CHAPTER – VI
SURVEY FINDINGS
CHAPTER 6 - SURVEY FINDINGS

The following chapter discusses the main findings of the household survey conducted in select pockets of Guwahati. The main aim of the chapter is to provide a background of the households — their demographic characteristics, income and consumption pattern, living conditions, health conditions etc., in an attempt to understand how members of household are affected by air and vehicular pollution. This chapter is organized in six sections.

Section I provides a demographic background of the households surveyed.

Section II provides an idea of the income and consumption expenditure of the households.

Section III gives an idea of the living conditions of the households.

Section IV is a discussion of the health conditions of households and their awareness about air pollution and its impacts.

Section V enumerates preventive measures, if any, undertaken by members of households to shield themselves from air pollution.

Section VI tries to elicit households’ willingness to pay (WTP) for an improvement in air quality with regard to a hypothetical market condition.

Section VII is an attempt to calculate the health cost of vehicular pollution of the residents of Guwahati in terms of their work day loss and mitigating expenses.
Section I:
6.1 Demographic Characteristics

6.1.1 Distribution of households by area
A sample of 270 households was selected from four areas of Guwahati. The percentage distribution of households according to area are 37.8%, Sharabhatti; 34.4%, Paltanbazar; 20.4%, Adabari; and 7.4%, Sunsali. As already discussed in Chapter 4, Sharabhatti, Paltanbazar and Adabari comprise study areas of the sample while Sunsali comprises the control area of the sample. (Refer to Annexure (I), Section 1, Table 6.1)

6.1.2 Average size of the household by area
The average household size of the sample is found to be 4.03. The average household size is reportedly highest for Adabari with the mean hovering around 4.4 and it is the lowest for Paltanbazar, with the mean household size at around 3.7. The mean household size in Sharabhatti and Sunsali are found to be 4.1 and 4.0 respectively. (Refer to Annexure (I), Section 1, Table 6.2)

6.1.3 Religion and Caste of households
Majority of the households in the sample are Hindus (78.5%) while 21.5% are reportedly Muslims. Area wise distribution of the households reveals that Sharabhatti and Sunsali have an absolute majority of (100%) Hindu households while Adabari has a majority (92.7%) of Muslim households. In Paltan bazar, most of the households (92.5%) are Hindus while 7.5% are reportedly Muslims. Classification of the households in the sample on the basis of caste reveals that majority of the households (81.4%) may be classified under the 'others' category. A relatively smaller percentage of households (11.1%) reportedly belong to OBC category, 5.9% belong to SC category while 2.2% reportedly belong to ST category.
Area wise distribution of households on the basis of caste reveals that the highest percentage of households classified under the ‘others’ category reportedly belong to Adabari (90.9%). This is so because Adabari being a Muslim dominated area, SC and ST households are commonly not found among Muslims. Only a small percentage of households (9.1%) belonging to OBC category were reported in the area.

Besides Adabari, in all the other areas also, majority of the households reportedly belong to ‘others’ category. The related percentages are 81.4% in Sharabhatti, 80% in Sunsali and 74.2% in Paltan bazar.

An equal percentage of households (11.8%) belonging to OBC category were reported in Paltan bazar and Sharabhatti each, followed by Sunsali (10%) and Adabari (9.1%).

Highest percentage of households (10.8%) belonging to SC category were reported in Paltanbazar while highest percentage of households (10%) belonging to ST category were reported in Sunsali. (Refer to Annexure (I), Section 1- table 6.3.- 6.4).

Section II

6.2 Findings on Income and Consumption

The main findings under this section can be grouped under the following heads:

6.2.1 Income of Households

The household average monthly income of the sample is estimated to be Rs. 17714 and the per capita monthly income is estimated to be Rs.4717.

According to statistics published in the Guwahati Metropolitan Area (GMA) Database Report of the Guwahati Master Plan document, the average monthly income of GMA was estimated to be Rs. 8651 and the per capita average monthly income was estimated to be Rs. 2126 in 2005. The report further predicted that the household average
The monthly income would be Rs. 12173 (at 5% CAGR) and Rs. 13444 (at 6.5% CAGR) in 2011.

In order to compare the average monthly per capita income of Rs. 4717 (so obtained from the present study in 2010) with the corresponding income figure of Rs. 2126 (obtained from the GMA survey of 2005), the present monthly per capita income figure has been deflated as per comparable Consumer Price Index (CPI) for urban non menial employees. The per capita income of Rs. 4717 is estimated to be Rs. 3826 as per the price index of 2005 (base = 1984-85).

An analysis of sample household income also reveals considerable inequalities of income among households. The estimated Standard deviation (SD) of monthly household income (19212) and monthly per capita income (4963) corroborates the above argument. Furthermore, Gini coefficients of monthly household income and monthly per capita income estimated at 0.45 and 0.42 respectively also point towards high inequality of income among sample households (refer to Annexure (I), Section 2, Table 6.5).

6.2.2 Consumption Expenditure of Households

The household average monthly consumption expenditure of the sample is estimated to be Rs. 12552 and the monthly per capita consumption expenditure (MPCE) is estimated to be Rs. 3293. Like income, analysis of consumption expenditure also reveals high inequality in standards of living among sample households. An estimated SD of 9537 for household consumption expenditure and an SD of 2588 for MPCE point to considerable inequality of expenditure among sample households.

The average MPCE of the sample is also found to be much higher than the average urban MPCE of Assam observed at Rs. 1452 as per the NSSO estimates [(Report No.
530 (64/1.0/1), Household Consumer Expenditure in India, 2007-08.]. This obviously brings out the limitation of comparing the State’s average with that of the city’s (Guwahati) average and opens up room for further research and analysis. (Refer to Annexure (I) Section 2- tables 6.6)

6.2.3 Distribution of Households by MPCE

Table 6.7 Quintiles of MPCE distribution of households

<table>
<thead>
<tr>
<th>Quintile No</th>
<th>Quintile</th>
<th>Mean MPCE</th>
<th>Standard Deviation (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1849</td>
<td>1453</td>
<td>294.6</td>
</tr>
<tr>
<td>2</td>
<td>2477</td>
<td>2213</td>
<td>176.5</td>
</tr>
<tr>
<td>3</td>
<td>3084</td>
<td>2798</td>
<td>166.2</td>
</tr>
<tr>
<td>4</td>
<td>4083</td>
<td>3534</td>
<td>292.2</td>
</tr>
<tr>
<td>5</td>
<td>32636</td>
<td>6467</td>
<td>4306.0</td>
</tr>
</tbody>
</table>

Source: Survey Finding

Table 6.7 shows the MPCE of the sample distributed across quintiles. For each quintile class, 20% of the households lie below quintile value of the respective class. For instance 20% of the sample households lie below the first quintile value of Rs. 1849, 40% below the second quintile value of Rs. 2477 and so on. In other words, it may also be said that 20% of the sample households lie above the 4th quintile or below the 5th quintile value. The mean MPCE of each quintile class is shown along the third column of table 6.7.

Data shows that differences between mean MPCE declines across successive quintile classes 1, 2 and 3 and thereafter starts increasing. The differences between the mean MPCE is observed to be the highest among the fourth and the fifth quintile classes. The
corresponding standard deviation figures along the fourth column (table 6.7) also bring forth the disparity in MPCE among different quintile classes more distinctly. Data shows a wide gap in the consumption expenditures of the lowest and highest MPCE quintile classes. Within classes, the SD figures point to the least disparity of consumption expenditure among the third quintile class and the widest disparity among the fifth quintile class, indicating greater inequality of spending among higher expenditure classes.

6.2.4 Composition of MPCE by item categories

(Refer to Annexure (I) Section 2- table 6.8) It may be observed from the table that food occupies the largest share (46.8%) of total MPCE in the consumption basket followed by education (8.4%), house rent (7.3%) and vehicle fuel (6.8%).

