

### Technical details of sample design

#### I. SAMPLE DESIGN FOR THE MICS PUNJAB, 2011

The major features of the sample design are described in this appendix. The primary objective of the sample design for MICS Punjab, 2011 was to produce statistically reliable estimates of most indicators, at tehsil level, for urban and rural areas. Sample design features included target sample size, sample allocation, sampling frame and listing, choice of domains, sampling stages, stratification, and the calculation of sample weights.

#### Universe

The universe of this Survey consists of all urban and rural areas of Punjab defined as such by 1998 population census and changes made thereafter by the Provincial Governments. The military restricted areas and cantonment have been excluded from the scope of the survey.

#### Sampling Frame

##### A. Urban Areas

PBS has developed its own sampling frame through Quick Count Record Survey. This frame is an area frame wherein each city/town has been divided into a number of small compact areas called enumeration blocks (EBs).

Each EB consists of an average of 200-250 households, with well-defined boundaries in the prescribed forms and maps thereof with physical features. Each Enumeration block has been divided into low, middle and high-income group, keeping in view the majority of households located in the enumeration block belonging to a particular income class. Similarly each enumeration block has been classified as residential, commercial and industrial in accordance with the predominance of an activity therein. This sampling frame now comprises all urban areas of the Punjab except Military restricted areas. The frame is regularly up-dated after every 5 to 7 years due to rapid growth in cities/towns/urban areas. It was updated last in 1998 and there are 14683 enumeration blocks in all urban areas of Punjab.

##### B. Rural Areas

The sampling frame for rural domain consists of list of villages/mouzas/dehs prepared by Population Census. A village/mouza/deh is the smallest revenue estate identified by its name, had-bast number, cadastral map, name of Tehsil, District & Province in which it is located. The rural sampling frame comprising 25846 villages/Mouzas/Dehs has been used for drawing the sample for Multiple Indicator Cluster Survey.

### STRATIFICATION PLAN

#### A. Urban Domain

There are eight major cities in the Punjab province as shown below:-

<u>City</u>	<u>Approximate Population</u>
1. Lahore	5,000,000
2. Faisalabad	2,000,000
3. Rawalpindi	1,500,000
4. Gujranwala	1,210,000
5. Multan	1,180,000
6. Sargodha	455,000
7. Sialkot	417,000
8. Bahawalpur	404,000

All the major cities were further subdivided into towns except Sargodha, Sialkot and Bahawalpur. Each of these towns/tehsils constitutes a separate stratum. The smallest domain of estimation is tehsil/town.

## **B. Rural Domain**

In the rural domain, each administrative tehsil and some towns in big cities in Punjab Province constituted separate and an independent stratum. The sample selection has been undertaken separately within each rural part of corresponding tehsils/towns.

### **Sample size and its Allocation:**

Keeping in view of the variability for the characteristics for which estimates are to be prepared, requirements of provincial government in terms of logistic cost, population distribution and main objectives of the survey, a sample of 102048 households has been considered appropriate to provide reliable estimates of population parameters within acceptable reliability limits. This sample size is capable to yield estimates of literacy related variable at 95% of confidence level at 5% margin of error. Meanwhile, for other variables like child mortality, net primary school attendance, contraceptive prevalence and use of improved water and sanitation etc. Coefficient of variation (CV) will be expected about 8%. The entire sample of households, i.e., Secondary Sampling Units (SSUs) is drawn from 7249 Primary Sampling Units (PSUs) out of which 3488 are urban and 3761 are rural. The sample households have been allocated to 150 domains i.e., tehsils/towns in proportion to their population according to the 1998 population census with adjustment. The distribution of sample (PSUs & SSUs) in 150 tehsil/towns is given in the table below:

