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Some Aspects of Estimating Poverty at Small Area Level*

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SUMMARY

Issues relating to poverty have been at the core of development process in all developing countries. Measurement of poverty has been extremely important for evaluation of development strategies. Disparities do exist in the income as well as consumption and expenditure levels in different groups of society as also there are spatial dispersions. There are indicators for measuring incidence, depth and severity of poverty. Most of these indicators are estimated at State level with the help of data as obtained from Consumption Expenditure Surveys. For poverty alleviation programmes, as well as for planning other development strategies at micro-level, small area level estimates for poverty indicators are necessary. In this paper, an attempt is made to review some of the existing procedures for poverty mapping and an application of a Small Area Estimation technique is made for estimating poverty indicators at district level in Uttar Pradesh. Data from Consumption Expenditure Survey of NSSO (61st round 2004-05) has been used for this application.

Key words: Poverty indicators, Small Area Estimation, Area level models.

1. INTRODUCTION

Measurement of poverty and its estimation has been at the center stage of the planning process in every developing country. Household surveys for consumption expenditure have been main instruments of poverty measurement. These surveys are facilitated in most of the developing countries by United Nations through the National Household Survey Capability Programmes. But, India has been in an advantageous position with availability of regular data flow through National Sample Survey Organization (NSSO). As a part of its national level household surveys, Consumption Expenditure surveys are conducted every five years on a larger sample and annually on a thinner sample.

Poverty is commonly visualized as a state of not having enough resources to take care of basic needs such as food, clothing, and housing. The criterion developed for measurement of poverty revolves around quantification of minimum (food and non-food) requirements of individuals for a healthy living. The monetary value for such a requirement is termed as poverty line. Poverty is also sometimes defined as the state of living in a family with income below the defined poverty line. Poverty lines are obtained at the state levels with rural-urban classifications.

One of the most commonly used indicators of poverty is the poverty ratio which is a Head Count Ratio (HCR) of poor people and it measures the incidence of poverty. There are other indicators as well, which measure the depth and severity of poverty. In the Indian context, state-wise poverty lines are defined for rural and urban areas and are updated to take care of price changes. Poverty ratios for the States are estimated periodically using the current poverty lines and the NSSO data for Household Consumer Expenditure Surveys.

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Poverty estimation at small area levels is a practical necessity in view of growing needs for micro level planning. Presently, estimates for number of poor as well as for poverty ratios are provided only at state level. In many countries, poverty mapping is done, based on small area level estimates. In the Indian context, even district level precise estimates are not available. Direct estimates, based on NSSO data are likely to be less precise due to smaller sample sizes at district level.

Several other aspects of poverty estimation, such as measuring the incidence, depth and severity of poverty, inequalities as well as distribution of poverty to different groups of population at district level are of interest. In this paper, some of these aspects are addressed and illustrated with the help of NSSO, 61st round (2004-05) data for Consumer Expenditure for Uttar Pradesh.

2. MEASURING POVERTY

The process for measuring poverty in the country was initiated in early sixties (1962), when a working group from Planning Commission provided a quantification of minimum (food and non food) requirements of individuals for a healthy living. At that time a poverty line was set up for national level at Rs. 20 per month at 1960-61 prices. In the late 70's and early 80's, several methodological issues relating to poverty estimation were sorted out. A weighting diagram was developed, with due consideration to age, sex and the nature of work performed by individuals. Subsequently, a poverty line was specified by the Planning Commission, Government of India in 1979. Using the calorie norms for individual groups, the average requirements in rural and urban areas were obtained as 2435 and 2095 K cal respectively. These were further rounded off to 2400 and 2100 K cal respectively. Based on NSSO 28th round (1973-74) data and the corresponding prices in the same year for a consumption basket satisfying the above calorie norms, monthly per capita consumption expenditures were worked out as Rs. 49.09 and Rs 56.64 for rural and urban areas respectively. These were poverty lines at the national level at that time i.e. in 1979.

An Expert Group on Estimation of Proportion and Number of Poor was constituted by the Planning Commission in 1989 which recommended that the above poverty lines should be adopted as the base line and it should be uniformly adopted for all the States. The Expert Group also suggested an approach for disaggregating the national level poverty lines to State specific poverty lines on the basis of State specific prices and inter-state price differential. The group also suggested a mechanism for regularly updating the poverty lines for rural and urban areas on the basis of prices using the Consumer Price Index of Agricultural Laborers (CPIAL) for rural poverty line and Consumer Price Index for Industrial Workers (CPIIW) for urban poverty line. Presently, the Expert Group method is being used for estimating the number and percentage of poor at national and State level by the Planning Commission, which is the nodal agency for estimation of poverty.

The Planning Commission released poverty estimates for 1973-74, 1977-78, 1983, 1987-88, 1993-94, 1999-2000 and 2004-05. It has, however, been noted that 1999-2000 estimates are not strictly comparable with the estimates of previous years due to different reference periods used in 55th round (1999-2000) of the NSSO consumer expenditure survey. Choice of different reference periods for different group of items has been a cause of considerable debate and experimentation in some of the previous rounds of NSSO surveys. The major concerns have been the quality of data and comparability of results. In the 61st round data (2004-05), two different consumption distributions have been obtained. The first one relates to 30-day recall period for all the items. The other one relates to data collected using 365-day recall period for five infrequently purchased non-food items i.e. clothing, footwear, durable goods, education and institutional medical expenses and 30-day recall period for remaining items. The two consumption distributions have been termed as Uniform Recall Period (URP) and Mixed Recall Period (MRP) consumption distributions respectively. For 2004-05 data, poverty estimates for both the distributions have been obtained. However, it is the URP approach which is comparable to previous results.

The debate on methodological issues for measurement of poverty has passed through many critical stages. In the early stages, national poverty line was uniformly followed for all the States. Also there were significant differences in the consumption expenditure data as obtained from NSSO, and the other from National Accounts Statistics (NAS). For quite some time the NSSO results used to be adjusted pro-rata with the NAS results. However, with the recommendations of the Expert group and with the introduction of State- specific poverty lines, the practice of adjustment in urban areas was discontinued. Sudden decline in the poverty estimates in 1999-2000 from 37.24 per cent to 27.1 per cent in the rural areas and from 32.4 per cent to 23.6 per cent in urban areas was partially attributed to the change in the reference periods. Some of these issues are discussed in detail in a collection of papers in *The Great Indian Poverty Debate, eds. Deaton and Kozel.*

3. INDICATORS OF POVERTY AND ECONOMIC INEQUALITY

Some of the commonly used indices for studying poverty and income inequality are as follows:

3.1 Poverty Ratio

As already mentioned earlier, most commonly used indicator of poverty is the poverty ratio which is a head count ratio (HCR) of poor people and it measures the incidence of poverty. Define

x^* = poverty line

x_i = monthly per capital consumption expenditure of i^{th} individual

N = total number of persons

P = number of persons with consumption expenditure less than x^*.

Poverty Ratio (PR) is defined as

$$\text{PR} = P/N$$

Poverty ratio is, thus, simply a head count ratio and it only measures the incidence of poverty. It is most commonly used measure of poverty globally. However, a major limitation of this index is that it does not take into account the level of poverty within poor people. Poverty ratio is not affected by upward or downward movement of poor people unless they cross the poverty line.

3.2 Income Gap Ratio

Income Gap Ratio (IGR) is defined as

$$\text{IGR} = \frac{1}{P}\sum_{i=1}^{P}\left(1 - x_i / x^*\right) \text{ for all } x_i < x^*$$

$$= 1 - \bar{x}_p / x^*$$

where $\bar{x}_p$ is the average consumption of the persons below poverty line. IGR provides information on the depth of poverty. It captures the average expenditure shortfall, or gap, for the poor in a given area to reach the poverty line. Another indicator for measuring the depth of poverty is Poverty Gap Ratio, which is defined as follows.

3.3 Poverty Gap Ratio

Poverty Gap Ratio (PGR) is defined as

$$\text{PGR} = \frac{1}{N}\sum_{i=1}^{P}(1 - x_i / x^*)$$

$$= \frac{P}{N}\frac{1}{P}\sum_{i=1}^{P}\left(1 - x_i / x^*\right)$$

$$= (\text{PR}) \cdot (\text{IGR})$$

This is an improved indicator for measuring the depth of poverty. It is more consistent with poverty ratio regarding persons crossing the poverty line.

3.4 Squared Poverty Gap Ratio

The Squared Poverty Gap Ratio (SPGR) is a measure for severity of poverty and is defined as

$$\text{SPGR} = \frac{1}{N}\sum_{i=1}^{P}\left(1 - x_i / x^*\right)^2$$

3.5 Foster-Greer-Thorbecke (FGT) Index

A generalized version of poverty indices was considered by Foster *et al*. (1984) as follows:

$$\text{FGT} = P_\alpha\left(x, x^*\right) = \frac{1}{N}\sum_{i=1}^{P}\left(1 - x_i / x^*\right)^\alpha$$

= PR when $\alpha = 0$

= PGR when $\alpha = 1$

= SPGR when $\alpha = 2$

This measure becomes more and more sensitive to poorer persons with higher values of α. Thus, it becomes a good indicator for more vulnerable poorest of the poor classes of society. An interesting feature of FGT is that it is decomposable to different components of the population. If the population is divided into g groups of households with ordered income vectors $x^{(j)}$ and population sizes N_j, then for $\alpha > 1$

$$P_\alpha(x, x^*) = \sum_{j=1}^{g} \frac{N_j}{N} P_\alpha\left(x^{(j)}, x^*\right)$$

If we define $T_j = \frac{N_j}{N} P_\alpha\left(x^{(j)}, x^*\right)$ and $T = \sum_j T_j$, then percentage contribution of j^{th} group to overall poverty is

$$\text{CTP}_j = (T_j / T) \times 100$$

Thus, FGT is an important tool for measuring the contribution to total poverty for various subgroups of the population.