(Refer to Annexure (I) Section 2- table 6.9) Disaggregating the MPCE of households by item categories according to Quintile classes, it is observed that share of essentials, like food and cooking gas, decrease across successively higher expenditure quintile classes. The share of cooking gas declines steadily from 5.8% for quintile class 1 to 3.2% and 2.1% for Quintile classes 4 and 5 respectively. The share of MPCE on food is also found to be the largest for Quintile class 1 (65.1%) followed by Quintile classes 2 (60.1%), 3 (54.7%), 4 (49.3%) and 5 (33.2%) respectively. In fact the percentage share of MPCE on Quintile class 5 is found to be lower than the average MPCE on food (46.8%). This pattern of spending on essentials is in conformity with Engel’s law. For other essentials like clothing, medical expenses, electricity etc., a particular pattern however, does not emerge.
For medical expenses, house rent vehicle fuel and education, the percentage share of MPCE of the fifth quintile class is observed to be way ahead of the other relatively poorer expenditure classes.

The proportion of expenditure on house rent is seen to be steadily rising along successively higher expenditure classes from 5.6% in Quintile class 1 to 8.8% in Quintile class 5. It may be inferred that escalating expenditure on house rent on the one side points to the mounting pressure of population triggered by urbanization, while on the other, it indicates preference for luxurious and comfortable living among relatively affluent economic classes.

For medical expenses; a share of 4.4% is reported for quintile class 1 which increases further along quintile classes 2, 3, and 4 and reaches a high of 9.4% for quintile class 5. A substantially high proportion of MPCE on medical expenses (9.4%) and education (11.8%) among the relatively affluent Quintile class 5, as compared to their corresponding proportion among the relatively poorer expenditure classes (Quintile class 1 to Quintile class 4) indicates the preference and capacity of the higher economic classes to avail more expensive private services. The pattern that emerges from the sample implies the prevalence of wide spread disparities in standards of living among the top 20% and the other 80% of the total population.

Steadily rising share of expenditure on item categories like toiletry, entertainment and domestic help among successively higher expenditure quintile classes draws our attention to the fact that people take to spending on non-essentials only when discretionary expenditure is high indicating a relatively higher income elasticity of demand.
With respect to vehicle fuel, it may be observed that a rising expenditure pattern emerges among successively higher quintile classes reflecting a growing preference for personalized vehicles among citizens. Proportion of expenditure on vehicle fuel at 10.5% is visibly high among Quintile class 5 as compared to other quintile classes. More vehicles mean more pollution and higher health and environmental costs. This inequitable pattern of spending among economic classes apparently indicates that the lowest economic strata of the society, while contributing the least to (air and vehicular) pollution could be the worst sufferers of the negative externality of pollution in terms of exposure and vulnerable living conditions.

6.2.5 Expenditure on Air Pollution Related Diseases

The percentage share of medical expenses of households on air pollution related illness (APRI) (like cold, cough, fever, breathing problems, skin problems etc.,) is estimated to be 15% of total medical expenditure. The percentage share of total household medical expenses on APRI is found to be relatively higher in the study areas as compared to the control area. In fact, the percentage share of household medical expenses on APRI is observed to be the highest in Paltan bazar (21.3%), followed by Adabari (16.8%) Sharabhatti (11%) and Sunsali (9.9%). This apparently indicates that vehicular air pollution does contribute to higher medical expenses on APRI in the study areas (Refer to Annexure (I) Section 2- tables 6.10 - 6.11).

It may be observed that the share of MPCE on APRI is approximately 23.5% of total MPCE on medical expenses. It must be noted here that this figure pertains to the number of members who are reportedly more exposed to outdoor air pollution. These members remain outdoors for at least 4 hours on a daily average basis (Refer to Annexure (I), Section 2 – tables 6.12- 6.13).
6.14 Share of MPCE on Air Pollution related Illness to monthly per capita medical expenditure of households by Quintile class and area

<table>
<thead>
<tr>
<th>Quintile Class</th>
<th>Share of MPCE on APRI</th>
<th>Area wise break-up of HM by MPCE on AP related illness (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>58.7</td>
<td>Sharabhatti 35.2, Adabari 37, Patlan Bazar 24.1, Sunauli 3.7</td>
</tr>
<tr>
<td>2</td>
<td>27.9</td>
<td>24.1, 31.5, 0, 100</td>
</tr>
<tr>
<td>3</td>
<td>43.6</td>
<td>20.4, 22.2, 14.8, 100</td>
</tr>
<tr>
<td>4</td>
<td>42.6</td>
<td>13, 40.7, 3.7, 100</td>
</tr>
<tr>
<td>5</td>
<td>24.1</td>
<td>7.4, 53.7, 14.8, 100</td>
</tr>
</tbody>
</table>

Source: Survey Finding

The percentage share of monthly per capita medical expenses on air pollution related illness is observed to be the highest (Refer table 6.14) for quintile class 1 and generally declining across successively higher expenditure quintile classes except for quintile class 4. The monthly per capita medical expenses on APRI is observed to be 50.7% for quintile class 1, followed by 27.9% in quintile class 2, 24.4% in quintile class 3 and 16.2% in quintile class 5. For quintile class 4, the MPCE on APRI is observed to be 36.0% approx. The vulnerability of the weakest quintile class (here quintile class 1) to the onslaught of pollution is evident from a higher proportion of MPCE being spent on APRI. The weaker classes have the least resources at their command to ward off or protect themselves from pollution. The relatively higher quintile classes have better living conditions and more discretionary income to spend on mitigating and averting activities in order to protect themselves from air and vehicular pollution.
Area wise break-up of households by MPCE on APRI shows that among quintile class 1 (which has a 50.7% share of MPCE on APRI) highest percentage of households are located in Adabari (37%) followed by Sharabhatti (35.2%), Paltan bazar (24.1%) and Sunsali (3.7%). Among quintile classes 2, 3, 4, highest percentage of households in terms of MPCE on APRI are located in Sharsbhatti followed by Paltan bazar, Adabari and Sunsali in that order. However, for quintile class 5 (which has 16.2% share of total MPCE on APRI) the highest percentage of households (53.7%) are found in Paltan bazar (53.7%), followed by Sharabhatti (24.1), Sunsali (14.8) and Adabari (7.4%) (Refer table 6.14).

**Section III**

6.3 Living Conditions

The main findings of this section can be grouped under the following –

6.3.1 Structure of dwelling unit

Majority of the respondents in the sample are found to be living in pucca houses. In fact, 96.7% households are reported to be living in pucca houses while 3.3% in semi pucca houses. (Refer to Annexure (I), Section 3 – Table 6.15)

6.3.2 Drinking water

Almost 96% households in the sample reported to be using filtered water for drinking purposes. The users of unfiltered drinking water (4%) is reportedly highest among Quintile class 1 which yet again exposes the vulnerability of this expenditure bracket to other sources of pollution as well. (Refer to Annexure (I), Section 3 – Table 6.16)
6.3.3 Indoor Air Pollution

Enumeration of indoor air pollution sources gives a background of general living conditions. Members who stay at home for longer hours are usually more affected by indoor air pollution. In this case, health information concerning those members of the household who stay outdoors for longer hours automatically shield them from indoor air pollution and in a way reduces the impact of confounding. Thus, quite in conformity to expectations, it is found that indoor air pollution variable does not count as statistically significant contributor of ill-health (as is evident from later analysis). For the study, efforts to determine the presence of indoor air pollution are based on the following sources.

6.3.3.1 Having a separate kitchen

84.4% households within the sample reported cooking in a separate kitchen while 15.6% said that they do not have a separate kitchen. Highest percentage of households who do not have a separate kitchen is located among MPCE quintile class 1 (27.8%) A few households among the higher MPCE quintile classes who said that they do not have a separate kitchen are single members who usually do not cook at home (Refer to Annexure I, Section 3, tables 6.17).

6.3.3.2 Use of Chimney/ exhaust fans in the kitchen

The use of chimney or exhaust fans does not appear to be very wide-spread in the selected pockets of Guwahati. Out of 228 households who reported having a separate kitchen, about 57% households reported to be using chimney/ exhaust fans in the kitchen. Among those who reported using chimney/ exhaust fans in the kitchen (130 households), their incidence is highest (30.3%) among the most affluent class (MPCE
Quintile class 5). Use of chimney/exhaust fans are observed to be gradually declining across successively lower quintile classes of 4, 3, 2 and 1 respectively.

In terms of area, the use of exhaust fans or chimney is reportedly highest (68.4%) in Sunsali, followed by Paltan bazar, Sharabhatti and Adabari (45.5%) (Refer to Annexure (I) Section 3- tables 6.18).