## NUMBER OF SAMPLE EBs AND VILLAGES FOR MICS PUNJAB, 2011

SR. NO.	DIVISION/ DISTRICT/ Tehsil	NO. OF SAMPLE AREAS (PSU)				NO. OF HOUSE HOLDS (SSU)			
		MAJOR CITY	URBAN	RURAL	TOTAL	MAJOR CITY	URBAN	RURAL	TOTAL
	<b>TOTAL</b>	<b>837</b>	<b>2651</b>	<b>3762</b>	<b>7250</b>	<b>10044</b>	<b>31812</b>	<b>60192</b>	<b>102048</b>
<b>1-Bahawalpur</b>		<b>24</b>	<b>323</b>	<b>442</b>	<b>789</b>	<b>288</b>	<b>3876</b>	<b>7072</b>	<b>11236</b>
D	<b>Bahawalnagar</b>	-	<b>98</b>	<b>117</b>	<b>215</b>	-	<b>1176</b>	<b>1872</b>	<b>3048</b>
1	Bahawalnagar	-	24	27	51	-	288	432	720
2	Haroonabad	-	18	20	38	-	216	320	536
3	Minchinabad	-	18	21	39	-	216	336	552
4	Chishtian	-	23	26	49	-	276	416	692
5	Fort Abbas	-	15	23	38	-	180	368	548
D	<b>Bahawalpur</b>	<b>24</b>	<b>101</b>	<b>168</b>	<b>293</b>	<b>288</b>	<b>1212</b>	<b>2688</b>	<b>4188</b>
6	Bahawalpur City	24	-	21	45	288	-	336	624
7	Bahawalpur Sadar	-	17	20	37	-	204	320	524
8	Hasil Pur	-	18	21	39	-	216	336	552
9	Khair Pur Tamewali	-	17	20	37	-	204	320	524
10	Yazman	-	19	53	72	-	228	848	1076
11	Ahmed Pue East	-	30	33	63	-	360	528	888
D	<b>Rahim Yar Khan</b>	-	<b>124</b>	<b>157</b>	<b>281</b>	-	<b>1488</b>	<b>2512</b>	<b>4000</b>
12	Rahim Yar Khan	-	37	39	76	-	444	624	1068
13	Khan Pur	-	32	34	66	-	384	544	928
14	Sadiqabad	-	35	38	73	-	420	608	1028
15	Liaqat Pur	-	20	46	66	-	240	736	976
<b>2-D.G Khan</b>		-	<b>248</b>	<b>368</b>	<b>616</b>	-	-	<b>5888</b>	<b>8864</b>
D	<b>D.G.Khan</b>	-	<b>54</b>	<b>72</b>	<b>126</b>	-	<b>648</b>	<b>1152</b>	<b>1800</b>
16	Dera Ghazi Khan	-	34	51	85	-	408	816	1224
17	Tounsa	-	20	21	41	-	240	336	576
D	<b>Layyah</b>	-	<b>44</b>	<b>94</b>	<b>138</b>	-	<b>528</b>	<b>1504</b>	<b>2032</b>
18	Layyah	-	26	32	58	-	312	512	824
19	Karore Lal Esan	-	18	27	45	-	216	432	648
20	Choubara	-	0	35	35	-	-	560	560
D	<b>Muzaffargarh</b>	-	<b>102</b>	<b>121</b>	<b>223</b>	-	<b>1224</b>	<b>1936</b>	<b>3160</b>
21	Muzaffargarh	-	36	40	76	-	432	640	1072
22	Kot Adu	-	30	35	65	-	360	560	920
23	Ali Pur	-	15	24	39	-	180	384	564
24	Jatoi	-	21	22	43	-	252	352	604
D	<b>Rajanpur</b>	-	<b>48</b>	<b>81</b>	<b>129</b>	-	<b>576</b>	<b>1296</b>	<b>1872</b>
25	Rajanpur	-	20	28	48	-	240	448	688
26	Jampur	-	23	27	50	-	276	432	708
27	Rojhan	-	5	26	31	-	60	416	476
<b>3-Faisalabad</b>		<b>145</b>	<b>317</b>	<b>470</b>	<b>932</b>	<b>1740</b>	<b>3804</b>	<b>7520</b>	<b>13064</b>
D	<b>Faisalabad</b>	<b>145</b>	<b>118</b>	<b>199</b>	<b>462</b>	<b>1740</b>	<b>1416</b>	<b>3184</b>	<b>6340</b>
28	Chak Jhumra Town	-	23	20	43	-	276	320	596
29	Jaranwala Town	-	39	35	74	-	468	560	1028

