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An Empirical Quantitative Model Based on the Composite Disaster Risk Index to Estimate the Quantum of Disaster Response Force for a State / Union Territory

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ABSTRACT

Instances of natural and anthropogenic disasters are on a steadyrise, all over the world. These instances have accentuated the need for a well-trained, adequately equipped force to ensure that mitigation measures are in place, preparedness for disasters is complete as also to conductrelief and rescue operations when disasters strike. The answer to a simple question - "What is the most appropriate strength of a Disaster Response Force at a State / Union Territory (UT) level?" proved to be the start point for this intriguing academic study. While evaluating the Disaster Score Cards (DSC) for each State / UT, aspects such as the Population, Number of Districts, GDP, Hazards, Vulnerability, Exposure, Capacity were considered. The basic equation of Risk=[Hazard ×Vulnerability ×((Exposure)/Capacity)] forms the bedrock of the study which draws on existing datasets based on a set of common indicators for deriving the variables for each State and UT in the above-mentioned equation, on a scale of 1 - 10. These values collectively derive a Composite Disaster Risk Index (DRI), and a Disaster Resilience Index (DResI) based on a scale of 1 to 100. These factors together are evaluated to arrive at a cogent, empirically sound quantitative model to estimate the probable strength of a Disaster Response Force, which may be mandated for a particular State / UT.

KEYWORDS: *Disaster Risk Index, Quantitative Model, Empirical Study, Hazar – Vulnerability – Exposure – Capacity, Disaster Response Force*

An Empirical Quantitative Model Based on theComposite Disaster Risk Indexto Estimate the Quantum of Disaster Response Force for a State / Union Territory

INTRODUCTION

During the preliminary discussions, the study team had with peers about the way to proceed, on this study an interesting perspective was presented by Professor David E. Alexander, PhD, Institute for Risk and Disaster Reduction, University College London. His counterpoint observation about the question we were attempting to find an answer to provide us with a pragmatic mooring to all the data crunching which we were attempting. His astute observation was, that to answer the question - *"What is the most appropriate strength of a Disaster Response Force at a State / UT level?"*, the most appropriate answer ought to be *"As Large as Possible"*(Alexander, 2020).

From any Disaster Managers perspective this answer is spot-on; but to the pragmatic Disaster Management professional / Administrator, constantly battling the debilitating lack of resources(money, manpower, time etc.), this answer is misplaced. Hence, comes the necessity of deriving a quantitative model based on the Disaster Score Cards (DSC) (Dhar Chakrabarti, 2018; National Disaster Management Authority, 2018)of the States / UT to provide the base figure for the strength which would be required to tackle any disaster situation.

This empirically derived value for a Disaster Response Force can thereafter be once again reappraised by the State Disaster Management experts / Administrators in line with the following aspects –

- How are they organised?
- What skills (and equipment and training) they possess and can utilise?
- What tasks they will be expected to perform?
- What contingencies they will have to face?

LITERATURE REVIEW

The study team reviewed various government reports, journal articles and available open-source literature to get a sense of how to evaluate the veracity of the datasets created and subsequently to understand the methodology for deriving a valid quantitative model, based on the existing datasets.

The basic document, which helped the study team was the 2018 Report titled "Disaster Score Card for

States and Union Territories of India" submitted by the Advisory Committee tasked to formulate the Disaster Score

Card (DSC), under the chairmanship of Joint Secretary (DM), representative of the National Disaster Management Authority, nominated representatives of the State Governments of AndhraPradesh, Assam, Himachal Pradesh, Maharashtra and Odisha alongwith numerous experts in DM, DRR and DRM (National Disaster Management Authority, 2018).

Another, very insightful Report titled "Measuring Disaster Risks and Resilience at Sub-National Level in India"was authored by Dr P. G. Dhar Chakrabarti - a key member of the Advisory Committee tasked to create the DSC for States / UT. This paper gave out in ample detail the specifics of the multiple parameters of 14 Hazards, 14 Vulnerabilities and 2 Exposures and the way they were collected from primary sources. The paper also delves into the exact methodologies which were developed for measuring Risks through an ingenious combination of different weights on the selected parameters(Dhar Chakrabarti, 2018).

