

P.K.Chaubey*

A Generalised Measure of Sectional Disparity: Its Application to Literacy Data

Introduction

MOST researchers use the difference between the sectional rates of prevalence or achievement when they wish to measure the level of disparity between two mutually exclusive yet exhaustive sections of a society such as male and female or urban and rural populations. So, did the office of the Registrar General of India (1992) in its Brief Analysis of Primary Census Abstract while considering male-female and urban-rural disparity in literacy. However, it used two additional ratio measures. Dealing with urban-rural disparity, it employed, in addition, the rural-urban ratio of literacy rates while dealing with male-female disparity, it resorted to female-male ratio of literates'.

However, as Sopher (1974) points out, the ratio and difference measures are used with some want of confidence. Comparing the two indices of disparity viz., the difference between two literacy rates and the sex ratio of literates, the Registrar General of India (1992) admits that the latter is a better measure. He could not combine the ideas contained in two measures into one single composite index².

Sopher (1974) provided a different measure of disparity, which was studied, used, criticised and improved by Raza *et al.* (1990), Kundu and Rao (1986), and Aggarwal and Murlidhar

*Indian Institute of Public Administration. New Delhi.

¹ Obviously, this ratio is a measure of parity or equity rather than of disparity as it increases with relative betterment of the worse off section. Should the number of female exceed that of male, the index would exceed one in the event of everybody being literate. It seems that the user goes with the understanding that the two genders will have equal number. This appears to be the reason that this kind of index was not devised for use in the case of rural-urban differential for urban or rural population could even be nil.

² The two indices can show quite different results because at low levels of literacy a small male-female difference is compatible with either a high or a low sex ratio whereas at high levels of literacy a small male-female difference necessarily means a female-male ratio close to one. Thus, the trend in male-female difference may indicate a worsening sex differential while the trend in sex ratio among literates simultaneously may indicate a narrowing sex differential. This has been pointed out by the Registrar General of India (1992, p. 58).

(1986) in their papers written in the context of literacy. However, all the variants of Sopher's measure also fail to address to the central issue raised here.

All the measures used so far for measuring disparity between two sections actually ignored to consider the division of population between the two sections³. When two sections differ considerably in size from one population to another, the comparison across populations may be compromised⁴. We propose to make up for this deficiency.

Chaubey (1999) has used a simple geometrical device to draw implications of poverty reduction in terms of growth and redistribution. Incomes of two persons were plotted on two axes. An intuitively appealing measure of inequality to gauge redistribution was employed therein. It was as if the two sections were of equal size. The same could however be generalised to capture the difference in size of two sections of a population.

The paper is organised as follows. Section 2 described the development of the index. In Section 3, an axiomatic framework is mentioned to examine the desirable features in a disparity index and briefly discusses the features of the proposed index. In Section 4, an application of the measure is presented by making use of literacy data for 1981 and 1991. The last section ends with some concluding remarks.

Development of Index

Let the society consist of two sections S_1 and S_2 . Let S_1 and S_2 have achievement rates R_1 and R_2 . Further, let $R_2 > R_1$. Still further, let P_1 and P_2 be the proportions of population with the two sections. Then, we know, the rate of achievement for the population as a whole, to be denoted by R , is given by

$$R = p_1 R_1 + p_2 R_2 \quad (1)$$

Now, let the two components of R viz., $p_1 R_1$ and $p_2 R_2$ be represented on the abscissa and the ordinate respectively. We will require two basic lines for our purpose. One is the line of distribution between two sections for a given level of R and the other is the line of no-disparity for changing level of R (see Fig. 1). For a given level of R , the negatively sloped 45° line represents the line of distribution. For changing level of R , the line of no-disparity is the locus of points for which $R_1 = R_2 = R$ holds true. A point with equal rates is obviously $\{p_1 R, p_2 R\}$. The line of no-disparity will be positively sloped with slope of (p_2 / p_1) . Ignoring the size difference is tantamount to drawing the positively sloped line of no-disparity at the angle of 45° .

³In the case when people considered division of literates by gender, they ignored even the division of population by gender.

⁴Let the problem be posed with an example. Suppose for a given positive attribute (like literacy) rural rates are the same for Delhi (or Chandigarh) and Dadra & Nagar Haveli (or Arunachal Pradesh) and so are the urban rates for the two populations. Shall we say that the level of disparity in two states are the same even when we come to know that over 90 percent population in Delhi is urban while in Dadra & Nagar Haveli the urban population is not even 9 percent (6.8 per cent in 1981)? Most people would say 'no'. If that is the case, then, there is scope for improvement over disparity indices so far proposed, in fact the sex ratio of literates, as suggested by the Registrar General of India (1992) would miss the relationship between number of literates of a gender to its absolute size.