6.3.3.3 Energy for cooking

An overwhelmingly high percentage of about 96% households reported to be using LPG as fuel for cooking. Therefore, it may safely be inferred that dangers of air pollution from cooking sources is low in the sample pockets of Guwahati (Refer to Annexure (I) Section 3- tables 6.19).

6.3.3.4 Carpet use

Carpets to some degree may also act as sources of indoor air pollution as they retain dust and dust mites. Carpet use is found to be quite low (35.2%) among sample households (Refer to Annexure (I) Section 3- tables 6.20).

6.3.3.5 Use of mosquito repellents.

Varieties of mosquito repellents at times may add to respiratory problems of people. A very high majority of households (97%) in the sample areas reportedly use mosquito repellents probably to protect themselves from other serious diseases like malaria which is relatively common in this part of the country (Refer to Annexure (I) Section 3- tables 6.21).

6.3.3.6 Use of heater/ geyser

Few households surveyed in Guwahati reported to be using heater/ geysers. In fact the percentage of households reportedly using heater/ geysers are only 19.6%. Among those who reported using heater or geysers i.e a total of 53 households, 39.6%
reportedly belong to MPCE quintile class 5, 32.1% to MPCE quintile class 4 with the percentage successively declining across lower quintile classes. (Refer to Annexure (I) Section 3- tables 6.22)

6.3.4 Asset Ownership

Responses about possession of durable assets are presented in table 6.23. Information on asset ownership aids in assessing the living conditions of households and helps to form an idea about the extent to which consumer durables have been able to make inroads into an average Guwahatian’s life.

Table 6.23 Asset ownership

<table>
<thead>
<tr>
<th>Assets</th>
<th>NO of Hhs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing machine</td>
<td>18.1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>6</td>
<td>34.7</td>
<td>51.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>71.5</td>
<td>119</td>
<td>2</td>
<td>11</td>
<td>17</td>
<td>6</td>
<td>21</td>
<td>18.3</td>
<td>24.9</td>
<td>100.0</td>
</tr>
<tr>
<td>TV</td>
<td>90.4</td>
<td>244</td>
<td>2</td>
<td>4</td>
<td>13</td>
<td>2</td>
<td>22</td>
<td>25.9</td>
<td>34.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Heater - geysers</td>
<td>19.6</td>
<td>53</td>
<td>3</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>17</td>
<td>32.1</td>
<td>39.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Computer</td>
<td>40.0</td>
<td>108</td>
<td>2</td>
<td>4</td>
<td>13</td>
<td>2</td>
<td>22</td>
<td>25.9</td>
<td>34.3</td>
<td>100.0</td>
</tr>
<tr>
<td>DVD player</td>
<td>47.8</td>
<td>129</td>
<td>1</td>
<td>1</td>
<td>25</td>
<td>2</td>
<td>22</td>
<td>24.0</td>
<td>27.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Bicycle</td>
<td>40.0</td>
<td>108</td>
<td>3</td>
<td>1</td>
<td>23</td>
<td>2</td>
<td>18</td>
<td>14.8</td>
<td>12.0</td>
<td>100.0</td>
</tr>
<tr>
<td>2W</td>
<td>48.3</td>
<td>125</td>
<td>4</td>
<td>7</td>
<td>24</td>
<td>2</td>
<td>22</td>
<td>24.8</td>
<td>27.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Car</td>
<td>17.4</td>
<td>47</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>31.9</td>
<td>48.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Car + 2W</td>
<td>11.1</td>
<td>6.7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>36.7</td>
<td>36.7</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Source: Survey Finding

With respect to durable assets, the most commonly owned assets are televisions and refrigerators. It is observed that about 90.4% households reportedly own TV sets and
71.5% households own refrigerators. Among other assets, 47.8% reported having DVD players while 40% households reported having personal computers or laptops. Only 18% households reported using washing-machines. With regard to vehicles, a substantial 46.3% households reported owning two-wheelers and 17.4% reported owning cars. 11.1% own cars as well as two-wheelers while 40% households reported owning bicycles.

Among MPCE quintile classes, quintile class 5 topped the list with respect to possession of all assets except bicycles. The ownership and use of bicycles is observed to be the highest (31.5%) among quintile class 1, followed by quintile classes 2, 3, 4 and 5 in that order. Bicycles being a non-motorized, pollution free mode of transport, it is sad to note that the use of bicycles is generally getting restricted among the relatively economically weaker classes. For other motorized vehicles like cars and two-wheelers (2W), ownership of vehicles is found to be steadily increasing across successively higher quintile classes (Refer table 6.23).

It may be inferred from the above discussion that with an increase in income or spending capacity people usually prefer personalized vehicles, like cars and 2W as modes of travel, over public ones. A number of factors are responsible for the shift of preference in modes of transport. Changing work pattern, constraints of time and the need for speed, innovative technology and a host of available hire purchase schemes are some of the reasons worth noting. In this age of consumerism, demonstration effect perhaps plays a significant role in inducing ownership of vehicles. The state of public transport system vis-à-vis personalized modes is also important, as an inconvenient and trailing public transport system could be a leading factor in driving people towards
vehicle ownership. Higher usage and ownership of vehicles translate into high levels of pollution which has deleterious impact on health and environment.

6.3.5 Perceived Air Quality and sources of air pollution

Attempts were made to assess the respondents' perception about the ambient air quality in their respective areas. The respondents were asked to rate the air quality around their residential area according to a scale- with 5 ranked 'excellent', 4 ranked 'very good', 3 ranked 'good', 2 ranked 'average' and 1 ranked 'poor'.

Table 6.24 Rating of Air Quality

<table>
<thead>
<tr>
<th>Rating of Air Quality</th>
<th>Distribution of HH by Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sharabhatti</td>
</tr>
<tr>
<td>Total HH</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>19.6</td>
</tr>
<tr>
<td>Poor</td>
<td>19.6</td>
</tr>
<tr>
<td>Average</td>
<td>71.9</td>
</tr>
<tr>
<td>Good</td>
<td>7.8</td>
</tr>
<tr>
<td>Very good</td>
<td>0.7</td>
</tr>
<tr>
<td>Excellent</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Survey Finding
It may be observed from table 6.24 that a majority of (71.9%) households rated the air quality around their respective areas as ‘average’. A relatively smaller percentage of households (19.6%) rated the air quality as ‘poor’. Few households (7.8%) rated the ambient air quality as ‘good’ while a negligible 0.7% households rated the air quality as ‘very good’. It is only in the control area, Sunsali, that few respondents were found rating the air quality as ‘very good’. However, none of the respondents in the study areas or in the control areas rated the air quality around their residences as ‘excellent’.

Area wise analysis of responses reveals that among the control areas a larger majority of (87.3%) households in Adabari rated the air quality as average as compared to Sharabhatti (71.0%) and Paltan bazar (75.5%). A higher percentage of households in Paltan bazar (26.9%) as well as Sharabhatti (22.5%) rated the air quality as ‘poor’ as compared to Adabari (9.1%). In the control area Sunsali, majority of respondents (75.0%) rated the air quality as ‘good’, followed by 15% rating it as ‘average’.

It would have been interesting to compare the perceived rating of ambient air quality with actual ambient air quality statistics in respective areas but in the absence of an updated database, this task remains unaccomplished.

**Table 6.25 Sources of Air Pollution**

<table>
<thead>
<tr>
<th>Source of AP</th>
<th>Total</th>
<th>Sharabhatti</th>
<th>Adabari</th>
<th>Paltan</th>
<th>Sunsali</th>
</tr>
</thead>
<tbody>
<tr>
<td>vehicles</td>
<td>96.4</td>
<td>95.0</td>
<td>98.1</td>
<td>100.0</td>
<td>0.0</td>
</tr>
<tr>
<td>others</td>
<td>2.0</td>
<td>1.0</td>
<td>1.9</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>vehicles+others</td>
<td>1.6</td>
<td>4.0</td>
<td>1.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Survey Finding
Those who rated air quality as 'poor' or 'average' (referring to Table 6.24) were asked what according to them was the source of air pollution around their respective areas. From Table 6.25, it may be observed that an overwhelming majority of 96.4% households reported vehicles as the predominant source of air pollution. In Sharabhatti, 95% reported 'vehicles' as the major source of air pollution, while in Adabari and Paltanbazar the corresponding percentages are 98.1% and 100% respectively. In contrast, cent per cent households in Sunsali reported 'other' sources as the major cause of air pollution. Among these 'other' sources, a few households mentioned air pollution from trucks carrying sand from adjoining river bed.