3.6 A Measure of Income Inequality – Gini Coefficient

One of the most widely used measures for the extent of inequality is the Gini Coefficient. An important feature of this measure is its association with Lorenz curve in which the proportion of the population arranged from the poorest to the richest are represented on the horizontal X-axis and the proportion of income enjoyed by the bottom x proportion of the population is depicted on the vertical Y-axis. The mathematical formulation is as follows:

Let the income $y(\geq 0)$ has a continuous distribution with density function $f(y)$ with mean $\mu = \int_0^\infty y f(y) \mathrm{d}y$

Define

$$\mathrm{F}(x) = \int_0^x f(y) dy \text{ and } \mathrm{F}_1(x) = \frac{1}{\mu} \int_0^x y f(y) \mathrm{d}y$$

F(x) is the proportion of persons with income less than or equal to x and $\mathrm{F}_1(x)$ is the proportionate share of these persons in the aggregate income of all persons. Clearly, F(x) and $\mathrm{F}_1(x)$ both lie between 0 and 1 for x ranging from 0 to ∞ and F_1 is a monotone increasing function of F. The graph of F_1 against F is called Lorenz curve or the Concentration curve of the given distribution of income. The area between the Lorenz curve and the egalitarian line is called the area of concentration. Lorenz ratio, also known as the Gini coefficient is defined as

$$\mathrm{G} = 2 \times \text{area of concentration}$$

$$= 1 - 2\int_0^1 \mathrm{F}_1 \mathrm{d}\,\mathrm{F}$$

G may also be represented in several alternative ways. Some of the representations and corresponding interpretations in terms of welfare economics are available in literature (Sen 1973).

4. POVERTY ESTIMATION

As mentioned earlier, poverty ratios are estimated for each State (rural and urban) as percentage of persons below respective poverty lines and then a pooled poverty ratio is obtained for the State by combining rural and urban estimates. The all India poverty ratio is obtained as a weighted average of state-wise poverty ratios. These estimates are available since 1973-74 (base year) and then for the years corresponding to five yearly larger samples for Consumption Expenditure Surveys of the NSSO. Since a time series data on poverty is available in the country, comparisons of poverty over space and time makes an interesting study. Debates and controversies on poverty estimates have also been a part of the entire process. Some of the issues have been discussed in *The Great Indian Poverty Debate eds. Deaton and Kozel (2005).*

To get an idea about, how the poverty lines and poverty ratios have moved over the years, State specific poverty lines and poverty ratios for 16 States at different period of times are given in Table 1 and Table 2 respectively.

From these tables, it is possible to study the spread of poverty over the States and also the trends and changes

Table 1. State-specific poverty lines (Rupees per capita per month)

S. No.	State	Rural			Urban		
		1973-74	1993-94	2004-05	1973-74	1993-94	2004-05
1	Andhra Pradesh	41.71	163.02	292.95	53.96	278.14	542.89
2	Assam	49.82	232.05	387.64	50.26	212.42	378.84
3	Bihar	57.68	212.16	354.36	61.27	238.49	435.00
4	Gujarat	47.10	202.11	353.93	62.17	297.22	541.16
5	Haryana	49.95	233.79	414.76	52.42	258.23	504.49
6	Himachal Pradesh	49.95	233.79	394.28	51.93	253.61	504.49
7	Karnataka	47.24	186.63	324.17	58.22	302.89	599.66
8	Kerala	51.68	243.84	430.12	62.78	280.54	559.39
9	Madhya Pradesh	50.20	193.10	327.78	63.02	317.16	570.15
10	Maharashtra	50.47	194.94	362.25	59.48	328.56	665.90
11	Orissa	46.87	194.03	325.79	59.34	298.22	528.49
12	Punjab	49.95	233.79	410.38	51.93	253.61	466.16
13	Rajasthan	50.96	215.89	374.57	59.99	280.85	559.63
14	Tamil Nadu	45.09	196.53	351.86	51.54	296.63	547.42
15	**Uttar Pradesh**	**48.92**	**213.01**	**365.84**	**57.37**	**258.65**	**483.26**
16	West Bengal	54.49	220.74	382.82	54.81	247.53	449.32
	All India	49.63	205.84	356.30	56.76	281.35	538.60

Source: Planning Commission, Government of India

Table 2. State-specific poverty ratios (Percentage)

S. No.	State	Rural			Urban			Combined		
		1973-74	1993-94	2004-05	1973-74	1993-94	2004-05	1973-74	1993-94	2004-05
1	Andhra Pradesh	48.41	15.92	11.2	50.61	38.33	28.0	48.86	22.19	15.8
2	Assam	52.67	45.01	22.3	36.92	47.73	3.3	51.21	40.86	19.7
3	Bihar	62.99	58.21	42.1	52.95	34.50	34.6	61.91	54.96	41.1
4	Gujarat	46.35	22.18	19.1	52.57	27.89	13.0	48.15	24.21	16.8
5	Haryana	34.23	28.02	13.6	40.18	16.38	15.1	35.36	25.05	14.0
6	Himachal Pradesh	27.42	30.34	10.7	13.17	9.18	3.4	26.39	28.44	10.0
7	Karnataka	55.14	29.88	20.8	52.53	40.14	32.6	54.47	33.16	25.0
8	Kerala	59.19	25.76	13.2	62.74	24.55	20.2	59.79	25.43	15.0
9	Madhya Pradesh	62.66	40.64	36.9	57.65	48.38	42.1	61.78	42.52	38.3
10	Maharashtra	57.71	37.93	29.6	43.87	35.15	32.2	53.24	36.86	30.7
11	Orissa	67.28	49.72	46.8	55.62	41.64	44.3	66.18	48.56	46.4
12	Punjab	28.21	11.95	9.1	27.96	11.35	7.1	28.15	11.77	8.4
13	Rajasthan	44.76	26.46	18.7	52.13	30.49	32.9	46.14	27.41	22.1
14	Tamil Nadu	57.43	32.48	22.8	49.40	39.77	22.2	54.94	35.03	22.5
15	**Uttar Pradesh**	**56.53**	**42.28**	**33.4**	**60.09**	**35.39**	**30.6**	**57.07**	**40.85**	**32.8**
16	West Bengal	73.16	40.80	28.6	34.67	22.41	14.8	63.43	35.66	24.7
	All India	56.44	37.27	28.3	49.01	32.36	25.7	54.88	35.97	27.5

Source: Planning Commission, Government of India over time. However, for micro level planning, estimates at district and even smaller levels are more meaningful.

5. ESTIMATION OF POVERTY AT DISTRICT LEVEL

For poverty estimation at micro-level, various approaches are available. One such approach, which is commonly used for poverty mapping, is essentially based on unit level data from surveys and corresponding census approximately of the same period. The approach is briefly described as follows.

5.1 Poverty Mapping

For poverty mapping, micro-level estimates of poverty parameters are needed. One of the methods, which is based on unit level small area model approach was developed by a group at the World Bank. (Hentschel *et al.* 2000 and Elbers *et al.* 2001).

The method requires data from a household survey which includes household consumption expenditure data (y). To calculate more specific poverty measures linked to a poverty line, log normal regressions are estimated to model per capita expenditure using a set of explanatory variables (x) that are common to both the household survey and the census (*e.g.* household size, education, housing and infrastructure characteristics and demographic variables).These first stage regression models are modeled at the lowest geographical level for which the household survey data is representative and a different first stage model is estimated for each stratum (*e.g.* region, rural and urban). Next, the estimated coefficients from these regressions are used to predict log per capita expenditure for every household in the census. This household level predicted data are then aggregated to small areas such as sub-counties, counties etc. to obtain estimates of the percentage of households below poverty line. These poverty rates are used to produce poverty maps, showing the spatial distribution of poverty.

This method has been used by the World Bank in a number of developing countries for poverty mapping. To start with, an initial exercise is needed to select the set of common variables in the survey and the census records. In some cases, the distributions of individual concomitant variables are examined with respect to their moments and percentiles for both the survey and census data. The success of method heavily depends on the suitable choice of these variables. One of the limitations of this method is that it requires unit level data for the census. Davis (2003) observes that one virtue of this methodology is the relative ease of checking the reliability of estimates that are built into the programmes provided by the World Bank to national poverty mapping analysis and the other virtues of this approach is that it has the institutional backing of the World Bank and a team of researchers concerned with developing methodology and training.

The method has got its own merits for poverty mapping, provided unit level data for census are available. Since unit level household expenditure values are predicted for each and every household, it is possible to estimate poverty parameters at reasonably smaller levels. In many of the developing countries, estimates at sub county level, which are much smaller than districts, have been obtained for poverty mapping purposes. In the Indian context, however, its application for poverty mapping has not been attempted.

5.2 Small Area Estimation Approach

Small area typically refers to the part of a population for which reliable statistics of interest cannot be produced due to small sample sizes. The topic of small areas has gained importance in view of growing needs of micro level planning. Demands for reliable small area statistics (SAS) are increasing with growing concerns of governments relating to issues of distribution, equity and disparity. The traditional sampling theory fails to provide reliable and valid estimates for small areas. Many Small Area Estimation (SAE) techniques have been developed which make use of information from other sources. They also borrow strength from related or similar areas through explicit and implicit models that connects the small areas via supplementary data. The need for statistics at lower levels has been felt for a long time and efforts have been made to meet the requirements through some traditional approaches. The initial SAE methods were invariably based on certain assumptions in the form of implicit models. These models were, however, subsequently explicitly modeled and a number of model based SAE techniques are now available. We consider some explicit model-based methods which are essentially mixed models and are used in specific situations based on data availability on the response variables of interest. These are (i) area level models where information on response variable is available only at the small area level; and

(ii) unit level models where information on the response variable is available at the unit level.