The Fritz Institute, Disaster Preparedness Assessment Project by the Centre for Hazards Research and Policy Development, University of Louisville developed a metric like the DRI evolved by the Advisory Committee. The complete project was presented in detail in the Report titled "Indicator Issues and Proposed Framework for a Disaster Preparedness Index (DPi)" (Simpson, 2006). Unfortunately, the Report was restricted to the academic world and it never found its implementation for DRR / DRM / DM in the real world.

In addition to these three documents, the study team also perused and comprehended how similar subjects had been treated by various other authors by studying and assimilating the following seminal papers –

A Grounded Theory for the Performance of Temporary Disaster Response Teams (Wegmann, 2020).

Disaster Resilience through Big Data: Way to Environmental Sustainability (Sarker, Peng, Yiran, & Shouse, 2020).

Knowledge Management Practices in Disaster Management: Systematic Review (Oktari, Munadi, Idroes, & Sofyan, 2020).

Measuring Resilience and Recovery (Platt, Brown, & Hughes, 2016).

Quantitative Assessment of Disaster Resilience: An Empirical Study on the Importance of Post-Disaster Recovery Costs (Yu, Kim, Oh, An, & Kim, 2015).

A Framework for Crisis Management in Developing Countries(Daneshgar & Chattopadhyay, 2011).

Balanced Scorecard for Natural Disaster Management Projects(Moe, Gehbauer, Senitz, & Mueller, 2007).

The Raison d'Être for creating Disaster Score Cards (DSC) for States / UT

Figure 1 - The Three-Pronged Approach

To comprehend the rationale behind the concept of creating a DSC for each State / UT, based on the year-long study undertaken by the National Disaster Management Authority at the behest of Ministry of Home Affairs, Government of India, supported by the UNDP (Dhar Chakrabarti, 2018) lies at the very root of the methodology which the study team adopted to derive the empirical quantitative model.

The three-pronged vision of the Advisory Committee – when they set out to create the DSC for the States / UT were -

- Benchmark activities relevant to DRM.
- Conceive a common set of indicators, duly weighted to derive uniform datasets for all States / UT and generate scorecards on Disaster Risk Index (DRI).
- Based on a common set of indicators, duly weighted, quantify the level of Resilience achieved by all States / UT and generate scorecards on Disaster Resilience Index (DResI).

NATIONAL DISASTER RESPONSE FORCE (NDRF): THE UBIQUITOUS INDIAN ENTITY

It would be pointless to extoll the yeoman work which the NDRF - an Indian specialized force constituted "for a special response to a threatening disaster situation or disaster" under the aegis of the Disaster Management Act, 2005(Ministry of Law and Justice : Legislative Department, 2005). The NDRF is a 13000 strong, well trained and well-equipped force which operates pan-India under the Ministry of Home Affairs.

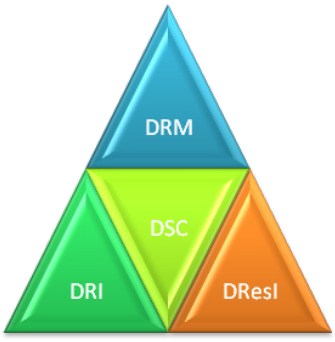

Figure 2- The NDRF Logo

What Is A Disaster?

A disaster is an extreme disruption of the functioning of a society that causes widespread human, material, or environmental losses that exceed the ability of the affected society to cope with its resources. Disasters, both natural and man-induced are not new

to mankind. They have been the constant, though inconvenient, companions of human beings since time immemorial. The High-Power Committee on Disaster Management constituted in 1999, has identified 31 types of disasters categorized into five major sub-groups (Government of India, 2011; National Centre for Disaster Management, 2002).