Section IV

6.4 Health Effects of Air Pollution

This section discusses travel habits, duration of exposure to outdoor air pollution and other factors that usually contribute to air pollution related illness. Efforts were also made to assess awareness regarding air pollution related illness at the household level. Health related information was collected for those members of households who usually stay outdoors for a daily average of atleast 4 hours. Based on this criteria, from 270 households in the sample, health related information was gathered for 620 members. The composition of members (for whom health data was collected) are a mix of employed and unemployed members, children and adults. Out of these 620 members 76% are reportedly males and approximately 24% females.
6.4.1 Hours spent Outdoors

Exposure to outdoor air pollution is assessed from the number of hours spent outside by members of household on an average day. The average number of hours daily spent outdoors is estimated to be 8.05 hours. However, the average number of hours differ considerably with respect to age groups. Children and the elderly are found to be staying outdoors for lesser number of hours as compared to other age groups. The average number of hours spent outdoors for children i.e., (0 – 14) age group, are estimated to be 5.7 hours while for the elderly, i.e., above 60 years, the average is estimated to be 5.8 hours. For the other age groups of (24-35) years and (35-60) years, the average number of hours daily stayed outside is estimated to be 8.8 hours and 8.2 hours respectively. It is expected that exposure to air pollution in terms of number of hours stayed outdoors will be higher for the age groups of (24-35) years and (35-60) years as seen from the study, since these groups are usually a mix of students and employed members.

In terms of area, the average number of hours spent outdoors is reportedly longest in Paltan bazar (7.8 hours) followed by Sharabhatti (7.7 hours), Adabari and Sunsali each recording a mean of 7 hours daily (Refer to Annexure (I), table 6.27).

6.4.2 Average distance travelled daily

The average distance travelled daily is estimated to be 9.8 Kms for the sample (sample size = 620). This indicates that most of the members in the study areas remain within the environs of their residences and are apparently more or less affected by the same level of air pollution as the area of their residences.

The grouped (grouped by kilometres) frequency distribution (refer to Annexure (I) Section 4- table 6.28) shows that the reported average distance travelled by 20.5% of
household members are within (0-1) Km. 17.5% reported to be travelling a distance between (5-8) Kms. and 11.6% reported travelling a distance between (1-3) Kms. 9.4% reported travelling a distance of (8-10) Kms daily. A small percentage of 3.1% members reported travelling a greater distance of (30-50) Kms and even smaller percentage of members (0.8%) reported travelling an average distance of 50 Kms and more.

6.4.3 Mode of Travel

Majority of the respondents depend on public transport as their means of travel. 26% members are reported depending on public transport like buses and trekkers.. It is worth noting that in the recent years in Guwahati, trekkers have become a common mode of travel. Approximately 10.7% members are reported using buses and trekkers in combination with other personalized modes like cars and two-wheelers, and non-motorized mode of travel like rickshaw etc.

A substantial percentage of members (24.5%) reportedly use two-wheelers as a means of daily commuting while another 7.1% reportedly use two-wheelers in combination with other modes of transport. Around 7% members were reportedly using cars while around 3% reported using cars in combination with other modes.

The travel behavior apparently confirms the increasing use of personalized modes of transport among residents in Guwahati as does consumption behaviour and ‘Asset ownership’ discussed in Sections II and Section III respectively.

A sizeable percentage of 23.4% members depend on non-motorized means of transport like cycles and rickshaws or reportedly walk down to their place of work. This is not uncommon since the average distance travelled is quite small (9.8 Kms.) Further, as stated above, more than 20% reported travelling a distance between (0 – 1) Km (Refer
to Annexure (I) Section 4- tables 6.29). Some people commented that they prefer to walk down to the place of work because traffic snarls and congestion often tests their patience while sitting in a bus. This is apparently indicative of the discomfort experienced by commuters caused by traffic jams and air pollution.

6.4.4 Awareness about Air Pollution Related Diseases.

It appears that people in sample areas of Guwahati are more or less aware about the effects of air pollution on health. Respondents from all the households surveyed said that they are aware about the adverse effects of air pollution on health. They were presented with a list of diseases which have been clinically proven to be caused by air pollution and asked to choose from the list, diseases they thought were caused by it. Majority of the respondents associated air pollution with symptoms like eye, nose or throat irritation, runny nose, cold, flu/fever, skin infections, dry scratchy throat, cough, headache etc. In addition to the symptoms already stated, a few respondents also associated air pollution with shortness of breath, chest pain, drowsiness, and bronchitis. However, very few people associated pneumonia and hypertension with air pollution. On enquiring if members who were more exposed to pollution (those who stayed outdoors for atleast 4 hours on a daily average basis) suffered from any of the clinically proven symptoms discussed, an overwhelming majority of 97% respondents replied in the affirmative.

6.4.5 Duration of illness

Illness symptoms associated with air pollution like cold, fever, skin, eye problems, dry and scratchy throat, etc. are definitely a cause of constant irritation but are not always severe enough to restrict patient’s movement to bed. Therefore, two questions pertaining to duration of illness were asked - one regarding the total duration for which
illness symptoms lasted throughout the year and the other regarding the number of days one was confined indoors owing to such illness.

6.4.5.1 Reported duration of illness

There were many persons within the sample who reportedly suffered illness symptoms mentioned above for a reasonable length of time within a year. However, in many cases they did not think it severe enough to take leave from work, or could not afford to rest indoors although having admitted that it was a source of nagging irritation and unease which did hamper their everyday activities. Such days are commonly termed as restricted activity days (RAD). The average reported duration of illness or RAD for the past year is calculated at 32.2 days. Frequency distribution of RAD by age groups yields more informative results.

It may be observed that from the table 6.30 (Refer to Section 4 Annexure (I) table 6.30) that the average number of RAD is estimated to be around 90 days for members above 60 years of age and 41 days for the age group of (3-14) years. Grouped Frequency distribution shows that 37.5% of the elderly i.e., members above 60 years of age, reportedly suffered RAD more than 60 days followed by 31.3% reporting RAD between 40 and 50 in the past year.

In case of children, most of them (28.6%) reportedly suffered from air pollution related illness symptoms between a period of (20-30) days followed by 23.1% who reportedly suffered for a period of (30-40) days and 17% who suffered for a period of (40-50) days.

For the other age groups, the reported RAD is relatively low. It may be observed that for the age group of (14-24) years the average RAD in a year is estimated to be 25
while for the other two age-groups of (24-35) years and (35-60) years, the annual averages are approximately 30 and 36 days respectively.

From above it appears that in terms of RAD, children and the elderly are the worst sufferers of air pollution related illness while the youth i.e, within the age group of (14-35) years seems to be the least affected by air pollution related illness.

Area wise distribution of RAD reveals that the annual average number of RAD is reportedly highest in Sharabhatti (38.4 days) followed by Paltan bazar (35.8 days) and Adabari (30.8 days). The number of RAD is reportedly lowest in Sunsali recording an average of 25.4 days. In Sharabhatti, Adabari, Paltanbazar and Sunsali, majority of the members reportedly suffered for a period of (20-30) days in a year. The respective percentages for the areas mentioned are 23.3%, 25.8%, 21.9% and 25.6% (Refer to Section 4 Annexeure (I) table 6.31).

6.4.5.2 Days stayed Indoors.

The average annual duration of days stayed indoors or days absent from work is estimated to be 3.5 days although people reported suffering from air pollution related illness for longer periods of time. Similar to the reported duration of illness discussed above, the annual average number of days stayed indoors owing to APRI is also found to be higher for children and the elderly as compared to other age groups.

The annual average number of days stayed indoors for children i.e., for the age group of (3-14) years and for the elderly (i.e., above 60 years of age) is approximately 6 days for each group. For other age groups of (14 – 24) years, (24 – 35) years and (35 – 60) years, the annual average of sick days or days stayed indoors is worked out to be approximately 2 days each. It may further be observed that a relatively substantial percentage (24.5%) of children reported staying indoors owing to APRI for a period of
5 to 7 days. For all other age-groups, most of the members did not take leave for a single day. That is why '0' days has the highest frequency for all other age groups (Refer to table 6.32- Section 4, Annexure (I)).

