Sample Design and Estimation Procedure

1. **Geographical coverage:** The survey covered all urban areas of the Indian Union.

2. **Period of survey and work programme:** The period of survey was of one year duration starting on 1st July 2008 and ending on 30th June 2009. The survey period of this round was divided into four sub-rounds of three months' duration each as follows:

sub-round 1 : July - September 2008
sub-round 2 : October - December 2008
sub-round 3 : January - March 2009
sub-round 4 : April - June 2009

2.1 In each of these four sub-rounds equal numbers of sample villages/ blocks (FSUs) were allotted for survey with a view to ensuring uniform spread of sample FSUs over the entire survey period. Attempts were made to survey each of the FSUs during the sub-round to which it was allotted. Because of the arduous field conditions, this restriction is not strictly enforced in Andaman and Nicobar Islands, Lakshadweep, participated and rural areas of Arunachal Pradesh and Nagaland.

3. **Schedules of enquiry:** During this round, the following schedules of enquiry were canvassed:

Schedule 0.0 : list of households
Schedule 21.1 : domestic tourism
Schedule 1.2 : housing condition
Schedule 0.21 : particulars of slum

4. **Participation of States:** All the States and Union Territories of India, except for Andaman & Nicobar Islands, Chandigarh, Dadra & Nagar Haveli and Lakshadweep, participated in the survey by surveying an independently drawn sample of urban blocks (and villages for the surveys of housing condition and domestic tourism). This report is based on the Central sample, that is, the blocks surveyed by NSSO officials, in all States and UTs except Leh and Kargil districts of Jammu & Kashmir, where no Central sample was surveyed and the State sample

data were used in preparing the State and all-India estimates for the report. The ratio of the State/UT sample size (number of FSUs planned to be surveyed by State survey officials) to the size of the Central sample (number of FSUs allotted for survey by NSSO officials) for the participating State/UTs was as follows:

Nagaland (U)	: triple
J & K , Manipur & Delhi	: double
Maharashtra (U)	: one and half
Gujarat	: less than equal
Remaining States/ UTs	: equal

5. **Sample Design**

5.1 **Outline of sample design:** A stratified multi-stage design was adopted for the 65th round survey. The first stage units (FSUs) in the urban sector were Urban Frame Survey (UFS) blocks. For towns with no UFS frame available (applicable to Leh and Kargil towns of J&K), each town was treated as an FSU. For the survey of slums, there was, unlike the other surveys of the 65th round, no second stage of sampling involving selection of households. Nevertheless, the paragraphs that follow will refer to the sampling units for the slum survey (towns in case of of Leh and Kargil, and UFS blocks elsewhere) as FSUs.

5.2 **Sampling Frame for First Stage Units:** *For the urban sector*, the list of latest available Urban Frame Survey (UFS) blocks was considered as the sampling frame. However, for Leh and Kargil towns of J&K, UFS frame was not available. Accordingly, Census 2001 served as the frame for these two towns (referred henceforth to as non-UFS towns).

5.3 **Stratification in Urban sector:** In the urban sector, strata were formed within each NSS region on the basis of size class of towns as per Census 2001 town population. The stratum numbers and their composition (within each NSS region) are given below.

Stratum	Composition (within NSS region)
1	All towns with population < 50,000
2	All towns with population 50,000 – 99,999
3	All towns with population 1,00,000 – 4,99,999
4	All towns with population 5,00,000 – 9,99,999
5, 6, ….	Each million-plus city

The non-UFS towns of Leh and Kargil of J & K within the NSS region (region number '014') were grouped together to form a separate urban stratum.

5.4 **Sub-stratification**: There was no sub-stratification in the stratum consisting of non-UFS towns. However, to net an adequate number of slums, each of the other strata were divided into 2 sub-strata as follows:

sub-stratum 1: all UFS blocks having area type 'slum area'
sub-stratum 2: remaining UFS blocks

5.5 **Total sample size (FSUs):** A total number of 4738 UFS blocks formed the Central sample.

5.6 **Allocation of total sample to States and UTs:** The total number of sample FSUs was allocated to the States and UTs in proportion to population as per Census 2001 subject to a minimum sample allocation to each State / UT. While making this allocation, the resource availability in terms of number of field investigators was also taken into consideration.

5.7 **Allocation of State/ UT level sample to rural and urban sectors:** The State / UT level sample was allocated between rural and urban sectors in proportion to population as per *Census 2001* with 1.5 weightage to urban sector, subject to the restriction that the urban sample size for bigger states like Maharashtra, Tamil Nadu, etc. should not exceed the rural sample size. At least 4 FSUs were allocated to each state / UT separately for rural and urban areas. Further, the State level allocations- both rural and urban- were adjusted marginally in a few cases to ensure that each stratum got a minimum allocation of 4 FSUs.

5.8 **Allocation to strata/ sub-strata:** Within each sector of a State / UT, the sample size was allocated to the different strata in proportion to the stratum populations as per Census 2001. Allocations at stratum level were adjusted to multiples of 4 with a minimum sample size of 4. Stratum-level sample size in the urban sector for strata belonging to UFS towns was further allocated to the 2 sub-strata in proportion to the number of UFS blocks in them with double weightage to sub-stratum 1, subject to a minimum allocation of 4 to each of the two sub-strata.

5.9 **Selection of FSUs:** Within each urban sub-stratum (formed from UFS towns), the UFS blocks were arranged in ascending order of population of the towns to which they belonged, and sample FSUs selected by circular systematic sampling with equal probability. Within each sub-stratum, the number of sample FSUs was a multiple of 4. Sample FSUs were selected in the form of two independent sub-samples and an equal number of sample FSUs was allocated to the four sub- rounds.

