

An Economic Analysis of Air Pollution: A Case Study of Lucknow, India

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VANDANA AHIRWAR

DEPARTMENT OF ECONOMICS
SCHOOL OF ECONOMICS AND COMMERCE
BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
(A CENTRAL UNIVERSITY)
VidyaVihar, Raebareli Road Lucknow-226025(U.P.), India

Enrolment No. 395/13

Year 2019



Dedicated
To my
Beloved Family



CERTIFICATE

This is to certify that the thesis titled “An Economic Analysis of Air Pollution: A Case Study of Lucknow, India” submitted by Ms. Vandana Ahirwar is an original research work and has not been previously submitted in part or full for the award of any other degree or diploma to this or any other university.

The thesis submitted to Babasaheb Bhimrao Ambedkar University Lucknow satisfies all the requirements as stipulated in the *Doctor of Philosophy (Ph.D.) regulations -1999 as amended in 2008/2010/2013* and it is fit for submission and evaluation for the award of the degree of Doctor of Philosophy of the University.

Date: 28/03/2019

Sanat̄ Nāyā
Supervisor

Sanat̄ Nāyā
Head of the Department

DECLARATION

I declare that the entire thesis entitled “**An Economic Analysis of Air Pollution: A Case Study of Lucknow, India**” submitted to the Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow for the award of Doctor of Philosophy in Economics. It is my original work and it has not previously been produced for the award of any degree, diploma, fellowship or similar other titles anywhere.

This research study is carried out under the supervision of Prof. Sanatan Nayak, Department of Economics, School of Economics and Commerce (SEC), Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow, Uttar Pradesh, India.

Vandana Ahirwar

Place: Lucknow

Date: 28/03/2019

Vandana Ahirwar
Department of Economics
Babasaheb Bhimrao, Ambedkar,
Lucknow, Uttar Pradesh

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Date: 20/03/2019
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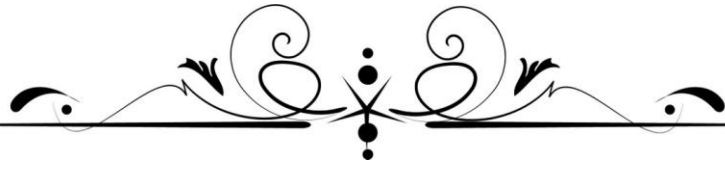
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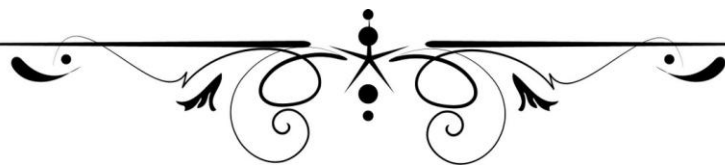
ABBREVIATIONS

Ambient Air Pollution	: AAP
Acute Respiratory Infections	: ARI
Air Quality Index	: AQI
Ambient Air Pollution	: AAP
Benzene	: C ₅ H ₆
Brazil, Russian Federation, India, China, South Africa	: BRICS
Carbon Dioxide	: CO ₂
Carbon Monoxide	: CO
Central Pollution Control Board	: CPCB
Clean Development Mechanism	: CSM
Common but Differentiated Responsibilities	: CBDR
Contingent Valuation Method	: CVM
Cost of Illness	: COI
Double Bounded Dichotomous Choice Method	: DBDC
Emissions Reduction Units	: ERUs
Environmental Kuznets Curve	: EKG
Global Burden of Disease	: GBD
Global Environment Monitoring System	: GEMS
Global Environmental Facility	: GEF
Government of India	: GOI
Green House Gases	: GHGs
Indoor Air Pollution	: IAP
Intergovernmental Panel on Climate Change	: IPCC
International Council of Scientific Unions	: ICSU
Ministry of Environment and Forest	: MOEF

National Action Plan on Climate Change	: NAPCC
National Air Quality Index	: NAQI
National Air Quality Monitoring Programme	: NAMP
National Ambient Air Quality Monitoring	: NAAQM
National Ambient Air Quality Standards	: NAAQS
National Environmental Engineering Research Institute	: NEERI
Nationally Determined Contribution	: NDCs
Pollution Control Committees	: PCC
Purchasing Power Parity	: PPP
Respirable Suspended Particulate Matter	: RSPM
Single Bounded Dichotomous Choice Method	: SBCD
State Pollution Control Board	: SPCB
Suspended Particulate Matter	: SPM
The Green Climate Fund	: GCF
The United Nations Framework Convention on Climate Change	: UNFCCC
United Nations Environment Programme	: UNEP
United Nations Framework Convention on Climate Change	: UNFCCC
Value for Preventing a Statistical Fatality	: VPF
Value of Life Year	: VOLY
Willingness to Accept	: WTA
Willingness to Aspect	: WTA
Willingness to Pay	: WTP.
World Climate Programme	: WCP
World Health Organisation	: WHO
Year of Life Loss	: YOLL



Chapter- 1
Economic Development
and Environmental
Degradation: Theoretical
and Conceptual
Development



1.0 Introduction

The environment is affected by human and natural causes and creates environmental degradation condition. Natural causes are heavy rain, floods, storms, earthquakes, volcanoes, etc. But in present times, anthropogenic causes are highly responsible for environmental problems. Due to human induced activities such as industrial process, deforestation, heavy transport system, chemical effluents, change land use patterns cause increase in gases like SO₂, CO₂ consequently pollution level increases at global level. It is also the result of socioeconomic, institutional and technological factors. It is increasing through the depletion of natural resources such as air, water, soil and the destruction of ecosystems and the extinction of wildlife (Tyagi Swati, et al., 2014, p.1491). Growing population, deforestation, global warming, unsustainable agricultural & fishing practices, overconsumption, increase in corporation, and the third world debt crises are the other factors of national and global causes of environmental degradation and social injustices (Donohoe Martin, 2003, p. 573). As a result of poverty, pollution, loss biodiversity, animal extinction, deforestation and global warming and in totality environmental degradation on depletion of resources on quality deterioration take place (Gupta K. Anil, Sreeja S. Nair, 2012). Environmental pollution denotes to the contamination of the earth's ecological balance with materials that interfere with human health, quality of life or the natural functioning of the ecosystems.

There are many types of environmental pollution has been speared in the world level such as water pollution and water scarcity, solid and hazardous waste, soil degradation, deforestation and air pollution and other less-recognised forms related to thermal pollution and radioactive hazards (Rizwan SA, et al., 2013, p. 4). These factors are directly or indirectly creating health problem and likelihood adversely especially water pollution and air pollution. In cities across the world level, air pollution is a major global public health risk as well as it is one of the highest ranking environmental health challenges in the world.

1.1 Economic Development and Environmental Degradation

The relationship between economic development and environmental degradation has been a source of great controversy for quite a long time. Economic activities include

production and consumption processes which cannot be disentangle form the environment in which they are located. In the process of economic growth, its impact on the environment increases (Kahuthu A., 2006, p.56). Environment and pollution relationship is the subject of intense public debate which is further linked with sustainable development. Economic development is a part of sustainable development. Sustainable development is the most common phrase used by the world economy. According to Brundtland Commission in 1987 sustainable development means “meeting the need of present without compromising the need of future generation”. The relationship between economic activities on environment is more harmful in developing countries due to production structure mainly due to the overexploitation of natural resources. Due to this paradox, in recent year the effects of climate change and global warming on the quality of life have increased (Alvarado, R., & Toledo, E. 2017, p.1205). About this relationship, the theoretical and empirical literature is rooted in the Environmental Kuznets Curve (EKC).

1.1.1 Environmental Kuznets curve

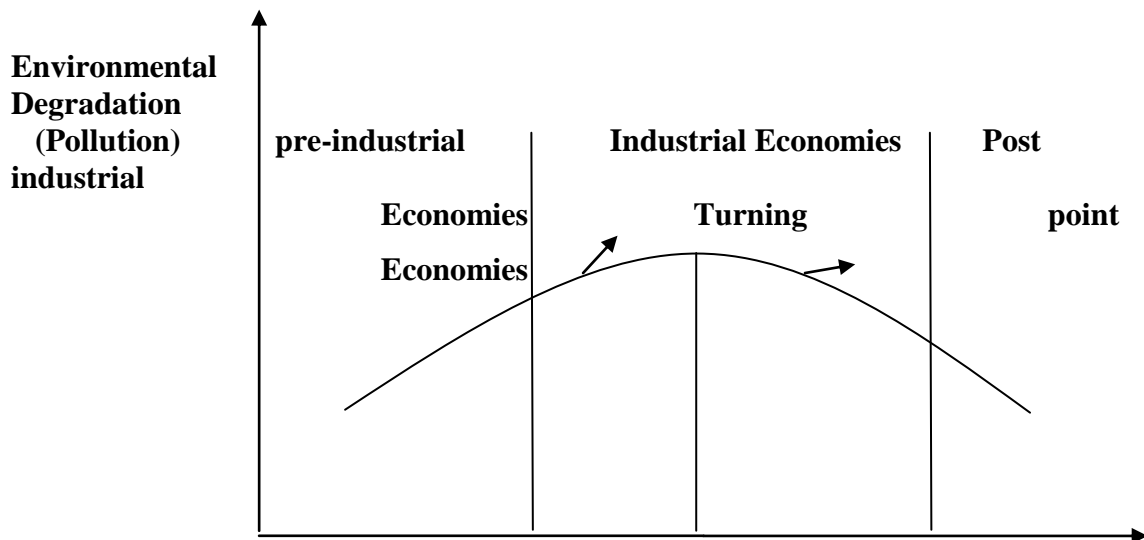
In 1955, Nobel laureate Simon Kuznets hypothesized the incerted “U” relationship between “Economic Growth and Income Inequality”. Which is known as Kuznet Curve. In this hypothesis Kuznets says that at initial level income inequality increases as income rise and reach to peak where average income is attained and further declines with increase in income level.¹ Later, economists’ viz., Grossman and Krueger in 1995 found this hypothesis and used in context of income & pollution relation and it is named as “Environmental Kuznets Curve.” Environmental Kuznets curve proposes that there is an inverted U shaped relation between environmental degradation and per capita income. In EKC hypothesis contends that environmental degradation first rise, and then fall with increasing per capita income. Therefore, it can be said that there are three stages in the EKC. First environmental pollution increases with rise in economic growth, second environmental pollution terns with rise economic growth, third environmental pollution decline with rise in economic

¹ Basically, the concept of environmental Kuznets curve started with the Kuznets theory that is related to the “Economic Growth and Income Inequality”.

growth. In this EKC hypothesis turning point is a main point which decides the rise and fall condition.

Basically, before the advent of EKC, scholar believed that richer economies damage and even destroyed their natural resource endowments at a faster pace than those of poorer countries. Accordingly that environmental quality could only be achieved by escaping the clutches of industrialization and the desire for higher income. But Kuznets has provided empirical test with their environmental Kuznets curve.

Figure 1.1: Environmental Kuznets Curve



Stage of Economic Development on Per Capita Income Economic Growth

Source: Panayotou, 1994, p.46

In the first phase with increase in economic development and environment degradation is very high (Figure 1.1). It reveals pre-industrial period where development action have just started. In this phase, level of income reported lower, trend of poverty hunger & income inequality; low basic amenities, higher birth and death rate, less medical facilities are some characteristics which are reflecting socio economic profile of the society. However people do not aware of the word sustainability (Panayotou, 1994, p.46). They have used all kinds of available resources for increasing their living standards. Therefore, economic development and

environment degradation have reported massive growth trends in this stage (figure 1.1).

In the second phase, society has been able to invest some part of their saving on protection of environment quality. This is showing with downward slope, it means rate of environment degradation showing decreasing trends. Due to industrial development, new technology will help the society that they could protect their environment. New industries have changed their production facilities by keeping in mind the environment. They are replaced with renewable resources from non-renewable resources. This is turning point of development. Policy makers as well as capitalist have tried to establish an environment friendly economic development framework. However, it has an ideal situation because a growing population has increased demand of resources which are available in limited stock. Faster economic growth and higher population density increase moderately the environmental price of economic growth. But better policies can offset these effects and make economic growth more environments friendly and sustainable (Panayotou 1994, p.47).

In the third phase, which is called postindustrial period. People have tried to protect their environment with the help of technology. Income level in this phase has reported increasing trends. Krueger (1991) has argued that rising incomes from trade would lead to stricter environmental control. In other words, free trade would protect the environment to address the hypothesis. Furthermore, any new policy has implemented on the basis of scientific assessment. Industries have produced eco-friendly goods. People have better understanding on the importance of environment Concept of limits of growth has not existed in an economy. Problem of resource scarcity have resolved with technology. Efficient energy resources have become wheel of development. However, it is an ideal situation. Once developed countries are putting environmental regulations on polluting industries then they shift their industrial units in developing countries whereas environmental regulations are not yet applied.

The debate between environment versus the economy had received the more attention in the 1990s and the discovery of a so-called “Environmental Kuznets Curve” (EKC). It shows the inverse relationship between the certain type of pollutants and income levels. Environmental quality deteriorates during early stages of economic

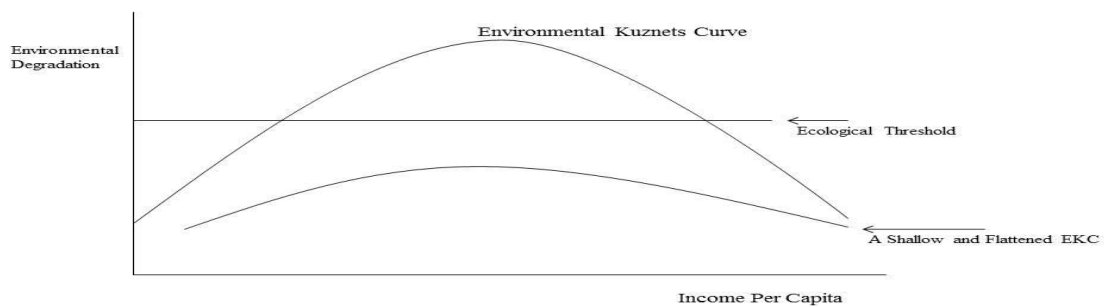
development but improves in later stages according to the EKC hypothesis (De Bruyn, S. M, 1997, p.485). Grossman and Krueger In 1991 and World Bank in 1992 provided the evidence that the environmental quality appears to deteriorate with countries of economic growth at the low level of per capita income and then it's improved with economic growth at higher levels of income. The environmental quality of the poor countries gets more polluted with economic growth while rich countries improve their environment (Levinson Arik, 2000, p.1). This study was based on the North America Free Trade Agreement (NAFTA) for 42 different countries different time period and a cross-country sample of comparable measures of ambient air pollution (Sulphur Dioxide and Dark Matter Suspended) and GDP (per capita) and found inverse-U-shaped relationship (Grossman and Kruger, 1991, p.5).

While another concept was explored by Shafik and Bandyopadhyay on EKC model, by the analysis patterns of environmental transformation at different income level. It shows economic growth is necessary along with environmental quality as a part of the sustainable development (Shafik, N., & Bandyopadhyay, S., 1992, p.1a). it confirmed robust inverse U-shaped relationship between development and environment. Many particulates, sulphur oxide and some others indicators worsen steadily such as dissolved oxygen in rivers, municipal solid wastes and carbon emissions. Therefore, the social choice for environmental quality at different income levels reflect by these patterns that is reflect the functional forms of the costs and benefits of certain environmental problems. Due to energy intensive and industrialization, abatement cost of air pollution is very high in middle-income level. Because in this analysis, sulphur dioxides increase at twice the rate of particulates in middle-income countries but this declines more quickly than particulates at higher income, therefore, this inverted "U-shaped" relationship for sulphur dioxides.

On the other hand, municipal solid wastes (fecal coliform) is the environmental indicator which is rapidly increasing in faecal content of rivers at low-income levels and followed by a rapid decline at middle income then after a slow increase at high incomes. This shows the "cubic shaped" relationship between development and environment (Shafik and Bandyopadhyay, 1992, pp.11-23b). To shows the relationship between economic development and environmental condition, there are many environmental indicators found in the atmosphere such many polluted gases,

deforestation, and others which relates to the EKC model. Panayotou (1993) study is also suggested about the structures of environmental Kuznets curve and trying to hypothesize a Kuznets type inverted U-shape relationship between environmental degradation and level of economic development. Where, the low level of development in terms of quantity and intensity of environmental degradation is limited to the impacts of subsistence economic activity on the resource base. While as economic development rapidly rises with the intensification of agriculture and other resource extraction and the industrialization and the rate of depletion of resources greater than the rate of generation of resources. Therefore, the excess uses of natural resources are responsible for generating toxic and hazardous byproducts in the environment. At a higher level of development, the level of environmental degradation declines due to structural changes for information-intensive industries and services, better technology, enhancing environmental awareness, environmental regulation as well as higher environmental expenditure. But the EKC curve shows the condition of developed and developing countries. However, it may also turn out to be the wrong conclusion if there are “ecological thresholds” beyond which environmental degradation is irreversible.