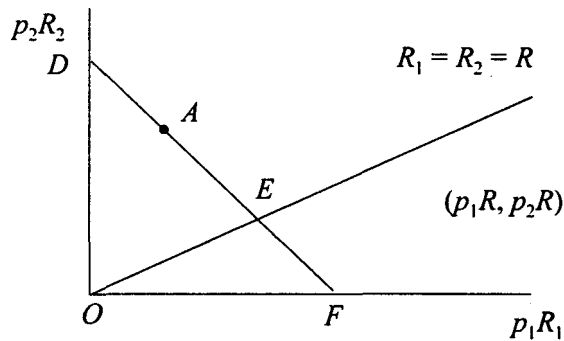


Fig. 1

For the present level of overall R , E is the point of no-disparity. Actual point of distribution of the attribute would lie somewhere on DF . Let this be point A . If A slides towards E , disparity will decrease. If it slides towards D , disparity will increase. At E , disparity level is zero and at D , it should obviously be the maximum.

In order to contain the disparity measure D between zero and unity, as is usually insisted, the distance AE could be divided by DE . Let the new index be denoted by D_c . Then,

$$D_c = \frac{AE}{DE} \tag{2}$$

Let us now draw a line CE parallel to x -axis and another AB parallel to y -axis, as shown in Fig. 2.

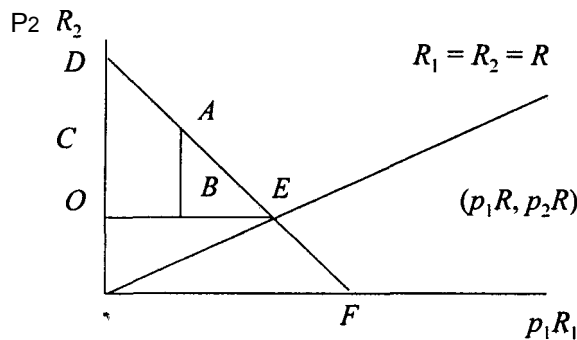


Fig. 2

Let us note the coordinates of the points A , B , C , D , and E :

$A = (p_1R_1, P_2R_2R_1)$; $B = (p_1R_1, P_2R)$; $C = (0, p_2R)$; $D = (0, R)$; $E = (p_1R, P_2R)$. Now, let us first compute the square of D_c . From (2), we can write

$$D_c^2 = \frac{AE^2}{DE^2} \tag{3}$$

It is easy to see, using Pythagoras theorem, that

$$\begin{aligned} AE^2 &= BE^2 + AB^2 \\ &= p_1^2 (R - R_1)^2 + p_2^2 (R_2 - R)^2 \end{aligned}$$

$$\begin{aligned}
&= p_1^2 p_2^2 (R_2 - R_1)^2 + p_1^2 p_2^2 (R_2 - R_1)^2 \\
&= 2 p_1^2 p_2^2 (R_2 - R_1)^2 \\
DE^2 &= CE^2 + DC^2 \\
&= P_1^2 R^2 + (R - P_2 R)^2 \\
&= 2 p_1^2 R^2
\end{aligned}$$

Substituting these expressions in (3), we immediately get

$$D_C^2 = \frac{P_2^2 (R_2 - R_1)^2}{R^2} \quad (4)$$

and therefore,

$$D_C = \frac{P_2^2 (R_2 - R_1)^2}{P_1 R_1 + P_2 R_2} \quad (5)$$

It is obviously a very simple measure. Sectional population proportions along with sectional rates make sufficient informational base for the index⁵. In fact, one can see, the measure comes out to be a weighted normalised differential of rates. It is easy to see that for $P_1 = P_2 = 1/2$, D_C yields:

$$D_C^0 = \frac{R_2 - R_1}{R_1 + R_2} \quad (6)$$

which is twice the difference between the sectional rates normalised by the average rate. For the purpose of comparison, we shall be using this index rather the difference or ratio of the difference with respect to one of the rates, as is normally done⁶. For the purpose of comparison we shall treat it as the trivial version of our index, as it considers both the sections as equi-numerous,

Desirable Features

While appraising rural-urban disparity in literacy for different states of the country, Chaubey and Chaubey (1998) have proposed some desirable features. With slight modification in some and one major modification in one, they are presented below:

- (1) The index should lie in the interval of (0.1).
- (2) For a rise in differential k between R_2 and R_1 , a decrease should result in disparity.
- (3) For a given differential k between R_2 and R_1 , a rise in R_1 (and consequently in R_2) should result in decrease in disparity.
- (4) For given R_1 and R_2 an increase in P_1 should result in decrease in disparity.