5.9.1 Since UFS frames were not available for Leh and Kargil towns of Jammu and Kashmir, each of these two towns was treated as an FSU. Both these towns were selected and repeated in each of the sub-rounds 1 to 4 of the sample list.

5.10 **Survey on urban slums:** Information on each slum, notified or non-notified, found in the entire selected FSU was collected through Schedule 0.21. In case the slum was spread over more than one FSU, only the part within the selected FSU was surveyed (provided it had at least 20 households) and considered as 'one slum'.

6. **Estimation Procedure**

6.1 **Notations**

s = subscript for stratum
t = subscript for sub-stratum (only for UFS towns)
m = subscript for sub-sample (m =1, 2)
i = subscript for FSU (block / non-UFS town)
N = total number of FSUs in any urban sub-stratum
n = number of sample FSUs surveyed including zero cases but excluding casualty for a particular sub-sample and stratum / sub-stratum.

x, y = observed value of characteristics *x*, *y* under estimation

$\hat{X}$, $\hat{Y}$ = estimate of population total X, Y for the characteristics *x*, *y*

In terms of the above symbols,

y_{stmi} = observed value of the characteristic y of the ith FSU belonging to the mth sub-sample for the tth sub-stratum of the sth stratum.

However, for ease of understanding, a few symbols have been suppressed in following paragraphs where they are obvious.

6.2 **Formulae for estimation of aggregates for a particular sub-sample and stratum (non-UFS towns of urban i.e. Leh and Kargil)/ sub-stratum (for UFS towns):**

(i) For estimating the aggregate value of a characteristic (no. of slums with a given feature) for the tth sub-strata of the sth stratum on the basis of the mth sub-sample:

$$\hat{Y}_{sm} = \sum_{t=1}^{2} \hat{Y}_{stm}$$

where $\hat{Y}_{stm} = \frac{N_{st}}{n_{stm}} \sum_{i=1}^{n} Y_{stmi}$ and Y_{stmi} is the total of observed values for the characteristic *y* for the i-th FSU.

Note: There are only two FSUs (Leh and Kargil towns) in NSS region '014' of J & K. Both of these have been selected and repeated in each of the sub-rounds and they belong to sub-stratum 2. In this case, N = 2 in the above formula and n is the number of FSUs actually surveyed including repetitions (n = 8 for the whole round and n = 4 for a sub-sample of the whole round assuming no casualty).

6.3 **Overall estimate for aggregates**:

Overall estimate for aggregates for a stratum ($\hat{Y}_s$) based on two sub-samples is obtained as:

$$\hat{Y}_s = \frac{1}{2} \sum_{m=1}^{2} \hat{Y}_{sm}$$

6.4 **Overall estimate of aggregates at State/UT/all-India level**:

The overall estimate $\hat{Y}$ at the State/ UT/ all-India level is obtained by summing the stratum estimates $\hat{Y}_s$ over all strata belonging to the State/ UT/ all-India.

6.5 **Estimates of Ratios**:

Let $\hat{Y}$ and $\hat{X}$ be the overall estimates of the aggregates Y and X for two characteristics *y* and *x* respectively at the State/ UT/ all-India level.

Then the combined ratio estimate $(\hat{R})$ of the ratio $(R = \frac{Y}{X})$ is obtained as $\hat{R} = \frac{\hat{Y}}{\hat{X}}$.

6.7 **Estimates of Error**: The estimated variances of the above estimates are as follows:

6.7.1 **For aggregate** $\hat{Y}$:

$$\hat{Var}(\hat{Y}) = \sum_s \hat{Var}(\hat{Y}_s) \qquad \text{where } \hat{Var}(\hat{Y}_s) \text{ is given by}$$

$$\hat{Var}\left(\hat{Y}_s\right) = \sum_t \frac{1}{4}\left(\hat{Y}_{st1} - \hat{Y}_{st2}\right)^2$$, where $\hat{Y}_{st1}$ and $\hat{Y}_{st2}$ are the estimates for sub-sample 1 and sub-sample 2 respectively for stratum '*s*' and sub-stratum '*t*'.

6.7.2 **For ratio** $\hat{R}$:

$$\hat{MSE}(\hat{R}) = \frac{1}{4\hat{X}^2}\sum_s\sum_t\left[\left(\hat{Y}_{st1} - \hat{Y}_{st2}\right)^2 + \hat{R}^2\left(\hat{X}_{st1} - \hat{X}_{st2}\right)^2 - 2\hat{R}\left(\hat{Y}_{st1} - \hat{Y}_{st2}\right)\left(\hat{X}_{st1} - \hat{X}_{st2}\right)\right]$$

where $\hat{Y}_{s1}$, $\hat{Y}_{st1}$ and $\hat{Y}_{s2}$, $\hat{Y}_{st2}$ are the estimates for sub-sample 1 and sub-sample 2 respectively for stratum 's' and sub-stratum 't'.

6.7.3 **Estimates of RSE**:

$$\hat{RSE}\left(\hat{Y}\right) = \frac{\sqrt{\hat{Var}\left(\hat{Y}\right)}}{\hat{Y}} \times 100$$

$$\hat{RSE}\left(\hat{R}\right) = \frac{\sqrt{\hat{MSE}\left(\hat{R}\right)}}{\hat{R}} \times 100$$

7. **Multipliers**:

The formula for multipliers at stratum / sub-stratum level for a sub-sample is given below:

$$M(s,t,m) = \frac{N_{st}}{n_{stm}}$$

Note: (i) For estimating any characteristic for any domain not specifically considered in sample design, indicator variable may be used.

(ii) Multipliers have to be computed on the basis of information available in the listing schedule irrespective of any misclassification observed between the listing schedule and detailed enquiry schedule.

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