Figure 1.2: Environmental Kuznets Curve and “Ecological Thresholds”



Source: Panayotou, 1993, p.16

In figure 1.2, A B reflects the ecological threshold. The study is based on the deforestation and air pollution data in developed and developing countries. These thresholds exist in developing countries that are located in tropics resources (forests, fisheries and soils). These resources are positive option for high-income countries and the future for developing countries. Therefore, it can make for assistance to developing nations to help them flatten their EKC as to avoid the limit of irreversible environmental damage (Panayotou, 1993, p.1). Basically, there are two directions found of this hypothesis where one tests the robustness of the early findings to functional form assumptions that are related to the pollution-income related inverted U shaped pattern. Second is a set of paper seeks to expand early results to other pollutants such as carbon, lead, toxic waste, indoor air pollution. Selden and Song (1993, p.148) also examined the two air pollutants (oxides of nitrogen and carbon monoxide) studies by Grossman and Kruger. To model the relationship between per capita income and air pollution, they used Global Environment Monitoring System (GEMS) data across countries and across time. Their results lend support to the existence of an EKC relationship for four airborne emissions viz., SO₂, NO₂, SPM and CO₂. They suggest that ambient pollution level is likely to decline before aggregate emission. They find out a substantially higher turning point in to the use of aggregate air quality data which includes both rural and urban areas and expect urban air quality improve to improve before aggregate data reveal improvement there are many empirical studies supported to Environmental Kuznets Curve. However few studies critiqued to the hypothesis, after the emergence of sustainable development in 1987.²

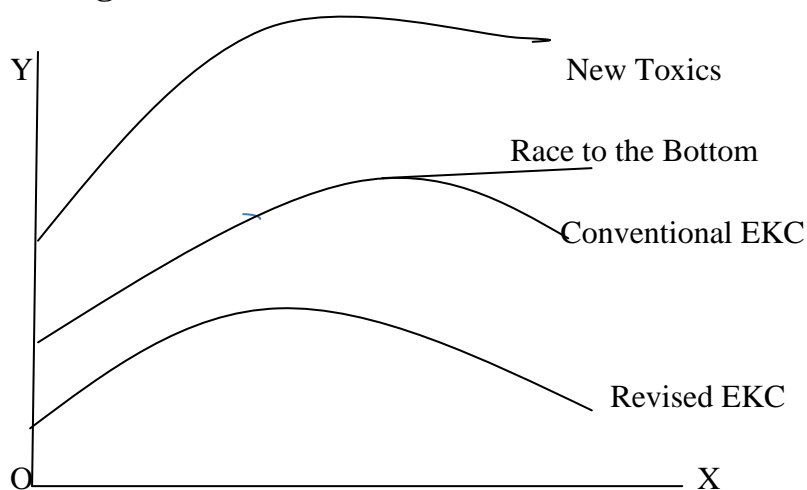
The EKC hypothesis suggests that firstly environmental damage increase with increase in income then declines. Which is applied only selected set of pollutants while some economist estimated that the curve applies to environmental quality (Stern D. I., et.al., 1996, p.1152). Economic development is not a panacea for environmental quality. In fact, this is not the main issue too. However, economists indicate that economic development may be associated with improvement in some environmental indicators. They neither say that economic development is generally enough to inspire

² Sustainable development is the most common phrase used by the world economy. According to Brundtland Commission, 1987 sustainable development means meeting the need of present without compromising the need of future generation.

environmental improvement, nor is that the environmental impacts of development can be ignored, nor in fact the resource base of the earth is indefinite economic ability to support development. In fact, if we ignored the above basis for a long time, then economic activity could be itself in danger (Arrow, K., et.al., 1995, pp.92-93). Some other economists criticized this type of hypothesis. There are two aspects of this hypothesis, first is the empirical result of the special issue which are compared with the previous finding of the EKC. And second is the additional insights offered by the special issues on EKC are discussed.

Other questions also found that environmental degradation should first increase than decline with income focused on a number of underlying relationships include, the effects of structural economic change on the use of the environment for resource inputs and to assimilate waste. However, some economists has argued that the empirical evidence on the EKC relationship supported the general idea to opposing environmental damage is economic growth itself. Other economists point out the aggregate global emissions are projected to rise over time and found that the existence of an EKC relationship for such pollutants did not necessarily imply that at the global level and associated environmental damage is likely to disappear with economic growth (Barbier, E. B., 1997, p.370). Basically, EKC always demonstrates the hypothetical parameters of environmental pollution with respect to their controversial stages of the hypothesis. Where income rises beyond that level than pollution starts to deteriorate that is called “Conventional EKC”.

Figure 1.3: Environmental Kuznets Curve: Different Scenarios



Source: Dasgupta, S, 2002, p.148

Environmental risks continuously increase because if some sources of pollution are reduced but new pollutants may continue to grow. In general, the EKC is monotonic first the "new toxics" which include carcinogenic chemicals, carbon dioxide, etc. As the older pollutants are cleaned up, new ones emerge, so that overall environmental impact is not reduced. Second is "race to the bottom" this line rise to a horizontal line at maximum existing pollution levels because globalisation promotes this race in environmental standards. Scenario posits that emissions were reduced in developed countries by outsourcing dirty industries to developing countries. Some economist critiques the conventional environmental Kuznets curve. Because the new results suggest that the level of the curve is actually dropping and shifting to the left. As the development is created less pollution in the early stages of industrialisation and starts falling at lower income levels. This condition shows the "revised EKC" (Dasgupta, S., et.al, 2002, p.148). The hypothesis says that environmental degradation does not significantly reduce economic activity to prevent the development process and that any irreversibility is not so serious that it will reduce the level of income in the future. In other words, there is a belief that the economy is sustainable. However, if the high level of economic activity is not sustainable then it can be counterproductive at the initial level of environmental degradation. It means environmental degradation should be controlled in the initial stage with economic development (Stern, D. I., 2004, p.1426).

1.2 Sustainable Economic Development

Nature provides natural resources for economic development in terms of natural resources such as water, land, air, forest and exhaustible resources. Basically, natural resources can be classified in to two categories namely, renewable and non-renewable natural resources. Renewable resources are those which are easily available for reuse. However non-renewable resources are those which cannot be reused. The use of non-renewable resources are causing many types of environmental problems, burning fossil fuel, increased volume of GHGs, which are further leads to many health related incidents in the mankind history. Increased surface temperature, which is further responsible for forest fire in west hemisphere, erratic pattern of rainfall, shifting in climatic pattern, more warmer days in cold areas and more cold days in warmer areas are causing several kinds of environmental as well as health related problems (IPCC,

2007; UNEP, 2009). Sustainable development concept was emerged in the 80s as an attempt to make a bridge between economic progress, involving consumption of raw materials and finding ways to save natural resources and reduce pollution factors. This is combines three factors such as economic, social and environmental components, focuses on the human, cultural and social dimension, on technical and scientific progress, and generating a higher level of development embodied in the sustainable development concept (Scutaru Liliana, 2013, p.35). The United Nations Conference on Environment and Development, 1992 addressed the concept of sustainable development in view of “reconciliation between economy and environment as well as a new development path to support human progress not only for some places and some years but also for the planet and for long future. There were many agreements related of this meeting such as climate change and the need to reduce emissions of methane and carbon dioxide due to economic activities, the use of better technology for reduce toxic waste, biodiversity, combating desertification, protecting forests, population growth and alternative energy sources.

1.2.1 Global Climate Change

Climate change is the result of both natural and anthropogenic factors (IPCC, 2007, p.2). However, anthropogenic factors are mostly responsible for global climate change. In recent year, climate change challenge has become complicated because it is increased by two reasons. First, it is already found that the impact of climate change increases the frequency of drought, more floods, more storms and heat waves with the increasing process of economic development. Second, continuing climate change will be severe a challenges to development (World Development Report, 2010). Basically main three following anthropogenic factors viz., increasing GHGs, increased volume of surface as well air temperatures, increase in volume of industrial aerosols and lastly, changes in land use patterns (IPCC, 2007a, p.2, Working Group I).

1.2.2 Greenhouse Gases Emission (GHG)

Many major greenhouse gases are naturally occurring but increasingly, in the last 250 years, their atmospheric concentrations are largely due to human activities. Other greenhouse gases are completely the result of human activities (IPCC, 2007b, p.23). The continuous emission of GHG results in the warming of all elements of the climate

system and causes permanent change in that system. The average ground temperature on earth has increased by 0.85 C by 1880 to 2012, and it is predicted to continue rising over the next 100 years (Yang Xuechun, et.al., 2017, p.162). United Nations Framework Convention on Climate Change (UNFCCC) focuses on carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and several fluorinated gases as indicators of GHG emissions. Worldwide emissions from human activities estimate that in 2010, about 46 billion metric tons of greenhouse gases were produced in the form of carbon dioxide equivalent. It represents an increase of 35 percent from 1990. These numbers represent net emissions, which include the effects of land use and forestry (EPA, 2016, pp.1-2). Per capita carbon dioxide emission also reported an increasing trend in both developed as well as developing countries (World Bank Meta data, 2012). In 2005, the global atmospheric concentration of carbon dioxide has increased from pre-industrial value of approximately 280 ppm to 379 ppm. The annual carbon dioxide concentration growth rate was large during the last 10 years (1995 – 2005) and average estimated 1.9 ppm per year. It has been continuously since the onset of direct atmospheric measurements due the growth rate there is variability in year to year (IPCC, 2007c, p.2). Basically increasing rate of vehicles and road based transportation are the mostly responsible for GHG emissions (NAPCC, 2008, p.30).

Recent report of IPCC (2012) reconfirmed about increasing trends of global temperature. Globally average surface temperatures have increased since the beginning of the 20th century and the warming has been particularly marked since the 1970s. Each of the last three decades has been significantly warmer than all preceding decades since 1850s. Moreover, domestic consumption of electricity based products has increased tremendously in both developing as well as developed countries. In India, where most of power generation plants are based on non-renewable resources increases environmental threat (NTPC, 2012, p.47).. UNEP report estimates that the inefficient patterns of consumption and production of energy resources by industry, transport and household sectors have been the leading sources of key indoor and outdoor air pollutants. Basically the current air pollution is the major problem in developing countries. For example, nearly 40,000 people die prematurely every year in India because of outdoor air pollution (World Bank, 1997, IPCC, 2007, p.460). Therefore Air quality is also one of the main concerns for environmental health.

1.3 Air Pollution: Concepts, Composition & Causes

Air pollution is an important global risk factor for disease because approximately 4.2 million die every year. Further, exposure to PM_{2.5} is the fifth among all risk factors alone (Health Effect Institute, 2017, p.1). Air pollution is the imbalance in quality of air so as the cause adverse effects on the living organisms existing on earth. Many type of air pollutant exists in the atmosphere but some most important types from a regulatory prospective viz., particulate matter, nitrogen oxides, sulfur oxides carbon oxides, hydrocarbons, ozone, and air toxics. Air pollutant divided into two categories such as primary air pollutants and secondary air pollutants.

Primary air pollutants are directly emitted in the atmosphere. These pollutants are carbon oxides, particulate matter, sulphur compounds, nitrogen oxide, ammonia, organic compounds, and hydrocarbons. Particulate matters consist of thousands of different solid and liquid particles suspended in the atmosphere. These are very harmful substance. Secondary pollutants are very harmful chemical those are released by other subsistence into the atmosphere. Ozone and sulfur dioxide are the example of secondary pollutants.

There are many sources of common air pollutant. Where, sulphur Dioxide is produced by the coal and oil combustion and certain industrial sources. This is create many health problems such as respiratory irritant, aggravate asthma and other lung and heart disease, reduces lung function. Nitrogen Oxides is a brownish orange gas produced by motor vehicles and combustion at major industrial sources. Lungs problem is the main problem by this pollutant. For carbon monoxide, burning of coal, gasoline, motor exhausts are the main causes and it reduces oxygen carrying capacity of blood. Solid or liquid particles produce by combustion and other processes at major industrial sources (steel mills, power plants, chemical plants, incinerators and almost every manufacturing process) are the main sources for suspended particles. This is very hazardous for health because it creates many problems like respiratory irritant, aggravates asthma and other lung and heart disease (especially in combination with sulphur dioxide) and many are known as carcinogens. Due to emphysema is responsible for eye irritation and possibly cancer (Anjaneyulu Y., 2004, pp.317-317).

Basically, particulate matter in the air is a combination of particle from primary sources (direct emissions to the atmosphere) and secondary sources (chemical transformation in the atmosphere). There are two types of particulate matter in the atmosphere. First are inhalable coarse particles such as those found near roadways and dusty industries, ranging between 2.5-10 micrometers in diameter. Second are fine particles such as those found in smoke and fog which are smaller in size that is 2.5 micrometer and even smaller. These particles are directly emitted from sources such as forest fires, gases emitted from power plants, industries, automobiles etc. There are some air emission sources for particulate matter like fire, dust agriculture, fuel combustion, mobile, industrial process etc. (Environment and Climate Change Canada, 2017, pp.22-25). Particulate matter measured at different places may differ considerably in sizes as well as in chemical and physical properties.

Air pollution in India is mostly due to emission of gases from vehicles moving on road. The rate of pollutant emission like carbon dioxide per vehicle in India is 33 percent higher than USA. In year 2000, there were over 40 million vehicles of all kinds on Indian roads and nearly 30 percent of them were concentrated in 12 metropolitan cities where a big 87 percent of all of the categories of individual transport. Approximately 1.1 million deaths or 10.6 percent of the total number of deaths have been estimated in India due to particulate matter (PM) in 2015 (GBD MAPS Working Group Report 21, 2018, p.3). For exposure to outdoor air pollution, PM_{2.5} is the third leading risk factor contributing to mortality among the 79 risk sources. It represents nearly a quarter of the 4.2 million deaths due to outdoor air pollution as well as 29.6 million years of healthy life lost also estimated at a world level (GBD Maps Working Group, 2018, p.13).

Air pollution in India has rapidly increased because India's population is use of intensive population growth, increase in the numbers of vehicles, use of fuels with poor environmental performance, badly mentioned transportation systems, poor land use pattern, industrialization, and above all, ineffective environmental regulations (Chattopadhyay et al., 2010, pp.264-265). Industrialization and urbanization are result in a profound deterioration of India's air quality. Mega cities of India are among the most polluted in the world, with concentrations of a number of air pollutants much

higher than WHO recommended levels. Therefore, the capital city, New Delhi, for instance, is one of the top ten most polluted cities in the world.

1.3.1 Types of Air Pollution

Air pollution is a key element which is responsible for increasing volume of GHGs gases, which is further responsible for global warming & climate change (IPCC, 2007). Basically, air pollution is directly affecting human life and other living species. Further air pollution is classified into two categories viz. Indoor and outdoor air pollution.

1.3.1.1 Indoor Air Pollution (IAP)

Indoor pollution is related to residential & commercial place. Many activities inside a home, which include cleaning, cooking, heating by open or enclosed fires, smoking etc. are related to the indoor air pollution. Coal and biomass fuel are major sources of indoor air pollution. Basically energy is essential for human survival, sustaining basic needs such as temperature regulation, cooked food, and lighting. Therefore, indoor air pollution refers to chemical, biological, and physical contamination of indoor air. It may result in adverse health effects (WHO, 2014). Indoor air pollution comes from the breathing and smoking, viruses and bacteria, microorganisms, and cooking fumes and the effects of air-condition system. Therefore, indoor combustion is a source of pollution causing severe burden to health, especially for children and women in developing countries.

1.3.1.2 Ambient air Pollution (AAP)

Outdoor air pollution has been recognized as a source of discomfort for centuries as smoke, dust, and obnoxious odors (WHO, 2014). Basically, there are many reasons of outdoor air pollution, such as combustion of fossil fuels (domestic heating, power generation, and motor vehicles), industrial process, agricultural process, waste incineration and natural process (Thunderstorms and Volcanoes). WHO estimates that 80 percent of outdoor air pollution-related premature deaths are due to ischemic heart disease and strokes, while 14 percent of deaths are due to chronic obstructive pulmonary disease or acute lower respiratory infections; and 6 percent of deaths are

due to lung cancer. Therefore, outdoor air pollution is highly affected human health. In a recent global burden of disease (GBD) estimate that, outdoor air pollution is estimated to account approximately 1.4 percent of total mortality, 0.4 percent of all disability adjusted life years (DALYs) and 2 percent of all cardiopulmonary disease (WHO, protection of the human environment Geneva, 2004). In 2013 assessment report of WHO's on International Agency for Research on Cancer (IARC) estimated that outdoor air pollution is carcinogenic to humans, with the particulate matter component of air pollution most closely associated with increased cancer incidence, especially cancer of the lung. An association also has been observed between outdoor air pollution and increase in cancer of the urinary tract/bladder.

1.4 Research Gap

An extensive literature review has been done for assessing air pollution situation, I.e., global level, national level and its impact on health with secondary data. Present study has added secondary as well as primary study in economic aspect in India. Further, it identify that in Lucknow city part of Uttar Pradesh, no such type of primary study has earlier conducted to examine the socio economic condition, perception of air quality, measuring health cost and willingness to pay, where earlier researcher have studies in a staggered manner.

1.5 Objectives of the Study

Objectives of the study are based on the theoretical, conceptual and review of case studies. Following objectives are developed.

1. To understand extent and dimension of air pollution specifically carbon dioxide emissions at the global level and its linkage with GDP.
2. To critically evaluate the development of acts, institutions, mechanisms and budgetary provisions to control air pollution in India.
3. To evaluate the cost of illness due to air pollution in the study area, in Lucknow
4. To evaluate the willingness to pay for determining the price for improving air quality in Lucknow

1.6 Hypothesis of the Study

1. The carbon dioxide emission is directly linked with the GDP
2. Legal and economic controlling mechanism are not sufficient to control air pollution effectively in India
3. Cost of illness is positively linked with the air pollution
4. Suffering people have willingness to pay for mitigation of air pollution.

1.7 Methodological Framework

(a) Type & Sources of Data & Type

In this study, primary as well as secondary data is used to assess impact of air pollution. Secondary data is collected from many sources international, national, and regional sources. International sources such as reports of Intergovernmental Panel on Climate Change (IPCC), World Bank, United Nations Environment Programme (UNEP), World Health Organisation (WHO), etc., National source is Central Pollution Control Board (CPCB), and regional sources such as State Pollution Control Board (SPCB), Indian Institute of Toxicological research (IITR) reports, regional edition of the Hindu newspaper and health related journals reports. Primary data is collected from the Lucknow district through household based survey.