They are intuitively appealing axioms. It may however be noted that the axiom (3) basically owes to Kundu (Kundu and Rao, 1986). Use of little mathematics will show that index D_C

⁵In case population proportions of the sections are not easily available but overall average rates available, it is easy to find the proportions. For section with higher rate of achievement, we can find that $P_2 = (R - R_1)/(R_2 - R_1)$. Respite the rise in literacy rates of both the genders in 1991 over 1981, the absolute difference of literacy rates shows that disparity has increased in the case of Arunachal Pradesh, Madhya Pradesh, Chandigarh and Dadra & Nagar Haveli. The increase in the case of Dadra and Nagar Haveli is substantial. The ratio measures will unduly increase it and load it on one side.

possesses all of them while its trivial version possesses the first three. Differential calculus would be good enough to show the results⁷.

Application to Literacy Data

The index D_c along with its trivial version is computed for gender and area disparity for all the states and union territories for literacy data for census years 1981 and 1991 (see Table 1). Tables 2 and 3 for change in disparity levels between 1981 and 1991 by trivial and main versions of the new index developed here. The basic rates and proportions are provided in the Appendix Tables 1 and 2.

TABLE 1: GENDER AND AREA DISPARITY BY BOTH VERSIONS OF NEW INDEX

Sfate/U.T:	Trivial Version				Main Version			
	Gender		Area		Gender		Area	
	1981	1991	1981	1991	1981	1991	1981	1991
Andhra Pradesh	31.93	24.10	37.30	30.00	32.30	24.60	21.90	18.93
Arunachal Pradesh	42.96	26.82	47.30	31.80	45.00	28.60	10.69	10.99
Assam		17.96		23.60		18.70		06.86
Bihar	47.66	39.27	38.10	33.50	48.40	40.20	13.52	12.08
Goa	15.89	10.87	09.30	05.10	15.90	11.00	06.21	04.23
Gujarat	25.75	20.11	23.90	18.10	26.30	28.40	19.50	38.70
Haryana	37.01	26.13	28.40	19.50	38.70	27.50	15.03	10.86
Himachal Pradesh	26.03	18.22	22.80	15.30	26.30	18.20	04.46	03.14
Jammii & Kashmir	38.65				40.19			
Karnataka	27.82	20.54	28.00	21.70	28.60	20.80	18.55	14.90
Kerala	07.40	04.14	03.90	01.80	07.30	04.00	01.53	00.99
Madhya Pradesh	43.65	34.81	42.10	32.80	44.50	35.40	23.14	18.85
Maharashtra	25.89	18.81	23.90	17.60	26.50	19.30	18.23	14.41
Manipur	29.89	19.93	16.30	11.70	30.30	20.00	09.23	06.86
Meghalaya	11.30	08.44	37.20	33.10	11.60	08.60	18.16	16.39
Mizoram	07.28	03.97	12.80	12.60	07.60	04.20	06.85	11.91
Nagaland	18.46	10.52	17.40	18.40	19.70	11.20	09.12	07.16
Orissa	38.37	29.06	26.40	22.60	38.60	29.30	07.79	07.39
Punjab	16.69	13.14	21.80	15.50	17.60	13.90	13.28	09.80
Rajasthan	52.37	45.80	44.20	36.50	53.50	47.00	25.32	21.21
Sikkim	31.91	16.94	27.50	19.50	34.30	18.10	17.25	12.88
Tamilnadu	25.46	17.92	23.90	17.60	25.60	18.10	11.14	04.45
Tripm-a	23.60	17.41	29.10	19.40	24.20	17.90	08.62	07.22
Uttar Pradesh	46.82	37.54	31.60	24.90	48.50	39.00	14.40	11.88
West Bengal	24.85	18.58	27.50	19.70	25.80	19.40	17.39	12.48
Andaman & Nicobar	13.88	09.37	13.80	07.90	15.80	10.30	07.98	04.49
Chandigarh	06.40	06.28	17.70	14.90	07.30	07.10	28.79	24.03
Dadra & N. Haveli	37.36	33.00	36.90	35.90	39.30	34.10	07.37	09.11
Daman & Din	23.10	16.37	19.80	14.00	22.60	16.30	15.84	13.55
Delhi	11.78	10.08	11.60	06.50	13.00	11.00	19.60	11.14
Lakshadweep	18.98	10.60	04.60	03.10	18.90	10.80	04.31	03.54
Pondicherry	18.49	12.09	13.20	10.00	18.50	12.40	13.77	12.54
INDIA	31.21	24.02	30.20	24.30	32.10	24.80	17.15	14.54

Note: All figures have been expressed in percentage form.