The results indicate that health condition need not be the sole factor for deciding to stay indoors when affected by APRI and vocation of a person may play an important role in this. To elaborate, within the age group of (14 to 60) years, most of the members are either students or professionals who would not readily be absent or avail of sick leaves or casual leaves, when affected with APRI, unless he or she feels that it is severe enough. The opportunity cost of staying indoors for students, in terms of missing their classes; and the opportunity cost of professionals in terms of missing their work days is perceived to be more than the opportunity cost of the dependent population (i.e., children).

(Refer to Annexure (I) Section 4, table 6.33) Area wise analysis of days stayed indoors reveals that that most people did not take leave for a single day from work when affected with air pollution related illness. The percentage of members who did not take leave is the highest in Sharabhatti (45.8%) followed by Paltan bazar (43.5%), Sunsali (39.5%) and Adabari (36.4%).

Among those members who had taken leave, the frequency of (1 – 3) days leave is found to be the most common. It is worth mentioning that quite a substantial percentage (23%) in Sunsali reported staying indoors for a period of 3-5 days in the past year owing to APRI. This is apparently a contradiction, considering that Sunsali being the least polluted of all the sample areas, the reported duration of illness is also observed to be the least in Sunsali. One of the possible reasons for this could be that when people from a relatively pollution free zone have to spend long hours in a
polluted environment due to work or other reasons, they fail to develop the immunity level typical of those persons who are constantly exposed to pollution (here air and vehicular pollution) and may frequently fall ill.

However, here one needs to consider the importance of other factors like age, nature of work etc., which perhaps has a greater influence 'on the number of days stayed indoors owing to APRI' rather than the area to which the respondent belongs.

The argument that age is a significant factor for the decision to 'stay indoors' owing to APRI is established by Barlett's test for equal variances and Bonferroni's tests for identifying group differences. A null hypothesis Ho, is set up which states that samples have the same variances across age groups with respect to days stayed indoors and whatever differences there are, is due to chance. (Refer to Annexure (I), Section 4, Tables 6.34). Since Barlett's test for equal variances shows that $\chi^2(4) = 40.3715 \ p< 0.05$, therefore we reject the null hypothesis that the sample have the same variance with respect to different age groups.

Bonferroni's test for identifying group differences shows that there are significant differences in days stayed indoors with respect to different age-groups. Results confirm that with respect to days stayed indoors, differences between children i.e., (3 - 14) years of age and the elderly i.e., above 60 years of age are not significant. However, the differences of the age groups (14 - 24) years, (24 - 35) years and (35 - 60) years with that of the age groups of (3 - 14) years and (above 60) years are found to be significant.

6.4.6 Chronic Illness

Information on chronic illness is important as chronic illness affects the general health of people and increases the chances of being affected by air pollution related illness.
For instance, a person suffering from asthma definitely has a greater chance of being affected by vehicular pollution.

Out of the sample of 620 members, an overall percentage of 12.7 (%) members are reported to be suffering from chronic illnesses. The most common chronic illness is high BP with 34.2% members reportedly suffering from it. The incidence of 'high BP' is found to be the highest among the age group of (35-60) years with 77.8% belonging to this group. Other common ailments are reportedly Diabetes (16.5%), Asthma (15.2%) and Gastritis (13%). Diabetes is also reportedly highest among the age group of (35-60) years with around 77% suffering from it. The incidence of asthma is reportedly highest among the younger age-groups of (24-35) years and (35-60) years with around 33.3% in each group suffering from it. The incidence of gastritis is reportedly highest among (24-35) years of age with around 54.5% reported to be suffering from it (Refer to Annexure (I) Section 4- tables 6.35- 6.37). However, the incidence of reporting of gastritis should be considered with some caution because in common parlance, many people refer symptoms of acidity, appetite problems etc., as gastritis and might not have been typically diagnosed with the ailment.

6.4.7 Smoking habits

Smoking habits are also known to aggravate respiratory problems and may even pose a serious threat if one is under its influence for a long time.

In the survey households, not many reported to be addicted to smoking. Approximately 7.3% reported to have smoking habits with the highest incidence of smoking reportedly in the age-group of (35-60) years (refer to Annexure (I) Section 4- tables 6.38 – 6.39).
From the above analysis on health effects of air pollution, it may be surmised that although people appeared to be more or less aware about adverse health effects of vehicular air pollution, one gets the impression that people do not relate air pollution with very serious health hazards. The nature of illness symptoms (related to air pollution) being such, people generally need not always confine themselves to bed when affected with flu, fever, headache, dry cough, skin and eye irritation etc. Most people reportedly suffered for a reasonable length of time with the average duration of illness estimated to be above 30 days. They also admitted that these symptoms were a source of unease and discomfort which did affect their daily activities. However, for obvious reasons stated above, the number of days stayed indoors due to such illness symptoms is low with the mean estimated around 3.5 days in a year. Data shows age to be a relatively important factor with regard to the impact of air pollution related diseases on health. It clearly emerges that children and the elderly are the most vulnerable groups to air pollution related diseases.

Section V

6.5 Avertive Measures

Avertive measures typically mean preventive measures undertaken by households for reducing the impact of air pollution. Travelling extra distance for avoiding congestion and air pollution may be seen as an avertive measure. Other measures include use of air purifiers in the house or using face masks while travelling. In a broader sense, medical insurance may also be considered as a form of avertive expenditure although it must be borne in mind that having medical insurance will mean being covered for all medical contingencies rather than air pollution related illness only.
The use of avertive measures was found to be negligible among sample households in Guwahati. (Refer to Annexure (I) Section 5- tables 6.40 – 6.43) Only 1.1% reported using masks to protect themselves from air pollution while travelling. Few respondents (0.8% approximately) used air purifiers in the house. The use of air purifiers was limited to the relatively affluent quintile class 5. Some owners of two-wheelers remarked that they used full helmets not only as a safety measure as traffic rules demand, but preferred to do so as it also acts as a shield against air pollution. 2.3% members reportedly travel longer distances to avoid vehicular pollution and congestion. 11% are reportedly covered by medical insurance.

**Section VI**

**6.6 Stated Willingness to Pay**

An attempt was made to elicit direct response from the households with regard to willingness to pay for improvement in air quality. The household members were first informed about the soaring SPM and RSPM levels in Guwahati which are regularly found to surpass the national ambient air quality standards. It was also informed that secondary sources confirmed vehicular pollution to be the key contributor of air pollution in Guwahati and that vehicular pollution inevitably poses a serious health threat. Thereafter, the respondents were asked hypothetical questions on their willingness to pay for a reduction of vehicular air pollution in their area.

Majority of the respondents (88% approx.) replied in the affirmative when asked if they would be willing to contribute for reduction of vehicular air pollution in their area. A few households among them stated that they would be willing to pay to privately run
organizations or NGOs, or community collectives, rather than a Government affiliated agency (Refer to Annexure (I) Section 6- tables 6.44).

Those who were willing to pay were asked to tick their preference amount options from among the range of options given which is similar to a payment card. With regard to the amount of payment, a majority of 84.4% said that they would be willing to pay something within the range of Rs. (1 – 100) per month. 12.2% said that they would be willing to contribute something within the range of Rs. (100 – 200) per month while a minimal percentage (3.4%) of respondents expressed their payment choice for the range Rs.(200-500) per month (Refer to Annexure (I) Section 6- tables 6.45).

(Refer to Annexure (I) Section 6- tables 6.46) Analysis of responses across MPCE quintile classes reveal that 63% in MPCE quintile class 1, 92% in MPCE quintile class 2, 90.7% in MPCE quintile class 3, 92.6% in MPCE quintile class 4 and a high of 98% among quintile class 5 are willing to pay for a reduction in vehicular air pollution or alternatively for an improvement in air quality.

