CHAPTER 7

SUMMARY AND CONCLUSION

- Until man duplicates a blade of grass, nature can laugh at his so-called scientific knowledge

—Sir Isaac Newton.

7.0 Summary of the Study

The EBDs is a menace that is caused by deterioration of ambient air quality in Bangalore city. It is associated with rapid urbanization, increase in transportation, industrial development and energy consumption. Urban air pollution is a public bad, which is accompanied by uncompensated human welfare loss in the form of an external social cost (i.e. health damage, mortality, morbidity etc.) imposed on the society at large. Although, urban air pollution is attributed to domestic heating and cooking, industrial boilers and power plants and community service like municipal incinerators, biomedical incinerator, fossil fuel burning etc., the vehicular growth has contributed to 72 per cent of the total urban air pollution followed by industries (20 per cent) and domestic activities (8 per cent).

The air pollutants, such as Suspended Particulate matters (PM$_{10}$ and PM$_{2.5}$), cause wide range of health effects, especially on the cardio-respiratory system when compared to other air pollutants. It is found that 23 Indian cities are critically polluted with the PM$_{10}$, PM$_{2.5}$, CO$_2$ and NO$_X$ in the ambient air exceeding the standard prescribed by WHO. Air pollution causes 25 per cent of respiratory ill health in the world and PM along with SO$_2$ causes 500,000 premature death and 4–5 million new cases of chronic bronchitis each year in the world.

This has also resulted in welfare loss; for example, EBD is responsible for 4.6 million losses of life years each year around the globe. In South East Asia, it causes 39 per cent burden of disease in the form of loss of life years and 20 per cent in other Asian
countries. The prevalence of asthma has increased in the developed countries with an increase in urban air pollution. Every year 800,000 people die prematurely from lung cancer, cardiovascular and respiratory diseases, and 150,000 deaths occur in South Asia alone.

Studies have revealed that the health damage cost is 9 per cent of the respective income (GDP/capita) in the 12 large Indian cities, implying that the cost to the society as direct productivity loss due to EBD. It is more than 10 per cent of the income generated from all economic sources. The study also estimates the social cost of US$3 billion due to urban air pollution, of which 64 per cent is only towards health cost. It is also found that the total number of emergency hospital visits avoided due to 10\(\mu\)g/Nm\(^3\) reduction in PM\(_{10}\) is in the range of 609–25,578. The corresponding total economic benefit is US$0.05–1.9 million per year.

In Indian context, a study on Kanpur city has revealed that an individual would gain Rs 165 per year, if air pollution is reduced from the current high level to safe level. The annual benefit for the entire population in the city is Rs 213 million per annum. Another study estimates the total cost of medication due to air pollution to be Rs 58,98,087 for Chennai city.

There are legislations to control air pollution, such as Motor Vehicle Act, 1938, the Air (Prevention and Control of Pollution) Act, 1981 and the Environment (Protection) Act, 1986. However, there are no universal air quality management strategies, which could be applied to all cities throughout the world. Each urban area is unique in terms of its air pollution problems, spatial and temporal patterns of emission sources and cultural, economic, physical and social characteristics. Hence, urban air pollution is increasing due to uncontrolled growth of vehicles, improper traffic management system and implementation of alternatives.

EBD also causes economic cost on the society through human welfare loss in the form of an external cost (i.e. health damage, mortality, morbidity etc.). Hence, internalizing
this negative externality necessitates estimation of cost of environmental damage. Health impact assessment will help in policy formulation to abate air pollution and to improve the public health. Therefore, the social cost borne by individual households and the society have to be estimated.

Increasing rate of EBD is attributed in Bangalore with the increasing presence of SPM (PM$_{10}$ and PM$_{2.5}$) in ambient air quality with increasing level of vehicular pollution. The air quality monitoring data for above pollutants has clearly indicated alarming level of pollutant concentration that is three times higher than that of the INAAQS, making Bangalore an unhealthy city to live.

In this regard, the Government of Karnataka has constituted a task force as per the Hon’ble Supreme Court Direction for controlling urban air pollution. But it has not made significant improvement in air quality status of the city. There is lack of emission inventory for primary pollutants to identify the exact number of sources and their contribution quantity. The geographical area of the city has also increased leading to increase in population and vehicles. There is lack of coordination among current modes of transportation for better usage of public transport system. There are no epidemiological studies on exposure to PM and respiratory morbidity. Therefore, this study tries to fill the gap in this area of research by studying EBD, i.e. negative externality caused on account of economic impact of urban air pollution.