(b) Criteria for Selection of Study Area

Selection of study area is based on the national and state level air pollutant phenomena. National Air Quality Index (NAQI) report was launched on April 2015 for air quality monitoring across the country on a real-time basis and enhancing public awareness for mitigation and preventive actions. According to this report there are 10 monitoring stations viz., Delhi, Agra, Kanpur, Lucknow, Varanasi, Faridabad, Ahmedabad, Chennai, and Bangalore Ahmedabad. NAQI is measuring many pollutants like PM₁₀, PM_{2.5}, NO₂, CO, O₃ at India level. According to CPCB, air pollution in seventeen cities of India is highly affected and facing many problems (CPCB, 2010). These are Agra, Ahmedabad, Bangalore, Chennai, Delhi, Hyderabad,

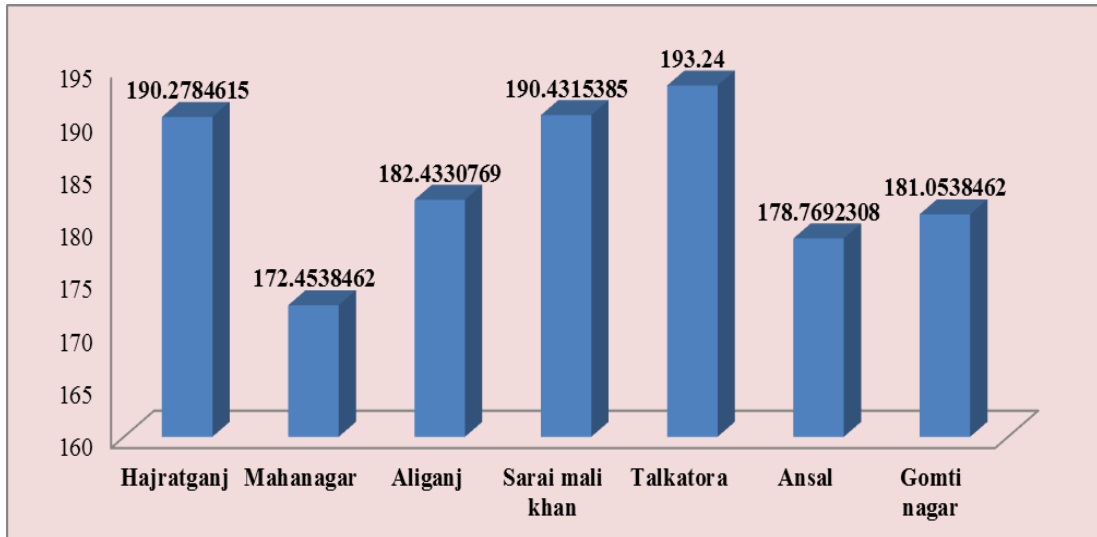
Kolkata, Lucknow, Kanpur, Faridabad, Jodhpur, Patna, Pune, Solapur, Varanasi, Jharia, and Mumbai.

The status of respirable suspended particulate matter & NO₂ from seventeen Major Pollutants Cities are described (Table 1.2A). The condition of RSPM is high in the India's capital city Delhi as well as Jharia city, but the condition of NO₂ is high in Kolkata, Delhi and Patna cities. Basically, there are four cities of Uttar Pradesh viz., Agra, Kanpur, Lucknow and Varanasi. NO₂ have high NO₂ & RSPM. Kanpur is an industrial city and it is known as the Manchester of the East and the economic capital of Uttar Pradesh. The condition of pollutant is NO₂ 34 µg/m³ and RSPM is 203 µg/m³. But in present time Lucknow pollution is also growing with the increasing rate. Because the condition of RSPM is high compared than Kanpur city which is 204 µg/m³ and it is 211 µg/m³ in 2012 (CPCB, 2014) and the NO₂ is same to the Kanpur. Therefore, Lucknow is most polluted city of Uttar Pradesh.

Lucknow is also center of urban air pollution having poor quality like other metropolitan cities. Long quantities of fossil fuel are consumed by vehicles, industries, generator sets, railway engines, domestic cooking and heating. State Pollution Control Board of Lucknow has shown the condition of air pollutant such as a Particulate Matter, Sulphur Dioxide and Nitrogen Oxide pollutant in different zones.

SPCB (2016) report identified the status of the Particulate Matter (PM₁₀) in different zone of Lucknow city, which are Hazratganj, Mahanagr, Aliganj, Sarai Malikhan, Talkotra, Ansal and Gomti Nagar in Lucknow. Based on this report, the condition of air pollution is very high in talkatora (industrial area), Hazratganz (commercial area) and Sarai Mali Khan (figure 1.4)

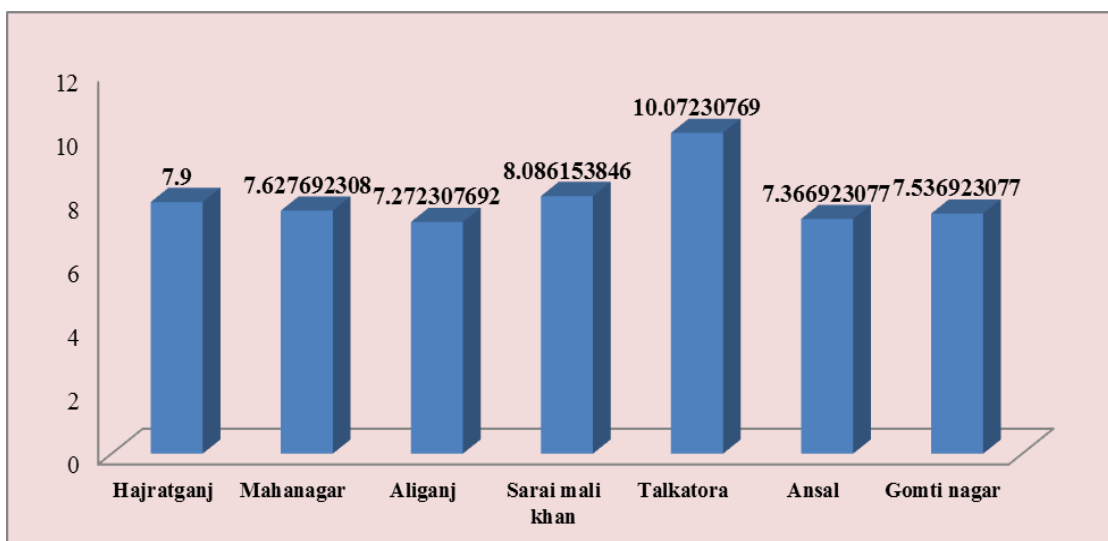
Figure 1.4: The mean value of PM10 during October, 2015 to October, 2016



Source: Estimated from State Pollution Control Board, 2016

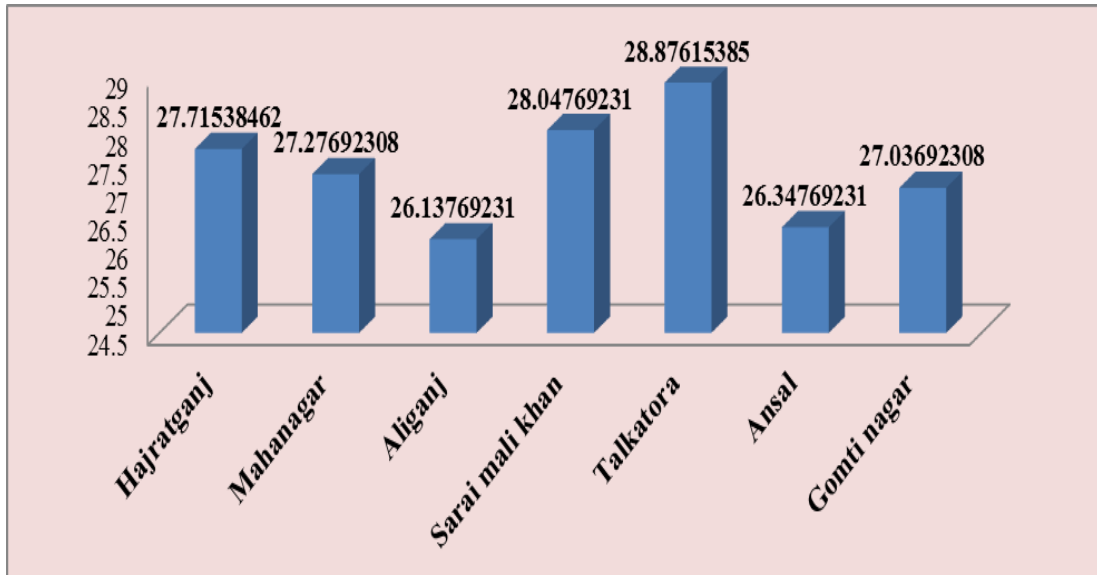
Sulphure dioxide is also responsible for air pollution in Lucknow city. The mean estimated value of SO₂ during October 2015 to October 2016 shows that it is highest in Talkatora, followed by Sarai Mali Khan and Hazratganj (figure 1.5). SO₂ is highly responsible for vehicular air pollution and it is continuously increasing in Lucknow

Figure 1.5: The mean value of Sulphur dioxide during October 2015 to October 2016



Source: Estimated from State Pollution Control Board, 2016

Figure 1.6: The mean value of Nitrogen Oxide during October 2015 to October 2016



Source: Estimated from State Pollution Control Board, 2016

Figure.1.6 shows the mean value of NO₂ in various stations in Lucknow cities. It is high in Talkatora, Sarai Malikhan and Hazratganj. The condition of Mahanagar and Gomtinagar are same and it is low in Aliganj. Basically, there are many sources of air pollution in Lucknow city such as burning of diesel and petrol and CNG by the vehicles, LPG, Kerosene, Wood. Particulate matter related pollution is rising due to large number of vehicles as well as extent of dust problems have also increased due to large scale construction. Other sources of pollution in this city are Festival, marriage, political rallies and parades, and religious celebrations etc. Many activities like building and road construction, solid waste from road side open dumps are polluting of this city (Verma, K.A., A.Saxena and D.G.Sharma, 2015, p.1184).

There are four industrial areas having large, medium and small scale industries with cluster. These are Amousi industrial area, Aishbagh (industrial area), Talkatora (industrial area), Sarojini Nagar (industrial area). Where Talkatora and Aishbagh are very congested area and Amousi and Sarojini Nagar are continuously growing in industrial sector (CPCB, 2006, p.132). According to the CPCB particulate matter is highly responsible for outdoor air pollution, largely due to vehicular pollution. SPM is also reported to be exceeded the National Ambient Air Quality Standard limits in

many studies, but SO₂, NO₂ were within the limit so 80 µg/m³. Based on the mean value of above indicators of pollutants viz., PM₁₀, SO₂, NO₂, it is observed that Talkatora and Sarai Mali Khan are highly polluted areas in the Lucknow city. Therefore, these two most polluted areas are selected for household survey.

(c) Sample Design & size

Simple stratified sampling method is used for primary data collection and 230 households are covered. Further, 115 household have been selected form each polluted zone viz., Talkatora and Sarai Malikhan. The household survey was conducted through a pre-tested schedule. During February 2016 to March 2016, the primary survey has been conducted.

(d) Approaches for Data Analysis

The present study tries to assess extent of air pollution and its impact on human health. Basically air pollution is affecting human health in two ways, through outdoor and indoor. Many diseases are evolved in environment due to air pollution which affects human health viz., asthma, cancer, allergy etc. victims of air pollution related diseases are treated to mitigate the effect on their health. They use different kinds of preventive measure to minimize the effects of diseases through spending a substantial proportion of their income. Therefore, the living standard on economic standard adversely affected due to air pollution.

There are two methods for assess the health cost viz., cost of illness and contingent valuation method. Cost of illness method includes the medical expenses, lost wages resulting from inability and defensive expenditure and activities associated. This morbidity function asses that the health of a person is measured by the number of sick days like averting activities, pollution level and medical treatment.

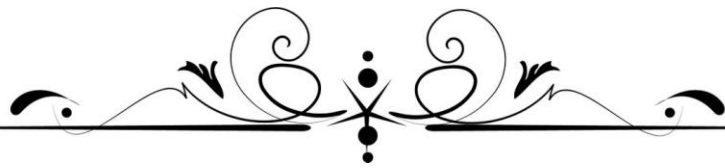
To assess economic values of air pollution and its impact health, several kind of techniques are available in literature namely mortality method and morbidity method. Mortality is directly related to death. It is measured as total number of deaths from all causes during a period of time to the average number of the population. Morbidity is directly related to time duration of illness. It includes acute (a few days of illness with a well-defined beginning and end) or chronic (long-term illness of indefinite

duration). It also includes restrictive activity days, bed disability days, and work loss days (Herath M. Gunatilake, 2003, pp.113-114).

Contingent Valuation Method (CVM) method is the survey technique that attempts to obtain stated preference. It is an example of a hypothetical direct valuation technique requiring the involvement of respondents. This develops a framework of a hypothetical market used to elicit valuations for and/or goods from habitants and habitant's preference, expressed in terms of willingness to pay (WTP). This is directly asked to the respondents that how much they are willingness to pay to avoid impact of air pollution. Basically, there are two viz., single-bounded dichotomous choice and double-bounded dichotomous choice methods. In the single-bound form the respondent is bounded by the bid and the limit of the WTP distribution (the upper limit if the answer was positive, the lower limit otherwise). In the double-bound form the respondent is enclosed within two bids, if one answer to the two questions was positive and the other negative (double bound); otherwise, the interval is bounded by the second bid and the limit of the WTP distribution (Calia Pinuccia & Elisabetta Strazzeria, 1999, p.3). The double-bounded dichotomous choice method is used in this present study.

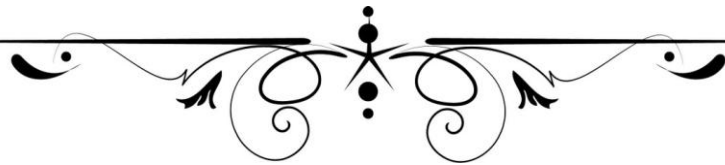
(e) Statistical Techniques for the Study

Various tools and techniques have been used for the analysis of primary as well as secondary data such as Frequency distribution, Descriptive analysis, Simple regression model, Dummy regression model, Logistic regression model. For graphical presentation, bar diagram and histogram etc. are used. In dummy variable, each category of independent variable in a regression model is represented ordinally by a pattern of 1 and 0 forming a dummy variable (Oyeka I.C.A, C.H.Nwankwo, 2012, p.1). In the logit regression model, the dependent variable is the log of the odds ratio. The estimation of logit model is based on the cumulative logistic distribution function or cumulative logistic probability function. This is interpreted by using odds and odds ratios. Bivariate logit model and multinomial logit model has been used in this study.



Chapter-2

Air Pollution and Economic Development: Theoretical Linkage



2.0 Introduction

The concept of the relationship between economic development and the environment is, and will always remain controversial because of emerging pollution problems and lack of proper controlling mechanism global warming. Basically, environment plays a key role for economic development. It provides direct input by natural resources such as minerals and fossil fuels for production and many other services. To enable economic activities, the environment provides other services like sequestering carbon,³ filtering air and water pollution, protecting against flood risk, and soil formation (Everett Tim et.al, 2010, p.12). Therefore, ecological economics is related to the limits of natural capital to handle human impact and the potential for human systems to maintain human well-being. Well-being is a multi-dimensional phenomenon and it is based on the many key dimensions such as material living standards (income, consumption), health, education, personal activities including work, political voice and governance, social connections and relationships, environment (present and future condition) and uncertainty (economic and physical nature). People are more able to respond to difficult circumstances with the other people with a higher level of well-being. Thus, the well-being of a society can be explained as an advantage for all people in the society which is suggesting the achievement of economic development (Ivkovic, A.F., et.al., 2014, p. 2). The environment provides the raw material for economic development in terms of natural resources. The natural resource consists of water, land and plants. Basically, natural resources are divided into two categories, renewable and non-renewable natural resources. Renewable resources have properties that are easily available for reuse. However, non-renewable resources are not easily available for reuse. Moreover, the use of non-renewable resources cause many types of environmental related problems viz., erratic pattern of rainfall, shifting in climatic pattern, warmer days in cold areas and more cold days in warmer areas. This further leads to several kinds of economic obstacles as well as health-related problems (IPCC, 2007; UNEP, 2009).

³ Carbon sequestration describes the long-term storage of carbon dioxide or other forms of carbon in order to reduce or reduce global warming and prevent dangerous climate change. It is proposed as a method of slowing atmospheric and marine accumulation of greenhouse gases, which are released from burning fossil fuels.

Since the discovery of non-renewable resource, development initiatives have been ignited at massive levels and results shown in forms of rapid economic development. Basically, they were used as engines of economic development. Although, these resources have impacted in two ways such as positive externalities and negative externalities. Positive externality plays a positive role in economic development in the form of infrastructure development, production at massive levels and employment generation; on the other hand, excess use of these resources releases some exogenous products which are responsible for environmental degradation which is denoted as negative externality. Previously, it was assumed that these exogenous products such as large amount of GHGs, industrial waste, human waste and medical waste further change the environmental quality. However, environmental degradation has now become a global concern, once, the limits of these exogenous products exceed beyond the capacity of earth. In general, when these resources are used in an unsustainable manner, they become hazardous products, affecting entire earth and livelihood patterns of all living species. The increased volume of hazardous products has become a barrier to natural circulation of heat transformation and resulted in the form of increasing surface temperature. History, increased temperature and less rainfall has led to forest fire in 1910 in Montana, the USA that burned about three million acres (12,000 Km², approximately the size of Connecticut) in northeast Washington, northern Idaho (the panhandle), and western Montana (Diaz, H.F., & Swetnam, T.W. 2013, p.1361). Further, the London smog of 1952 was one of the important incident of air pollution in terms of its impact on science, public perception of air pollution and government regulation. This also showed the relationship between air pollution and health (morbidity and mortality) of the general public (Bell, M. L., et.al, 2004, p.6). Basically, due to rapid urbanization, use of fossil fuels for industrial and domestic use resulted in black smog. Thus, it can be said that economic development comes with overutilization and degradation of natural resources in the form of more waste products, more hazardous products, migration, new diseases etc. No doubt, economic development has increased our living standard, made our life easier but how much cost we are really paying for this comfort now becomes a question, not only in front of policymakers but also for individuals who are using these resources in an unsustainable manner. Furthermore, many economists, as well as ecologists, viewed that how economic development is responsible for climate change. In the classical view, Boulding suggested that without recycling techniques, resources will be lost and

life will not be easy on the earth. Basically, development is required more and more inputs are available only in terms of natural resource (Jarrett H., 1966, p.1). Once these resources are consumed by users, no one economic action has been finalized because these are like a bone marrow of economic development. Moreover, empirical research was carried out by Arthur Kuznets. He has established three hypotheses on the basis of economic trends of both developing as well developed countries.