i.	Water and climate related disasters	a)	Floods and drainage management
		b)	Cyclones
		c)	Tornadoes and hurricanes
		d)	Hailstorm
		e)	Cloud burst
		f)	Heat wave and cold wave
		g)	Snow avalanches
		h)	Droughts
		i)	Sea erosion
		j)	Thunder and lightening
		k)	Tsunami
ii.	Geological related disasters	a)	Landslides and mudflows
		b)	Earthquakes
		c)	Dam failures/ Dam bursts
		d)	Minor fires
iii.	Chemical, industrial and nuclear related disasters	a)	Chemical and industrial disasters
		b)	Nuclear disasters
iv.	Accident related disasters	a)	Forest fires
		b)	Urban fires
		c)	Mine flooding
		d)	Oil spills
		e)	Major building collapse
		f)	Serial bomb blasts
		g)	Festival related disasters
		h)	Electrical disasters and fires
		i)	Air, road and rail accidents
		j)	Boat capsizing
		k)	Village fire
v.	Biological related disasters	a)	Biological disasters and epidemics
		b)	Pest attacks
		c)	Cattle epidemics
		d)	Food poisoning

Figure 3 - Types of Disaster

Not many scholars realise that Disaster Management (DM) is an interdisciplinary subject - as is amply borne out by the following graphic.

Disciplines	Subjects
Earth sciences	Geography, Geology, Seismology, Hydrology, Oceanography, Glaciology
Atmospheric sciences	Meteorology, Climatology
Environmental sciences	Climate Change
Agriculture sciences	Agriculture, Horticulture, Fisheries
Engineering sciences	Civil Engineering, Structural Engineering, Earthquake Engineering, Architecture, Town and Country Planning
Information & Communication sciences	Remote Sensing, Information Technology, Telecommunication
Social sciences	Economics, Sociology, Anthropology, Social Work, Political Science, Psychology, Behavioral Science
Medical sciences	Emergency Health Management, Trauma and Stress Management,
Management and Business Studies	Public Administration and Management, Supply Chain Management, Risk Finance & Insurance, Business Continuity Studies
Security related studies	Disaster and National Security, Role of Armed and Para-Military Forces in Disaster Response, Nuclear-Chemical-Biological Warfare.
Diplomatic studies	International Conventions on Humanitarian Aids and Disaster Risk reduction., Regional Cooperation on Disaster Risk Reduction and Management

Figure 4 - Interdisciplinary Nature of DM

Classification of Disasters Based on their Magnitude

Having seen the overall macro picture about disasters, it is equally important to appreciate that the intensity of disasters has also been classified for ease of understanding.

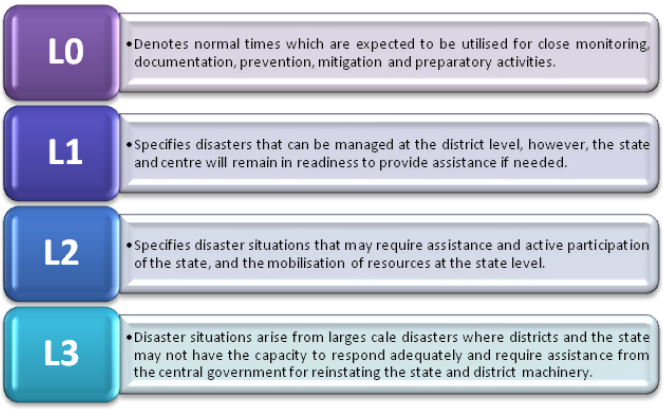

Figure 5 - Classification of Disasters

Quoting verbatim from page 82 of the Report presented by The High-Power Committee on Disaster Management, (National Centre for Disaster Management, 2002)*"Disasters have been classified into three groups based on their intensity or magnitude (Level 1, Level 2 and Level 3). The classification has been made with the philosophy that for Level 1 emergency, the District Emergency Response Group would be able to take control of the situation. For a Level 2 scenario, the State Emergency Response Group would be activated and for a Level 3 disaster, the National Emergency Response Group comes into the picture. It has been assumed that we are dealing with off-site emergencies, which call for action from the district emergency authorities or higher-level authorities."*

The Inextricable Quandary

The problem which is being faced by the NDRF is of being pulled in too many directions, simultaneously, thereby progressively dissipating their efficacy. Craig Groeschel states in his book "Weird: Because Normal Isn't Working" that "*When something small loudly demands all our attention, its noise often drowns out the whisper of what's enormously important." This is exactly what* Is happening to the resources of the NDRF.