The EBDs and economic valuation of health impact is carried out through the concept of “Attributable Fraction”. The attributable fraction is the difference in the incidence health risks such as morbidity and mortality among the people who are constantly exposed to the risk factor and those who are not. This means, if two groups are similar in all respects, except that one group is exposed to pollution, then any difference in the disease rate between the two groups is said to be attributable (caused by) to the exposure.
The economic cost of urban air pollution is measured by considering household health production function model, which consists of health production function, demand function for mitigating activities and demand function for averting activities. To supplement the analysis of COI approach, the WTP based on the CV survey is also considered. The ordered logistic regression model is used to analyze the factors affecting WTP for reducing urban air pollution.

The time series data of KSPCB, which monitors the city’s ambient air quality in 6 manual stations, viz., Graphite India Limited, KHB Industrial Area, Peenya Industrial Area, Victoria Hospital, Amco Batteries and Yeshwanthpur police station under NAMP, are used for the study. The above stations are monitored for air pollutants such as SO2, NOx, RSPM (PM2.5) and SPM (PM10) as per the CPCB guidelines. The monitoring locations, particularly Graphite India Limited and KHB Industrial Area are excluded from the present study in order to avoid duplication as these two stations represent similar characteristics as that of Peenya Industrial Area, both in terms of pollutant concentration pattern; instead Dairy Circle is included as an additional monitoring location.

Further, in order to observe and analyze ambient air quality and also the health profile of the people, three different control areas, viz., ISEC Campus, Khajisonnenahalli and Vijayapur were considered for comparison.

7.1 Major Findings of the Study

The major findings of the present study can be summarized as follows:

- The ambient air pollution concentration of PM10 and PM2.5 in all the monitoring stations in the study area is high, compared to NAAQ standard (60 μg/Nm³ for PM10 and 40 μg/Nm³ for PM2.5). At some stations, it is three to four times (688 μg/Nm³ for PM10 and 241 μg/Nm³ for PM2.5) higher than the standards.

- Share of transport sector for PM10 concentration is 19 per cent and for PM2.5 it is 50 per cent in the city.
• The contribution for PM concentration from the industrial activity within the city limit is low due to absence of large-scale industries. However, its contribution in the industrial area is high.

• The ambient air quality with respect to RSPM and SPM are moderate to high in industrial and mixed zones (residential, rural and other areas), whereas in the sensitive zone, it is high to critical.

• High incidences of cough, dust allergy and asthma are seen among the people residing in the study area of higher pollutant concentrations, i.e. Peenya Industrial Area, Yeshwanthpura (commercial area) than the control area (Vijayapura, Khajisonnenahalli).

• Men had high incidences of cough, dust allergy and asthma in the industrial (62 per cent) and commercial area (56 per cent) due to high concentration exposure, compared to the control area (18 per cent).

• The induced respiratory illness is more prevalent among the respondents within the age group of 25–55 years, when compared to the age group of more than 65 years. This is due to the high travel time and long distance through high polluted area.

• Approximately 33 per cent of men suffering from cough and dust allergy belong to the age group of 30–40 years in the study area, when compared to the control area.

• Increased frequency of hospital admission is seen among the respondents from Peenya Industrial Area, Yeshwantpur, Majestic and Amco Batteries, where pollutant concentration is high. Air pollutant concentration is positively associated with increased hospitalization due to respiratory disease.

• For every one lakh population, the mortality per annum is 560 (for all-cause mortality for all ages) and 230 from cardiopulmonary disease and 305 from acute respiratory infections.

• Approximately 334 children aged less than 6 years would die due to high air pollutant concentration.

• The total attributable mortality among children aged <6 years due to short-term exposure is 0.06 per cent per year and it is 0.18 among the people with <45 years.
- If the PM$_{10}$ concentration from the current level of 211.6 µg/m$^3$ is reduced to standard of 60 µg/m$^3$, annually approximately 366 number of mortality can be avoided from acute respiratory infection, approximately 125 from cardiopulmonary disease and approximately 10 from lung cancer.

- Similarly, if the PM$_{2.5}$ concentration is reduced from the current level of 80.7 µg/m$^3$ to ambient standard of 40 µg/m$^3$, approximately 48 deaths can be prevented from lung cancer and 923 from cardiopulmonary diseases.