5.2.1 Area level models

An area level mixed model is represented as

$$\hat{\theta}_d = z_d^T \beta + v_d + e_d , \quad d = 1, ..., D$$

where $\hat{\theta}_d$ is the direct survey estimate of the parameter θ_d, as obtained from the sample survey data, z_d^T is the vector of concomitant variates, the model errors v_d are assumed to be independent and identically distributed with mean zero, variance σ_d^2 and e_d are the sampling errors which are assumed to be independent across small areas with mean zero and known variances χ_d. Here e_d and v_d are design-based and model-based random variables respectively. The model variance σ_d^2 is a measure of homogeneity of the areas after accounting for the covariates z_d.

Empirical best linear unbiased prediction (EBLUP), empirical Bayes (EB) and hierarchical Bayes (HB) methods have played an important role in the estimation of small area means. EBLUP method has been used in many practical applications.

The other methods EB and HB are applicable under specific distributional assumptions. The inferences in HB methods are obtained through posterior distributions. EBLUP and EB are identical under normality assumptions. For EBLUP and EB, an estimate of Mean Square Error, $\text{MSE}(\theta_d^*) = \text{E}(\theta_d^* - \theta_d)^2$ is used as a measure of variability of θ_d^*, where the expectation is with respect to the model as considered above.

One of the early applications of this method was due to Fay and Herriot (1979). In fact, this method was adopted by the U.S. Bureau of Census in 1974 to form Per Capita Income (PCI) estimates for small places. An excellent example of recent application of this method is in a study on "Small Area Estimates of School-Age Children in Poverty" (Constance and Graham eds. 2000). In this application, estimates for number of school-age children, belonging to households in poverty has been estimated at the county level in USA. These estimates are used for distribution of Title-I funds of the Elementary and Secondary Education Act to Counties for onward distribution to School Districts.

We intend to apply this method for obtaining district level poverty estimates for the area level models and provide the estimation procedure, along with the method of obtaining the estimates of MSEs of estimated parameters.

Procedure for estimation

For the mixed model considered above, an Empirical Best Linear Unbiased Predictor (EBLUP) of θ_d is given by

$$\theta_d^* = \gamma_d \hat{\theta}_d + (1 - \gamma_d) z_d^T \hat{\beta}$$

This estimator is a linear combination of direct estimator $\hat{\theta}_d$ and the regression synthetic estimator $z_d^T \hat{\beta}$. Further γ_d and $\hat{\beta}$ are defined as follows:

$$\gamma_d = \frac{\hat{\sigma}_v^2}{\psi_d + \hat{\sigma}_v^2}$$

and

$$\hat{\beta} = \left[\sum_d^D \frac{z_d z_d^T}{\psi_d + \hat{\sigma}_v^2} \right]^{-1} \left[\sum_d^D \frac{z_d \hat{\theta}_d}{\psi_d + \hat{\sigma}_v^2} \right]$$

Calculation of $\hat{\sigma}_v^2$

One of the methods for obtaining $\hat{\sigma}_v^2$, which is the method of moments and was suggested by Fay and Herriot (1979), is an iterative procedure and is described as follows:

Define

$$h(\sigma_v^2) = \sum_d \frac{(\hat{\theta}_d - z_d^T \hat{\beta})^2}{\psi_d + \sigma_v^2}$$

and

$$h'(\sigma_v^2) = -\sum_d \frac{(\hat{\theta}_d - z_d^T \hat{\beta})^2}{(\psi_d + \sigma_v^2)^2}$$

This is an approximation to the first derivative of $h(\sigma_v^2)$.

The iterative equation is

$$\sigma_v^{2(\alpha+1)} = \sigma_v^{2(\alpha)} + \frac{1}{h'(\sigma_v^{2(\alpha)})}\left[m - p - h(\sigma_v^{2(\alpha)})\right]$$

Constraining $\sigma_v^{2(\alpha+1)} \geq 0$ and taking $\sigma_v^{2(0)} = 0$ when no solution exists for any a.

For iterations, we have to start with $\alpha = 0$ taking $\sigma_v^{2(0)} = 0$ and continue to α = 1, 2, 3, 4, . . . and so on, till the value of σ_v^2 stabilizes. Normally less than ten iterations are needed.

It may be noted that only some of the woredas are represented in the sample. For the woredas not represented in the sample, it would not be possible to develop direct estimators and regression synthetic estimator will be used.

Estimation of MSEs

The procedure for estimating MSEs may be given in two steps.

Step 1. Estimation of MSE (θ_d^*) for small areas which are in the sample

Estimate for MSE for sampled small areas is given by

$$mse(\theta_d^*) = g_{1d}(\hat{\sigma}_v^2) - b_{\hat{\sigma}_v^2}(\hat{\sigma}_v^2)\nabla_{g_{1d}}(\hat{\sigma}_v^2) + g_{2d}(\hat{\sigma}_v^2) + 2g_{3d}(\hat{\sigma}_v^2)$$

where

$$g_{1d}(\hat{\sigma}_v^2) = \gamma_d \psi_d$$

$$g_{2d}(\hat{\sigma}_v^2) = (1-\gamma_d)^2 X_d^T \left[\sum_d \frac{z_d z_d^T}{\psi_d + \hat{\sigma}_v^2}\right]^{-1} z_d$$

$$g_{3d}(\hat{\sigma}_v^2) = \psi_d^2(\psi_d + \hat{\sigma}_v^2)^{-3}\bar{\mathrm{V}}(\hat{\sigma}_v^2)$$

where

$$\bar{\mathrm{V}}(\hat{\sigma}_v^2) = 2m\left[\sum_i \frac{1}{\psi_d + \hat{\sigma}_v^2}\right]^{-2}$$

$$b_{\hat{\sigma}_v^2}(\hat{\sigma}_v^2) = \frac{2\left[m\sum_d(\psi_d + \hat{\sigma}_v^2)^{-2} - \left\{\sum_d(\psi_d + \hat{\sigma}_v^2)^{-1}\right\}^2\right]}{\left[\sum_d(\psi_d + \hat{\sigma}_v^2)^{-1}\right]^3}$$

and

$$\nabla_{g_{1d}}(\hat{\sigma}_v^2) = (1-\gamma_d)^2$$

Step 2. Estimation of MSE (A_i^*) for small areas which are not in the sample

For non-sampled small areas, the EBLUP estimator reduces to regression synthetic estimator $z_{d'}^T\hat{\beta}$, where $\hat{\beta}$ is the weighted least square (WLS) estimator computed from the sampled small areas $d \in s$.

A nearly unbiased estimator of MSE for regression synthetic estimator for d'-th non-sampled small area is given by

$$mse(\theta_{d'}^*) = z_{d'}^T\left[\sum_i \frac{z_d z_d^T}{\psi_d + \hat{\sigma}_v^2}\right]^{-1} z_{d'} + \hat{\sigma}_v^2$$

Here the subscripted notation d stands for sampled small areas whereas d' stands for the non-sampled small areas.

It may be observed that the leading term of $\mathrm{MSE}(\theta_d)$ is given by $\gamma_d \chi_d$ which shows that the EBLUP estimate can lead to large gains in efficiency over the direct estimate with variance χ_d, when γ_d is small i.e. the model variance σ_v^2 is small relative to the sampling variance χ_d. Choice of good auxiliary data to provide a good model fit is, therefore the key to successful application of the small area technique.

5.2.2 Unit level models

Consider a population of N units with d-th small areas consisting of N_d units. Let y_{dj} and x_{dj} be the unit level y-value and correlated covariate x-value for j-th unit in the d-th small area. It is assumed that the domain means $\bar{X}_d$ is known. Consider the following one-folded nested error linear regression model

$$y_{dj} = x_{dj}^T\beta + \mathrm{v}_d + e_{dj},\ j = 1,\ldots,N_d;\ d = 1,\ldots,D$$

where the random small area effects v_d have mean zero and common variance σ_v^2 and are independently distributed. Also, e_{dj} are assumed to be independently distributed with mean zero and variance σ_e^2 and are also independent of area effects v_d. This model was initially considered by Battese *et al.* (1988).

If N_d is large, the population mean $\bar{Y}_d$ is approximately equal to $x_d^T \beta + v_d$. The sample data $\{y_{dj}, x_{dj}, j = 1, \ldots n_d; d = 1, \ldots, D\}$ is assumed to satisfy the above population model. This happens in equal probability sampling. This will also follow in probability proportional to size sampling when the size measure is taken as the covariate in the model. Assuming $\bar{Y}_d = \bar{X}_d^T \beta + v_d$, the EBLUP estimate of $\bar{Y}_d$ is of the form

$$\bar{y}_d^* = \hat{\gamma}_d [\bar{y}_d + (\bar{X}_d - \bar{x}_d)^T \hat{\beta}] + (1 - \hat{\gamma}_d) \bar{X}_d^T \hat{\beta}, d = 1, \ldots, D$$

Here, $\hat{\gamma}_d = \hat{\sigma}_v^2 / (\hat{\sigma}_v^2 + \hat{\sigma}_e^2 n_d^{-1})$ with estimated variance components $\hat{\sigma}_v^2$ and $\hat{\sigma}_e^2$, and $\hat{\beta}$ is the weighted least square estimate of β. It may be noted that the EBLUP estimator is a composite estimator combining the survey regression estimator with the regression synthetic estimator.