SR. NO	DIVISION/ DISTRICT/ Tehsil	NO. OF SAMPLE AREAS (PSU)				NO. OF HOUSE HOLDS (SSU)			
		MAJOR CITY	URBAN	RURAL	TOTAL	MAJOR CITY	URBAN	RURAL	TOTAL
	<b>TOTAL</b>	<b>837</b>	<b>2651</b>	<b>3762</b>	<b>7250</b>	<b>10044</b>	<b>31812</b>	<b>60192</b>	<b>102048</b>
30	Jinnah Town	34	-	18	52	408	-	288	696
31	Lyallpur Town	34	-	24	58	408	-	384	792
32	Madina Town	37	-	18	55	444	-	288	732
33	Iqbal Town	40	-	25	65	480	-	400	880
34	Sumundari Town	-	30	29	59	-	360	464	824
35	Tandlianwala Town	-	26	30	56	-	312	480	792
D	<b>Jhang</b>	-	<b>73</b>	<b>128</b>	<b>201</b>	-	<b>876</b>	<b>2048</b>	<b>2924</b>
36	Jhang	-	33	47	80	-	396	752	1148
37	18 Hazari	-	-	39	39	-	-	624	624
38	Ahmed Pur Sial	-	18	20	38	-	216	320	536
39	Shorekot	-	22	22	44	-	264	352	616
D	<b>Chinot</b>	-	<b>52</b>	<b>65</b>	<b>117</b>	-	<b>624</b>	<b>1040</b>	<b>1664</b>
40	Chinot	-	23	23	46	-	276	368	644
41	Bhawana	-	11	21	32	-	132	336	468
42	Lalian	-	18	21	39	-	216	336	552
D	<b>Toba Tek Singh</b>	-	<b>74</b>	<b>78</b>	<b>152</b>	-	<b>888</b>	<b>1248</b>	<b>2136</b>
43	Toba Tek Singh	-	26	28	54	-	312	448	760
44	Gojra	-	24	24	48	-	288	384	672
45	Kamalia	-	24	26	50	-	288	416	704
	<b>4-Gujranwala</b>	<b>104</b>	<b>432</b>	<b>613</b>	<b>1149</b>	<b>1248</b>	<b>5184</b>	<b>9808</b>	<b>16240</b>
D	<b>Gujranwala</b>	<b>71</b>	<b>108</b>	<b>166</b>	<b>345</b>	<b>852</b>	<b>1296</b>	<b>2656</b>	<b>4804</b>
46	Aroop Town	24	-	22	46	288	-	352	640
47	Kamoki Town	-	20	21	41	-	240	336	576
48	Khiali Shah Pur Town	27	-	25	52	324	-	400	724
49	Nandipur Town	20	-	20	40	240	-	320	560
50	Newshehra Virkan Town	-	20	23	43	-	240	368	608
51	Qila Dedar Singh Town	-	38	23	61	-	456	368	824
52	Wazirabad Town	-	30	32	62	-	360	512	872
D	<b>Gujrat</b>	-	<b>81</b>	<b>99</b>	<b>180</b>	-	<b>972</b>	<b>1584</b>	<b>2556</b>
53	Gujrat	-	34	42	76	-	408	672	1080
54	Kharian	-	30	37	67	-	360	592	952
55	Sarai Alamgir	-	17	20	37	-	204	320	524
D	<b>Hafizabad</b>	-	<b>44</b>	<b>46</b>	<b>90</b>	-	<b>528</b>	<b>736</b>	<b>1264</b>
56	Hafizabad	-	26	26	52	-	312	416	728
57	Pindi Bhattian	-	18	20	38	-	216	320	536
D	<b>Mandi Bahauddin</b>	-	<b>57</b>	<b>67</b>	<b>124</b>	-	<b>684</b>	<b>1072</b>	<b>1756</b>
58	Mandi Bahauddin	-	22	24	46	-	264	384	648
59	Phalia	-	19	22	41	-	228	352	580