2.1 Air pollution and Environment: The Linkage

With the appearance of humans, environmental pollution has started. When Homo sapiens lighted a fire and its smoke proved to be the first environmental pollution. Air pollution of inner spaces has been started with the burning of fuels for heating and cooking. Before many thousand years ago, walls of caves are covered by a thick layer of soot. Therefore, it is assumed that breathing of cavemen was difficult due to the smoke as well as also their eyes irritated in the closed room. In Palaeolithic era, lungs of mummified bodies are frequently black. In the ancient era, smoke was not driven away (one of the practical reasons might have been protection against mosquitoes) and cave people suffered in these inner areas found shelter in the smoke (Borsos, E., et.al. 2003, p.6). In the medieval era, many of the small scale industries in London have required a source of heat such as ovens for bakers, kilns for brick makers and furnaces for metal-workers. Even though, the domestic needs requirement for fuel must have been greater than it's city's industrial requirement. The burning of fuels becomes large during in the winter season. In order to find large scale use of fuel in the medieval period, it is necessary to look at industries related to the production of building materials which increases the air pollution in the making of pottery, tile, glass, iron, steel and lime. The formation of iron, like many other early industries, will probably be located in the forest near the source of wood and the possibility of complication to pollution will be far from the urban population (Brimblecombel Peter, Makra Laszlo Makra, 2005, p.354).

A recent study shows in Nepal, where many accommodations of small villages found at local houses on the southern slopes towards the high Himalayas the smoke of fire is not driven away from the buildings even today. The walls of the houses are made up of metamorphic stones with no bonding, carrying roofs covered with rush matting.

When the fire was there, it produced a thick smoke inside the house, irritating the eyes and its make breathing too difficult. It was very intolerable to sleep in such kind of houses for a short time. In this area, peoples seem to have been living together with this unhealthy form of air pollution for many thousands of years (Brimblecombel Peter, Makra Laszlo Makra, 2004, p.642).

The concept of economic development and environmental protection always gets burning in academic circles. Research on the relationship between economic development and environmental quality has been in debate about the impact of economic development on the environment over the last five decades. In the 1960s, many researchers analyzed the meaning of economic development for the environment based on the conservation of mass principle. Increasing production in the economic system will lead to the increasing use of the natural environment, as well as increasing the amount of waste discharge. In 1971, the Rome Club said that the economic effort of important resources and economic development is not sustainable due to the limited capacity of the environment to absorb the waste. While other researchers disagree with this argument because under the market mechanism, the rising cost of scare resources encourage people to use alternative resources. As a result, the range of pollution can be avoided. Therefore, the result of the debate helped the researchers to understand the problems of environmental pollution through scare resources (Yu Xinyu, 2013, p.1). Thereafter, during the 19th century, American judicial decisions also referred to various types of pollution which include several references to environmental pollution. American courts and counsel worried about the pollution, which was spreading by the legal or political processes. The pollution was increasing due to the effects of foreign innovations and enhancing the wrongful business practices and inmates by using disparate sources of pollution (Nagel, J. C, 2009, p.11). Carbon dioxide (CO₂), nitrogen oxide (NO_X), sulphur dioxide (SO₂), methane (CH₄) and (CFCs) pollutants have been seriously caused for environmental consequences in the last decade of 20th century. This was the concerns and discussions by people about economic growth and the environment.

Due to many factors (external diseconomy, regional development strategy and so on), many environmental problems created. Therefore, the market mechanism can solve these problems (Yu Xinyu, 2013, p.1). Basically, air pollution generates from various

different sources such as factories, electrical power and chemical plants, chimneys, landfills, solid waste disposal farming, home and business activities etc. and all transportation activities also responsible for air pollution. In the world level, three billion people cook and heat their homes with coal and biomass. Therefore, to control air pollutant emissions, there is needed to be reduced not only inefficient energy systems but also control agricultural waste incineration, forest fires and charcoal production. Due to the rapid development of its cities and megacity in Africa, the use of traditional biomass and due to the burning of fossil fuels is expected to be used in the near future for a huge increase in air pollutant emissions and energy services (Book, U. Y. 2014. p.44).

In India, outdoor air pollution is mainly urban areas, due to large scale automobiles with concentration of industries and thermal power plants in major industries and some other areas. Industries (toxic gases), thermal power plants (fly ash and sulphur dioxide), and motor vehicles (carbon monoxide, particulate matter, hydrocarbons and oxides of nitrogen) are the major sources of air pollution in India. The National Capital, Delhi, is already one of the most polluted cities in the world. The incidences of respiratory diseases are found in the major cities in India. This has also increased considerably over the years.

2.2 Air Pollution and Health Cost

Air pollution is a major hazard to human health. Globally 1.1 billion breathe in unhealthy air, estimated by the United Nations Environment Programme. Many epidemiological studies have shown that the concentrations of ambient air particles are associated with a wide range of effects on human health especially on the cardiorespiratory system and air pollution is also associated with increased risk of acute respiratory infections (ARI). This is an important cause of infant and child mortality in developing nations (Md. Haque Saul & R.B. Singh, 2017, p.1). There are 2031 children and adult's case found in the five major cities of India where 1852 children tested and 51.4 percent had levels of lead in their blood above 10 µg/dl and the percentage of children, having a level of 10 / g / dl or higher level ranged from 39.9 percent in Bangalore to 61.8 percent in Mumbai. Among the adults, 40.2 percent had lead levels of about 10 µg/dl (Singhal, S., 2003, p.2).

Basically, exposure to air pollutants can affect human health in numerous ways, which lead to a rise in mortality and morbidity. It can show the various types of results. First evidence of epidemiology is increasing on the health effects of air pollution that is growing rapidly. At present, air pollution is the biggest environmental risk factor. Second exposure to air pollutants and related effects on health are critical to inform policy-makers, as well as other health and development partners. It is necessary to implement, monitor and evaluate policies that help in tackling air pollution while protecting health. Third, resolution adopted by 194 WHO members to control the adverse impact of air pollution. As well as fourth is related to a road map for improved global response. Approaches for monitoring and reporting of air pollution, enhancing systems and structures and processes necessary to support monitoring and reporting on health trends related with air pollution and its sources are included in the road map outlines goals (WHO, 2016, p.19).

The adverse effects on the health of children are more at risk with air pollution than that of adults due to a combination of behavioural, environmental and physiological factors. Children are particularly vulnerable and susceptible due to air pollution during the development of embryos in their early years. Their lungs, limbs and brains are still not matured. Their breathing rate is faster than adults which result taking in more air and, with it more pollutants. Children living near the ground, where some pollutants reach extreme concentrations. Children may spend maximum time outside, playing and engaging in physical activity in potentially polluted air. Their bodies and especially their lungs are growing rapidly and therefore more sensitive to swelling and other disorders due to pollutants. In the womb, they are vulnerable to exposure to the pollutants of their mothers (WHO, 2018, p.10).

According to Health Effects Institution report (2017, p.2), to understand the importance of air pollution and its contribution to health, it is important to keep air pollution risks in the context of other widely-recognized risk factors for the disease for example smoking and diet. They focus on two measures of outdoor air pollution included first ambient fine particulate matter (airborne particles less than or equal to 2.5 micrometres in aerodynamic diameter, or PM_{2.5}) and second is ozone which a very reactive gas with air pollutants. That is the most widely studied and monitored air pollutants around the world.

Recent study of GBD 2015 shows that the exposure to PM_{2.5} was the fifth highest ranking risk factor for heart disease and stroke, lung cancer, chronic lung disease and respiratory infection which was responsible for 4.2 million deaths and an approximately 254,000 deaths occurred due to the exposure of ozone on human health which was impacts on chronic lung disease. PM_{2.5} was accountable for a substantially larger number of attributable deaths than other more well-known risk factors, such as alcohol use or physical inactivity. It contributed to the same number of deaths as high sodium intake and high cholesterol. Although it was not the focused on given year's report, indoor air pollution from the household use of solid fuels such as coal, wood, dung, etc. for cooking and heating also has a substantial effect on health and it also contributes to outdoor air pollution. In 2016, the Health Effect Institute published a report on the most important sources of PM_{2.5} which are related to human activity in China. They found that coal-burning by industry, power plants, and households accounted for nearly 40 percent of population-weighted PM_{2.5} concentrations in China overall (Health Effects Institute, 2017, pp-1-2). Many studies have discussed air quality and social factors impact upon health.

Social indicators included as explanatory factors for poorer health such as overcrowding (defined as more than one person per room), or the presence of a smoker, was frequently cited as a contributing factor to poor respiratory health. Air quality and lack of social awareness relationship are also used to test the concept of environmental justices. Basically, for environmental and public health policy assessment, Environmental justice emerged initially in the US. There have been many environmental justice studies in the USA addressing associations between emissions from industrial facilities and landfills with attributes of nearby populations. The environmental justice movement in the US emerged in a sphere only peripherally related to transportation. Their scope within the transportation sector, however, has grown enormously in recent years with the publication of several studies evaluating the environmental justice impacts of transport improvement projects (Namdeo Anil & Claire Stringer, 2008, pp.585-586).

Major concerns for human health by exposure with PM₁₀ include effects on breathing and respiratory system, loss of lung tissue, cancer and premature death. The elderly, children and people with chronic lung disease, influenza or asthma are sensitive to

particulate matter. A large number of studies have been examined the effect of air pollution on respiratory functions and related morbidity in Delhi. Central Pollution Control Board in 2008 has conducted the most comprehensive study among them, which identified significant associations with all relevant adverse health outcomes (Rizwan, S.A., et.al, 2013, p.5). Air pollution has remained a major health concern in India. In the recent past decades, several studies have been highlighted the important contribution of outdoor air pollution to excess morbidity and mortality. Most of the Indian cities the ambient air contains respirable suspended particulate matter in levels that are above the national ambient air quality standards. The most responsible reason for air pollution in these cities is exhausted from petrol and diesel-fueled vehicles. Due to this poor quality of air for many years, millions of people have been exposed. Therefore, it is showing the adverse health effects which may be sub-diagnostic or overt. The awareness of health impact urban air pollution in megacities people is very lack. For example, the health impact of air pollution in Kolkata a city is increasing with the high level of air pollution from vehicular traffic (Roy, M. R., & Lahiri, T., 2010, p.1).

Air pollution causes significant health burden across the world. World Health Organization (WHO) estimates that globally, 3 million deaths were annually in 2012 due to air pollution. About 480,000 premature deaths are estimated in the WHO in the European Region, which includes 53 countries. Health effects of due particulate matter (PM) have been well documented in the literature. There is no evidence of the safe level of PM concentration and over 80 percent of the population of WHO European region lived in those cities, where the level of PM was higher than the WHO air quality guidelines. Human health burden includes morbidity and premature death rates (mortality) lead to significant economic and social costs due to air pollution. These include, but are not limited to the cost of the society of premature deaths, the cost of healthcare for the sick due to poor air quality and the loss of productivity associated with the disease and for themselves or others. Thus, significant cost savings can be added to health benefits received through air pollution eradication abatement (Martinez, G. S., et.al, 2018, pp.1-2).

The harmful effects of air pollution on public health have long been evaluated by the results of mortality and morbidity data have been described extensively. While these

issues involve a complete set of health effects, this study intentionally focuses on the economic cost of the health effects of air pollution, considering health consequences that allow for economic evaluation. Health effects of air pollution not only affect the social costs of mortality and morbidity but also have many important financial and economic effects, which was a major issue of interest for this report, but to make decisions within the home, hospital and public budget and within the health sector. These effects also have been associated with social equity within the two countries. Evidence from the literature shows that due to such pollution being responsible for those deaths. There is a so-called economic cost for society several trillion dollars per year as reported by the OECD (OECD, 2014).

In the report of AAP for the 34 OECD countries including China and India, this cost can be approximated at a combined total of 3.5 trillion United States dollars (US\$) for the year 2010. Economists have face the problem here because they often need to address those anti-projections, which are produced by those peoples who are not experts in their field and do not understand the earlier principles. Apart from this, they are often obliged to address those people who can challenge the area from the philosophical starting point of the debate, making misleading decisions with proposals based on estimates of cost (including health costs), which are clear underlying, and remain a default value of zero on Loss of life. Therefore, it appears necessary to restate, briefly about the earlier principles of economics as they apply to the problem at hand (WHO, OECD, 2015, p.14).

Many economists had to identify the various cost components related to health effects and they had to determine a method of pricing in monetary terms. In addition to population exposure for the annual average of total air pollution was registered for three countries in 1996, a hypothetical situation was established without the stake related to air pollution exposure. After learning about the exposure of air pollution in the study population and the risk and frequency of health consequences, due to air pollution, mortality and morbidity cases can be calculated for both conditions: for the total air pollution and the hypothetical situation without the traffic-related air pollution (Seethaler, R. K.,et.al, 2003, p.3).

Economics of air pollution is directed to measure the cost for individuals and society on a large extent. The purpose of health economics is to determine the cost of any

disease, which is different from the mortality rates of people associated with morbidity. There are two general methods to estimate the monetary value of life viz., the most common is the value of a statistical life, this value is defined as a person making a slight change in the likelihood of his/her death. The second is the value of a life year, and it gives a monetary value for years of disability-adjusted life, one measure is how much people will pay for living another (healthy) year. The value of a statistical life and the value of a life year are correlated, and often it comes from the latter half (Franchini, M., et.al, 2015, p.931).

Basically, economic activity generates air pollution, which imposed its biophysical effects (morbidity and mortality) on economic cost. This cost can be based on market and materialize by concrete economic transactions that have a monetary cost, like loss of labour productivity, admissions to hospitals and disease treatment, diminished agricultural yields or decreased tourism revenues. This cost can also be non-market based which is not give rise to the concrete monetary transaction and it is assumed by inferred from the sum of money that people would be ready to pay to avoid their detrimental consequences (death and suffering). To calculate the total market-based cost of pollution requires the combination of at least three different models viz., one that translates economic activity into air pollution, another that quantifies the biophysical effects of air pollution (number and geographical extent of deaths and diseases) and one that models the effect of death and disease on economic activity (LI. Mark and Leo Mallat, 2018, p.22).

Air pollution is also responsible for an increase number of mortality and morbidity cases in India cities. In a recent study, information based on air quality monitoring from the Central Pollution Control Board (Delhi, India) and hospital admissions records cities across India, the city Delhi was declared the “Asthma Capital “of India (Sarath Guttikunda and Puja Jawahar, 2011, p.7). This mortality is due to exposure to small particulate matter of 10 microns or less in diameter (PM₁₀), which causes cardiovascular and respiratory disease, and cancers. WHO addressed that most sources of outdoor air pollution are well beyond the control of individuals and demand action by cities, as well as national and international policymakers in sector like transport, energy waste management, buildings and agriculture (WHO, 2014).

Basically, premature mortality risk reduction is still highly uncertain, especially in applications of mortality risks related to air pollution. There are many differences between the study of labor market EPA uses to obtain a value of statistical life (VSL)⁴ estimates and air pollution context to which that VSL is applied. VSL method includes age, attitudes towards risk, and voluntariness of the risk and the nature of death, i.e. immediate versus a long illness (Hubbell, B. J., 2001, p.5).

In most developed countries, government recommends or requires economic analysis of the proposed regulations and public policies. In the United States, United Kingdom, Canada, Sweden, and New Zealand, for example using regulatory agencies value of Statistical life (VSL) estimates to evaluate the benefits of the proposed environment, health and safety rules. In these countries, estimates of the risk of lower mortality often show approximate total profits (Vassanadumrongdee, S., & Matsuoka, S., 2005, p.261).

Another concept to valuing premature deaths is to calculate the economic value attributed to the number of years lost, or loss of life expectancy is value of a life year (VOLY). The empirical values of VOLY have been determined using WTP studies, in which respondents assigned monetary values for small gain in life expectancy, usually on the order of a few months, due to lack of mortality in contact with ambient pollution (Martinez, G., 2018, p.5). VOLY is used to change the timing of death without a significant change in the nature of death (matter of air pollution). Most appropriate method for determining VOLY is Stated Preference approaches like Contingent Valuation (CV) (Desaigues, B., 2011, pp.903-904).

Health economic evaluations take into account costs involved with the provision of medical services/health care programs (for instance, pharmaceutical therapy, prevention and control measures, diagnostic methods, and screening methods), any costs associated with the illness and/or health risks (or economic outcome), and how best to apply costing data (Riewpaiboon, A., 2014, 17). The cost of illness is defined as the economic burden to society caused by a disease or illness. It relates various

⁴ The Value of Statistical Life (VSL) approach is a convenient short-hand method for describing the effect of small changes in the risk of premature death for a large population of potentially exposed people. The VSL is “built” by dividing the value of a small risk change by the actual change in risk.

aspects of the diseases impact on the health outcomes in a country, specific regions, communities and individuals. Its effect on longevity, morbidity along with the decrease in the health status and quality of life as well as financial aspects including direct and indirect expenditure in terms of premature death, disability or injury due to corresponding diseases. Basically, direct costs include health care costs and non-health care costs. Care cost include to the medical care expenditure for diagnosis, treatment and rehabilitation etc. While non-health care cost such as transport, domestic expenditure, transportation, property loss and informal care of any kind does it. Indirect cost is related to the productivity losses or productivity costs. It form a part of the social welfare losses due to diseases, while the remaining welfare losses are represented by the losses in healthy time resulting from pain, suffering and grief caused by diseases (Jo, Changik, 2014, pp.327-328). Therefore, Environmental economics focuses on assessing non-market costs (often evaluated through expressive priorities of the public) as a better indicator of how much society will value the intervention, as opposed to just indicating market cost savings Which can be made.