As observed, most of the households are willing to pay within the range of Rs. (1-100) which is the lowest payment range. However, the percentage of households willing to make a payment in lowest payment range of Rs (1-100) are found to be declining as the MPCE expenditure increases across successively higher quintile classes. Interpreted from another angle, this would mean that with higher expenditure levels, households are willing to pay more for improvement in air quality. For instance, it may be observed that in quintile class 1, a majority of 94.1% are reportedly willing to pay within the range of Rs (1-100) per month which falls to 92.2% across quintile class 2, further to 91.8% across quintile class 3, 84% across quintile class 4 and 64% across quintile class 5.
Similarly for the second payment range of (100-200), we find that percentage of households willing to make a payment between Rs. (100-200) steadily increases across higher MPCE quintile classes. Across quintile class 1, only 2.9% are willing to pay in the range Rs.(100-200). Along quintile class 2 the figure rises to 5.9% which improves to reach a high of 24.5% in quintile class 5.

For the payment range of Rs.(200-500), a steady pattern however, does not emerge. Nevertheless, the highest percentage of households (11.3% approx) willing to pay within the range of Rs.(200-500) per month lies in the highest MPCE quintile class 5. (Refer to Annexure (I) Section 6- tables 6.47) When analysed by area, the number of households willing to pay for an improvement in air quality are reportedly highest in Paltanbazar (92.5%), followed by Sunsali (90%), Sharabhatti (87%) and Adabari (80%). In all the areas, majority of the households are willing to pay an amount within the smallest range of Rs (1-100) per month for a reduction in vehicular air pollution.

For the second payment bracket of Rs.(100-200), the highest percentage of households willing to pay are found in Sunsali (16.7%), followed by Adabari (13.6%), Sharabhatti (12.4%) and Paltan bazar (10.5%). For the third payment range of Rs. (200-500) per month, the highest percentage of households are found in Paltan bazar (5.8%) followed by Adabari (2.3%) and Sharabhatti (2.2%). Households in Sunsali are reportedly not willing to pay anything beyond Rs. 200 per month. From the analysis it appears that income levels (expenditure here used as a proxy variable) do influence people's willingness to pay. However, an interesting point that comes across is that a high percentage of households in Sunsali, the relatively less polluted area, are willing to pay for an improvement in air quality. Hence, to assume that it is only air pollution or capacity to spend that determines households’ willingness to pay would not be fully
correct. Hours of exposure of household members, awareness about air pollution related illness, general health status etc., could also have significant influences on willingness to pay. One needs to consider that people here, were responding to a hypothetical question and might act differently when faced with real situation—perhaps a reminder of the warm glow effect frequently talked about in environmental economics.

In retrospect, at this juncture, one is inclined to mull over if rising inequality, increasing pollution and its impacts allude to the implications of the Environmental Kuznet’s curve (EKZ) hypothesis. The EKZ hypothesis states that in the early stages of development, environmental degradation as well as inequality of income will increase, but after a certain income level is reached, environmental improvement will occur. The relationship between per capita income and pollution is shown as an inverted U shaped curve. Suggested rationale for this behavior is that income elasticity of demand for environmental quality increases at higher levels of income. Also economic growth furthers the possibility that modern and less pollution intensive technology be introduced (Grossman & Krueger, 1995). Yet another explanation by Cole and Neumayer (2005) is that with increases in economic growth and income, developed countries shift their pollution intensive industries to less developed ones. With regard to the less developed countries, there is no unanimity among economists about the applicability of (EKZ) hypothesis. The conventional environmental Kuznets curve implies that less developed countries will have to experience rising pollution levels, primarily air and water pollution, until their per capita incomes rise significantly. However, there is no evidence to support the view that this would be economically
advantageous. Several benefit cost analyses have made a persuasive case for stricter pollution control, even in very low income economies including that of Asia and Africa. Countries whose economic policies induce a rapid expansion of income and employment may experience severe environmental damage unless appropriate environmental regulations are enacted and enforced. Economic analysis can be employed to justify environmental regulatory policies that result in a flatter and lower environmental Kuznets curve (Dasgupta et al, 2002).

Section VII

6.7 Estimating the Health Cost of Vehicular Air Pollution

The key objective here is to obtain a monetary measure of the revealed willingness to pay (WTP) (for a given health status) for a small change in vehicular air pollution, which is the sum of marginal lost earnings, marginal medical expenditure and marginal cost of averting activities (Referring to Chapter 4, Section 4.1.7 and 4.1.8). Quantitative measure of avertive expenditure is not attempted here, as avertive activities are found to be negligible in the sample. A monetary measure of the health cost of vehicular air pollution in Guwahati is obtained by computing the quantitative estimates of workday loss and mitigating expenditures on vehicular air pollution induced illness. Hence, the measures so obtained are rough estimates of the COI which gives a lower bound estimate of the WTP.

Poisson regression is applied to obtain the quantitative estimates of workday loss and Tobit regression is applied to estimate mitigating expenditures. The estimated workdays lost and mitigating expenditures using Poisson and Tobit regression models are discussed below (Refer to Annexure (I) Section 4, Tables 6.48 – 6.49).
It may be pointed out here that cross-section data are often subject to the problems of multicollinearity and heteroscedasticity. Application of appropriate post regression tests helped detect the presence of heteroscedasticity in case of OLS regression of mitigating expenditures, although the presence of multicollinearity was ruled out. Suitable measures were taken to adjust for heteroscedasticity in the data [See endnote]3

6.7.1 Poisson Regression for estimating work-day loss

Regressing the no of days stayed indoors due APRI denoted by 'Days_absent' on the independent variables RSPM, age, reported duration of illness (Rep_dur), hours of exposure (Exposure_hrs) and chronic illness (D_chron1) (Dummy variable) we obtain the following results (for a description of the variables, refer to Chapter 4, Section 4.4, and details of regression results and calculation, refer to Annexure (I), Section 7, subsection 6.7.1) A part of Poisson regression estimates is reproduced in table 6.48

Table 6.48 Poisson Regression Coefficients for estimating work day loss

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSPM</td>
<td>.0010345</td>
</tr>
<tr>
<td>Age</td>
<td>-.0360021</td>
</tr>
<tr>
<td>Rep_dur</td>
<td>.0117245</td>
</tr>
<tr>
<td>Exposure_hrs</td>
<td>-.0005401</td>
</tr>
<tr>
<td>D_chron1</td>
<td>.4097027</td>
</tr>
<tr>
<td>constant</td>
<td>2.668569</td>
</tr>
</tbody>
</table>

No of observations = 620

(Refer to table 6.48) The estimated Poisson regression coefficients are found significant at 5% level of significance, except RSPM which is found significant at 10% level of significance. The coefficients of the variables RSPM, Rep_dur, and D_chron1 are found to be positive.
This means that with an increase in RSPM (which signifies air pollution), the number of days stayed indoors owing to APRI is likely to increase.

Similarly, for the variables Rep_dur and D_chron1, the number of days stayed indoors owing to APRI will move in the same direction, i.e., higher the reported duration of illness, higher will be the days stayed indoors owing to APRI and so on.

The coefficient of age however, is observed to be negative which indicates that as age increases, the number of days stayed indoors decline. This is in conformity with the earlier finding of children being more vulnerable to air pollution induced illness and is prone to staying indoors when affected by it.

On the other hand, negative coefficient of hours spent outdoors (Exposure_hrs) means that as hours of exposure increases, number of days stayed indoors due to air pollution related illness decreases. This is apparently contrary to theoretical claims. However, simple linear regression analysis of hours of exposure to days stayed indoors, with respect to age groups, reveals a positive partial regression coefficient for the age group of (3-14) years of age, which means that as hours of exposure increases, the possibility of days stayed indoors also increase for children affected with APRI. However, for all other age groups, the coefficient of the variable Exposure_hrs is negative indicating that as hours of exposure increases, days stayed indoors due to APRI reduces and vice versa. Rethinking about the negative coefficient of (Exposure_hrs) one might also consider the possibility that those who spend long hours outside the home, does not necessarily spend their time out in the open but often in schools, colleges and office buildings where they are protected from outdoor air pollution. Again from the results of the Tobit model [as dealt with in the next section i.e., Section 6.7.2], mitigating expenditures when regressed on hours of exposure, the
partial regression coefficient is found to positive ($\beta = .1173047$), significant at 5% level. This means that as hours of exposure increases, mitigating expenditure increases and vice versa. From this it may be inferred that when people are exposed to outdoor air pollution for longer hours, the number of days stayed indoors owing to APRI will possibly reduce subject to the condition that mitigating expenditures on APRI increases.