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60	Malikwal	-	16	21	37	-	192	336	528
D	<b>Narowal</b>	-	<b>68</b>	<b>100</b>	<b>168</b>	-	<b>816</b>	<b>1600</b>	<b>2416</b>
61	Narowal	-	27	31	58	-	324	496	820
62	Zafarwal	-	14	21	35	-	168	336	504
63	Shakar Garh	-	27	48	75	-	324	768	1092
D	<b>Sialkot</b>	<b>33</b>	<b>74</b>	<b>135</b>	<b>242</b>	<b>396</b>	<b>888</b>	<b>2160</b>	<b>3444</b>
64	Sialkot	33	-	43	76	396	-	688	1084
65	Sambrial	-	17	21	38	-	204	336	540
66	Daska	-	31	31	62	-	372	496	868
67	Pasroor	-	26	40	66	-	312	640	952
	<b>Lahore</b>	<b>345</b>	<b>295</b>	<b>405</b>	<b>1045</b>	<b>4140</b>	<b>3540</b>	<b>6480</b>	<b>14160</b>
D	<b>Kasur</b>	-	<b>105</b>	<b>115</b>	<b>220</b>	-	<b>1260</b>	<b>1840</b>	<b>3100</b>
68	Kasur	-	36	36	72	-	432	576	1008
69	Kot Radha Kishan	-	17	21	38	-	204	336	540
70	Pattoki	-	27	30	57	-	324	480	804
71	Chunian	-	25	28	53	-	300	448	748
D	<b>Lahore</b>	<b>345</b>	-	<b>84</b>	<b>429</b>	<b>4140</b>	-	<b>1344</b>	<b>5484</b>
72	Aziz Bhatti Town	28	-	16	44	336	-	256	592
73	Data Gunj Buksh Town	44	-	-	44	528	-	-	528
74	Gulberg Town	36	-	-	36	432	-	-	432
75	Iqbal Town	38	-	22	60	456	-	352	808
76	Nishtar Town	34	-	26	60	408	-	416	824
77	Ravi Town	33	-	-	33	396	-	-	396
78	Samman Abad Town	35	-	-	35	420	-	-	420
79	Shalimar Town	39	-	-	39	468	-	-	468
80	Wagha Town	20	-	20	40	240	-	320	560
81	Cantonment	38	-	-	38	456	-	-	456
D	<b>Sheikhupura</b>	-	<b>109</b>	<b>114</b>	<b>223</b>	-	<b>1308</b>	<b>1824</b>	<b>3132</b>
82	Sheikhupura	-	33	31	64	-	396	496	892
83	Ferozwala	-	36	30	66	-	432	480	912
84	Muridke	-	19	32	51	-	228	512	740
85	Sharqpur Sharif	-	21	21	42	-	252	336	588
D	<b>Nankana Sahib</b>	-	<b>81</b>	<b>92</b>	<b>173</b>	-	<b>972</b>	<b>1472</b>	<b>2444</b>
86	Nankana Sahib	-	29	38	67	-	348	608	956
87	Safdarabad	-	16	18	34	-	192	288	480
88	Sangla Hill	-	18	17	35	-	216	272	488
89	Shahkot	-	18	19	37	-	216	304	520
	<b>Sahiwal</b>	-	-	<b>237</b>	<b>442</b>	-	-	<b>3792</b>	<b>6252</b>
D	<b>Okara</b>	-	<b>85</b>	<b>100</b>	<b>185</b>	-	<b>1020</b>	<b>1600</b>	<b>2620</b>
90	Okara	-	34	35	69	-	408	560	968
91	Depalpur	-	34	45	79	-	408	720	1128

