1. Estimation Procedure

1.1.Notations:

s	subscript for s^{th} stratum
t	subscript for t^{th} sub-stratum
i	subscript for i^{th} FSU [SU/ Village / panchayat ward/ UFS block]
k	subscript for k^{th} sample household within an FSU
D_1	total number of sub-divisions formed in the sample FSU. D_1=1, if no Sub-division is formed in the SU)
N	total number of FSUs in any rural/urban sub-stratum
n	number of sample FSUs surveyed including 'uninhabited' and 'zero cases' but excluding casualty for a particular sub-stratum
H	total number of households listed in an FSU
h	number of households surveyed in an FSU
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

Let y_{stik} be the observed value of the characteristic y for the k-th household of the i-th FSU for the t-th sub-stratum of s-th stratum.

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

1.2. Formulae for Estimation of Aggregates for a stratum × sub-stratum:

1.2.1. Schedule 0.0 (Rural/Urban):

For estimating the number of households in a stratum × sub-stratum possessing a characteristic:

$$\hat{Y} = \frac{N}{n} \sum_{i=1}^{n} D_1 \times y_i$$

where, y_i is the total number of households possessing the characteristic y in i-th FSU.

1.2.2. Schedule NHTS 25: National Household Travel Survey:

For t-th sub-stratum of s-th stratum:

$$\hat{Y}_{st} = \frac{N_{st}}{n_{st}} \sum_{i=1}^{n_{st}} \left[D_{1sti} \times \frac{H_{sti}}{h_{sti}} \times \sum_{k=1}^{h_{sti}} y_{stik} \right]$$

where n_{st} is the number of sample FSUs surveyed including zero cases and uninhabited in t-th sub-stratum of s-th stratum.

1.3. Overall Estimate of Aggregates for a stratum:

Overall estimate for s-th stratum ($\hat{Y}_s$) will be obtained as

$$\hat{Y}_s = \sum_t \hat{Y}_{st}$$

1.4. Overall Estimate of Aggregates at District/State/UT/all-India level:

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

1.5. 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 district / State / UT / all-India level.

Then, the combined ratio estimate $(\hat{R})$ of the ratio $\left(R = \frac{Y}{X}\right)$ will be obtained as $\hat{R} = \frac{\hat{Y}}{\hat{X}}$.

1.6. Estimation of Errors:

1.6.1. Formula for estimated Variance and Mean Square Error (for Rural / Urban):

Here, the required number of FSUs (which is the annual allocation within the given stratum × sub-stratum) will be selected by SRSWOR. Subsequently, USUs will be selected by SRSWOR within each of the selected FSUs. If the i^{th} FSU has been selected, h_i unit is selected from the i^{th} FSU by SRSWOR method.

(a) **Formula for aggregate $\hat{Y}$ (for Rural/Urban)**:

$\hat{Y}_i = H_i \times \bar{y}_i \times D_{1si}$ and $\overline{y_i} = \sum_1^{h_i} y_{ik} \Big/ h_i$

$$\hat{Var}(\hat{Y}) = \sum_S \hat{Var}(\hat{Y}_s) = \sum_s \sum_t \hat{Var}(\hat{Y}_{st})$$

$$\hat{Var}(\hat{Y}_{st}) = N_{st}^2 \left(\frac{1}{n_{st}} - \frac{1}{N_{st}}\right)\left(\frac{1}{n_{st}-1}\right)\sum_1^{n_{st}}(H_{sti} \times D_{1sti} \times \bar{y}_{sti} - \frac{1}{n_{st}} \sum_1^{n_{st}} H_{sti} \times D_{1sti} \times \bar{y}_{sti})^2 + \frac{N_{st}}{n_{st}} \sum_1^{n_{st}} H_{sti}^2 \times D_{1sti}^2 \times (\frac{1}{h_{sti}} - \frac{1}{H_{sti} \times D_{1si}}) \times s^2_{wi}$$

where ${s^2}_{wi} = \frac{1}{(h_{sti}-1)} \sum_{k=1}^{h_{sti}} (y_{stik} - \bar{y}_{sti})^2$

(b) **Formula for ratio $\hat{R}$ (for Rural/Urban)**:

Note that $X^2\ MSE\ (\hat{R})$ is unbiasedly estimated by $V(\hat{Y} - \ R\hat{X})$

$V(\hat{Y} - \ R\hat{X}) = v(\hat{u})$ where $u_{ik} = (y_{ik} - Rx_{ik})$,

$U_i = (Y_i - RX_i)$ and $U = (Y - RX) = 0$ at domain level (State/District).