2.3 Air Pollution and Contingent Valuation Method

When the values of public environmental good such as clean air, unpolluted water or biodiversity cannot be derived from observation of individual behavior in the context of markets (revealed preferences), than this is commonly determined by responses to questions in surveys (stated preferences). Contingent valuation method (CVM) is still the most important technique of the stated preference methods in nonmarket valuation, where respondents are directly asked for their monetary values of environmental goods. For CVM, there are two main fields of application, first economic valuation of environmental projects to improve environmental quality and The second important field of application for the CVM is damage assessment after environmental accidents, i. e. after incidents that deteriorate environmental quality (Alheim, M., & Bucholz, W., 2000, p.2). CVM can be categories into three groups, first explanations supporting standard theory which involved in eliciting WTP and WTA, second includes explanations from psychological research involving individual choice behavior, and third group includes options within economics that can be responsible for the underlying difference between WTP and WTA (Macnab, B. J., & Adamowicz, W. L., 1990, p.3)

2.4 Willingness to Pay (WTP) and Willingness to Accept (WTA)

WTP responses in surveys capture more than purely hypothetical values. WTP measures of value, where individuals buy an item, while WTA measured of value where individuals sell the same item (Shogren, J. F., 1994, p.255). WTP is the maximum amount a person would be willing to bid for a good, on the other hand WTA is the minimum monetary amount required for an individual to forgo some good, or to bear some harm (Martín-Fernández, J., et.al., 2010, p.1). In case of WTP, if the bidding price is higher than a drawn number than individual pays the drawn number and buys the asset. In case of WTA, if the bidding price is lower than a drawn number than the individual receives the amount of the drawn number and sells the asset. Therefore, WTP follows up order and WTA follows the down order (Shahrabani, S., et.al., 2008, p.153).

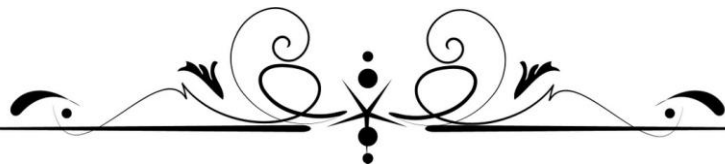
In case of air pollution, WTA is the minimum amount that the household would accept in exchange for his right clean air, While WTA is the maximum amount that the household would pay for the right to clean air (Haffman, E., & Spitzer, M. L., 1993, p.64). In this study, willingness to pay method is used for the reduction of cost of illness. Because, household members were agree for the highest amount of the bid.

2.5 Willingness to Pay and Air Pollution

For air pollution, there is no specific market transaction. Therefore, non-market valuation method is also trustworthy. Focusing on inferring willingness to pay from data on actual behaviour is the type of revealed preference method or indirect method. For example, it is possible to estimate some measures of willing-to-pay such as housing prices to improve air quality indirectly through market events indirectly. While, using stated preference approach which has become increasingly popular. Therefore, these methods may use surveys to assess willingness to pay directly (Diener, A. A., Muller, R. A., & Robb, A. L., 1997, p.2). Contingent valuation method is very flexible and it can create a hypothetical market with the desired provision structure and payment vehicle for a very wide range of public or private goods. Environmental amenities, resources, new private commodities and health risks are included in the CV method related goods. There are two important issues of the stated valuation method first the potential impact of the provisioning mechanism of

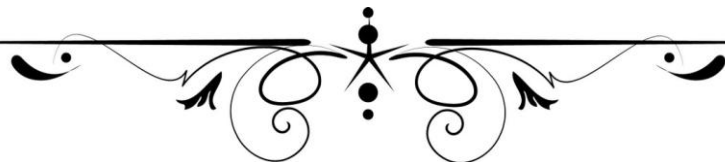
value should be value-private provisioning mechanism and second is public provision mechanism to people's WTP. Since health care can be provided with either privately or in public, it is important for an economist to know whether the provision mechanisms would affect people's WTP for the same health risk reduction. The value of a statistical case of asthma is estimated with the value of a statistical life at the end (Guo, X., Haab, T. C., & Hammitt, J. K., 2006, p.2). Since air pollution can impact on society in various ways which are included human health, agricultural yield and industrial production and traditional dose-response method was difficult to measure the benefit of air quality improvement. CVM is a useful tool to deal with this type of issue because it can obtain a monetary value for an intangible good that does not have market value. In order to do this, CVM provides hypothetical opportunities for consumers to buy public goods and elicits the priorities by asking people about the willingness to pay (WTP), for them, Thus it bypasses the absence of a real market (Wang Yan and Yi-Sheng Zhang, 2008, p.1). CV survey method is implemented for assessing a VPF (Value for Preventing a statistical Fatality) for the air pollution risk of death and this is collected Willingness to pay (WTP) for changes in risk of air pollution. By privatizing public commodity air pollution, they succeeded in eliminating any kind of altruism (on behalf of other people, assess the VPF sample for the risk of air pollution). It is done by implementing a CV survey which collects Willingness to Pay (WTP) for a change in air pollution risk (Chanel, O., & Luchini, S., 2008, p.2). Individual's willingness to pay (WTP) for a specific reduction in air pollution is strongly related to general health risks and the impact of the current level of air pollution on the environment. It is expected from those individuals who were living in the same area, there were similar assessments in the level of air pollution, which was similar to the specific deficiencies expressed in the same area by persons living with a different level of air pollution. Thus, variations in the evaluation of a specific reduction are due to differences between both individuals and areas. (Carlsson, F., & Martinsson, P., 2001, p.17). This CV method is based on two concept willingness to pay (WTP) and willingness to aspect (WTA). the existence of income and replacement effects, transaction costs and property rights factors can be attributed to the divergence between WTA and WTP. In most cases in the empirical studies, WTA values have found to be larger than WTP. Economists generally like to use WTP on WTA, because WTA is not considered convergence validity as well as it does not adequately measure the economic surplus (Maloma, I., & Sekatane, M. B.,

2014, p.4). The losses from air pollution can be measured by how much people are willing to pay to avoid them, or by the minimum compensation which they demand to accept them. The decision to execute it by the WTP or the necessary compensation to recover it can be justified. However, there was one of the most popular discrepancies among the resource economists and behavioural psychologists, economic value is observed inequality between two familiar and perceived equivalent measures of WTP and WTA (Vlachokostas, C., et.al, 2011,p.275).



Chapter- 3

Extent, Dimensions and Negotiation of Carbon Dioxide Emission at Global Level



3.0 Introduction

Numerous environmental issues are raised at a global level such as depletion of natural resources, water pollution, air pollution, toxic chemicals and soil pollution, ozone layer depletion, global warming, and loss of biodiversity. Growth of urbanization and sectoral growth is Continuous increase in population growth along with economic development damage to environment (Anand, S. V., 2013, p.1). In an industrial process, natural resources are used in three stages, i.e., energy production, manufacturing of production and consumption of goods. Then by products waste are generated by these processes and create externalities in the environment. Therefore, these by-products have settled in the water, settled on air and deposited in the soil. This is known as environmental pollution. Basically, the population is highly affected by this pollution and health problem is a burning issue at present time. The result of environmental pollution shows in terms of water pollution, air pollution, etc. Air pollution is directly related to the greenhouse gases (GHGs), which are responsible for climate change. A climatic pattern such as increasing water stress, raising of sea level due to polar ice melting, destruction of the ecosystems, and also increase climatic results like droughts, hurricanes and floods are the main impacts of global climate change. Therefore, the emission of greenhouse gases is a serious threat to human sustainable development globally (Appiah, K., et.al, 2017, p.160).

IPCC (2007) has estimated that global GHGs emission increases due to energy supply (26 percent), forestry (17 percent), industry (19 percent), agriculture (14 percent) and transport with the (13 percent). Out of the total GHG emissions, nearly 74 percent is of carbon dioxide and mainly 57 percent is emitted by the combustion of fossil fuel.

There are many sources of GHGs emissions like energy, forestry industry, agriculture, transport, residential and commercial building. Therefore, all these sources are related to economic development (IPCC, 2007, P.36a). The anthropogenic origin in the atmosphere such as carbon dioxide, methane (CH₄), and nitrous oxide (N₂O) has continuously increased, since the late 19th century. Increasing greenhouse gas in the atmosphere in the last few years the surface temperature has risen by 0.4-0.8°C globally (IPCC, 2007, p.2b).

**Table 3.1: Increase in Selected Atmospheric Greenhouse Gasses,
During to Present Pre Industrial Period**

Gas	Estimated Preindustrial Concentration	2010 Concentration
Carbon dioxide	288 ppm**	391 ppm
Methane	848 ppb***	1800 ppb
Nitrous oxide	285 ppb	323 ppb
Cholorofluorocarbon-12	0 ppt****	530 ppt
Chlorofluorocarbon-11	0 ppt	245 ppt

Source: National Oceanic and Atmospheric Administration (NOAA) Annual Greenhouse Gas Index (2010). Note: **ppm = parts per million, ***ppb = parts per billion ****ppt = parts per trillion.

The concentration of atmospheric carbon dioxide rises from 288 parts per million (ppm) approximately 200 years ago (before the Industrial Revolution began) to 391 ppm in 2010. The burning of fossil fuels such as coal, oil, and gas are most of the human contribution to total carbon dioxide. Basically, transport activity is a key component of economic development and human welfare. Many policymakers suggest that due to the increase in transport activities, several problems are created such as like, traffic and injuries, crowding, air pollution and petroleum dependence. These problems are especially acute in the most rapidly growing economies of the developing world. Transport predominantly depends on a single fossil resource, petroleum that supplies 95 percent of the total energy used by world transport. Transport was responsible for 23 percent of world energy-related GHG emissions with about three quarters coming from road vehicles in 2004 (IEA, 2006). Over the past decade, transport's GHG emissions have increased at a faster rate than any other energy using sector. GHG emission reduction will be only one of several key issues in transport during the coming decades and will not be the primary issue in many areas. Many countries are worried about transport related to local traffic, pollution effects. The global warming issue in the transport sector will have to be addressed in the context of the broader goal of sustainable development.

The world economy has more than tripled over the past forty years. Despite economic growth raised standards of living in most nations, this is also responsible for the

reduction of natural resources and an increase in CO₂ emissions. The levels of emissions of carbon dioxide are related to industrial, economic and social factors (Mardani, A., et.al, 2018, p.32). Due to climate change global warming has become one of the most important issues in recent years as well as CO₂ emissions is the most prominent contributors to global warming. In present time, human activities, mainly fossil fuel consumption such as coal, oil and gas, the main power of source of electricity generation, manufacturing, transport and consumption of goods and services which are directly linked with economic growth, are the main causes for growing CO₂ emissions in the atmosphere (Alam Janifar, 2014, p.36).

3.1 CO₂ Emission and Economic Growth

Global warming and climate change have become a major threat to all nations. World CO₂ emission is rising mostly by the use of fossil fuel in the energy sector and from some part of land use change. The key sectors of the economy use energy are industry, residential, commercial buildings, and transportation. The energy sector is divided into two categories. First is use of primary energy sector like coal, oil, gas which includes mainly manufacturing, construction and transportation. Further the transportation sector is divided into the road, air, rail, and ship and other. The second category includes the use of energy for production of electricity and heat mainly using energy industries. Primary energy sector creates direct emissions while indirect emissions are continuously arising from the use of secondary energy (Anderson, Jason, Fergusson Malcolm and Valsecchi Carolina, 2007, p.1). According to the International Energy Agency (IEA, 2009), the environment and society are getting unsustainable by the current trend of energy supply. It is estimated that primary energy demand will rise by 1.5 percent per year between 2007 and 2030. It is expected that due to increasing energy demand, CO₂ emissions will more than double till 2050. International Energy Outlook estimated in 2006 that world CO₂ emissions from the consumption of fossil fuels are expected to grow at an average rate of 2.1 percent from 2003 to 2030. due to the continued growth of developing countries and economic recovery within the industrialized world, global CO₂ emissions increased by more than 5 percent in 2010 (Jariyapan. P, 2012, p.1).

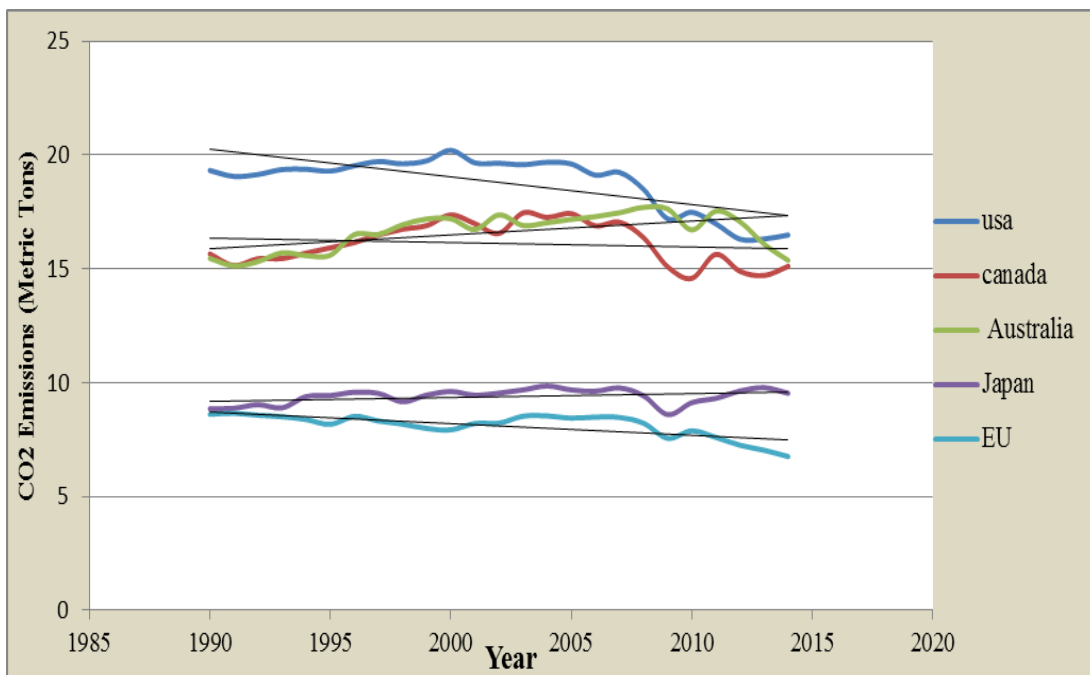
The carbon dioxide emission is responsible for 60 percent global warming. It increases due to economic growth. The relationship between economic development and environmental degradation shows by the Environmental Kuznets Curve. There are some explanations for the inverted U shaped of EKC such as scale effect, composition effect and displacement effect. With scale effect, it is normally assumed that a 1 percent increase in scale returns in a percent increase in emissions. This shows a positive relationship. Composition effect adds to the scale effect that it leads to environmental damage at a faster rate than income. The composition effect acts against but does not fully counteract the scale effect. And the last displacement effect when

economies go through displacement effects, in which rising income is the result of increasing demand for environmental quality (Sinha, A., & Bhatt, M. Y., 2017, p.268). The debate on the issue of GHGs especially carbon dioxide emission is often argumentative during the discussion of Environmental Kuznets Curve. This shows different opinion with the past research while some researcher concluded that there is no EKC relationship with carbon dioxide as well as other pointed to the existence of explicit turning point (Huang, W. M., et.al 2008, p.240).

The chapter is trying to find out the shape of the EKC model and the relationship between economic development and the environment in developed and developing countries. For this empirical study, the data is obtained from the World Bank. Gross Domestic Product purchasing power parity (PPP) per capita GDP data are collected for economic growth and for environmental quality (carbon dioxide emission per capita in metric tons) is the main indicator for this analysis. For this analysis, ten countries have included where five developed nations, viz., United States of America, Canada, Australia, Japan, and European Union and BRICS nations (Brazil, Russian Federation, India, China, South Africa). So we use per capita GDP (PPP) and per capita pollutant emissions (CO₂ emissions) for the developed countries and developing countries for the period of 1990-2014. The data is subdivided countries according to similarities in their CO₂ and GDP relation through the inspection of a trend for individual countries. This is also trying to test the hypothesis and found the presence of an EKC relationship from 1990 to 2014 (Table 3.2A).

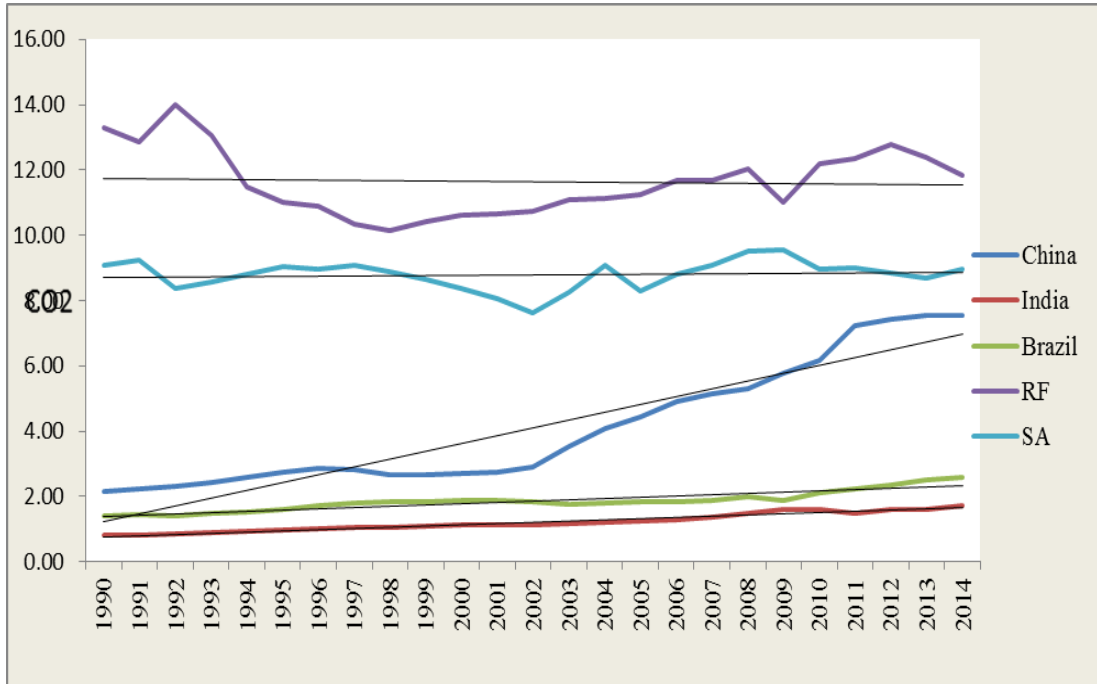
Figure 3.1 shows the trend line of CO₂ emission of the developed nations. Where after 1995 all countries show the fluctuating condition that means with emission is not stable. It is increase and down with the fluctuating condition of economic development. Basically, combustion fossil fuel is the main cause of increasing GHGs emission in USA, while transportation and electricity in Canada, electricity and coal power in Japan, vehicular pollution in EU and Hydrocarbon and petroleum product are responsible for increasing carbon emission in these countries.