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	<b>TOTAL</b>	<b>837</b>	<b>2651</b>	<b>3762</b>	<b>7250</b>	<b>10044</b>	<b>31812</b>	<b>60192</b>	<b>102048</b>
92	Renala Khurd	-	17	20	37	-	204	320	524
D	<b><u>Pakpattan</u></b>	-	<b>58</b>	<b>66</b>	<b>124</b>	-	<b>696</b>	<b>1056</b>	<b>1752</b>
93	Pakpattan	-	30	36	66	-	360	576	936
94	Arif Wala	-	28	30	58	-	336	480	816
D	<b><u>Sahiwal</u></b>	-	<b>62</b>	<b>71</b>	<b>133</b>	-	<b>744</b>	<b>1136</b>	<b>1880</b>
95	Sahiwal	-	33	37	70	-	396	592	988
96	Chichawatni	-	29	34	63	-	348	544	892
	<b><u>Multan</u></b>	<b>130</b>	<b>286</b>	<b>388</b>	<b>804</b>	<b>1560</b>	<b>3432</b>	<b>6208</b>	<b>11200</b>
D	<b><u>Khanewal</u></b>	-	<b>99</b>	<b>108</b>	<b>207</b>	-	<b>1188</b>	<b>1728</b>	<b>2916</b>
97	Khanewal	-	26	27	53	-	312	432	744
98	Mian Channu	-	28	31	59	-	336	496	832
99	Kabirwala	-	30	32	62	-	360	512	872
100	Jahanian	-	15	18	33	-	180	288	468
D	<b><u>Lodhran</u></b>	-	<b>59</b>	<b>64</b>	<b>123</b>	-	<b>708</b>	<b>1024</b>	<b>1732</b>
101	Lodhran	-	23	24	47	-	276	384	660
102	Dunya Pur	-	15	20	35	-	180	320	500
103	Karore Pacca	-	21	20	41	-	252	320	572
D	<b><u>Multan</u></b>	<b>130</b>	<b>42</b>	<b>121</b>	<b>293</b>	<b>1560</b>	<b>504</b>	<b>1936</b>	<b>4000</b>
104	Bosan Town	24	-	24	48	288	-	384	672
105	Mumtazabad Town	37	-	23	60	444	-	368	812
106	Shahrukan-E-Alam Town	36	-	18	54	432	-	288	720
107	Sher Shah Town	33	-	19	52	396	-	304	700
108	Shuja Abad Town	-	21	18	39	-	252	288	540
109	Jalalpur Pirwala Town	-	21	19	40	-	252	304	556
D	<b><u>Vehari</u></b>	-	<b>86</b>	<b>95</b>	<b>181</b>	-	<b>1032</b>	<b>1520</b>	<b>2552</b>
110	Vehari	-	28	30	58	-	336	480	816
111	Mailsi	-	28	35	63	-	336	560	896
112	Burewala	-	30	30	60	-	360	480	840
	<b><u>Rawalpindi</u></b>	<b>49</b>	<b>311</b>	<b>481</b>	<b>841</b>	<b>588</b>	<b>3732</b>	<b>7696</b>	<b>12016</b>
D	<b><u>Attock</u></b>	-	<b>107</b>	<b>99</b>	<b>206</b>	-	<b>1284</b>	<b>1584</b>	<b>2868</b>
113	Attock	-	18	16	34	-	216	256	472
114	Fateh Jang	-	20	20	40	-	240	320	560
115	Jand	-	15	17	32	-	180	272	452
116	Pindi Gheb	-	18	18	36	-	216	288	504
117	Hasalabdal	-	18	13	31	-	216	208	424
118	Hazro	-	18	15	33	-	216	240	456
D	<b><u>Chakwal</u></b>	-	<b>51</b>	<b>100</b>	<b>151</b>	-	<b>612</b>	<b>1600</b>	<b>2212</b>
119	Chakwal	-	22	30	52	-	264	480	744
120	Talang Gang	-	16	20	36	-	192	320	512
121	Chowa Saidan Shah	-	13	19	32	-	156	304	460