$\hat{X}^2 M\hat{S}E(\hat{R}) = \hat{V}\ (\hat{U})$ at $R = \ \hat{R}$

$$\hat{Y}_{sti} = \frac{1}{N_{st}} \times \sum_{k} y_{stik} \times n_{st} \times \text{multiplier}$$

$$\hat{X}_{sti} = \frac{1}{N_{st}} \times \sum_{k} x_{stik} \times n_{st} \times \text{multiplier}$$

$M\hat{S}E(\hat{R}) = \frac{1}{\hat{X}^2} \sum_s \sum_t M\hat{S}E_{st}(\hat{R})$

$M\hat{S}E_{st}(\hat{R}) =$

$$N_{st}{}^2 \left(\frac{1}{n_{st}} - \frac{1}{N_{st}}\right) \frac{1}{(n_{st}-1)} \sum_{1}^{n_{st}} (H_{sti} \times D_{1sti} \times \bar{u}_i - \frac{1}{n_{st}} \sum_{1}^{n_{st}} H_{sti} \times D_{1sti} \times \bar{u}_i)^2$$

$$+ \frac{N_{st}}{n_{st}} \sum_{1}^{n_{st}} H^2{}_{sti} \times D_{1sti}{}^2 \left(\frac{1}{h_{sti}} - \frac{1}{H_{sti} \times D_{1sti}}\right) \times {s_{ui}}^2$$

where ${s_{ui}}^2 = \frac{1}{(h_i-1)} \sum_{k=1}^{h_i} (u_{ik} - \bar{u}_i)^2$, $\bar{u}_i = \bar{y}_i - \hat{R}\bar{x}_i$

The formulae for multipliers are as given in Section 2.

1.6.2. Estimates of Relative Standard Error (RSE):

$$R\hat{S}E\ (\hat{Y}) = \frac{\sqrt{V\hat{a}r\ (\hat{Y})}}{\hat{Y}} \times 100$$

$$R\hat{S}E\ (\hat{R}) = \frac{\sqrt{M\hat{S}E\ (\hat{R})}}{\hat{R}} \times 100$$

2. Multipliers:

2.1. The formulae for multipliers at stratum/sub-stratum level for different types of schedules are given below.

Schedule	Sector	Formula for multipliers
0.0	Rural / Urban	$\frac{N_{st}}{n_{st}}$
NHTS 25	Rural / Urban	$\frac{N_{st}}{n_{st}} \times D_{1sti} \times \frac{H_{sti}}{h_{sti}}$

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 0.0, irrespective of any misclassification observed between the listing Schedule and detailed enquiry Schedule of NHTS.

3. Treatment for zero cases, casualty cases etc.:

3.1. While counting the number of FSUs surveyed (n_{st}) in a stratum/sub-stratum, all the FSUs with survey codes 1 to 6 in Schedule: 0.0 will be considered. In addition, even if no household is available in the frame, that FSU will be treated as surveyed. However, if households for a particular type of schedule are available in the frame of the FSU but none of these could be surveyed then the FSU will be treated as casualty, and not as surveyed in respect of that Schedule.

3.2. *Casualty cases*: FSUs with survey code 7 as per Schedule: 0.0 are treated as casualties. In addition, an FSU, although surveyed, may have to be treated as casualty for a particular Schedule type in the following situation:

3.2.1. FSUs with survey codes 1 or 4 as per Schedule: 0.0 having number of households in the frame greater than 0 (i.e., H > 0) but number of households surveyed according to data file as nil (h = 0), will be considered as casualties for this particular FSU.

3.2.2. *All the FSUs with survey codes 1 to 6 as per questionnaire 0.0 minus the number of casualties as identified above will be considered as the number of surveyed FSUs (n_{st}) for that (stratum/sub-stratum).*

4. Treatment in cases of void sub-strata /strata at FSU or household level

4.1. A stratum/sub-stratum may be void because of the casualty of all the FSUs belonging to the stratum/sub-stratum.

4.2. When a stratum/sub-stratum is void, the following procedure is recommended:

Case(A): Stratum/Sub-stratum void at FSU levels (i.e. all FSUs having survey code 7):

(i) If a rural/urban sub-stratum is void, then it may be merged with the other sub-stratum of the same Group of the stratum. If for a particular group only one sub-stratum is there and only one FSU is allocated and that FSU becomes a casualty, then it will be merged with next sub-stratum group with proper size adjustment. Merged (in which void sub-stratum is merging) sub-stratum size may be calculated as:

*Merged stratum size + Merging stratum size * (per FSU size of merging sub-stratum/per FSU size of merged sub-stratum)*

Explanation of notation:

- ✓ Merging sub-stratum means void sub-stratum
- ✓ Merged sub-stratum means in which void sub-stratum is merging
- ✓ Per FSU size of a sub-stratum is the average number of households per sub-unit in urban area or average population per sub-unit in rural area.

Rule for sub-stratum in which the void sub-strata will merge –

Say, the per FSU size of t^{th} void sub-stratum within a particular stratum = X_t , whereas, the per FSU size of neighbouring non-void sub-stratums say, $(t-1)^{th}$ and $(t+1)^{th}$ are X_{t-1} and X_{t+1} respectively. Then void stratum will merge with $(t-1)^{th}$ sub-stratum if $| X_t - X_{t-1} | < | X_t - X_{t+1} |$; otherwise merge with $(t+1)^{th}$ sub-stratum.

If the first or last sub-stratum is void, it will merge with the next non-void sub-stratum within the same group / stratum.

(ii) If a rural/urban stratum (district) is void due to all FSUs being casualty, it may be excluded from the coverage of the survey. The state level estimates will be based on

the estimates of districts for which estimates are available and remarks to that effect may be added in appropriate places.