Figure 3.1: Trend of CO₂ Emissions in Developed Countries



Source: Estimated from World Bank Data, <https://data.worldbank.org>

Figure 3.2 shows the trend of CO₂ emissions of developing countries, viz., China, India, Brazil, the Russian Federation and South Africa. The trend line of developing countries reflects upward slope over the years with slight fluctuation, because industrial process in China and Russia, agriculture sector in Brazil, domestic demand in India are the main causes for this.

Figure 3.2: Trend of CO₂ Emissions in Developing Countries

Source: Estimated from World Bank Data, <https://data.worldbank.org>

3.1.1 Model Specification

The model shows the linear relationship between CO₂ emissions and GDP in type 1 countries. Linear regression function is used for the period from 1990 to 2014. An empirical model has been developed to find the factors affecting environmental pollution, as follows:

$$Y_t = \beta_0 + \beta_1 X_t + \mu_t$$

Where Y_t = CO₂ emissions per capita, β_0 is a country-specific intercept, X_t GDP per capita (PPP) and μ_t is an error term. Therefore, the model is written as,

$$CO2_t = \beta_0 + \beta_1 GDP_t + \mu_t$$

In 1991 the theoretical relationship between environmental degradation and economic growth is usually described by Grossman and Kruger. The relationship between GDP and CO₂ is non-linear (Allard, A., et.al, 2018, p.5851). Therefore, the model is described as,

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_1^2 + \beta_3 X_1^3 + \mu_i$$

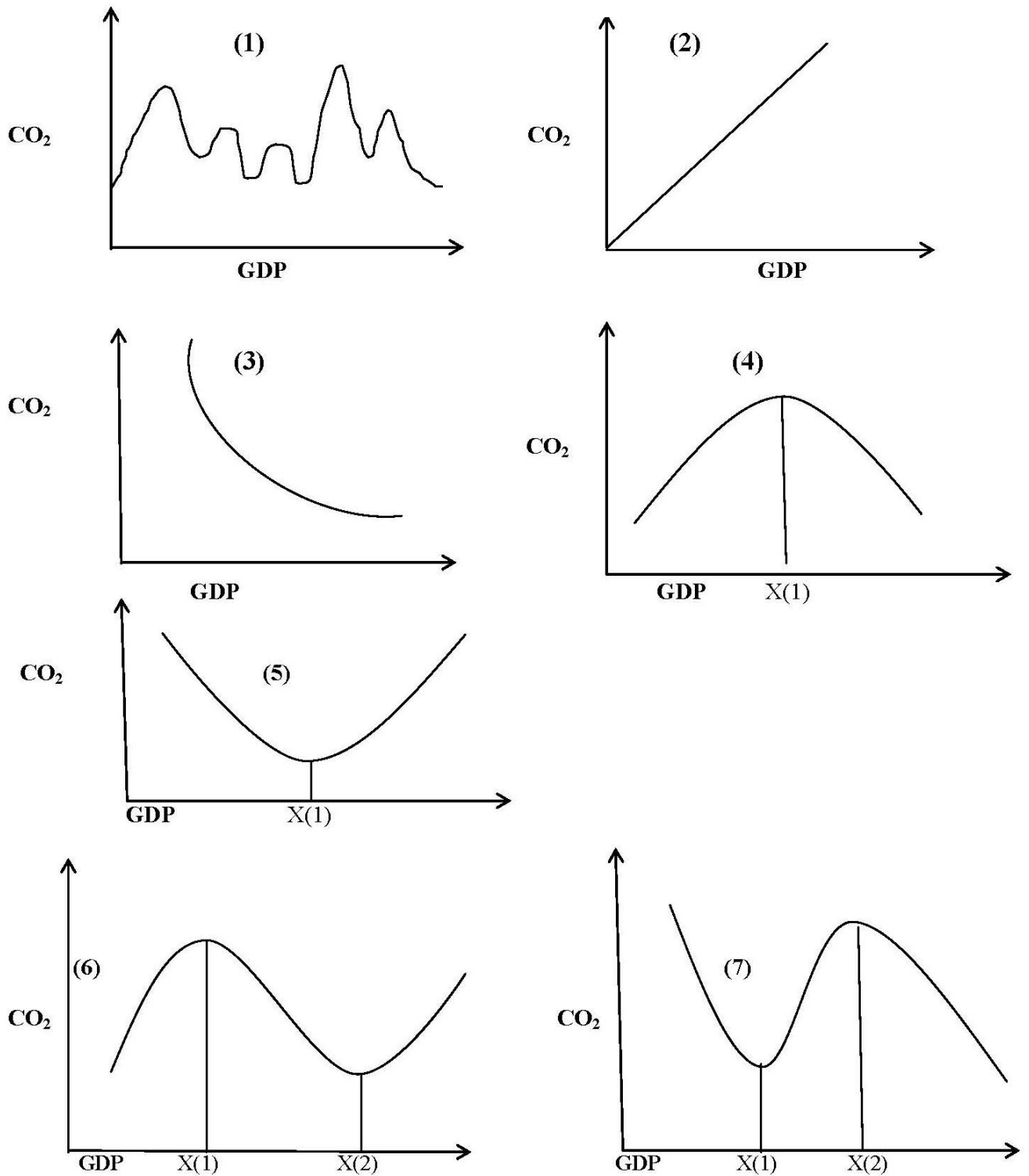
$$CO_2_t = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 GDP_t^3 + \beta_4 Z_{it} + \mu_t$$

Where Carbon dioxide is the dependent variable and GDP is an independent variable and Z contains all other parameters that might affect environmental quality. The β_0 Coefficient involves the average environmental pressure when the income does not have any special relevance, β refer to the slop and importance of the exogenous variables. Basically, the shape of EKC is depended on the sign of the different β parameters related to GDP. The estimation of income and environmental pollution degradation model, EKC was achieved by the following possible results. This shows the different value of coefficient with different shapes such as:

1. $\beta_1 = \beta_2 = \beta_3 = 0 \Rightarrow$ There is no relation between GDP and CO_2
2. $\beta_1 > 0$ and $\beta_2 = \beta_3 = 0 \Rightarrow$ There is a linear or increasing monotonic relationship between GDP and CO_2
3. $\beta_1 < 0$ and $\beta_2 = \beta_3 = 0 \Rightarrow$ There is a monotonically decreasing relation between GDP and CO_2
4. $\beta_1 > 0, \beta_2 < 0$ and $\beta_3 = 0 \Rightarrow$ There is a quadratic relationship with an inverted U-shaped relation between GDP and CO_2
5. $\beta_1 < 0, \beta_2 > 0$ and $\beta_3 = 0 \Rightarrow$ There is a quadratic relationship with a U-shaped pattern between GDP and CO_2 , in direct contrast to the EKC.
6. $\beta_1 > 0, \beta_2 < 0$ and $\beta_3 > 0 \Rightarrow$ There is an N-shaped relationship between GDP and CO_2
7. $\beta_1 < 0, \beta_2 > 0$ and $\beta_3 < 0 \Rightarrow$ There is an inverted N-shaped relationship between GDP and CO_2 (a cubic polynomial an inverted N shape).

The turning points (TP) is calculated by $Y(TP) = \exp(-\beta / 2\beta)$

Figure 3.3: Different Behaviors for the Relationship between CO₂ Emissions and GDP



Source: Lorente, D B., & Alvarez-Herranz, A., 2016, p.16482

Figure 3.3 shows the different behaviour of the environmental Kuznets curve that is linked with the coefficient value of the model. The first graph shows the flat behaviour and it is indicated that the emissions are not influenced by the level of GDP. The second figure shows the linear relationship where a high level of GDP is associated with a high level of CO₂ emissions. Decreasing monotonic relationship shows by the third graph where a high level of GDP is associated with the low levels of pollution. Inverted U-shaped relationship between GDP and CO₂ shows in figure four, where high levels of income are associated with decreasing levels of pollution, beyond a certain level of income. The fifth figure shows the quadratic U-shaped relationship and this is directly different from the EKC. Cubic polynomial N-shaped relationship shows by figure six where inverted U hypothesis occurs at a certain point, after which the pollution rises again. The last graph shows the inverted N-shaped relation between CO₂ and GDP and this also cubic polynomial inverted N shape.

3.1.2 Results & Analysis

Table 3.4: Regression Results of GDP and CO₂ Emissions for Developed Countries during 1990-2014

Country	Variables	Coefficient	t value	P value	EKC Form
USA	(GDP)	.0022853	6.28	(0.000)*	
	(GDP) ²	-3.97E-08	-4.42	(0.000)*	
	(GDP) ³	2.61E-13	3.39	(0.003)*	N Curve
	Constant	1342.635	10.77	(0.000)*	
	R-square	0.9747			
	Adjusted R-square	0.9697			
	Prob. (F statistic)	0.0000			
Australia	(GDP)	.0031959	4.39	(0.000)*	
	(GDP) ²	-7.08E-08	-3.39	(0.003)*	
	(GDP) ³	6.11E-13	2.76	(0.012)*	N Curve
	Constant	1440.42	5.32	(0.000)*	
	R-square	0.8988			
	Adjusted R-square	0.8785			
	Prob. (F statistic)	0.0000			
Canada	(GDP)	.0010706	6.11	(0.000)*	
	(GDP) ²	-1.30E-08	-2.48	(0.003)*	
	(GDP) ³	-2.02E-14	-0.33	(0.744) ^{NS}	
	Constant	462.7698	2.27	(0.034)**	
	R-square	0.8085			

	Adjusted R-square	0.7702			
	Prob. (F statistic)	0.0000			
Japan	(GDP)	-.0007648	-2.52	(0.020)**	
	(GDP) ²	4.37E-08	2.69	(0.014)**	Inverted
	(GDP) ³	-6.39E-13	-2.85	(0.010)*	N Curve
	Constant	215.3895	1.75	(0.096)***	
	R-square	0.4283			
	Adjusted R-square	0.3139			
	Prob. (F statistic)	0.0197			
European Union	(GDP)	-.001076	-1.50	(0.149) ^{NS}	
	(GDP) ²	5.59E-08	2.03	(0.056)***	Inverted
	(GDP) ³	-8.52E-13	-2.37	(0.028)**	N Curve
	Constant	234.4329	2.44	(0.024)***	
	R-square	0.8908			
	Adjusted R-square	0.8689			
	Prob. (F statistic)	0.0000			

Source: Estimated from World Bank Data, (2016).

Table 3.4 shows the regression result of developed countries. The analysis is based on the linear, quadratic and cubic function between CO₂ emissions and GDP. All models are statistically significant and the shape of curve is based on the coefficient values. The analysis of USA and Australia shows the N shaped relationship between CO₂ and economic growth. That means after turning point, level of pollution is again high. While, for Canada, is showing inverted U-shaped relationship. Japan and the European Union show the inverted N shape relationship which means these countries are controlling their emissions from 1990 to 2014 after the turning point.

3.1.3 Panel data analysis

In this analysis panel data used to detect the EKC curve between CO₂ emissions and Economic growth. Turning points of EKC is calculated based on the estimation results. This data helps to identify the dynamics of changes in a short time series. It also provides more powerful regression by considering the place and the time dimensions of the data (Al Sayed, A. R., & Sek, S. K., 2013, p.1085a). The panel data model is written in general form as:

$$Y_{it} = \alpha + \beta' X_i + \mu_{it}$$

Where, i indicate the country and t indicates the temporal year. α is a constant term and β is a vector of coefficients and μ_{it} is the error term.

Basically, two basic models are used for the analysis of panel data, fixed effects model and the random effects model and present consistent estimators for these two models. Panel data is most useful when the outcome variable depends on explanatory variables which are not observable but correlated with the observed explanatory variables. If such exempt variables are stable over time, then the panel data estimator allows estimating the effect of the explanatory variable interpreted continuously (Schmidheiny, K., & Basel, U., 2011, p.1). In fixed effect analysis, it is assumed that the true effect size is the same in all studies and in the random effect, the model assumed that the true effect size varies from one study to the next (Borenstein, M., et.al, 2007, p.4). The fixed effects model has the following form:

$$Y_{it} = \alpha + \beta' X_i + \mu_{it}$$

$$\mu_{it} = \mu_i + \mu_{it}$$

Where α and μ_i are time-invariant or fixed over time. While under the random effects specification the mean error μ_i are randomized. Both error components are considered as random variables with normal distribution which is equally independent distributed (i.i.d.). These error components are unrelated to independent variables. The Hausman test is used to compare between the two estimated models. It is considered as a Wald χ^2 test with $(k-1)$ degrees of freedom where k is the number of regressors in the model. Here, this is used for the comparison of fixed effect and random effect model (Al Sayed, A. R., & Sek, S. K., 2013, p.1085b).

Table 3.5 EKC as a Panel Data in Developed Country (t-statistics in parentheses)

Variables	fixed effect	Cross Section (OLS)
Intercept (α)	13.8 (32.20)	8.55 (3.41)
GDP (β_1)	-.000 (-1.89)	.000 (0.51)
GDP Squared(β_2)	6.36 (3.91)	2.31 (0.24)
GDP Cubed(β_3)	-1.08 (-1.08)	-2.72 (-0.23)
R ²	0.1924	
Adjusted R ²	0.1724	

The results of CO₂ emission show that all values are statistically significant at 1 percent level of significance (Table 3.5). Unit root test of first differentiation is used for the cross section analysis. After the use of Hausman test, fixed effect model is applying for the developed nations. This analysis is also follow the EKC hypothesis.

**Table 3.6: Regression Results of GDP and CO₂ Emissions for
Developing Countries during 1990-2014**

Country	Variables	Coefficient	t value	P value	EKC Form
China	GDP	.000	0.79	0.438 ^{NS}	
	GDP2	7.55	2.88	0.009*	Inverted
	GDP3	-4.00	-3.15	0.005*	U-Shaped
	Constant	2.06	8.92	.000*	
	R-square	0.9857			
	Adjusted R-square	0.9837			
	Prob. (F statistic)	0.0000			
India	GDP	.000	3.18	0.005*	
	GDP2	-7.41	-1.41	0.173 ^{NS}	N-shaped
	GDP3	4.70	0.89	0.382 ^{NS}	
	Constant	.34	2.41	0.025**	
	R-square	0.9683			
	Adjusted R-square	0.9638			
	Prob. (F statistic)	0.0000			
Brazil	GDP	.002	8.88	0.000*	
	GDP2	-1.98	-8.69	0.000*	N-shaped
	GDP3	6.02	8.83	0.000*	
	Constant	-6.17	-7.23	0.000*	
	R-square	0.9677			
	Adjusted R-square	0.9631			
	Prob. (F statistic)	0.0000			
Russian Federation	GDP	.001	3.21	0.004*	
	GDP2	-5.70	-2.26	0.035**	N-shaped
	GDP3	1.13	2.07	0.051***	
	Constant	530.68	8.60	0.000*	
	R-square	0.8106			
	Adjusted R-square	0.7727			
	Prob. (F statistic)	0.0000			
South Africa	GDP	-.008	-2.50	0.021**	
	GDP2	9.06	2.43	0.024**	Inverted
	GDP3	-2.99	-2.34	0.029**	N-shaped
	Constant	36.56	3.34	0.003*	
	R-square	0.3164			
	Adjusted R-square	0.2187			
	Prob. (F statistic)	0.0427			

Source: Estimated from World Bank Data

Table 3.6 shows the result of regression analysis of developing countries. Where F-statistics of all countries models are statistically significant. N-shaped found in most developing countries. China is not statistically significant in the first stage that means GDP is not a statistically significant cause of increasing CO₂ emissions. But it is showing linear upward relationship. India is following N-shaped relationship but in second and third stage it is not significant. Therefore, it shows that GDP is not statistically affecting CO₂ emissions. Brazil and Russian Federation are showing the N-shaped relationship where level of pollution is increasing. South Africa also shows the inverted N-shaped relationship. Therefore. It is concluded that due to increasing economic growth, CO₂ emissions are also increased in most of the developing countries.

Table 3.7 EKC as a Panel Data in Developing Country

(t-statistics in parentheses)

Variables	Random effect	Cross Section (OLS)
Intercept (α)	2.00 (2.96)	-1.48 (-1.31)
GDP (β_1)	.000 (7.31)	.000 (4.75)
GDP Squared(β_2)	-5.03 (-4.62)	-1.65 (-3.73)
GDP Cubed(β_3)	9.45 (3.24)	4.29 (3.53)
R ²	0.3546	
Adjusted R ²	0.3386	
Prob. (F statistic)	0.0000	

Source: Estimated from World Bank Data

Table 3.7 shows EKC model in developing countries. After the using of unit root test and Hausman test, random effect model and cross section data is used. This model does not follow the inverted U shaped EKC hypothesis but also follow the N shaped EKC hypothesis. Which means level of pollution is increasing after the turning point.