⁷Substitution of k for $(R_2, -R_1)$ and $(R_1 + k)$ for R_2 , would be a good strategy before trying to find out partial derivatives with respect to k , R_1 , and P_1 .

TABLE 2: DECREASE IN LEVEL OF DISPARITY BY TRIVIAL INDEX

<i>State/ UT</i>	<i>Gender</i>	<i>Area</i>
Andhra Pradesh	24.54	19.64
Arunachal Pradesh	37.57	32.70
Bihar	17.61	12.07
Goa	31.56	45.28
Gujarat	21.91	24.44
Haryana	29.40	31.46
Himachal Pradesh	30.01	33.06
Karnataka	26.17	22.35
Kerala	44.00	53.43
Madhya Pradesh	20.25	22.21
Maharashtra	27.35	26.39
Manipur	33.31	28.55
Meghalaya	25.33	10.86
Mizoram	45.45	01.14
Nagaland	43.03	-06.86
Orissa	24.28	14.30
Punjab	21.27	28.97
Rajasthan	12.55	17.33
Sikkim	46.89	29.11
Tamilnadu	29.60	26.12
Tripura	26.23	33.31
Uttar Pradesh	19.83	21.09
West Bengal	25.24	28.41
Andaman & Nicobar	32.51	42.86
Chandigarh	01.84	15.83
Dadra & N. Haveli	11.66	02.69
Daman & Diu	29.12	29.17
Delhi	14.43	44.10
Lakshadweep	44.14	31.69
Pondichery	34.62	24.25
INDIA	23.05	19.51

Note: All figures are expressed in percentage form.

It is found that both gender disparity and area disparity have considerably reduced in 1991 in comparison to 1981 in the majority of cases. It is also observed that the trivial and full versions of the new measure yield almost the same results in the case of gender disparity. However, in the case of area disparity, the results are quite divergent. The reason is clear:

while gender proportions vary hardly between 48 per cent and 58 per cent, the area proportions vary between 6-7 percent to 92-93 per cent. In fact Dadra & Nagar Haveli did not have any urban areas till the other day.

Even for the country as a whole while the main version does slightly better than its trivial version in the case of gender disparity, it enormously changes the magnitude in the case of area disparity. By the trivial measure gender disparity for 1981 and 1991 comes out to be 31.2 and 24.0 while by the main new index for 1981 and 1991 it is found to be 32.1 and 24.8, which are larger only 3 to 4 per cent only. But when it comes to area disparity, in comparison

to 30.2 for 1981 and 24.3 for 1991 by the trivial version, the main index yields 17.1 for 1981 and 14.5 for 1991, which are substantially lower than their counterparts. It is important to note that the common measure we have chosen for comparison is the best in the genre of indices, which ignore population division.

TABLE 3: DECREASE IN LEVEL OF DISPARITY BY NEW INDEX

<i>State/U.T.</i>	<i>Gender</i>	<i>Area</i>
Andhra Pradesh	23.80	13.56
Arunachal Pradesh	36.51	2.80
Bihar	16.92	10.63
Goa	30.70	31.83
Gujarat	21.73	19.19
Haryana	28.91	27.76
Himachal Pradesh	30.62	29.59
Karnataka	27.19	19.69
Kerala	44.34	35.60
Madhya Pradesh	20.45	18.57
Maharashtra	27.37	20.96
Manipur	33.87	25.73
Meghalaya	25.67	09.73
Mizoram	45.26	73.75
Nagaland	43.01	21.49
Orissa	24.14	05.07
Punjab	21.33	26.20
Rajasthan	12.21	16.24
Sikkim	47.22	60.03
Tamilnadu	29.41	25.33
Tripura	25.87	16.30
Uttar Pradesh	19.63	17.49
West Bengal	24.92	28.23
Andaman & Nicobar	35.12	43.71
Chandigarh	03.16	16.55
Dadra & N Haveli	13.22	23.62
Daman & Diu	27.62	14.43
Delhi	15.26	43.16
Lakshadweep	42.88	17.87
Pondicherry	33.35	08.90
INDIA	22.78	15.23

Note: All figures are expressed in percentage form.