For the sampled data, in this model also, the leading term of MSE ($\bar{y}_d^*$) is given by $\gamma_d (\sigma_e^2 / n_d)$, which shows that EBLUP estimate can lead to large gains in efficiency over the survey regression estimate when γ_d is small. Battese *et al.* (1988) applied the nested error regression model to estimate area under corn and soybeans at county level in North-central Iowa using farm interview data in conjunction with LANDSAT satellite data.

It is seen that although the method used by World Bank is a unit level regression based approach, it is very much different than the mixed model approach described here.

For details of an exhaustive and thorough presentation of small area estimation, an excellent reference is the book by Rao (2003).

6. APPLICATION OF AREA LEVEL MODEL BASED SAE APPROACH FOR ESTIMATING POVERTY INDICATORS

As described earlier, in the Indian context, the main source of data for studying poverty is the Consumption Expenditure Surveys of NSSO. There have been some attempts to apply SAE techniques. Singh *et al.* (2005) used NSS data for application of Spatio-Temporal Models in Small Area Estimation. Sastry (2003) explored the feasibility of using NSS Household Consumer Expenditure Survey Data for estimation of district poverty estimates. The study was, however, confined to examining the distribution of relative standard errors (RSE) of direct estimates for Monthly Per Capita Expenditure (MPCE) and those of the sample sizes at district level as obtained from 55th round of NSS data. This was not an application of any SAE technique, but it was an attempt to obtain the district level estimates, following the usual approach of estimating domain parameters. It was observed that in rural areas, 451 out of 490 districts (92%) are having RSEs less than 5% only. It was also observed that only 2% districts had RSEs of 10% or more. Although this study shows a promise for estimating average MPCE at district level from the sample data, it has little bearing on estimation of poverty indicators. Most of the poverty indicators depend on the estimates of number of persons below poverty line, for which RSEs do not necessarily behave similar to those of estimated MPCEs.

Here, we are trying to illustrate an application of Area Level model based Small Area Estimation approach for estimating some of the poverty indicators at district level for Uttar Pradesh using 61st round of NSSO data (2004-05).

6.1 Some Features of the Data Used

As mentioned earlier, data from 61st round of the NSSO survey (2004-05) for Consumption Expenditure Survey has been used for estimation of district level poverty. Uttar Pradesh is one of the most important States in the country, with population at approximately 1.66 million (2001 Census) and population density as 690 per sq. km. It is also one of the poorest states with poverty ratio at 32.8, whereas national level is 27.5 (2004-05). A review of the nature and evolution of poverty in Uttar Pradesh (Kozel and Parker 2005) makes an interesting study. The state has experienced quite a bit of reorganization of districts in the recent past. Between 1991 and 2001 sixteen new districts have been carved out. A glimpse of reorganized districts is given in Table 3.

Table 3. Reorganization of districts between 1991 and 2001

Name of new district(s), 2001	Districts as in 1991 from which, new districts carved out
Jyotiba Phule Nagar	Moradabad
Baghpat	Meerut
Gautam Buddha Nagar	Ghaziabad, Bulandshahr
Hatharas	Mathura, Aligarh
Kannauj	Farrukhabad
Auraiya	Etawah
Mahoba	Hamirpur
Chitrakoot	Banda
Kaushambi	Allahabad
Ambedkar Nagar	Faizabad, Azamgarh
Shravasti	Bahraich
Balrampur	Gonda
Sant Kabir Nagar	Basti, Siddharthnagar
Kushinagar	Deoria
Chandauli	Varanasi
Sant Ravidas Nagar (Bhadohi)	Varanasi

At present, there are 70 districts in the State which are organized in four zones according to NSSO classification. The regions are as follows.

Table 4. Zone-wise distribution of districts in UP

Zones	Names of districts
Western	Saharanpur, Muzaffarnagar, Bijnor, Moradabad, Rampur, J Phule Nagar, Meerut, Baghpat, Ghaziabad, G. Buddha Nagar, Bulandshahr, Aligarh, Hathras, Mathura, Agra, Firozabad, Etah, Mainpuri, Budaun, Bareilly, Pilibhit, Shahjahanpur, Farrukhabad, Kannauj, Etawah, Auraiya
Central	Kheri, Sitapur, Hardoi, Unnao, Lucknow, Rae Bareli, Kanpur Dehat, Kanpur Nagar, Fatehpur, Barabanki
Eastern	Pratapgarh, Kaushambi, Allahabad, Faizabad, Ambedkar Nagar, Sultanpur, Bahraich, Shrawasti, Balrampur, Gonda, Siddharthnagar, Basti, S. Kabir Nagar, Maharajganj, Gorakhpur, Kushinagar, Deoria, Azamgarh, Mau, Ballia, Jaunpur, Ghazipur, Chandauli, Varanasi, S.R. Nagar (Bhadohi), Mirzapur, Sonbhadra
Southern	Jalaun, Jhansi, Lalitpur, Hamirpur, Mahoba, Banda, Chitrakoot

Sampling design: The sampling design of 61st round was broadly similar to the standard sampling designs used in NSSO. It was a stratified multi-stage design with first stage units (fsu) as the census villages in rural sector and Urban Frame Survey (UFS) blocks in the urban sector. The ultimate stage units, in both sectors, were households. Within each district, two basic strata were formed consisting of rural and urban sectors. However, in the urban sectors, larger cities with population of 10 lakhs or more were considered as separate basic strata. Further, sub-stratification was done in both rural and urban sectors. After determining the overall sample size, further downward allocation was done in proportion to population sizes. Selection of fsu's in rural areas was done by probability proportional to size with replacement (PPSWR) while in urban areas it was done with simple random sampling without replacement (SRSWOR). At the second stage further stratification was done with respect to affluence related criteria.

With the availability of unit level data of NSSO surveys along with the unit weights, further analysis at disaggregated levels has become quite convenient. It is simple to obtain direct estimates not only for districts but also for further disaggregated levels like different groups of the population. Although, sample sizes for these groups become smaller and smaller and estimates so obtained lack adequate precision levels.

Sample size: The sample sizes allocated were as follows:

Table 5. Sample sizes

Sample sizes	Uttar Pradesh		All India	
	Rural	Urban	Rural	Urban
No. of villages/ UFS blocks surveyed	792	336	7999	4602
No. of sample households	7868	3345	79298	45346
No. of sample persons	47067	18387	403207	206529

Source: Level and Pattern of Consumer Expenditure, 2004-05, NSSO 61st round, Report No. 508.

6.2 Predictor Variables Used in the Models

For different poverty related indicators and corresponding variables district level models were fitted.

A number of district-level variables were attempted but we present only those, which were ultimately chosen for the model on the basis of maximum R^2 value.

1) Total number of persons

In this case, for rural as well as urban sectors, as expected, the best predictor variable was the number of persons in the district as per 2001 Population Census with R^2 value as 0.955 and 0.934 in rural and urban sectors respectively.

2) Number of persons below poverty line

Rural: The variables were number of persons corresponding to female literacy, SC/ST population, persons having no specified assets, marginal and small landholding, households living in dilapidated houses and number of agricultural labour accounting for $R^2 = 0.649$.

Urban: Six predictor variables from census 2001 were taken as female literacy, SC/ST population, no assets, household size greater than equal to 5 and dwelling rooms less than equal to one, dilapidated houses and number of industrial labour. Corresponding R^2 was 0.671.

3) Poverty ratio

Rural: Initially seven predictor variables from Population Census 2001 were considered as proportion of female literacy, SC/ST population, no assets, marginal and small landholding, dilapidated houses, houses with no latrine and agricultural labour. Backward regression resulted in the improved set of variables as SC/ST population, no latrine, and agricultural labour as regressors with $R^2 = 0.414$. This model was further improved by including two more variables, female workers and infant mortality rate. Also, outliers were detected and removed and backward regression was applied to form the final model. It comprised of SC/ST population, no latrine, small & marginal landholding and agricultural labour as regressors with $R^2 = 0.573$.

Urban: Final set of variables comprised proportion of SC/ST population, dilapidated houses, infant mortality ratio and no specified assets with $R^2 = 0.357$.

4) Poverty gap ratio

Rural: The model consisted of proportion of SC/ST population, households with no latrine, small & marginal landholding, female literacy and agricultural labour as regressors with $R^2 = 0.487$.

Urban: The model finally consisted of proportion of SC/ST population, dilapidated houses, household size greater than equal to 5 and dwelling rooms less than equal to one and no assets as regressors with $R^2 = 0.286$.

6.3 Some Results on Different Poverty Indicators

Results on different poverty indicators were obtained based on direct estimators as well as model based Small Area Estimators. District wise results for Direct and Small Area Estimate (both rural and urban) along with the percent CVs are presented in Appendix-I. Also, Small Area Estimates for different poverty indicators such as poverty ratio, poverty density, poverty gap ratio, squared poverty gap ratio and Gini coefficient are given in Appendix-II.

A relative distribution of districts according to per cent CV (RSEs) is presented in Table 6. It may be seen that number of persons is being estimated quite precisely even with direct estimates. This number is being estimated with less than 10 per cent CV in nearly 75 per cent districts in rural areas. This is not the case with poverty related indicators. Direct estimates do not provide good estimates for number of persons below poverty line as well as for poverty ratio and poverty gap ratio. It is also seen that SAE estimates show considerable gains over direct estimates.