- For decrease of 10 µg/m$^3$ of PM$_{10}$ and PM$_{2.5}$ concentration, the average mortality reduction per annum from acute respiratory infection is 8 per cent, cardiopulmonary illness is 6 per cent and that of lung cancer is 5 per cent.

- The morbidity pattern of the study area has indicated more prevalence to air pollution induced illness when compared to control area (91 per cent in the study area when compared to 25 per cent in the control area).

- The cough is prevalent among 54 per cent, dust allergy is 26 per cent and asthma is 8 per cent in the study area. In the control area it is 14 per cent, 8 per cent and 3 per cent, respectively.

- Respondents suffering from cough in Dairy Circle, Majestic and Amco Batteries is 73 per cent, 63 per cent and 60 per cent, respectively, whereas 36 per cent, 26 per cent and 15 per cent of respondents are suffering from dust allergy in these areas respectively. The air pollutant concentration in these areas is classified as high to critical.

- The average number of days lost per year due to respiratory illness is high (5 days) in the study area compared to the control area (1 day).

- 20 per cent and 19 per cent of respondents in the study area has RAD of 5 and more than 10 days, respectively, in the previous year.

- The respondents from the study area have lost Rs 4,253 per year for not working for 11.5 days when compared to control area (i.e. loss of wage and WDL$^{61}$).

- The average travel cost per year to reach the doctor (for all types of respiratory illness) in the study area is Rs 149 and Rs 43 in the control area. Average doctor fee paid by the respondents in study area is Rs 1,430 per year and in control area it is Rs 247 per year.

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$^{61}$ For suffering from all types of diseases.
The out-of-pocket expenditure (as outpatient) incurred by respondents due to increase in illness is Rs 990 in the study area and is Rs 278 in the control area. Further, total money spent on medicine in the study area (for all types of diseases) is Rs 5,503 per year, in the control area it is Rs 1,982 per year.

The average number of days stayed (by the respondents suffering from different diseases) to avoid air pollution in the study area is 11 days and economic productivity loss is Rs 5,395, respectively, whereas in the control area, it is 4 days and Rs 1,980, respectively.

The average outpatient expenditure is Rs 2,845 for asthma in the study area compared to Rs 449 in the control area.

The average outpatient expenditure for cough and dust allergy is Rs 2,575 for the study area and Rs 1,865 per year, respectively, compared to Rs 530 and Rs 303 in the control area.

The average annual cost of inpatient care is significantly high in the study area (Rs 61,700) when compared to control area (Rs 13,300). Similarly the annual outpatient cost is Rs 4,080 in the study area compared to Rs 2,153 in the control area.

There is an additional expenditure of Rs 3,845 per household per year in the study area compared to the control area. This is due to the fact that the respondents of the study area were exposed to high concentration of air pollutants.

The health benefits achieved through air pollution reduction results indicated that low level of air pollutants reduces prevalence of chronic respiratory diseases and the risk of air pollution mortality by four times.

The respondents from highly polluted area have stated maximum WTP of Rs 2,154 (Amco Batteries), Rs 2,564 (Yeshwantpur) and Rs 2,095 (Peenya Industrial Area), respectively.

The respondents from moderately polluted area have stated maximum WTP of Rs 1,786 (Dairy Circle) and Rs 1,991 (Majestic Area), respectively; this shows clear evidence that WTP is positively influenced by increase in urban air pollution.

It is also observed that monthly income and MC incurred by the respondents have positive and significant impact on WTP value stated by the respondents.

The results of WTP analysis clearly indicated that the average WTP to avoid illness in the highly polluted area is greater than moderate and less polluted area.
• In highly polluted area, the mean WTP values are Rs 932, Rs 1,059 and Rs 1,245, respectively, whereas in moderately polluted area, these values are Rs 554 and Rs 636, respectively.

• The WTP for high and moderately polluted areas are different based on the changes in the level of pollution.

• The respondents who are in the high polluted area are willing to pay two to three times more than the respondents from low polluted area and one to two times more than the moderated polluted area.

• Based on the ordered logistic regression results, it is clear that income of the household has significant impact on the WTP. The results clearly indicate that as one moves higher in the income bracket, willing to pay more amounts towards pollution control also increases.