It is possible that the ranks by the two measures may not differ much in the case of gender disparity. In the case of area disparity, the ranks change drastically. For example, Bihar and Gujarat by the trivial index in 1991 have disparity level equal to 33.5 and 18.1 respectively while by the main index they reverse their positions and have disparity level equal to 12.1 and 38.7. A comparison of Gujarat with Maharashtra would be all the more revealing. Let us take Uttar Pradesh and West Bengal. While the trivial version shows Uttar Pradesh as having higher level of disparity, the main version shows West Bengal to be doing so. The difference though between the two magnitudes is rather small in 1991.

The Registrar General of India (1992) has shown that gender disparity, as measured by the difference measure, has risen in four states of Arunachal Pradesh, Madhya Pradesh, Chandigarh and Dadra and Nagar Haveli. Even our trivial version does not do so. Though our trivial version does not recognise the difference between population size of the two sections, it does normalise the difference appropriately by the levels, obtaining before and after. As far as area disparity is concerned the Registrar General of India (1992) shows no reduction in disparity in Bihar and Meghalaya⁸, and an increase in Mizoram, Nagaland, and Dadra and Nagar Haveli. Our trivial measure on the other hand shows a rise only in the case of Nagaland. When population adjusted full measure is applied, then Arunachal Pradesh and Mizoram show an increase in disparity. It can well be expected that ranks will considerably change.

Concluding Remarks

In order to accommodate the dimension of population distribution between two sections we have devised a new measure. This new measure in comparison to its own trivial version, which is by far the best in the genre of the difference-ratio measures, shows widely differing magnitudes when the division between populations under comparison vary rather widely. The short point is that while proper normalisation of the difference between two rates is important, not to consider the division of population in the construction is fatal.

While this exercise has been conducted in social, demographic context, it is full of potential for use in economic context too⁹.

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⁸In both the cases the reduction is of an order of 0.01 point—from 34.07 to 34.06 in Bihar and 40.70 to 40.69 in Mizoram. It may be noted that while Bihar has low literacy rates and Mizoram has high literacy rates.

⁹Division of an economy into two sectors with their respective rates along with respective contributions will yield the level of disparity.

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TABLE 1: BASIC DATA RELATING TO SECTIONAL LITERACY RATES AND POPULATION
PROPORTIONS (CENSUS 1981)

<i>Slum U. T.</i>	<i>Literacy Rate</i>					<i>Population Proportion</i>	
	<i>Rural</i>	<i>Urban</i>	<i>Female</i>	<i>Male</i>	<i>Total</i>	<i>Urban</i>	<i>Male</i>
Andhra Pradesh	27.85	61.00	24.16	46.83	35.66	23.56	50.77
Arunachal Pradesh	22.81	63.75	14.01	35.11	25.54	06.67	54.47
Bihar	27.70	61.77	16.51	46.58	32.03	12.71	51.59
Goa	61.63	74.33	55.17	76.01	65.71	32.13	50.00
Gujarat	43.57	71.00	38.46	65.14	52.21	31.50	51.56
Haryana	37.26	66.83	26.89	58.49	43.85	22.29	53.65
Himachal Pradesh	48.89	77.80	37.72	64.27	51.17	07.89	50.66
JaiTunu & Kashmir			19.55	44.18	32.68		53.33
Karnataka	37.63	66.91	33.16	58.72	46.20	29.27	51.65
Kerala	80.31	86.91	75.65	87.74	81.56	18.94	48.96
Madhya Pradesh	26.30	64.55	18.99	48.41	34.22	20.71	51.77
Maharashtra	45.65	74.29	41.01	69.66	55.83	35.54	51.71
Manipur	45.03	62.61	34.61	64.12	49.61	26.05	50.95
Meghalaya	34.39	75.09	37.15	46.62	42.02	18.75	51.51
Mizoram	69.17	89.46	68.60	79.37	74.26	25.09	52.30
Nagaland	45.62	64.81	40.28	58.52	50.20	23.87	54.29
Orissa	37.77	64.81	25.14	56.45	40.96	11.80	50.48
Punjab	41.73	64.96	39.64	55.52	48.12	27.51	53.38
Rajasthan	22.47	58.05	13.99	44.76	30.09	21.42	52.33
Sikkim	36.94	64.93	27.35	52.98	41.57	16.54	55.69
Tamilnadu	45.00	73.25	40.43	68.05	54.38	33.20	50.50
Tripura	45.78	83.36	38.01	61.49	50.10	11.50	51.53
Uttar Pradesh	28.53	54.87	17.18	47.43	33.33	18.22	53.44
West Bengal	40.18	70.68	36.07	59.93	48.64	27.74	52.65
Andaman & Nicobar	58.12	76.71	53.15	70.28	63.16	27.11	58.39
Chandigarh	53.27	76.24	69.31	78.79	74.81	93.77	57.45
Dadra & N. Haveli	30.29	65.70	20.38	44.69	32.70	06.80	52.84
Daman & Diu	50.42	75.29	46.51	74.45	59.91	38.16	48.39
Delhi	57.83	73.01	62.57	79.28	71.93	92.88	56.01
Lakshadweep	65.47	71.76	55.32	81.24	68.42	46.90	50.00
Pondicherry	56.17	73.25	53.03	77.09	65.14	52.52	50.20
INDIA	36.09	67.34	29.75	56.75	43.56	23.91	51.85