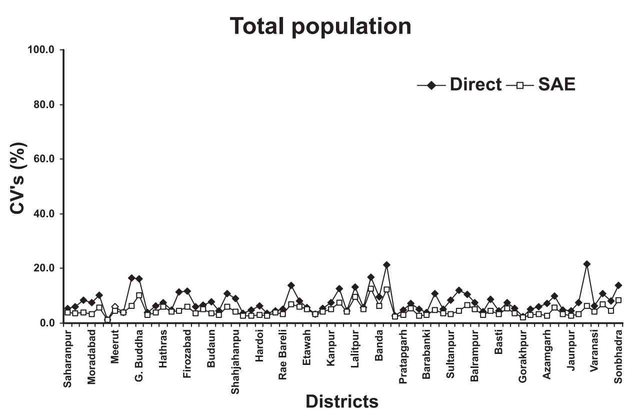
Table 6. Relative distribution of districts according to CV classes for different poverty related characteristics - Rural

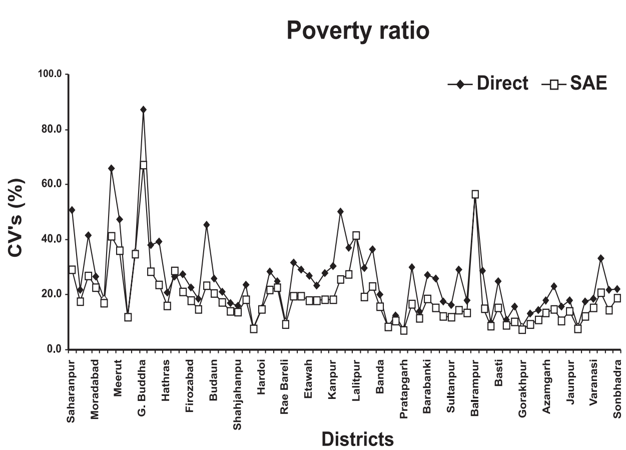
CV classes (%)	Number of persons		Number of persons below poverty line		Poverty ratio		Poverty gap ratio	
	Direct	SAE	Direct	SAE	Direct	SAE	Direct	SAE
0-5	31.4	68.6			8.6	12.9	2.9	2.9
5-10	44.3	27.1	4.3	4.3	31.4	57.1	18.6	37.1
10-20	21.4	4.3	27.1	45.7	35.7	21.4	37.1	42.9
20-30	2.9		35.7	31.4	11.4	2.9	20.0	11.4
30-40			11.4	14.3	5.7	2.9	12.9	1.4
40-50			12.9		7.1	2.9	8.6	4.3
>=50			8.6	4.3				
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

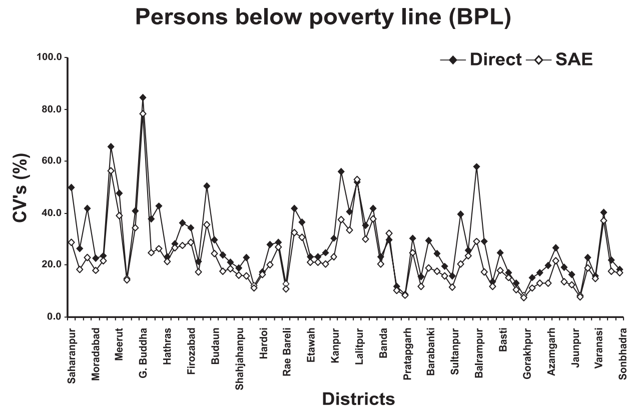
Table 7. Relative distribution of districts according to CV classes for different poverty related characteristics – Urban

CV classes (%)	Number of persons		Number of persons below poverty line		Poverty ratio		Poverty gap ratio	
	Direct	SAE	Direct	SAE	Direct	SAE	Direct	SAE
0-5	2.9	4.3	1.4	2.9	8.6	7.1	1.4	1.4
5-10	15.7	34.3	2.9	2.9	17.1	18.6	15.7	17.1
10-20	25.7	32.9	12.9	30.0	44.3	47.1	42.9	47.1
20-30	51.4	28.6	50.0	57.1	22.9	21.4	24.3	30.0
30-40	4.3		27.1	7.1	5.7	1.4	12.9	2.9
40-50			5.7		1.4	4.3	2.9	1.4
>=50								
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In the following figures the CVs for Direct Estimates and SAEs for total population, persons below poverty line, poverty ratio and poverty gap ratio are presented for rural areas (Fig.1) and urban areas (Fig. 2). Gains due to application of SAE technique are clearly evident.







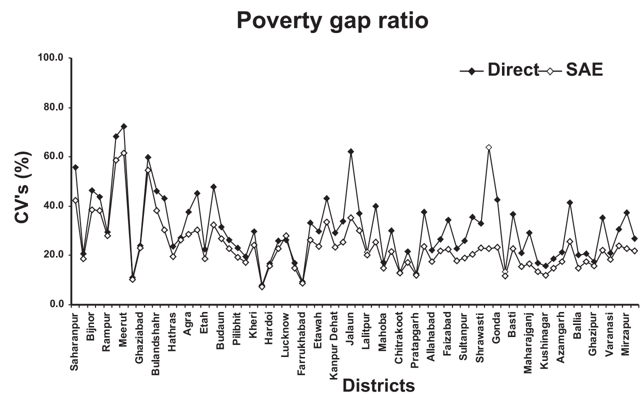
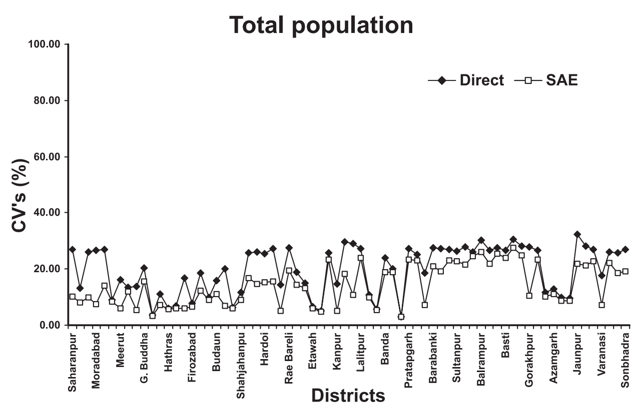
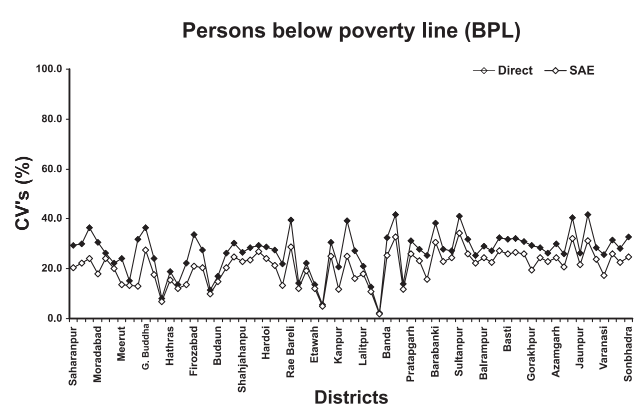


Fig. 1. CV's for Direct and SAE estimates - Rural





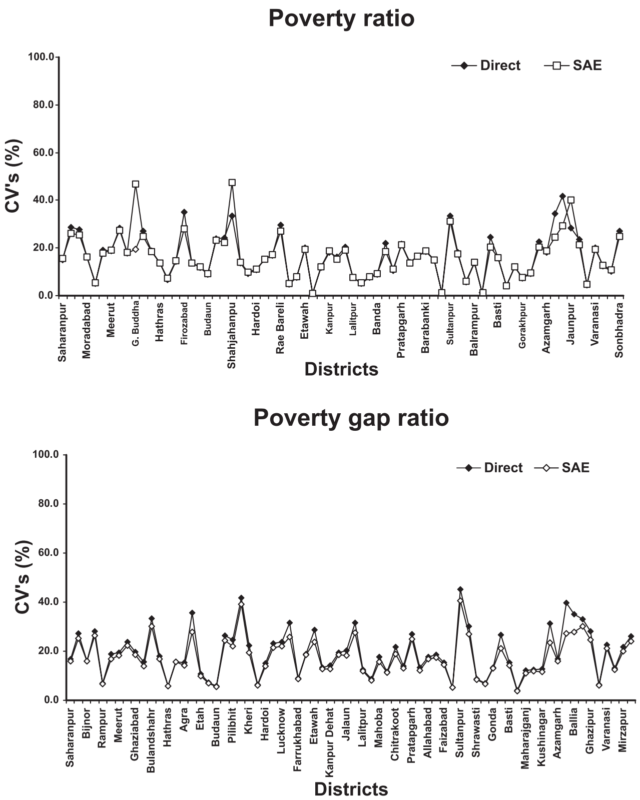


Fig. 2. CV's for Direct and SAE estimates - Urban

Following maps indicate the spatial distribution of poverty ratio, poverty density, poverty gap ratio, squared poverty gap ratio and Gini coefficients over the districts in UP. The map is, however, based on districts as existed in 1991 population census. Heavy concentration of high and medium range of poverty indicators in eastern districts is on expected lines. Also, inequalities as