• Although people who are younger are not so much willing to pay, as their age increases their desire to pay more towards pollution control also increases.

• Household size has a negative impact and the total COI incurred by the respondents in a year has a positive and significant impact on the WTP. Distance travelled has a positive impact though not significant.

• Educational qualification, total cost incurred towards health, distance travelled by the respondents, presence of illness among household members or in the respondents have positive factors.

7.2 Policy Recommendation

The present study has provided clear evidence that increase in air pollution concentration of PM$10$ and PM$2.5$ has impacted EBD and particularly rising of asthma, cough etc., in the city. It is proved that health damage and direct utility loses are high among the households who are constantly exposed to harmful air pollutants in the city. These health and economic burden can be effectively avoided by scientific monitoring of air pollutants, achieving NAAQ standards by adopting integrated environmentally sustainable urban planning. The sustainable urban planning imposes additional cost that will be less than the losses avoided in terms of money spent for treatment during ill-
health, loss of productivity, loss of work days. The environmental standard can be evolved by determining the carrying capacity or natural regenerative capacity of different environmental attributes in the region.

Following policy recommendations are suggested based on the present study:

1. Low level of PM$_{10}$ and PM$_{2.5}$ can be achieved by adopting process of backstop technology, and also modification and usage of clean fuel such as CNG and also meeting EU standards.

2. It can be controlled by mandating the pollution under control certification. This is also possible by imposing cost of pollution control (e.g., investment on air pollution control equipments such as catalytic convertors, dust collectors, ventury scrubbers etc.) to achieve safe environmental standard.

3. Using command and control, mandating the industries to achieve safe environmental standards by cumulative action (process modification, segregation and establishing pollution control equipment)

4. Imposition of guarantee money for establishment of pollution control equipments in industries and to ensure compliance for achieving safe air quality standard.

5. Imposition of fine or tax wherever there is an increase in the pollutant concentration to prescribed standards

6. Mandating the establishment of industries in designated industrial area, which will be decided based on the carrying capacity studies following the sited guidelines.

7. Pollution management shall be localized by introducing the concept of participatory planning, which comprises decentralized administration, planning and collaboration between government and general public.

   - This can be achieved by adopting in-house efficient environmental management system (EMS) with experts from different fields.

   - The EMS also can create coordination among government, industry and general public. Evaluating the efficiency of pollution control through committees on regular interval.
8. Developing efficient environmental strategy for sustainable industrialization by considering the local environmental needs, especially human health. Thorough review of individual projects through expert committees.

9. Characterize the effects of regulatory action on pollutant emissions control and improvement in the air quality.

10. Assess the relation between ambient pollutant concentrations and exposures—doses received by the population by conducting regular studies.

The following approach should be implemented for controlling urban air pollution by evolving a cost-effective approach for improving air quality:

1. Identification of emission sources and stringent emission controls on point and mobile sources.
2. Assessment of extent of contribution of these sources to ambient air.
3. Development of new strategies linking emission data for point and mobile sources to ambient concentrations. The chemical and meteorological conditions shall be considered while developing strategies. This will provide a basis for an assessment of the benefits of sources control on exposures to multiple pollutants.
4. Conducting emission inventory studies to target source control and to develop tools for modeling the contributions of specific sources to concentrations and exposures.
5. Prioritization of sources that need to be addressed.
6. Evaluation of various options for controlling the pollution at sources with regard to feasibility and economic viability; and formulation and implementation of local specific action plans.
7. Greening of Bangalore city by creating more green patches such as parks, planting of saplings and trees, may also reduce air pollution through pollution adsorption.
8. Strict monitoring of vehicles particularly autos, generators for usage of adulterated fuels will ensure less pollution.
9. Reduce economic activity and vehicular movements in high polluted area and diversion of vehicular movement to reduce the travel time.
10. Compensation by the government to people affected by high levels of air pollution. The money shall be collected by imposing tax on fuel, which is equal to the treatment cost for particular diseases.
11. Mandating the hospitals to create health status data on EBD caused by increasing in urban air pollution.
12. Conducting regular studies on health impacts of air pollution in the city by the government through competent agency.

13. Encourage people’s participation in creating awareness of using clean fuel, monitoring their vehicles through regular emission checkup, planting trees in their surroundings etc.

14. Diversion traffic in the centre of the city and encouraging the development of adjoining towns such as Bidadi, Hoskote, Ramanagar etc. in all directions.