TABLE 2: BASIC DATA RELATING TO SECTIONAL LITERACY RATES AND POPULATION

PROPORTIONS (CENSUS 1991)

<i>State/U.T</i>	<i>Literacy Rates</i>				<i>Population Proportion</i>		
	<i>Rural</i>	<i>Urban</i>	<i>Female</i>	<i>Male</i>	<i>Total</i>	<i>Urban</i>	<i>Male</i>
Andhra Pradesh	35.74	66.35	33.72	55.13	44.09	27.27	50.65
Arunachal Pradesh	37.02	71.59	29.69	51.45	41.59	13.22	54.61
Assam	49.03	79.39	43.03	61.87	52.64	11.89	52.18
Bihar	33.83	67.89	22.89	52.49	38.48	13.65	52.31
Goa	72.31	80.10	67.09	83.46	75.51	41.03	50.69
Gujarat	53.09	76.54	48.64	73.13	61.29	34.95	51.61
Haryana	49.65	73.66	40.47	69.10	55.69	25.18	53.46
Himachal Pradesh	61.86	84.17	52.13	75.36	63.86	08.98	50.13
Karnataka	47.69	74.20	44.34	67.26	56.04	31.49	50.87
Kerala	88.92	92.25	86.17	93.62	89.81	26.62	48.70
Madhya Pradesh	35.87	70.81	28.25	58.42	44.20	23.84	51.87
Maharashtra	55.52	79.20	52.32	76.56	64.87	39.48	51.58
Mizoram	55.79	70.53	47.60	71.30	59.89	27.86	50.65
Mizoram	41.05	81.74	44.85	53.12	49.10	19.78	51.23
Nagaland	72.47	93.45	78.60	85.10	82.27	46.70	52.55
Nagaland	57.23	83.10	54.75	67.62	61.65	17.07	53.85
Orissa	45.46	71.99	34.68	63.09	49.09	13.68	50.58
Punjab	52.77	72.08	50.41	65.66	58.50	29.69	53.16
Rajasthan	30.37	65.33	20.44	54.99	38.55	23.39	52.42
Sikkim	54.38	80.69	46.69	65.74	56.91	09.63	54.14
Tamil Nadu	54.59	77.99	51.33	73.75	62.66	34.49	50.60
Tripura	56.08	83.09	49.65	70.58	60.44	16.15	51.70
Uttar Pradesh	36.66	61.00	25.31	55.73	41.60	20.31	53.31
West Bengal	50.50	75.27	46.56	67.81	57.70	29.08	52.65
Andaman & Nicobar	69.93	81.89	65.46	78.99	73.22	27.50	55.60
Chandigarh	59.12	79.87	72.34	82.04	77.82	90.11	56.56
Dadra & N. Haveli	37.00	78.44	26.98	53.56	40.71	08.95	52.21
Daman & Diu	61.55	81.61	59.40	82.66	71.20	48.11	50.00
Delhi	66.90	76.18	66.99	82.01	75.29	90.39	55.27
Lakshadweep	78.89	83.99	72.89	90.18	81.79	56.79	51.17
Pondicherry	65.36	79.88	65.63	83.68	74.74	64.57	51.17
INDIA	44.49	73.08	39.29	64.13	52.06	26.47	52.01