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122	Kallar Kahar	-	-	31	31	-	-	496	496
D	<b>Jhelum</b>	-	<b>62</b>	<b>91</b>	<b>153</b>	-	<b>744</b>	<b>1456</b>	<b>2200</b>
123	Jhelum	-	25	23	48	-	300	368	668
124	Pind Dadan Khan	-	14	22	36	-	168	352	520
125	Sohawa	-	9	24	33	-	108	384	492
126	Dina	-	14	22	36	-	168	352	520
D	<b>Rawalpindi</b>	<b>49</b>	<b>91</b>	<b>191</b>	<b>331</b>	<b>588</b>	<b>1092</b>	<b>3056</b>	<b>4736</b>
127	Gujar Khan Town	-	26	37	63	-	312	592	904
128	Khauta Town	-	17	19	36	-	204	304	508
129	Murree Town	-	15	17	32	-	180	272	452
130	Rawal Town	49	-	-	49	588	-	-	588
131	Potohar Town	-	-	34	34	-	-	544	544
132	Kotli Satain Town	-	-	33	33	-	-	528	528
133	Kallar Sayaddan Town	-	-	34	34	-	-	544	544
134	Taixla Town	-	33	17	50	-	396	272	668
	<b>Sargodha</b>	<b>40</b>	<b>234</b>	<b>358</b>	<b>632</b>	<b>480</b>	<b>2808</b>	<b>5728</b>	<b>9016</b>
D	<b>Bhakkar</b>	-	<b>55</b>	<b>91</b>	<b>146</b>	-	<b>660</b>	<b>1456</b>	<b>2116</b>
135	Bhakkar	-	18	27	45	-	216	432	648
136	Mankera	-	7	24	31	-	84	384	468
137	Kalurkot	-	15	20	35	-	180	320	500
138	Darya Khan	-	15	20	35	-	180	320	500
D	<b>Khushab</b>	-	<b>46</b>	<b>70</b>	<b>116</b>	-	<b>552</b>	<b>1120</b>	<b>1672</b>
139	Khushab	-	28	28	56	-	336	448	784
140	Noor Pur	-	9	21	30	-	108	336	444
141	Quaid Abad	-	9	21	30	-	108	336	444
D	<b>Mianwali</b>	-	<b>47</b>	<b>60</b>	<b>107</b>	-	<b>564</b>	<b>960</b>	<b>1524</b>
142	Mianwali	-	18	25	43	-	216	400	616
143	Essa Khel	-	14	17	31	-	168	272	440
144	Piplan	-	15	18	33	-	180	288	468
D	<b>Sargodha</b>	<b>40</b>	<b>86</b>	<b>137</b>	<b>263</b>	<b>480</b>	<b>1032</b>	<b>2192</b>	<b>3704</b>
145	Sargodha	40	0	34	74	480	-	544	1024
146	Silanwali	-	14	18	32	-	168	288	456
147	Bhalwal	-	25	26	51	-	300	416	716
148	Shahpur	-	15	18	33	-	180	288	468
149	Sahiwal	-	15	21	36	-	180	336	516
150	Kot Moman	-	17	20	37	-	204	320	524
	<b>Total</b>	<b>837</b>	<b>2651</b>	<b>3762</b>	<b>7250</b>	<b>10044</b>	<b>31812</b>	<b>60192</b>	<b>102048</b>

### Sample Design

A two-stage stratified sample design has been adopted for this survey.

## Selection of Primary Sampling Units

Enumeration blocks demarcated as part of urban sampling frame in urban domain, mouzas/dehs/villages whose lists were prepared by Population Census Organization at the time of 1998 Population Census have been taken as PSUs. Sample PSUs from each stratum/sub-stratum have been selected with probability proportionate to size. The numbers of households and population have been considered as measure of size pertaining to urban and rural domain respectively.

## Selection of Secondary Sampling Units

Based on actual listing undertaking in respect of each sample PSU by the Field Staff 16 and 12 households have been selected from rural and urban sample areas respectively adopting systematic sampling technique with a random start. Households have been considered as secondary sampling units for urban while population has been taken as measure of size in respect to rural areas.

## Procedure to Select Housing Units

Whatever the distribution of sample Enumeration Blocks (EBs) in the different substrata might be, the selection of Housing Units (HUs) (or dwelling units, as were defined above), will follow the same procedure in all substrata.