The States / UT constantly clamour for the NDRF resources, even for tackling Level 1 and Level 2 disasters, thereby creating an untenable situation for the NDRF. The quote by Craig Groeschel is the root cause of why the requirement of deriving an empirical quantitative model to calculate the strength of Response Force which would be required for a State / UT arose in the first place. To comprehend the issue in context it is important to understand the various types and levels of disasters which can happen in the Indian subcontinent.

This is in contrast to the existing instructions available for the SDRF whose very rationale for existence is to be the First Responders within the States for "Level 1 (disaster within the coping capacity of district administration) & Level 2 (disasters within the coping capacity of State Govts.) and also to respond within "golden hour" before the arrival of NDRF". Moreover, the advantage of deploying the SDRF in real-time to handle the immediate criticality is also because of their "familiarity with terrain & area, local language, cultural sensitivities and also about available resources that can be used at the time of crisis" (National Disaster Response Force, 2011).

THE EMPIRICAL QUANTITATIVE MODEL FOR A DISASTER RESPONSE FORCE: STATE / UT

Problem

- Since the available data has already taken into consideration issues such as the State's population / Number of Districts / GDP / Hazards / Vulnerability / Exposure / Capacity etc and arrived at a Composite DRI – we proceed to evolve a Quantitative model to provide a suitable ballpark figure for the quantum of SDRF required for each State / UT.
- The figure arrived at, based on theproposed empirical quantitative model – will give the Administration a start point to commence the process of being self-reliant to tackle Level 1 and 2 disasters within the State / UT.

Data Available

- Appendix A - State / UT – Population & Number of Districts Data
- Appendix B - State / UT – Composite Disaster Risk Index

Proposed Quantitative Model

- Fix SDRF + X = (Vulnerability * Hazard* Exposure/ Capacity)*Correlation between DRI and Population/ District
- Fix SDRF + X = Disaster Risk * Correlation between DRI and Population/District

Or

- Fix SDRF + X = Disaster Risk Index *Correlation between DRI and Population/District
- Here we have made three new variables.
    - Fix SDRF + X = **total number of SDRF** needed (dependent variable).
        - Where Fix SDRF we can calculate by using the values of H*V*E (1to10) scale.
        - We will calculate the Mean of that series/column of H*V*E (from the table). So, thatthe Mean of the series we can use as Fix SDRF.
    - Disaster Risk Index, we can use the value of DRI for each state.
    - Correlation between DRI and Population/ District (according to each State / UT).
- Now with the help of values of Fix SDRF, Disaster Risk Index, Correlation between DRI and Population/District we can calculate the value of X (which gives the base figure of the quantum of SDRF required and will show how much need of extra member to disaster management for highly vulnerable region/ population).
- After that with the help of X and Fix SDRF we calculate the total number of SDRF needed.
- Once this base figure has been obtained, the peculiarities affecting any State / UT can be debated and discussed as relevant, to either accept the figure arrived at or based on the ground realities – increase or decrease the quantum of Disaster Response Force – derived empirically.

Sample Calculations for Uttar Pradesh

- The average value of H*V*E = 1.812142857 (Appx B - Calculated for H*V*E Column for all States)
- DRI for UP = 42.24
- Correlation Value = 0.757849037 (Appx A / B – Calculated)

	Population Per District	*DRI*
Population Per District	1	
DRI	0.757849037	1

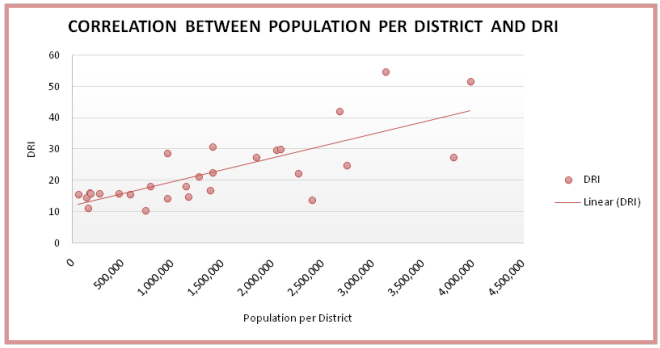

Figure 6 - Correlation between DRI and Population/District

Using the Formula

- Fix SDRF + X = Disaster Risk Index *Correlation between DRI and Population/District