3.2 Climate Change and Sustainable Development

The concept of sustainable development does indicate the limits, but not an absolute limit to the use of resources. Therefore, our common future emphasized an approach to development that meets basic needs but is limited by the environment's ability to meet present and future needs. Thus, our common future identified some planned interventions for sustainable development like reviving economic growth, improving the quality of growth while ensuring environmental and social soundness, conserving and enhancing the natural resource base, stabilizing population levels etc. (Katerere Mohamed, 2007, p.8). There are three issues related to climate change, the scientific approach of climate change, economic approach to understand climate change and international treaties on global climate change. The scientific approach of climate is defined as average weather that is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of year. There are four climatic periods found over the past millennium about the change in the warming pattern and cooling pattern of the globe. Medieval warm period (MWP 900-1350 AD) is the first period when the temperature has increased and linked to changes in the strength of the North Atlantic Thermohaline circulation (THC) (Cronin. T.M., et.al, 2003, p.17). The second period is the Transitional period (TP) from 1350-1550, AD when a great variability of climatic conditions found and temperature decreased by about 1.2⁰C at that time. The third period from 1550-1850 is called little ice age (LIA), when the temperature dropped. During the LIA, winter temperatures in combination with atmospheric circulation and ice conditions indicate four cold and three periods. (BACC, I., Team, A., 2015, pp.51-62). Contemporary warm period started after 1850. This period indicates the changes in land-use and other human activities such as biomass burning, deforestation and altered the composition of the atmosphere several millennia ago as well as show the variations in greenhouse gas concentration in terms of ppm (Hawkins, E., et.al, 2017, p.7). Climate change is a world level problem and it has increased. Therefore, its mitigation requires reducing the GHG emissions growth which causes by global warming. The first agreement to limit for global warming to no more than 2⁰C above pre-industrial levels decided in Copenhagen and Cancun and

global GHG emissions must be reduced to within a 2-degree limit (Warner, K., 2013, p.15).

The linkages between economic development and climate change found with the help of GHG emissions. First, consumption and production decision that is responsible for emitting GHGs especially carbon dioxide accounting for around three-quarters of the human-generated global warming. Second accumulation into stocks of the GHG in the atmosphere and third is stock converting into heat and results in global warming indicate climate sensitivity. Forth, climate change is a result of the process of global warming. Last, climate change affects people, species, and plants as well as water shape in form of storms, floods, droughts, sea-level, rise (Stern, 2008, p.1). The implications of growth for emissions, examining the economics of technological options, calculating the social costs of carbon as well as exploring tax, market and other structures are focused in the economics of climate change (Stern, 2006, p.5).

Basically, economic debate on climate change include many approaches such as business as usual (BAU) that estimates the carbon concentrations expected to double pre-industrial levels within next half century and predicted mean temperatures to rise by about 1⁰C by 2050 and 2.5 degrees by 2100 (Hanley, N., & Owen, A. D, 2004, p.79). The gradualist approach addresses the modest action in the reduction of GHGs emission in the near term and a sharp reduction in the medium and long term. With the gradual concentration of GHG emission through increased carbon taxes as scientific evidence for increased future global warming becomes more evident. The modelling of global warming in this approach is based on the estimates of damage costs of the future warming trends, economic conditions and time horizons (Hussain. M. A., 2007, pp.10-13). Last is the precautionary approach that is related to aggressive programs of international abatement of GHGs in the near term. It is a long term approach based on 200 to 300 years. When the cost-benefit analysis is conducted from a very long term perception then a more aggressive GHGs emissions abatement program is justified by the precautionary method.

3.2.1 International Treaties on Global Climate Change

In 1979, first world climate conference introduced climate change as an urgent world problem and issued a declaration calling on world government to foresee and prevent

potential man-made changes in the climate that is adverse to the well-being of humanity. Under the joint responsibility of World Meteorological Organisation (WMO), the United Nations Environment Programme (UNEP), and the International Council of Scientific Unions (ICSU), World Climate Programme (WCP) authorized plan was established (UNEP, 2001, p.17). To assess the magnitude and timing of changes, estimate their impacts and present strategies for how to respond, Intergovernmental Panel on Climate Change (IPCC) established by the WMO and UNEP in 1988. The first assessment report on the state of the global climate of IPCC shows the strong effect on policymakers and on public opinion. For negotiations under the United Nations General Assembly on climate change conventions, it became the main basis in 1990 (Blodel, D., et.al, UNFCCC, 2006, p.20a).

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the Earth Summit in Rio de Janeiro 1992 by 196 parties and nations of the world agreed to create for the first time a government structure for the future climate change negotiations. The ultimate objective was to stabilize greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. In Berlin 1995, the first session of COP-1 (Conference of the Parties) held where 117 parties were included. They agreed for the institutional and financial machinery needed to support an action under the convention in the upcoming years. In 1997 the Kyoto Protocol was adopted at COP-3 and 37 developed nations have negotiated to limit GHG emission. This agreement certain by the law of nations-requires worldwide greenhouse gas emission to be cut by 5 percent compared to 1990 levels by early in the next century 2008-2012 (UNFCCC, 2011, p.1).

3.2.1.1 CBDR

Common but Differentiated Responsibilities (CBDR) was one of the major discussions taken in Kyoto. It is the most effective principle in the international environmental law legal regime. There are two fundamental elements of CBDR. First, common responsibility and second differential responsibilities. Common responsibility applies where the resource is shared, under the control of no state, but subject to a common legal interest. Second is a concern that need to take into account

the differing circumstances, particularly each state's contribution to the evolution at a particular problem and its ability to prevent, reduce control the threat. Their aim is to promote substantive equality between developed and developing countries within a rule, rather than formal equality (Zaccai Edwin, Lugen Marine, 2014, p.2). Basically, CBDR concept relates to the international laws, governing resources labelled as "Common Heritage of Mankind" or of common concern.

There are seven principles already found in Rio declaration 1992. When developed nations accept the responsibility that they bear in the international pursuit of sustainable development in terms of pressures their societies place on the global environment and of technologies and financial resources. But developing countries hesitated to commit themselves to reduce target when they had historically not contributed to global. Kyoto protocol listed the Annex to the convention, where developed countries involved in Annex I group and developing include in Annex II group. These groups were differentiated in terms of their emissions reduction, the obligation of corporation towards technology transfer, implementation rules and provision of support in terms of financial aid for mitigation and adaptation to developing countries through the Global Environmental Facility (GEF) (Paula Castro, 2016, p.2).

Kyoto protocol, states that the Annex1 (developed nations) should reduce their overall emissions of Green House Gases (GHG) by at least 5 percent below 1990 levels in the commitment in the period 2008 to 2012 (UNFCCC). The developing countries are under no such responsibility, but at a global level in developing countries also generate high GHG emissions. The 5 percent reduction is a differentiated responsibility of all developed nations compared with developing nations.

Table 3.8 Quantified Economy-Wide Emissions Target For 2020 (in percent)

Countries	Low pledge	High pledge	Historical base year	In 2014, CO ₂ Per Capita Emissions (Metric tons)
Australia	15	25	2000	15.3
Canada	-	17	2005	15.11
European Union	20	30	1990	6.7
Japan	-	25	1990	9.5
USA	-	17	2005	16.4
Russian Federation	15	25	1990	11.8
China	40	45	2005	7.5
India	20	25	2005	1.3
Brazil	-	36.1to38.9	BAU	2.5
South Africa	-	34	BAU	8.9

Source- United Nations Framework Convention on Climate Change, (2010) <https://unfccc.int/>

The 5 percent reduction is the common responsibility of all developed nations. But based on their capability all developed nations have different commitment. Australia has committed that it will reduce 5 to 15 percent emissions till 2020 and the USA will also reduce 16.4 percent and European Union will deduct 20 to 30 percent and Japan also will reduce 25 percent target period. China will reduce 40 to 45 percent emissions according to the base year and India will also reduce 20 to 25 percent. Basically, pledges are not specified aspects like which sectors or gases are covered or which methodologies are used for estimating expected reductions. Therefore, it is challenging to track progress towards fulfilment of pledges, to estimating resulting emissions reductions, and to assess whether overall global emissions reduction are acceptable for meeting global temperature limits (Levin, K., & Finnegan, J. 2011, p.1).

3.2.2 Flexibility Mechanisms in the Kyoto Protocol

In the Kyoto Protocol, another rule established known as flexibility mechanisms. These are emissions trading, joint implementation and the clean development mechanism. The meaning of emissions trading is that the possibility for those nations that have assumed commitments regarding the limitation of emissions to sell their emissions rights, their right to pollute, to other Annex II countries in the commitment period (Estapa. J. Saura, 2004, p.113). This is a market-based instrument that potentially permits countries to meet their Kyoto commitment more cost-effectively than common and control policy approaches. Therefore, this trade allocation is based on the rights to emit or emissions quotas between countries (Heyhoe, E., et.al, 1998, p.11). The second mechanism is the Clean Development Mechanism (CDM), it is the ability to develop countries to sustain sustainable development by promoting environmentally friendly investment from governments and businesses of industrial countries. It can help to improve economic, social, environmental, sustainable development, employment, poverty, and reduced dependency on imported fossil fuels by the funding facilities in developing countries (UNEP, & Olhoff, A., 2004, p.14). While joint implementation projects are the projects of reduction in emission reductions made in the Kyoto Protocol from industrialized countries or transit countries (Annex I parties) with the aim of reducing emissions. They are defined in Article 6 of the Kyoto Protocol and also known as emissions reduction units (ERUs) (Mortier Laurence, Yvan Keckeis, Sebastien Bloch, 2014, p.9). This mechanism was finalized in CoP-4 Buenos Aires as well as some other important issue raised such as financial mechanisms which assisted the developing world to respond to the challenges related to climate change, development and transfer of technologies (IISD, 1998, P.5).

CoP-6 (2000) in Netherland changed some decisions and negotiation over major political issues and the USA and some other countries still have political problems with the Kyoto Protocol while EU was playing a vital role in making Kyoto agreements a reality. USA proposal to allow credit for existing carbon sinks in forests and agricultural lands that would satisfy a major proportion of the U.S. emission reductions (Metz, B., et.al, 2001, pp.167-178). In COP-13 Bali Action Plan 2007 also

recommended a cut in carbon emissions 25 to 40 percent in the advanced industrial countries by 2020 and total world emission reduction of 50 percent by 2050 (Christoff, P, 2008, pp.467-468). As well as, developing nations agreed to follow the reduction of CO₂ emission targets. These countries delegated agreed that “nationally appropriate mitigation action” should be developed in China, India, Brazil and the other emerging industrial countries, “supported by technology and enabled by financing and capacity-building and technology concept arise in this summit (Carpenter, C., 2008, p.3).

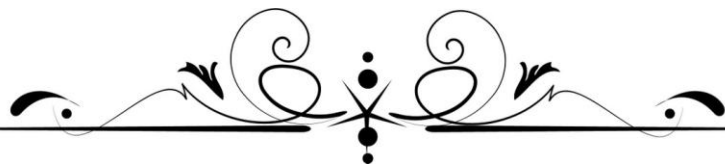
For controlling climate change problem other progress was found in the CoP-15 Copenhagen Conference 2009. The aim of this conference was 2 degree Celsius limit to global warming and also decided to establish a Green Climate Fund to provide long-term financing to poor countries to enable them to adapt to climate impacts. The mitigation in developed countries (Annex I) is “commit to implementing” economy-wide emissions targets for 2020, and developing countries (Non-Annex I) will implement mitigation (UNFCCC, 2010, pp.5-7). The Copenhagen Agreement was an ill-conceived, the collusive deal between a handful of countries which undermined the agenda of ambitious climate actions, including deep economy-side emissions cuts by the North, transfer of substantial funds to the South, and strong action by the big fast-growing Southern countries to their emissions below BAU scenarios (Praful Bidwai, 2012). Durban conference (2011) it was decided that to focus the cooperation on clean technology as well as forest protection, adaptation to climate impacts and finance and rich countries should try to help poor countries and the promised transfer of funds from rich countries to poor in order to help them protect their forests, adapt to climate impact and “green” their economies. In this conference led to agreement on a management framework for a future Green Climate Fund. The Fund is targeted to distribute \$ 100 billion per year to help poor countries adapt to climate impacts (Center for Climate and Energy Solutions, 2011, pp.1-2).

The Green Climate Fund (GCF) is an international financial institution which is connected to the UNFCCC. It was established in the Copenhagen conference (2009) and design in the Durban conference (2011). The main aim of the GCF is to assist developing countries in their efforts to fight climate change through the provision of grants and other concessional financings for mitigation and adaptation projects,

programs, policies and activities. In Cancun (2010), it was commitment by developed country to provide new and additional resources approaching \$30 billion for the period 2010-2012 to address the needs of developing countries and developed countries to achieve a goal of organizing jointly \$100 billion per year by 2020 to address the needs of developing countries (Lattanzio K Richanr, 2014, pp.1-4).

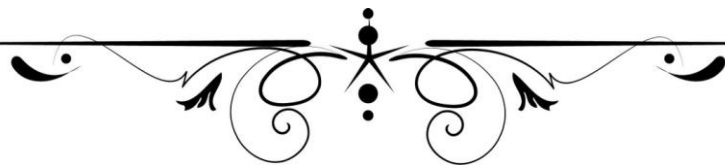
Doha summits were the turning point of international climate policy and the first time that it previously divided negotiation lines between developed and developing countries, it was showing the new global agreement for all countries (Netzer Nina, 2012). At COP 18 (Doha Conference, 2012, p.1) the countries that had agreed to reduce their GHGs emissions by 5 percent over the 1990 levels in the first commitment period (2008-12), now made commitments to reduce their overall emissions of such gases by at least 18 percent measured from the same period. However, Japan, Russia and Canada, three of the world's highest emitters of carbon-based greenhouse gases walked out of the agreement. The USA the world's largest emitter some years ago presently the second largest emitter after China, never ratified the Kyoto Protocol and promises not to do so it's extended phase either. It is also pointed out here that the commitment to reduce GHG emissions by 18 percent by 2020 from the 1990 level is much less than the 25-40 percent required restricting the global temperature rise to 2 degree Celsius. Paris conference CoP-21 target is the limit of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways and bottom-up by parties of Nationally Determined Contribution (NDCs). NDCs are the high-level policy plans setting out which indicates that what approach each country will take to reduce emissions and contribute to the global well-below 2° C goal where pledge are called Nationally Determined Contribution (Council, C. 2015, p.1).

It is observed that climate change is continuously increased while many rule, agenda, and target decided after the Kyoto protocol. Due to CO₂ emissions, global warming increasing day to day that is dangers for human health. Economic development is also the main factor for this. Developed and developing countries are committing but no control of GHGs emission especially carbon dioxide emissions.



Chapter- 4

Air Pollution in India: Acts, Institutions, Mechanisms & Budgeting



4.0 Introduction

Rising urbanization is a major reason for environmental concerns in India in terms of change land use pattern, increasing carbon emissions, solid waste generation and disposal, air and water pollution and poor sanitation amenities (Sridhar S. Kala & Surender Kumar, 2013, p.22). Air pollution is a major cause of health damages and it increases morbidity and mortality in urban areas of India. The common sources of air pollution are stoves at home, motor vehicles, industries and forest fires. Outdoor air pollution is due to the production of goods & services based on national and international policies in various sectors such as clean energy for cooking and other domestic needs, transport, energy waste management, buildings and agriculture.

Natural and anthropogenic both causes are responsible for air pollution. In urban areas, man-made sources are classified in terms of mobile cars, trucks, aeroplanes, marine engines, etc., and point sources like factories, electric power plants, etc. Further, road traffic is a major source of air pollution in big cities of developed countries. Combustion of carbon constituted fuel viz., coal, fuel oil, wood, and natural gas is never complete and it produces carbon monoxide (CO) and hydrocarbons (Pénard-Morand, C., & Annesi-Maesano, I., 2004, p.110). For developing countries like India, rapid industrial growth and urbanization has challenges of balancing between economy and environment. Therefore, human health is continuously getting affected. Air pollution is associated with increased risk of acute respiratory infection (ARI) that is principle cause of infant and child mortality in developing countries (Haque, M., & Singh, R., 2017, p.2). Lungs and heart diseases is directly associated with the size of the pollutant in the atmosphere. Premature death in people with heart and lung diseases including cardiac dysrhythmias, heart attacks, asthma and decreased lung functions are affected by the fine particles. Some respiratory diseases such as cough breathing problem etc. are also the resulted from air pollution as well as an increase of cardiopulmonary and lung cancer mortality are the main causes for the reduction in life expectancy (Ghorani-Azam, A., et.al., 2016, p.3). Due to outdoor air pollution, 0.62 million premature death cases found in 2005 and 0.69 million in 2010 in India. The total economic cost of health impacts due to outdoor air pollution was about US\$ 80 billion in 2010, which was equivalent to 5.7 percent of Indian GDP (Maji, K. J., Dikshit, A. K., & Deshpande, A ., 2017, p.832).

4.1 Developments of Air Pollution (Prevention & Control) Acts in India

The constitution of India has a number of provisions for the responsibility of the central and state/government towards environmental protection. Some constitutional articles (39, 42, 47, and 48) are indirectly dealing with the subject of environmental pollution and protection in the former constitutional law of India. While 42nd constitutional amendment in 1976 has been accepted in response to the Stockholm International Conference on Human Environment in 1972 and that came on 3rd January 1977 for effect (Bhave, P. P., & Kulkarni, N., 2015, p.259). Basically, article 49(A) is related to the amendment imposed a responsibility on every citizen in the form of fundamental duty of the state and it also includes fundamental duties for every citizen in article 51-A(g). That is related to protect and improve the natural environment including forests, lakes and wildlife and to have compassion for a living creature. To make any law for the whole or any part of the country for implementing any treaty agreement or convention with any other country, parliament has power through article 253. This suggests that in the wake of the Stockholm Conference of 1972, Parliament has the power to legislate on all matters linked to the preservation of the natural environment. That is also used to pass the acts related to Air and Environment Act confirms. Therefore, this act was enacted to implement the decisions reached the Stockholm Conference.

Many enactments are linked to health, pollution and environment in India. In due course of time, following environmental prevention & pollution control acts were implemented in India.