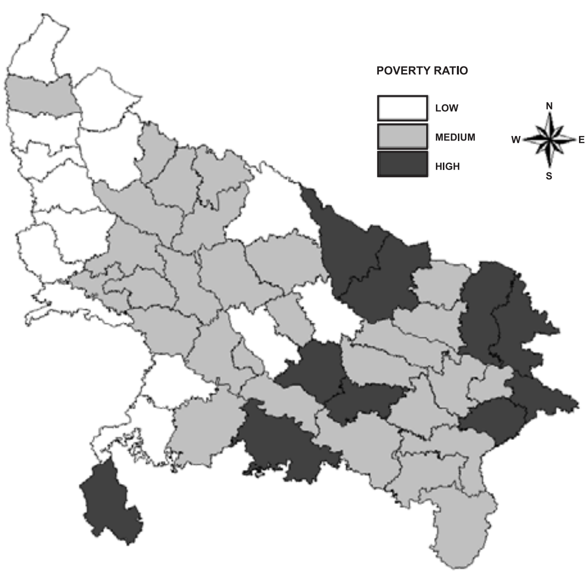


Fig. Spatial distribution of poverty ratio in UP

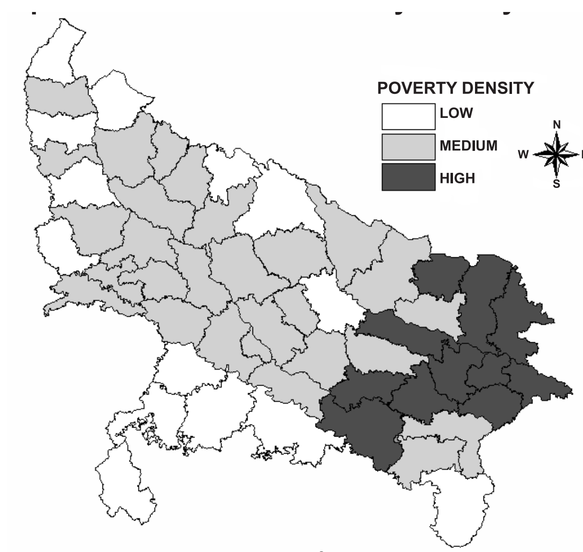


Fig. Spatial distribution of poverty density in UP

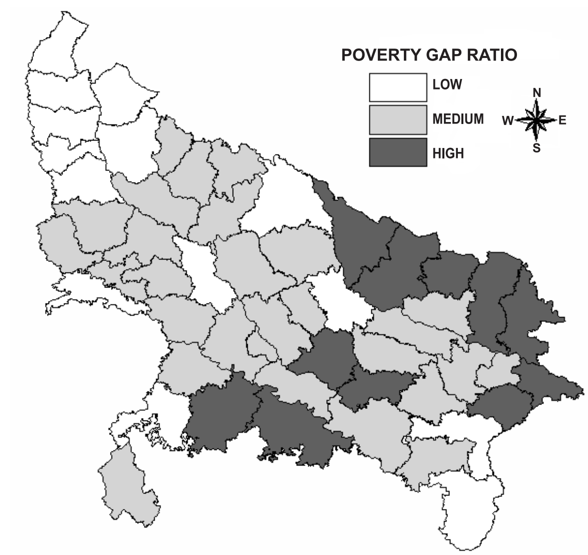


Fig. Spatial distribution of poverty gap ratio in UP

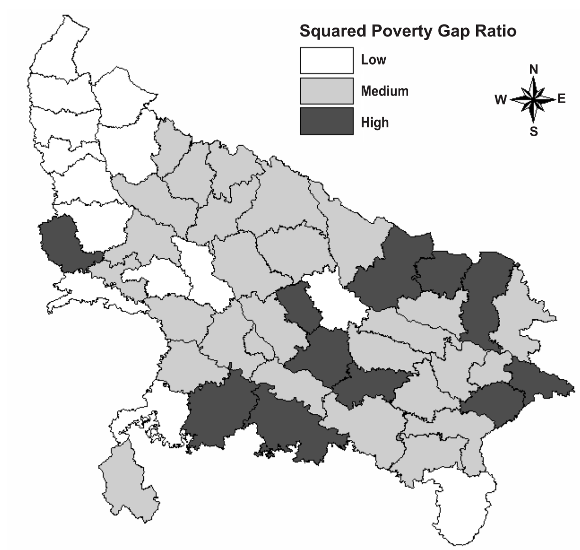


Fig. Spatial distribution of squared poverty gap ratio in UP

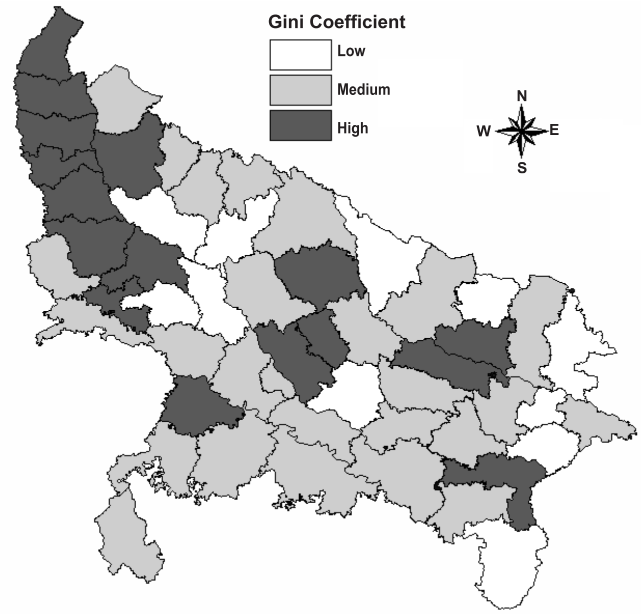


Fig. Spatial distribution of Gini eoefficient in UP

measured by Gini coefficients are more prominent areas having lesser levels of poverty.

As mentioned earlier, poverty ratio measures the incidence of poverty, poverty gap measures the depth of poverty and squared poverty gap provides an idea about severity of poverty. Poverty gap ratios are presented in the previous tables and graphs. As mentioned in Section 3.5, squired poverty gap ratio provides a measure for contribution to poverty (CTP). In the present illustration, share of poor (SP) and CTP has been calculated for each district. Wherever CTP is higher than SP, it indicates that those districts are under severe poverty conditions. Table 8 provides a list of districts with CTP more than SP.

7. CONCLUDING REMARKS

The analysis carried out here indicates that it is feasible to estimate poverty indicators at district level by scaling down the State level poverty estimates utilizing small area estimation techniques. The choice of SAE model and corresponding variables is crucial for successful application of the SAE method. In the process of application of SAE method, it was realized that still there is enough scope for the choice of variables. Efforts for improving the estimates and to apply it for other States, is in process. If unit level data from census may be available, then other methods for poverty mapping may also be attempted.

Table 8. Districts with CTP greater than SP

Districts	Rural	Urban
Bulandshahr		✓
Mathura	✓	✓
Agra		✓
Firozabad		✓
Etah	✓	
Mainpuri		✓
Kheri		✓
Sitapur		✓
Hardoi		✓
Unnao	✓	✓
Lucknow	✓	
Rae Bareli	✓	✓
Kannauj		✓
Etawah	✓	✓
Auraiya	✓	✓
Kanpur Dehat		✓
Jalaun	✓	✓
Lalitpur		✓
Hamirpur	✓	✓
Mahoba	✓	
Banda	✓	✓
Fatehpur		✓
Pratapgarh	✓	✓
Kaushambi	✓	
Faizabad	✓	
Ambedkar Nagar	✓	✓
Bahraich		✓
Shrawasti	✓	
Balrampur	✓	✓
Gonda	✓	
Siddharthnagar	✓	✓
Basti	✓	
S. Kabir Nagar	✓	
Maharajganj	✓	✓
Gorakhpur		
Kushinagar	✓	✓
Deoria		✓
Jaunpur		
Ghazipur	✓	✓

Estimates for poverty indicators are based on consumption expenditure survey data. It may be worthwhile to examine the poverty estimates based on income data, if reliable information on income may be obtained from household surveys. The distributions of expenditure and income are likely to differ and the differences should depend on the income expenditure levels of households. The socio-economic and spatial factors may also contribute towards the variability in the income expenditure patterns. One of the sources for household level income data is the surveys conducted by NCAER. SAE methods have got an important role to play in disaggregated estimates at small area levels.

Estimation of trends and changes are important in poverty studies. Comparability of results sometimes poses serious problems. One of the consumption expenditure surveys (55^{th} round) of NSSO is an example, in which an attempt was made to try different reference periods for different items. The idea was to take care of recall lapse and improve the quality of data, but there are problems in comparability of results with other rounds.

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APPENDIX I

District wise estimates of poverty ratio - Rural

S. No.	Districts	Number of households selected	Direct estimates		SAE estimates	
			Estimate (%)	C.V. (%)	Estimate (%)	C.V. (%)
1	Saharanpur	120	14.6	50.6	18.6	29.1
2	Muzaffarnagar	160	30.6	21.7	28.9	17.7
3	Bijnor	150	17.8	41.5	20.6	26.8
4	Moradabad	160	17.1	26.7	17.7	22.8
5	Rampur	80	31.7	18.5	28.8	17.0
6	J Phule Nagar	80	4.7	65.7	7.0	41.1
7	Meerut	80	6.5	47.1	7.9	36.2
8	Baghpat	80	28.2	12.5	27.6	11.7
9	Ghaziabad	70	14.9	35.3	12.8	34.9
10	G. Buddha Nagar	40	2.6	87.2	3.2	66.9
11	Bulandshahr	119	14.9	37.9	16.0	28.5
12	Aligarh	118	19.8	39.4	23.0	23.7
13	Hathras	79	31.5	20.8	30.9	16.0
14	Mathura	80	41.0	26.6	23.8	28.9
15	Agra	120	22.1	27.6	23.0	21.1
16	Firozabad	79	26.5	22.7	27.0	17.8
17	Etah	159	30.8	18.5	31.2	14.7
18	Mainpuri	80	22.9	45.5	26.5	23.4
19	Budaun	160	28.8	25.7	25.9	20.6
20	Bareilly	160	30.2	20.9	29.0	17.1
21	Pilibhit	80	27.3	17.0	28.6	14.0
22	Shahjahanpur	120	37.4	15.9	34.0	13.8
23	Kheri	160	21.5	23.6	23.1	18.3
24	Sitapur	199	27.6	8.1	27.5	7.8
25	Hardoi	160	34.2	15.1	29.4	14.8
26	Unnao	160	24.1	28.4	23.9	21.7
27	Lucknow	80	35.6	25.0	27.0	22.7
28	Rae Bareli	160	54.4	10.4	48.8	9.4
29	Farrukhabad	80	28.5	31.6	29.6	19.6
30	Kannauj	80	25.4	29.1	27.6	19.6
31	Etawah	79	32.3	26.8	31.3	18.0
32	Auraiya	80	28.8	23.4	28.0	18.0
33	Kanpur Dehat	80	35.6	27.7	32.6	18.2
34	Kanpur Nagar	80	28.6	30.3	30.9	18.3
35	Jalaun	80	15.3	50.1	22.0	25.5
36	Jhansi	80	19.8	37.2	19.8	27.6

APPENDIX I (Contd..)