6.7.1.1 Monetary estimate of opportunity cost or work-days lost

The first step in obtaining a monetary estimate of work day loss is to find out the number of work days lost by an individual when there is an increase of RSPM by one unit. The second step is to estimate the work day loss for a person when RSPM is reduced from the current level to the NAAQ safe limit standard. The third step is to obtain an annual monetary estimate of the work day loss and subsequently project the result for the entire population of Guwahati.

The average annual level of RSPM (for details of calculation see Annexure (I) Section 7, table 6.48) for the sample areas is estimated to be 217.9 $\mu$g/m$^3$ and the mean number of days stayed indoors in a year owing to APRI is 3.5.

A one unit rise in RSPM from its annual average present level of 217.9 $\mu$g/m$^3$ results in a loss (.0010345 x 3.5) = 0.003621 work days for a representative person in a year, Multiplying the loss in work days by $\Delta$RSPM (=157.96) which is the difference between the present level of 217.9 $\mu$g/m$^3$ and the prescribed safe limit of 60 $\mu$g/m$^3$ we obtain an estimate of the annual loss (or gain) of workdays for a representative person as (157.96 x 0.003621) = 0.57193367.
The mean wage / day of the sample is Rs.151.32. Therefore, in monetary terms, the annual loss (or gain) of work days for a representative person in Guwahati turns out to be 

\[(0.57193367 \times 151.32) = Rs. 86.5\] annually or Rs.87 approx.

Working members constitute 52.4% of the sample (sample size=620). Assuming the same percentage of population for the whole of Guwahati, the percentage of working population is calculated as 52.4% of 818809 = 429214.395.

[According to census 2001, the population of Guwahati is 818809]

Hence a monetary measure of workday loss for the working population of Guwahati is Rs (86.5 x 429214.395) = Rs. 37.3 million approx.

**6.7.2 Tobit Regression for estimating mitigating expenditure**

Mitigating expenditures for the present study constitute the sum of doctor’s fees, expenditure on medicines, diagnostic charges and hospital charges (if any). Mitigating expenditure is regressed on the variables RSPM, monthly per capita income (MPCI), hours of exposure (Exposure_hrs), reported duration of illness (Rep_dur), days stayed indoors (Days_absent) and chronic illness (D_chron1) which is a dummy variable [for a description of the endogenous and exogenous variables, refer to Chapter 4, Section 4.4, and details of regression results and calculation, refer to Annexure (I), Section7, sub section 6.7.2] A part of the Tobit regression estimates is reproduced in table 6.49.

**Table 6.49 Tobit Regression Coefficients for Estimating Mitigating Expenditures**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Coefficients</th>
</tr>
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<tbody>
<tr>
<td>RSPM</td>
<td>0.1275345</td>
</tr>
<tr>
<td>MPCI</td>
<td>0.0040139</td>
</tr>
<tr>
<td>Exposure_hrs</td>
<td>0.1275604</td>
</tr>
<tr>
<td>Rep_dur</td>
<td>18.75672</td>
</tr>
<tr>
<td>Days_absent</td>
<td>69.68022</td>
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<tr>
<td>D_chron1</td>
<td>32.56641</td>
</tr>
</tbody>
</table>
(Refer to Table 6.49) The estimated partial regression coefficients of the Tobit model for each of the independent variables are found to be significant at 5% level. The coefficients of all independent variables are found to be positive, i.e., they change in the same direction as mitigating expenditure. That is, with an increase in RSPM, income, level of exposure to outdoor air pollution, days stayed indoors and reported duration of illness, mitigating expenditure of air pollution related illness is also likely to increase and vice versa.

The detailed results in Annexure (I) Section 6.7.2 show that out of 620 members, 537 incurred mitigating expenses owing to APRI. The remaining 83 members did not incur any expenses (i.e., left censored). Therefore the probability of incurring mitigating expenditure is given by \( \frac{537}{620} = 0.87 \).

Marginal effect of a unit increase (or reduction) in air pollution is obtained by multiplying the coefficient of RSPM with the probability of incurring medical expenditure which is \( (0.1275345 \times 0.87) = 0.110955 \).

Therefore, the estimated mitigating expenditure (or benefit) for a reduction of RSPM to the safe level is \( (0.110955 \times 157.96) = Rs.17.53 \) per annum. [Here \( \Delta RSPM = 157.96 \)]

Projecting for the whole population of Guwahati according to the 2001 census, the mitigating expenditure is estimated to be \( (818809 \times 17.53) = Rs.14.35 \) million annually.

6.7.3 Estimating the COI

The estimated annual health cost of vehicular pollution for a representative individual in Guwahati is the sum of monetary measure of workday loss and mitigating expenses.
which is given by Rs (86.5 + 17.53) = Rs. 104.03 per annum. The cost of illness of vehicular air pollution for the entire population in Guwahati is estimated at Rs. 51.69 million / annum approximately. (Refer to Annexure (I), section 6.7.3)

The annual estimates of health cost derived in this study are low as compared to other studies in India and countries of South Asia. Results show that the annual estimate of COI of a reduction in air pollution for a representative individual is Rs. 164.43 per annum in Kanpur (Gupta, 2006), while it is Rs. 206.57 and Rs. 381.46 per annum in Kolkata and Delhi respectively (Murty et al., 2003). The annual savings from reduction of vehicular air pollution in Dhaka to meet the national safety standards is 281.86 Taka per person which amounts to Rs. 186.4 approx. [Current exchange rate of Taka = 0.66048 INR]. The annual savings from reduction in lost earnings is estimated to be Taka 131.37 in Dhaka which is approximately equal to Rs. 86.9 which is almost the same as that of the monetary estimate of annual loss of work days for a representative person in Guwahati. It may be mentioned here that the first two studies conducted in India relate to the monetary benefits accrued as a result of reduction in overall air pollution while the latter study is related to the health benefits of reduction of vehicular air pollution in Dhaka. One of the reasons for the variation in the cost of Illness figures in Guwahati with those of other Indian cities is probably due differences in wage rate and ARSPM (the difference between the national ambient air quality standards and the present annual average of RSPM) which are found to be higher in the other cities as compared to Guwahati. Also the latest available data of air pollution in Guwahati pertains to 2009 which has been assumed to remain the same in the consecutive year. With the predicted rate of increase of motor vehicles in Guwahati at 10% annually, the contribution of vehicles to air pollution is bound to rise. The results of the study...
vindicate that much is to be gained in terms of health benefits by adopting measures to control vehicular air pollution in Guwahati.

6.8 Examining Hypotheses

In this section a discussion is carried on the hypotheses of the study.

**Hypothesis 1**

As stated in the introductory chapter, according to *Hypothesis 1*, Income, education and exposure to vehicular pollution, each of these is likely to have a positive impact on the citizens' willingness to pay for reduction of vehicular pollution.

It may be observed from Table 6.49, that Tobit regression of mitigating expenditures (on APRI) on MPCI (monthly per capita income) results in a positive partial regression coefficient (.0040139) which is found to be significant at 5% level. Since the coefficient is positive, this means that as income increases, mitigating expenditure increases and vice versa. Mitigating expenditure being one of the components of WTP (refer Chapter 4, Section 4.1.7, Equation v), it may safely be inferred that as income increases, WTP for compensating a reduction in air quality also increases.

With regard to hours of exposure to outdoor air pollution, it may be observed that the relevant variable (Exposure_hrs) acts an explanatory variable in the estimation of work day loss as well as mitigating expenditures (Refer Table 6.48 and 6.49).

(Refer Table 6.48) The coefficient of hours of exposure in the Poisson equation model of workday loss shows \( \beta = -0.005401 \) which is significant at 5% level. Since the coefficient has a negative sign, it may be inferred that with increase in hours of exposure number of sick days or days stayed indoors reduces and vice versa. The result is apparently contradictory to theoretical claims according to which number of sick
days should ideally increase with an increase in the number of hours of exposure to outdoor air pollution and vice versa.