- Transposing the values in the above formula
    - Fix SDRF + X = Disaster Risk Index *Correlation between DRI and Population/District

$$1.812142857 + X = 42.24 * 0.757849037$$

$$1.8121 + X = 32.01154331$$

$$X = 32.01154331 - 1.812142857$$

$$X = 30.19940046$$

- Total number of SDRF = Fix SDRF + X = 1.8121 + 30.1994 = 32.0115
- Now Rounding off the value of 32.0115 obtained ≈ 32

Implication

- SDRF quantum value for UP has been derived as per the quantitative model derived above.
- It is recommended that a total of 32teams of SDRF be raised for the state of UP.
- These can be organised, trained and equipped like the NDRF Bns in the country.
- Similar calculations can be done for the balance States / UT.

CONCLUSION

The Disaster Management Act has been in existence since 2005 (Government of India, 2005), but regrettably the National Disaster Management Plan – saw the light of day only in 2016 (Government of India, 2016). This criminal delay in bringing out a comprehensive document to ensure that the provisions of the seminal Act passed by the Indian parliament, find reflection and execution in our extremely disaster-prone nation – speaks volumes of the importance that we give to ensuring Disaster Resilience and Disaster Risk Reduction of the subcontinent.In such a lackadaisical administrative environment, where the principle of laissez-faire – permeates all aspects concerning disaster management, it appears farfetched, that the states will take cognisance of their endemic failings. The fact that the SDRF is an important cog in the "Three Tier Disaster Management" (National Disaster Response Force, 2011)mechanism envisaged by the National Disaster Management Authority for the country – is conveniently lost sight of and the easiest was for the States, is to start looking over their shoulders – for the NDRF *"messiahs"* to arrive on the scene to provide relief and succour to the beleaguered population.

The choice is not going to be easy. On one hand is the easy path of remaining dependent on the NDRF and the Armed Forces to answer the SOS sent out by the States / UT, whenever a disaster strikes. The other, much more arduous choice is for the States / UT to put their shoulder to the wheel and ensure that they raise, train and maintain an adequate strength of SDRF, in consonance with the DRI calculated for them. The Empirical Quantitative Model, presented in this paper, will allow the States / UT to arrive at the correct quantum of Disaster Response Force required for their individual needs. As already stated, though the model has considered all aspects related to Population, Number of Districts, GDP, Hazards, Vulnerability, $Risk = \left[Hazard \times Vulnerability \times \left(\frac{Exposure}{Capacity}\right)\right]$ equation, in case the derived value appears unrealistic, based on the specific ground situation existing in the particular State/UT, them the derived value could be suitably increased or decreased as per the desire of the Administrative functionaries in the State / UT.

The study team is sanguine that this easy to use Empirical Quantitative Model, will encourage the States / UT to follow the advice of US President Thomas S. Monson, who stated that ***"May we ever choose the harder right, instead of the easier wrong."***

Total Words - 2491

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Appendix A

STATE / UT – POPULATION & NUMBER OF DISTRICTS DATA

(National Disaster Management Authority, 2018)

Name of State or Union Territory	Number of Districts	Population	Population/District
Andhra Pradesh	13	49,386,799	3,798,985
Arunachal Pradesh	25	1,383,727	57,656
Assam	33	31,169,272	944,523