District wise estimates of poverty ratio - Rural

S. No.	Districts	Number of households selected	Direct estimates		SAE estimates	
			Estimate (%)	C.V. (%)	Estimate (%)	C.V. (%)
37	Lalitpur	40	42.7	41.4	42.7	-
38	Hamirpur	40	44.1	29.6	36.9	19.3
39	Mahoba	40	23.2	36.4	26.1	23.2
40	Banda	79	52.8	20.0	41.0	15.8
41	Chitrakoot	40	81.5	8.2	81.5	-
42	Fatehpur	120	31.1	12.4	33.1	10.4
43	Pratapgarh	158	65.2	7.4	58.4	7.0
44	Kaushambi	80	45.5	30.0	42.2	16.5
45	Allahabad	200	34.5	13.9	35.8	11.4
46	Barabanki	160	14.2	27.2	18.6	18.5
47	Faizabad	80	25.0	25.9	32.1	15.3
48	Ambedkar Nagar	120	50.4	17.5	47.4	12.2
49	Sultanpur	160	28.5	16.3	33.7	11.8
50	Bahraich	120	43.7	29.2	45.2	14.5
51	Shrawasti	80	56.1	18.0	45.6	13.3
52	Balrampur	80	18.6	56.5	18.6	-
53	Gonda	160	39.0	28.7	41.0	15.6
54	Siddharthnagar	120	66.3	10.0	60.3	8.5
55	Basti	120	23.2	24.8	30.1	15.3
56	S. Kabir Nagar	80	58.0	10.8	55.1	8.8
57	Maharajganj	120	53.4	15.5	56.5	10.2
58	Gorakhpur	160	56.5	8.3	55.2	7.3
59	Kushinagar	160	54.8	13.2	58.6	9.3
60	Deoria	160	41.9	14.3	44.2	10.7
61	Azamgarh	190	29.5	17.7	32.3	13.4
62	Mau	80	39.5	22.9	39.3	14.7
63	Ballia	160	51.5	15.5	53.4	10.6
64	Jaunpur	200	27.9	17.8	29.9	14.1
65	Ghazipur	159	53.7	8.4	49.9	7.8
66	Chandauli	70	36.0	17.6	40.2	12.2
67	Varanasi	120	33.0	18.7	31.8	15.4
68	S.R. Nagar (Bhadohi)	80	30.6	33.3	30.1	20.8
69	Mirzapur	120	28.6	21.8	34.0	14.2
70	Sonbhadra	80	24.8	22.1	25.7	18.8
	Total rural	7868	33.3	2.6	33.3	0.0

APPENDIX I (Contd....)

District wise estimates of poverty ratio - Urban

S. No.	Districts	Number of households selected	Direct estimates		SAE estimates	
			Estimate (%)	C.V. (%)	Estimate (%)	C.V. (%)
1	Saharanpur	40	29.0	15.0	27.1	15.5
2	Muzaffarnagar	40	21.8	28.8	22.3	26.0
3	Bijnor	40	12.7	27.6	13.5	25.3
4	Moradabad	40	25.9	16.3	24.9	16.3
5	Rampur	40	42.2	5.2	38.8	5.6
6	J Phule Nagar	40	39.8	19.1	38.1	18.0
7	Meerut	119	16.0	18.9	15.6	19.1
8	Baghpat	40	13.2	28.5	13.4	27.3
9	Ghaziabad	40	33.9	17.9	31.3	18.0
10	G. Buddha Nagar	40	4.5	19.3	31.4	46.8
11	Bulandshahr	39	24.7	27.1	24.8	24.7
12	Aligarh	39	28.4	18.6	27.0	18.6
13	Hathras	39	28.0	13.7	27.1	13.8
14	Mathura	39	60.9	6.8	55.1	7.3
15	Agra	120	29.6	14.3	28.3	14.5
16	Firozabad	38	34.1	35.2	33.8	27.9
17	Etah	40	41.9	13.7	38.9	13.8
18	Mainpuri	40	28.7	11.9	27.5	12.1
19	Budaun	40	45.8	9.0	42.6	9.4
20	Bareilly	80	24.2	23.9	23.3	23.2
21	Pilibhit	40	46.8	24.2	40.6	22.4
22	Shahjahanpur	40	3.3	33.5	31.0	47.6
23	Kheri	39	34.0	13.8	31.8	14.1
24	Sitapur	38	53.4	9.2	47.5	9.8
25	Hardoi	40	42.1	10.9	38.8	11.3
26	Unnao	40	50.3	15.2	44.4	15.4
27	Lucknow	160	14.7	17.0	14.2	17.3
28	Rae Bareli	39	40.5	29.7	34.7	27.2
29	Farrukhabad	40	43.7	4.9	40.9	5.2
30	Kannauj	40	73.3	7.5	64.6	8.0
31	Etawah	40	17.7	20.2	18.0	19.3
32	Auraiya	40	62.8	0.8	58.6	0.9
33	Kanpur Dehat	40	61.5	11.8	53.9	12.2
34	Kanpur Nagar	160	15.0	18.2	14.3	18.8
35	Jalaun	40	68.1	16.2	59.1	15.3
36	Jhansi	40	24.1	20.3	24.6	19.0

APPENDIX I (Contd....)

District wise estimates of poverty ratio - Urban

S. No.	Districts	Number of households selected	Direct estimates		SAE estimates	
			Estimate (%)	C.V. (%)	Estimate (%)	C.V. (%)
37	Lalitpur	40	34.9	7.5	33.0	7.8
38	Hamirpur	40	54.5	5.2	50.7	5.5
39	Mahoba	40	49.1	7.5	46.2	7.8
40	Banda	40	71.6	9.1	64.3	9.3
41	Chitrakoot	40	54.0	21.9	50.9	18.5
42	Fatehpur	39	49.2	10.7	44.4	11.2
43	Pratapgarh	40	23.3	21.6	22.5	21.3
44	Kaushambi	40	53.2	14.0	49.0	13.8
45	Allahabad	79	35.6	16.5	33.0	16.7
46	Barabanki	40	30.3	18.4	28.1	18.7
47	Faizabad	40	37.9	14.8	35.0	15.1
48	Ambedkar Nagar	40	70.6	1.3	66.0	1.4
49	Sultanpur	40	13.2	33.5	13.5	31.4
50	Bahraich	40	36.8	18.2	35.5	17.4
51	Shrawasti	40	48.7	5.7	45.5	6.1
52	Balrampur	40	28.1	13.8	27.0	14.0
53	Gonda	40	43.8	1.2	41.0	1.3
54	Siddharthnagar	40	36.7	24.4	37.9	20.5
55	Basti	40	36.3	15.8	33.7	16.0
56	S. Kabir Nagar	40	69.3	4.0	63.6	4.3
57	Maharajganj	40	67.5	12.0	58.5	12.2
58	Gorakhpur	40	54.8	7.3	49.9	7.8
59	Kushinagar	40	57.1	9.3	51.9	9.7
60	Deoria	40	59.7	22.6	49.2	20.4
61	Azamgarh	40	12.3	18.2	11.8	18.8
62	Mau	40	36.2	34.4	39.6	24.5
63	Ballia	40	19.6	41.6	24.6	29.2
64	Jaunpur	40	7.7	28.3	36.8	40.2
65	Ghazipur	40	46.5	23.7	42.0	21.2
66	Chandauli	40	74.4	4.6	67.5	4.9
67	Varanasi	119	23.6	20.0	23.2	19.5
68	S.R.Nagar (Bhadohi)	39	45.5	12.6	41.6	12.9
69	Mirzapur	40	53.0	10.2	47.8	10.7
70	Sonbhadra	40	33.3	27.1	31.5	24.8
	Total urban	3345	30.1	2.7	30.1	