If the sample will be spread during a one-year period, each week, the sampler will have at his/ her disposal the Listing Form (obtained after the listing operation) pertaining to the corresponding updated sample EBs for the corresponding period. A fixed number of valid HUs (12 in the urban area, 16 in the rural area) will be selected systematically and with equal probability from the Listing Form

In general, it is good practice to select reserve units in case there are no responses or refusals to keep the actual sample size. However, in Pakistan, the response rate is very high (almost 99% in the MICS Punjab, 2007-08) and therefore, it will not be necessary to select reserve units.

Within each sample EB  $i$  of socioeconomic substratum  $h$ , we must identify and number the valid HUs, that is, the HUs that are occupied by one household on a permanent basis. They must have a correlative number between 1 and  $M'hi$ , the total number of valid HUs in the EB  $i$  and socioeconomic substratum  $h$ , after having listed the EB. The value  $M'hi$  will then be inserted in a spreadsheet from where a systematic sample of 12 units (16 in the urban area) will be selected.

The  $j$ -th HU to be selected within the EB  $i$  of socioeconomic substratum  $h$  is obtained during the following expression:

$$[Ahi + (j-1) * lhi] + 1$$

for  $j = 1, \dots, mhi$

omitting the decimals in the results, without rounding (truncation process).where,

$lhi = M'hi / mhi =$  sampling interval within the  $i$ -th EB and socioeconomic stratum  $h$ .

$M'hi =$  number of valid HUs in the  $i$ -th EB of socioeconomic stratum  $h$ .

$Mhi = m =$  fixed number of HUs to be selected within the  $i$ -th EB and socioeconomic stratum  $h$ .

$Ahi =$  a random number between 0 and  $lhi$ , including 0 but excluding  $lhi$



Note: when we omit the decimals, we must include 0 and exclude  $l_{hi}$  in order to preserve the probabilities of selection uniform.

## II ESTIMATION PROCEDURE ADOPTED FOR MICS PUNJAB, 2011

### Probabilities of Selection and Sampling Weights

In order to expand the data from the MICS Punjab, 2011 to the provincial or domain levels (tehsils), it is necessary to apply a weight (expansion factor) to the data from each survey questionnaire. The basic weight for a sample household would be equal to the inverse of the its probability of selection. Since the Ebs will be selected independently with probability proportional to size (PPS) within each domain of estimation, the probability of selection of an EB is given by:

$$P_{hi} = n_h \frac{M_{hi}}{M_h} = n_h \frac{M_{hi}}{\sum_{i=1}^h M_{hi}}$$

Where,

- $n_h$  = number of sample EBs selected in the  $h$ -th first-level stratum
- $M_{hi}$  = measure of size (total number of households from the census mapwork) for the  $i$ -th sample EB in the  $h$ -th first-level stratum
- $M_h$  = cumulated measure of size (total number of households from the census mapping work) for the  $h$ -th first-level stratum
- $N_h$  = Total number of EBs in first-level stratum  $h$

The basic weight for a sample household is equal to the inverse of its probability of selection and is given by:

$$W_{hi} = \frac{M_h}{n_h \times M_{hi}} = \frac{\sum_{i=1}^{N_h} M_{hi}}{n_h \times M_{hi}}$$

where:

- $W_{hi}$  = basic expansion factor for all households in the  $i$ -th sample EB in the  $h$ -th first-level stratum or domain of estimation.

Note that a separate weight would have to be calculated for each sample EB. An EXCEL spreadsheet can be developed for maintaining the sampling information for each sample EB and for calculating the weights.

This basic weight should be adjusted for non-interviews due to refusals, temporary absence (not-at-home), etc. This weight adjustment can be carried out as follows:

$$W'_{hi} = W_{hi} \times \frac{M'_{hi}}{M^n_{hi}}$$

where:

- $W'_{hi}$  = adjusted weight for households in the  $i$ -th sample EB in the  $h$ -th stratum
- $M'_{hi}$  = number of valid households enumerated in the  $i$ -th sample EB in the  $h$ -th stratum (excluding abandoned or vacant housing units)

$M_{hi}^n$  = number of households with completed interviews in the  $i$ -th sample EB in the  $h$ -th stratum.