Bihar	38	104,099,452	2,739,459
Chhattisgarh	28	25,545,198	946,118
Goa	2	1,458,545	729,273
Gujarat	33	60,439,692	1,831,506
Haryana	22	25,351,462	1,152,339
Himachal Pradesh	12	6,864,602	572,050
Jharkhand	24	32,988,134	1,374,506
Karnataka	30	61,095,297	2,036,510
Kerala	14	33,406,061	2,386,147
Madhya Pradesh	55	72,626,809	1,396,669
Maharashtra	36	112,374,333	3,121,509
Manipur	16	2,721,756	170,110
Meghalaya	11	2,966,889	269,717
Mizoram	11	1,097,206	137,151
Nagaland	12	1,978,502	179,864
Odisha	30	41,974,218	1,399,141
Punjab	22	27,743,338	1,261,061
Rajasthan	33	68,548,437	2,077,225
Sikkim	4	610,577	152,644
Tamil Nadu	38	72,147,030	2,254,595
Telangana	33	35,193,978	1,135,290
Tripura	8	3,673,917	459,240
Uttar Pradesh	75	199,812,341	2,664,165
Uttarakhand	13	10,086,292	775,869
West Bengal	23	91,276,115	3,968,527
Andaman and Nicobar Islands	3	380,581	126,860
Chandigarh	1	1,055,450	1,055,450
Dadra and Nagar Haveli and Daman and Diu	3	586,956	195,652
Jammu and Kashmir	20	1,247,953	311,988
Ladakh	2	1,247,953	311,988
Lakshadweep	1	64,473	64,473
Delhi	11	16,787,941	1,526,176
Puducherry	4	1,247,953	311,988
Total	**739**	**1,210,854,977**	**1,677,084**

Appendix B

STATE / UT – COMPOSITE DISASTER RISK INDEX

(National Disaster Management Authority, 2018)

SNo	STATES /UT's	Hazard	Vulnerability	Exposure	H * V * E	Capacity	Risk	Disaster Risk Index	Rank
		(Scale of 10)						(Scale of 100)	
States									
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	**25**
6	Goa	1.96	1.38	0.90	1.06	2.56	1.03	10.35	**28**
7	Gujarat	3.66	3.82	4.05	2.10	4.93	2.70	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	Jharkhand	2.46	2.34	2.09	1.20	1.71	1.70	17.03	**16**
11	Karnataka	2.78	3.60	4.03	2.11	3.29	2.98	29.82	**6**
12	Kerala	2.97	2.26	3.20	1.14	4.19	1.37	13.75	**26**
13	Madhya Pradesh	2.81	3.86	2.96	2.16	3.10	3.08	30.79	**4**
14	Maharashtra	4.07	4.75	5.67	5.69	4.43	5.48	54.75	**1**
15	Manipur	2.96	1.62	0.55	1.18	2.10	1.61	16.11	**17**
16	Meghalaya	2.65	1.53	0.63	1.20	3.00	1.59	15.88	**20**
17	Mizoram	3.06	1.47	0.46	1.16	2.96	1.47	14.71	**24**
18	Nagaland	2.82	1.67	0.55	1.18	2.12	1.59	15.92	**19**
19	Odisha	3.80	2.80	2.42	1.63	4.17	2.27	22.68	**11**
20	Punjab	2.67	2.45	2.62	1.46	3.06	2.13	21.29	**13**
21	Rajasthan	2.29	4.34	3.29	2.22	3.91	3.00	30.04	**5**
22	Sikkim	2.12	1.33	0.48	1.07	3.23	1.11	11.11	**27**
23	Tamil Nadu	2.84	3.34	4.47	1.64	4.63	2.24	22.36	**12**
24	Telangana	2.00	2.63	3.01	1.30	3.04	1.82	18.25	**14**
25	Tripura	2.81	1.64	0.77	1.23	4.08	1.60	15.99	**18**
26	Uttar Pradesh	2.62	5.41	5.09	3.29	3.03	4.22	42.24	**3**
27	Uttarakhand	3.38	2.07	1.63	1.32	3.65	1.82	18.16	**15**
28	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	**3**
2	Chandigarh	1.50	1.00	0.93	1.07	3.06	1.09	10.94	**4**
3	Dadra and Nagar Haveli	1.85	1.09	0.23	1.06	2.20	0.99	9.91	**7**
4	Daman and Diu	2.16	1.26	0.19	1.06	1.89	1.02	10.20	**6**
5	Delhi	1.85	1.46	4.07	1.16	3.57	1.44	14.43	**2**
6	Lakshadweep	1.58	0.99	0.11	1.06	1.86	0.97	9.72	**8**
7	Puducherry	1.99	1.17	0.74	1.06	2.85	1.04	10.41	**5**
8	Jammu and Kashmir	2.26	2.06	1.35	1.15	2.73	1.46	14.56	**1**

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