Again from the Tobit equation of mitigating expenditure in (Refer table 6.49) it is observed that the partial regression coefficient of hours of exposure to outdoor air pollution is positive ($\beta = .1173047$) which is significant at 5% level. This means that as exposure increases, mitigating expenditure increases and vice versa.

Rethinking on the above results in totality, one may infer that hours of exposure to outdoor air pollution in all likelihood leads people to be more affected by APRI (although air pollution affects different age groups differently) but this does not necessarily translate into higher work day losses. Availing medical expenses/mitigating expenses at that juncture apparently diminishes the adverse impact of APRI and thus people need not stay indoors for a length of time they would have, had they not taken medication. Therefore the number of sick days or days stayed indoors owing to APRI is likely to reduce even when hours of exposure increase, subject to the condition that mitigating expenditures for treating APRI increase.

This implies that as hours of exposure to outdoor air pollution increases, MWTP for compensating the loss of health also increases if mitigating expenses on APRI increase.

Education has not been included as an explanatory variable either in the estimation of workday loss or in the estimation of mitigating expenditures. In case of the estimation of mitigating expenditures education could have been included as one of the explanatory variables but was dropped from the main analysis as it was not found to be significant. The results of estimation of mitigating expenses when education is included as an explanatory variable in presented in Annexure I, Section 6.8.
It was hypothesized that higher education levels will indicate higher levels of awareness and knowledge about air pollution induced illness which in turn is likely to have a positive impact on mitigating expenditure translating into increased MWTP. Here education is included as a dummy variable (0 being assigned for educational level less than graduation and 1 assigned for graduates and higher level). Education as a dummy variable denoted by D_edu2 is introduced in the Tobit regression model. The partial regression coefficient of education so obtained is given by (β = -4.43962) where D_edu2 is not found to be significant at any preassigned levels of significance (10%, 5% or 1%). Also, a negative coefficient of D_edu2 apparently implies that mitigating expenditures and level of education are opposed to one another. However, nothing conclusive can be said about the contribution of education to MWTP which apparently indicates an outcome contradictory to the hypothesis. Since the result is not significant we fail to reject the null hypothesis and conclude that there is no significant relationship between mitigating expenditures and educational level.

**Hypothesis 2**

Secondly, according to hypothesis II, the willingness to pay of the residents of Guwahati is higher than their cost of illness.

(We know that by the household health production model, (MWTP) for a small change in pollution is the individual's sum of marginal lost earnings, marginal medical expenditure, marginal cost of averting activities, and monetary value of disutility caused by illness (Referring to Chapter 4, Section 4.1.7). Because of the practical difficulty of measuring the disutility of illness, researchers often exclude it from the estimation of health benefits. Estimation of avertive expenditures is ruled out for the present study as avertive activities were found to be negligible in the survey areas.)
Hence MWTP estimated in the present study is practically a measure of the Cost of Illness (COI) which is estimated to be around Rs. 51.69 million per annum for the residents of Guwahati. (The estimation of the COI has been discussed in detail in Sections 6.7.1, 6.7.2 and 6.7.3.)

Due to practical limitations discussed above, it is evident that the present study is not able to give a monetary measure of the subjective costs of the disutility of illness and the avertive costs of compensating the reduction of air quality due to an increase in vehicular air pollution and thus it has not been possible to measure the magnitude by which WTP exceeds COI. The COI measured here is a part of the MWTP (Refer to Chapter 4, Section 4.1.7, Equations (iv) and (v). From this it may be concluded that COI gives a lower bound estimate of the WTP for reduction in vehicular air pollution in Guwahati which is equivalent to stating that WTP for a reduction in vehicular air pollution is higher than the COI.

References


NSSO, (2007-08), Household Consumer Expenditure in India: NSS, 64th Round, Report No. 530 (64/1.0/1)

Alstine, J.V & Neumayer, E., The Environmental Kuznets Curve, Department of Geography and Environment and Center for Environmental Policy and Governance, Lecture Notes, (CEPG), London School of Economics and Political Science, UK. Accessible at www2.lse.ac.uk/geographyAndEnvironment/.../neumayer/pdf/EKC


NSSO, (2007-08), Household Consumer Expenditure in India: NSS, 64th Round, Report No. 530 (64/1.0/1

Endnotes

1 To deflate monthly per capita income of Rs. 4717 (as found from the household survey 2010) according to the CPI of 2005, the consumer price index for non Menial Employees in Assam has been used. The CPI of 2010 is not available, hence the CPI of 2008 (the latest published data available is March 2008) is used as a surrogate for the CPI of 2010. According to the figures of 2005 consumer price index (CPI) for non Menial Employees in Assam (Base = 1984-85), the price index for Guwahati is 425 while for March, 2008 the price index for Guwahati is 524 by the same base (Base = 1984-85). Therefore, deflating Rs. 4717 according to this index, the real income according to 2005 standards is calculated at Rs. 3826. \[(425/524)*4717= 3826\]
Source: Statistical Handbook Assam 2007 and 2009

2 In stated preference surveys, people often overstate or provide unreal statements about their WTP in an attempt to purchase moral satisfaction which is referred to as warm-glow effect.

3 Firstly, OLS regression was run and the number of days stayed indoors i.e., variable \rightarrow days_absent was regressed on the variables RSPM, Age, Reported duration of illness, Hours of Exposure, Chronic Illness (Dummy) which yielded the following results. The results of OLS regression are
### Regression Results

#### Model

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<th>Source</th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
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<td>Prob &gt; F = 0.0000</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>R-squared = 0.3632</td>
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<td>Adj R-squared = 0.3580</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Root MSE = 3.2999</td>
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<tr>
<td>Residual</td>
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<td>10.8895071</td>
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<td>Total</td>
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<td>16.961121</td>
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</tbody>
</table>

#### Standardized Coefficients

| days absent | Coef | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|-------------|------|-----------|-------|-----|----------------------|
| RSPM        | .0035507 | .0026642 | 1.33  | .183| -.0016812 .0087827   |
| Age         | -.1006444 | .0102418 | -9.83 | .000| -.1207576 -.0805313 |
| Rep_dur     | 0.587286  | .0050335 | 9.70  | .000| 0.0389588 .0587286   |
| Exposure_Hrs| -.0011856 | .0001962 | -8.01 | .000| -.0019563 -.0011856 |
| Chron1      | 1.581832  | .4473826 | 1.57  | .116| -.1753396 1.581832   |
| Constant    | 9.448782  | .7813989 | 10.13 | .000| 6.379705 9.448782    |

The post regression command of variable inflation factor (vif) for detecting multicollinearity and White's test of heteroscedasticity were applied to detect multicollinearity and heteroscedasticity respectively. Results indicated low multicollinearity and less than significant heteroscedasticity at 5% level of significance.

Secondly, variable mitigating expenditures was regressed on the variables RSPM, MPCI, Exposure_hrs, Rep_dur, Days_absent, D_chron1 (dummy variable) which yielded the following results.

#### Second Model

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<td>R-squared = 0.5231</td>
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<tr>
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<tr>
<td>Total</td>
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<td>8057.71138</td>
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</tr>
</tbody>
</table>

#### Standardized Coefficients

| days absent | Coef | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|-------------|------|-----------|-------|-----|----------------------|
| RSPM        | 1132975 | .0502615 | 2.25  | .025| .0145919 .212003    |
| MPCI        | .0043574 | .0005944 | 7.33  | .000| .0031902 .0055247   |
| Exposure_Hrs| .1187683 | .0445836 | 2.66  | .008| .0312133 .2063234   |
| Rep_Dur     | 17.01211 | 1.43141  | 11.88 | .000| 14.20105 19.82317   |
| Days_absent | 62.10296 | 7.673797 | 8.09  | .000| 47.03284 77.17308   |
| D_Chron1    | 26.28457 | 7.732542 | 3.40  | .001| 11.09908 41.47006   |
| Constant    | -93.50674 | 15.07305 | -6.20 | .000| 123.1078 -63.90566  |

The post regression variable inflation factor for detecting multicollinearity and White's test of heteroskedasticity were applied to detect multicollinearity and heteroscedasticity respectively. Results indicated low multicollinearity but significant heteroscedasticity, which has been corrected in the main model of Tobit regression using Robust standard errors. Details of tobit regression with robust standard errors may be found in Annex (i) Section 7, table 6.7.2.