APPENDIX II

District wise poverty indicators - Rural

S.No.	Districts	Poverty ratio	Poverty density	Poverty gap ratio	Squared poverty gap ratio	Gini coefficient
1	Saharanpur	18.6	117.6	2.9	0.6	0.30
2	Muzaffarnagar	28.9	207.4	3.9	0.7	0.30
3	Bijnor	20.6	100.6	3.2	0.7	0.25
4	Moradabad	17.7	132.3	2.4	0.5	0.34
5	Rampur	28.8	217.3	5.3	1.4	0.28
6	J Phule Nagar	7.0	36.4	0.4	0.0	0.24
7	Meerut	7.9	50.9	1.1	0.3	0.31
8	Baghpat	27.6	216.0	3.9	0.7	0.29
9	Ghaziabad	12.8	207.6	1.5	0.2	0.30
10	G. Buddha Nagar	3.2	20.9	0.3	0.0	0.23
11	Bulandshahr	16.0	87.7	2.3	0.4	0.36
12	Aligarh	23.0	154.0	3.9	0.7	0.34
13	Hathras	30.9	177.5	3.5	0.5	0.25
14	Mathura	23.8	110.7	6.7	2.7	0.28
15	Agra	23.0	118.8	3.2	0.5	0.25
16	Firozabad	27.0	157.7	5.0	1.2	0.30
17	Etah	31.2	166.5	7.1	2.1	0.30
18	Mainpuri	26.5	160.4	4.2	0.7	0.18
19	Budaun	25.9	149.3	5.1	1.5	0.20
20	Bareilly	29.0	186.6	5.6	1.5	0.26
21	Pilibhit	28.6	101.5	4.5	0.8	0.25
22	Shahjahanpur	34.0	154.9	6.8	1.6	0.19
23	Kheri	23.1	85.7	3.8	0.8	0.24
24	Sitapur	27.5	174.6	5.2	1.1	0.36
25	Hardoi	29.4	166.6	6.0	1.5	0.25
26	Unnao	23.9	129.8	4.9	1.6	0.30
27	Lucknow	27.0	184.6	6.4	3.5	0.38
28	Rae Bareli	48.8	258.8	10.0	3.2	0.19
29	Farrukhabad	29.6	199.9	3.8	0.7	0.19
30	Kannauj	27.6	178.7	3.4	0.8	0.15
31	Etawah	31.3	152.4	5.9	1.8	0.27
32	Auraiya	28.0	140.8	5.5	2.1	0.29
33	Kanpur Dehat	32.6	170.5	6.2	1.8	0.24
34	Kanpur Nagar	30.9	160.2	5.2	1.0	0.28
35	Jalaun	22.0	53.7	5.0	1.6	0.44
36	Jhansi	19.8	46.3	2.4	0.3	0.28
37	Lalitpur	42.7	81.1	6.1	1.5	0.24
38	Hamirpur	36.9	73.3	8.6	3.5	0.27

APPENDIX II (Contd....)

District wise poverty indicators - Rural

S.No.	Districts	Poverty ratio	Poverty density	Poverty gap ratio	Squared poverty gap ratio	Gini coefficient
39	Mahoba	26.1	59.4	6.5	2.1	0.23
40	Banda	41.0	100.6	9.3	3.2	0.24
41	Chitrakoot	81.5	206.1	10.7	2.5	0.13
42	Fatehpur	33.1	159.4	6.5	1.6	0.25
43	Pratapgarh	58.4	363.2	13.1	5.6	0.24
44	Kaushambi	42.2	263.4	9.1	3.7	0.37
45	Allahabad	35.8	262.1	6.9	1.7	0.27
46	Barabanki	18.6	107.8	2.7	0.5	0.26
47	Faizabad	32.1	300.9	6.4	1.6	0.50
48	Ambedkar Nagar	47.4	411.9	10.0	3.7	0.26
49	Sultanpur	33.7	203.1	4.8	0.8	0.23
50	Bahraich	45.2	206.1	9.0	1.9	0.22
51	Shrawasti	45.6	192.8	10.1	7.3	0.26
52	Balrampur	18.6	68.2	8.5	1.5	0.19
53	Gonda	41.0	257.1	9.2	5.0	0.26
54	Siddharthnagar	60.3	390.8	14.3	5.3	0.22
55	Basti	30.1	219.9	6.4	1.5	0.36
56	S. Kabir Nagar	55.1	462.7	11.4	4.0	0.18
57	Maharajganj	56.5	380.6	12.1	3.7	0.21
58	Gorakhpur	55.2	514.2	10.6	2.7	0.23
59	Kushinagar	58.6	597.1	12.2	3.0	0.24
60	Deoria	44.2	491.1	8.6	2.0	0.22
61	Azamgarh	32.3	284.1	5.9	1.4	0.25
62	Mau	39.3	326.8	6.7	1.4	0.22
63	Ballia	53.4	409.7	10.2	2.3	0.24
64	Jaunpur	29.9	271.9	5.0	1.1	0.26
65	Ghazipur	49.9	409.8	10.5	4.9	0.21
66	Chandauli	40.2	234.4	5.5	0.8	0.24
67	Varanasi	31.8	424.7	5.8	1.4	0.23
68	S.R. Nagar (Bhadohi)	30.1	328.3	5.2	1.0	0.19
69	Mirzapur	34.0	143.4	6.2	1.2	0.21
70	Sonbhadra	25.7	32.3	3.7	0.7	0.14
	Total rural	33.3	188.4	6.3	1.8	0.29

Appendix II (Contd...)

District wise poverty indicators - Urban

S.No.	Districts	Poverty ratio	Poverty density	Poverty gap ratio	Squared poverty gap ratio	Gini coefficient
1	Saharanpur	27.1	2019.9	5.9	1.4	0.29
2	Muzaffarnagar	22.3	1639.7	5.1	1.5	0.24
3	Bijnor	13.5	793.9	1.1	0.1	0.23
4	Moradabad	24.9	1360.7	4.0	0.9	0.31
5	Rampur	38.8	2123.7	7.3	1.7	0.21
6	J Phule Nagar	38.1	3010.2	8.2	1.9	0.23
7	Meerut	15.6	1011.2	2.9	0.8	0.28
8	Baghpat	13.4	522.0	2.8	0.5	0.22
9	Ghaziabad	31.3	1864.4	6.2	1.1	0.23
10	G. Buddha Nagar	31.4	350.7	1.0	0.2	0.24
11	Bulandshahr	24.8	1460.9	7.5	3.0	0.37
12	Aligarh	27.0	1367.1	6.5	2.2	0.28
13	Hathras	27.1	2153.6	4.9	1.1	0.22
14	Mathura	55.1	3180.3	16.2	6.8	0.30
15	Agra	28.3	2614.0	8.5	2.8	0.51
16	Firozabad	33.8	2537.7	9.8	3.5	0.36
17	Etah	38.9	2496.0	9.2	2.6	0.36
18	Mainpuri	27.5	635.9	7.3	2.3	0.22
19	Budaun	42.6	822.6	9.4	2.2	0.29
20	Bareilly	23.3	922.8	4.6	1.3	0.39
21	Pilibhit	40.6	2637.0	10.6	3.2	0.21
22	Shahjahanpur	31.0	208.0	0.8	0.2	0.14
23	Kheri	31.8	1529.6	9.1	3.2	0.28
24	Sitapur	47.5	1649.8	17.1	6.6	0.31
25	Hardoi	38.8	1674.1	10.6	3.4	0.24
26	Unnao	44.4	1987.3	14.8	8.2	0.35
27	Lucknow	14.2	1126.7	3.0	0.9	0.44
28	Rae Bareli	34.7	1645.3	10.5	4.0	0.31
29	Farrukhabad	40.9	2865.8	10.1	3.0	0.26
30	Kannauj	64.6	1430.4	18.4	10.9	0.36
31	Etawah	18.0	490.3	6.0	1.8	0.32
32	Auraiya	58.6	3379.2	18.5	8.0	0.31
33	Kanpur Dehat	53.9	1351.1	16.9	6.1	0.34
34	Kanpur Nagar	14.3	1537.0	3.4	0.9	0.40
35	Jalaun	59.1	1125.4	19.2	10.5	0.31
36	Jhansi	24.6	1406.8	5.8	1.8	0.25

Appendix II (Contd...)

District wise poverty indicators - Urban

S.No.	Districts	Poverty ratio	Poverty density	Poverty gap ratio	Squared poverty gap ratio	Gini coefficient
37	Lalitpur	33.0	2878.7	9.6	3.3	0.31
38	Hamirpur	50.7	2328.7	15.5	4.8	0.29
39	Mahoba	46.2	728.0	10.4	2.6	0.27
40	Banda	64.3	2574.7	21.9	12.2	0.29
41	Chitrakoot	50.9	5380.6	7.6	1.6	0.33
42	Fatehpur	44.4	1198.0	13.5	5.6	0.32
43	Pratapgarh	22.5	790.4	8.1	3.5	0.36
44	Kaushambi	49.0	1483.3	11.0	2.5	0.19
45	Allahabad	33.0	2313.5	6.7	1.9	0.32
46	Barabanki	28.1	861.5	5.1	0.8	0.32
47	Faizabad	35.0	1098.0	9.2	2.4	0.42
48	Ambedkar Nagar	66.0	4823.5	21.8	7.7	0.24
49	Sultanpur	13.5	397.6	2.2	0.4	0.22
50	Bahraich	35.5	1462.4	9.5	3.6	0.28
51	Shrawasti	45.5	1560.5	10.6	2.8	0.25
52	Balrampur	27.0	723.7	8.4	3.7	0.35
53	Gonda	41.0	1882.5	8.8	2.9	0.28
54	Siddharthnagar	37.9	1199.9	15.0	7.0	0.33
55	Basti	33.7	1066.3	4.8	0.7	0.38
56	S. Kabir Nagar	63.6	3513.2	17.0	4.6	0.26
57	Maharajganj	58.5	1485.0	18.1	5.3	0.27
58	Gorakhpur	49.9	1118.2	10.0	2.4	0.27
59	Kushinagar	51.9	1287.2	14.9	4.7	0.29
60	Deoria	49.2	1431.2	16.1	7.5	0.28
61	Azamgarh	11.8	633.5	3.3	0.9	0.26
62	Mau	39.6	1508.1	9.7	1.9	0.19
63	Ballia	24.6	747.7	4.1	0.8	0.23
64	Jaunpur	36.8	975.9	1.8	0.4	0.25
65	Ghazipur	42.0	2016.1	14.4	8.6	0.35
66	Chandauli	67.5	3234.4	17.3	5.3	0.28
67	Varanasi	23.2	1997.1	5.1	1.6	0.32
68	S.R.Nagar (Bhadohi)	41.6	1127.0	8.0	1.8	0.29
69	Mirzapur	47.8	2347.1	11.0	3.0	0.21
70	Sonbhadra	31.5	1154.7	4.5	0.8	0.21
	Total urban	30.1	1489.4	7.1	2.3	0.37