## (i): ESTIMATION FORMULAE FOR TOTALS AND THEIR VARIANCES

### NOTATIONS

$N_h$ : Total number of PSUs in the  $h^{\text{th}}$  stratum of a province.

$n_h$ : Total number of sample PSUs in the  $h^{\text{th}}$  stratum of a province.

$M_{hi}$ : Total number of SSUs in the  $i$ th sample PSU of  $h^{\text{th}}$  stratum of a province.

$m_{hi}$ : Number of sample SSUs in the  $i$ th sample PSU of  $h^{\text{th}}$  stratum of a province.

$P_{hi}$ : Assigned probability of selection of  $i$ th PSU of the  $h^{\text{th}}$  stratum of a province.

$y_{hij}$ : Value of any characteristic  $y$  of  $j$ th SSU within  $i$ th PSU of  $h^{\text{th}}$  stratum of a province.

$x_{hij}$ : Value of any characteristic  $x$  of  $j$ th SSU within  $i$ th PSU of  $h^{\text{th}}$  stratum of a province with whose respect proportion is required.

$$N = \sum_{h=1}^L N_h$$

$$n = \sum_{h=1}^L n_h$$

$$\hat{Y}_h = \frac{1}{n_h} \sum_{i=1}^{n_h} \frac{\hat{Y}_{hi}}{p_{hi}}$$

$$\hat{Y}_h = \frac{1}{n_h} \sum_{i=1}^{n_h} \frac{1}{p_{hi}} \frac{M_{hi}}{m_{hi}} \sum_{j=1}^{m_{hi}} y_{hij}$$

$$\hat{Y} = \sum_{h=1}^L \hat{Y}_h = \sum_{h=1}^L \frac{1}{n_h} \sum_{i=1}^{n_h} \frac{\hat{Y}_{hi}}{p_{hi}}$$

$$\hat{X}_h = \frac{1}{n_h} \sum_{i=1}^{n_h} \frac{\hat{X}_{hi}}{P_{hi}} = \frac{1}{n_h} \sum_{i=1}^{n_h} \frac{1}{P_{hi}} \frac{M_{hi}}{m_{hi}} \sum_{j=1}^{m_{hi}} x_{hij}$$

$$\hat{X} = \sum_{h=1}^L \hat{X}_h = \sum_{h=1}^L \frac{1}{n_h} \sum_{i=1}^{n_h} \frac{\hat{X}_{hi}}{P_{hi}}$$

$$\hat{R} = \frac{\hat{Y}}{\hat{X}}$$

OR

$$v(\hat{Y}_h) = \frac{1}{n_h} s^2_{ht} = \frac{1}{n_h(n_h - 1)} \left( \sum_{i=1}^{n_h} \frac{\hat{Y}_{hi}^2}{P_{hi}^2} - \frac{(\sum_{i=1}^{n_h} \frac{\hat{Y}_{hi}}{P_{hi}})^2}{n_h} \right)$$

For X, another variable of interest, we have

$$v(\hat{Y}) = \sum_{h=1}^L \frac{1}{n_h} s^2_{ht} = \sum_{h=1}^L \frac{1}{n_h(n_h - 1)} \left( \sum_{i=1}^{n_h} \frac{\hat{Y}_{hi}^2}{P_{hi}^2} - \frac{(\sum_{i=1}^{n_h} \frac{\hat{Y}_{hi}}{P_{hi}})^2}{n_h} \right)$$

### (ii): FORMULA FOR RATIO ESTIMATES

$$r = \frac{\hat{Y}}{\hat{X}}$$

where  $\hat{Y}$  and  $\hat{X}$  can be estimated by equations under item (i) given above.

$$Rel V(r) = \frac{1}{\hat{X}^2} \sum_{h=1}^L \frac{1}{n_h} s^2_{hb} + \frac{1}{\hat{X}^2} \sum_{h=1}^L \frac{1}{n_h} \sum_{i=1}^{n_h} \frac{M_{hi}^2}{p_{hi}^2 m_{hi}} \frac{(M_{hi} - m_{hi})}{M_{hi}} s^2_{hw}$$