharkhand	32988134	231294	414	59628	0.777	3.398	2.087	16
12	Karnataka	61095297	1016910	319	142906	0.928	7.125	4.026	6
13	Kerala	33406061	556616	859	147190	1.127	5.271	3.199	9
14	Madhya Pradesh	72626809	543975	236	62334	0.870	5.040	2.955	12
15	Maharashtra	112374333	2001223	365	147399	1.347	9.995	5.671	1
16	Manipur	2855794	19233	122	55603	0.127	0.980	0.553	25
17	Meghalaya	2966889	25767	132	70693	0.132	1.134	0.633	24
18	Mizoram	1097206	15339	52	114524	0.050	0.875	0.463	29
19	Nagaland	1978502	19816	119	83621	0.102	0.995	0.548	26

20	Odisha	41974218	341887	269	68293	0.707	4.131	2.419	15
21	Punjab	27743338	391543	550	119261	0.822	4.421	2.622	14
22	Rajasthan	68548437	672707	201	82325	0.779	5.795	3.287	8
23	Sikkim	610577	16954	86	233954	0.048	0.920	0.484	28
24	Tamil Nadu	72147030	1161963	555	137837	1.330	7.616	4.473	4
25	Telangana	35193978	567588	306	137955	0.691	5.323	3.007	11
26	Tripura	3673917	34184	350	93045	0.239	1.306	0.772	23
27	Uttar Pradesh	199812341	1120836	828	46299	2.707	7.480	5.093	2
28	Uttarakhand	10086292	176171	189	146826	0.290	2.966	1.628	19
29	West Bengal	91276115	1039924	1,029	113931	2.037	7.205	4.621	3
	UNION TERRITORIES								
1	Andaman & Nicobar Islands	380581	5932	46	124361	0.028	0.544	0.286	4
2	Chandigarh	1055450	29049	9,252	229976	0.657	1.204	0.931	2
3	Dadra & Nagar Haveli	343709	2440	698	70990	0.103	0.349	0.226	5
4	Daman & Diu	243247	1059	2,169	43536	0.154	0.230	0.192	6
5	Delhi	16787941	551963	11,297	273618	2.899	5.249	4.074	1
6	Lakshadweep	64473	407	2,013	63127	0.078	0.143	0.110	7
7	Puducherry	1247953	24701	2,598	157871	0.375	1.110	0.743	3