1. The Water (Prevention & Control of Pollution) Act, 1974
2. The Water (Prevention & Control of Pollution) Cess Act, 1977
3. The Air (Prevention & Control of Pollution) Act, 1981
4. The Environment (Protection) Act, 1981
5. The Motor Vehicles Act, 1988
6. The Public Liability Insurance Act, 1991
7. The National Environmental Tribunal Act, 1995
8. The National Green Tribunal Act, 2010

Several rules, agencies and acts are implemented by the Indian government for pollution control. These were also developed as an administrative mechanism for the implementation of these Acts and environmental protection (Gargava Prashant, et.al., 2000, p.2). Today, the reduction of outdoor air pollution is a major challenge in Indian in most polluted cities viz., Delhi, Kanpur, Allahabad, Lucknow etc. Many acts are related to the air pollution, which were initiated after independence in India. The Factories Act, 1948 was the first act that was indirectly focusing on air pollution. This law was regulating labour in factories. Chapter III of this act is focused on health which includes ventilation and temperature, dust and fume, and artificial humidification in section 13, 14 and 15 (GOI, Ministry of Labour Report, pp.18-21). The Mines Act, 1952 was indirectly linked with air pollution. It was created to limit the ventilation, action to be taken in respect of dust fire and inflammable and noxious gases and also including the precautions against spontaneous combustion, coal dust and underground fire. Further, the Atomic Energy Act, 1962, that was related to the health and safety from radioactive substances. By radiations to any radioactive substances affected to the health of persons employed, it prevents injury and in under sub-section (2) of section 17 was regulating the transport of such prescribed substance, which are declared harmful to health (GOI, Department of Atomic Energy Report, pp.10-16). To prevent radioactive hazards workers safety guarantees, public dealing with radioactive substances and the proper disposal of radioactive waste norms has laid down by the Government under this Act (Raut Anand, 2013, p.17).

4.1.1 The Air (Prevention and Control of Pollution) Act, 1981

This was the first act that was totally linked with air pollution. In India, the air (Prevention and Control of Pollution) act, 1981 was legislated to provide for the prevention, control and abatement of air pollution. It was enacted to take appropriate steps for the protection of the nature of the earth, which among other things include the preservation of the air quality and control air pollution (Government of India, 1981, p.1). This Act describes air pollutant as any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to a human being or the other living the creatures or plants or property or the environment. The objectives of the Acts are first, prevention, control and abatement of air pollution Second, the establishment of central and state pollution

control boards to implement the aforesaid purpose, and Third, to maintain the quality of air.

4.1.2 The Environment (Protection) Act, 1986

This act came to provide protection and improvement of environment and matter connected therewith the decisions were taken at United Nations Conference on the Human Environment held at Stockholm in June 1972 and it was necessary to further implement the decision to the protection and improvement of the environment and prevention of hazards to a human being, other living creatures, plants and property (CPCB, 2010, p.267).⁵ Under this act, the duty of Central Government was to set national ambient and emissions standards, establish procedures for managing hazardous substances, regulate industrial siting investigate and research pollution issues and establish laboratories and collect and disseminate information. Every polluting facility must submit an Environmental statement at the end of each financial year according to the National Environmental (Protection) Rules of 1986. These statements are related to air pollution such as air and water pollution discharged by a parameter that is based on average daily quantity and percentage of variation from the prescribed limit, hazardous waste generation, solid waste generation and disposal, and pollution abatement measures implemented (Organization for Economic Co-operation and Development, 2006, pp.6-17). Other points also found of this act that is helping as a support act for many other rules and laws, Such as from 1995 in metropolitan cities, there was a notification on free petrol and catalytic converters for vehicles (Bhave, P Prashant & Kulkarni, Shirish Nikhil, 2015, p.260).

4.1.3 Motor Vehicle Act, 1988

In the Air Act, 1981, section 20 is related to automobile pollution which regulates all aspects of road transport vehicles. It came into force from 1st July by replacing Motor Vehicles Act, 1939. In this Act, changes in the road transport technology, the pattern of passengers and freight movements, developments of the road network in the

⁵ Saheb Ussain Syed, Seshaiyah Sepuri & Viswanath Buddolla (2012, p.45), After the Bhopal disaster of 1984, parliament took action and ordered to create overarching national environmental legislation for enacting the Environment Protection Act. For this industrial disaster, Government of India filed a case in U.S Court for a claim of \$3.3 billion against the Union Carbide Corporation (UCC) in February of 1985. But all of these litigations in the U.S District were transferred to India transferred to India on the ground of forum non-convenient by 1986. That means the case should be transferred to a more convenient forum which can handle smoothly.

country and better techniques in the motor vehicles management are mentioned. Therefore, the Motor Vehicle Act, 1988 came to improving the environmental quality especially air quality.

Further, it means National Environment Tribunal was established under section 8 of this Act. For effective and expeditious disposal of cases arising from such accident, with a view to giving relief and compensation for damages to person, property and save to environment. The National Environmental Tribunal Act, 1995 provide strict liability for damages (MoEF, 1995). Subsequently, the Ministry of Environment and Forest enacted the act namely The Ozone Depleting Substances (Regulation and Control) Acts, 2000. In this Act, prohibition and regulation of production and consumption of ozone-depleting substances are enacted (MoEFCC, Report, 2000). Furthermore, in 2010, the National Green Tribunal Act was established under Article 21 of the Indian constitution. It was deal with environmental related legislation. Tribunal has jurisdiction over all civil cases are related environmental issues mentioned in Section 14 of the National Green Tribunal Act (Patra, S. K., Krishna V Venni, 2014, p.14). This act was tried to seek effect to promise made at Rio and to provide for effective and expeditious disposal of cases related environmental protection, forests and natural resources and provide relief and compensation for damage (Fatima Sumbul, 2017, p.44).

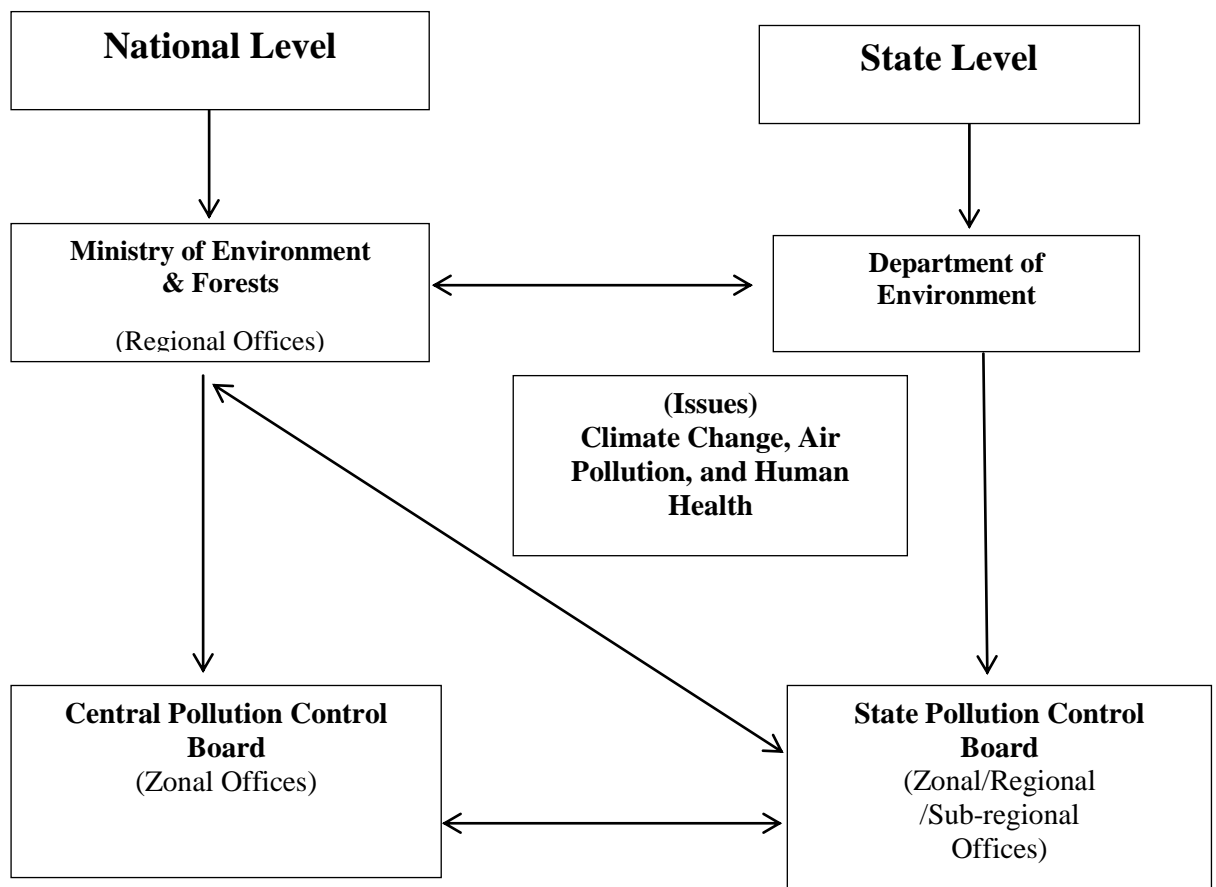
India has also pledged to control its air pollution based on the agreement at the international level organization, viz., UNFCCC. The purpose of the signed Basel Conference, 1989, was that it was related to reducing the movements of hazardous wastes among the developed countries that indirectly assist in the problem of air pollution. It was indicating the targets to reduce the generation of toxic wastes, to make sure the waste management was close to sources and to help less developed nations for waste management. The Stockholm Convention on Permanent Organic Pollutants, 2002 was a conference for a global treaty to control and reduce the use of organic pollutants (POPs) to protect human health and the environment. For developing countries and at least developing countries, the Lima Climate Change Conference, UNFCCC, COP20, 2014 has taken another step to implement the National Optimization Plan on Climate Change. For multilateral negotiations in

UNFCCC for Climate Change, the Indian government has set up a national work plan for climate change in 2008 with eight national missions.

4.3 Administrative Structure for Air Pollution Protection

The ambient air quality is monitored jointly by CPCB, SPCBs, Pollution Control Committees (PCCs) and National Environmental Engineering Research Institute (NEERI). Air pollution status of various pollutants is defined in terms of Low, Moderate, High and Critical category, vis a vis the notified ambient air standards. The administrative structure is based on central level and state levels on various environmental issues that have been well defining in the constitution of India. Various institutes are working at centre and state level under the government of India (Appendix).

Figure 4.1: Administrative Structure of Control Air Pollution in India



The Ministry of Environment & Forest was established in 1985 by the Government of India. It is the nodal agency in the administrative structure of the central government that is making planning, promotion, co-ordination and overseeing the implementation of environmental and forestry programs and policies. It includes some main activities such as conservation and survey of flora, wildlife and forest, prevention and control of pollution, afforestation and regeneration of degraded areas, protection of the environment etc. (MoEF, 2010, p.1). It fulfils the objective and goal by the surveys, impact assessment, and control of pollution, regeneration programmes, and support to institutions, and research to solve environmental problems, and creation of environmental awareness among all sectors of society in the country. Furthermore, it included a provision to establish the Center Pollution Control Board (CPCB) and State Pollution Control Board (SPCB). On 29 March 1981, the Air (Prevention and Control of Pollution) Act also established by the Ministry of Environment and Forest to control air pollution. Climate Change was already a responsibility of the Ministry, therefore in 2014 the name changed to Ministry of Environment, Forest and Climate Change.

4.2.1 Center Pollution Control Board (CPCB) and Air Pollution

Under the water (Prevention and Control of Pollution) Act, 1974, the Central Pollution Control Board (CPCB) a statutory organisation was constituted. Further, it was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. CPCB is legally and statutorily under Section 3 of Water/Air Acts. It was established to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution as well as improve the quality of air and prevent air pollution in the country level (CPCB, 2018). Basically, the Air (Prevention and Control of Pollution) Act, 1981, the Air (Prevention and Control of Pollution) Act, 1982, the Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983, the Environmental (Protection) Act, 1986 and The Environment (Protection) Rules, 1986 are under the preview of CPCB. The State Board shall be constituted by the State Government according to Section 4 and it is called as State Pollution Control Board (SPCB).

4.2.2 Function of CPCB

CPCB function comes under both the national level and as State Board for the Union Territories. There are many national level CPCB following function viz., (a) advise the Central Government on any matter concerning prevention and control of water and air pollution (b) Co-ordinate the activities of SPCB committees (c) provide technical assistance and guidance to the State Boards and PCCs (d) plan and organize training programmes (e) organize through mass media a comprehensive program regarding the prevention and control of water pollution (f) collect, compile and publish technical and statistical data relating to water and air pollution, prepare manuals, codes and guidelines relating to treatment and disposal of wastes, and disseminate information in respect of matters relating to water and air pollution (g) lay down, modify, water and air quality standards (h) plan and cause to be executed a nation-wide programme for the prevention, control or abatement of water pollution (CPCB, 2010, p.14). For air quality measurement, CPCB is run nationwide programs and there are 621 operating stations in this network covering 262 cities/towns in 29 states and 5 Union Territories. Four air pollutants such as sulfur dioxide (SO₂), nitrogen oxides NO₂, suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM / PM₁₀) have been identified for regular monitoring at all places.

4.2.3 National Ambient Air Quality Standards (NAAQS)

In 1982, the Central Pollution Control Board had adopted the first ambient air quality standard as per section 16 (2) (h) of the Air Act, 1981. That was revised in 1994 by the Central Pollution Control Board and notified in Gazette of India and in extraordinary Part-II Section 3, and subsection (ii). The ambient air quality standards were established for the effective management of ambient air quality and to reduce the damaging effects of air pollution in India. Some main objectives are related to air quality standards such as it indicates the level of air quality necessary with an acceptable margin of safety to protect the public health, vegetation and property. In establishing priorities for abatement and controls of pollutant level, measuring the air quality at the national level and indicate the need and extent of the monitoring programme (Table 4.1 A).

4.2.4 National Air Quality Monitoring Programme (NAMP)

At that time, it was needed to assess the present and anticipated air pollution through continuous air quality survey or monitoring programs. Therefore, the National Ambient Air Quality Monitoring (NAAQM) Network was started during 1984-85 by the Central Pollution Control Board at the national level. In 1984, there were seven monitoring stations with Agra and Anpara. Subsequently, the programme was renamed as National Air Quality Monitoring Programme (NAMP) (CPCB, 2006, pp.1-8). These monitoring stations were continuously growing from 365 in 2009 and 456 in 190 cities in 26 states and 5 Union Territories as of 31st March 2011 (CPCB, 2012, p.3). The number of operating monitoring station in 2016 under NAMP has again increased steadily that is 614 covering 254 cities across the country (CPCB ENVIS, 2016, p.6). Some objectives of NAPM are to determined the status and trends of ambient air quality. It determines further, identify the ambient air quality, identify non-acquiring cities, acquire the knowledge and understanding needed to develop preventive and corrective measures, and dilute the dispersion, pollution weakening, air-based movement, dry medium Understand the cleaning process in the environment from pollutants, rain and chemical changes (CPCB, 2009, p.7). Under this programme, there were four pollutants included viz., Sulphur Dioxide (SO₂), Nitrogen Oxide (NO₂), Suspended Particulate Matter (SPM), and Respirable Suspended Particulate Matter (RSPM) which are regularly identified and monitored all locations.

4.2.5 Revised National Ambient Air Quality Standards (NAAQS), 2009

National Ambient Air Quality Standards are revised in 2009 by the Ministry of Environment and Forest (MoEF), Government of India. Where, a new standard applies only to two areas, which are industrial, residential, rural and other areas and are ecologically sensitive areas notified by the Central Government. Some new pollutants are also included in this standard, such as particulate matter size less than 2.5 microns, ozone, ammonia (NH₃), benzene, benzo (A) pyrene (BAP), arsenic (AS) and nickel (Ni) (<http://dmc.kar.nic.in>) (Table 4.2 A).

Supreme Court of India had the orders in 2001 regarding formulation and implementation of action plans for control pollution in selected cities. It further directed initiatives relating vehicular pollution in Delhi and should be prepared that action plan for pollution control in the polluted cities and towns, which do not meet the ambient air quality standards. The action plan presents arrange the list of

abatement and another measure to improve air quality to maintain pre-described levels in the short and medium terms (CPCB, 2006, pp.16-17). According to CPCB, due to air pollution, seventeen cities in India are highly affected and facing many problems. These are Agra, Ahmedabad, Bangalore, Chennai, Delhi, Hyderabad, Kolkata, Lucknow, Kanpur, Faridabad, Jodhpur, Patna, Pune, Solapur, Varanasi, Jharia, and Mumbai.

Table 4.1: RSPM & NO₂ in Cities in India

Cities	NO ₂ (µg/m ³)	RSPM(µg/m ³)
Agra	20	185
Ahmedabad	21	95
Bangalore	31	89
Chennai	15	59
Delhi	55	261
Hyderabad	24	79
Kolkata	66	99
Lucknow	34	204
Kanpur	34	203
Faridabad	29	164
Jodhpur	22	181
Patna	40	181
Pune	39	82
Solapur	35	66
Varanasi	20	127
Jharia	38	237
Mumbai	19	97

Source- CPCB, 2010

Table 4.1 shows the high pollution affected seventeen cities in India that includes the respirable suspended particulate matter (RSPM) and nitrogen oxide (NO₂) pollutant. The condition of RSPM is high in India's capital city Delhi as well as Jharia city, but the condition of NO₂ is high in Kolkata, Delhi and Patna cities. Basically, there are four cities of Uttar Pradesh involve in the index, which are Agra, Kanpur, Lucknow and Varanasi. The NO₂ condition is the same in Agra and Varanasi. Kanpur is an industrial city and it is known as the Manchester of the East and the economic capital of Uttar Pradesh. The condition of the pollutant is NO₂ 34 µg/m³ and RSPM is 203µg/m³. But is the present time Lucknow pollution is also growing with the increasing rate. Because the condition of RSPM is high compared than Kanpur city which is 204 µg/m³ and it is 211 µg/m³ in 2012 (CPCB, 2014) and the NO₂ is same as the Kanpur. Therefore, Lucknow is the most polluted city of Uttar Pradesh as well as

India. Approximately 60 percent of air pollution in all major cities is caused by vehicles only. This has observed that the effect of these pollutants at an acute level on sensitive species, both plants and animals (Prasad Dipak and Sanyal Srabani, 2016, p.53).

4.3 Mechanism to Control Air Pollution

4.3.1 Air Quality Index (AQI)

The concept of the Air Quality Index was developed and used effectively in many developed nations for over the last three decades. It defines the transforms weighted value of individual air pollution related parameters (SO₂, NO₂, CO, etc.) into a single number or set of numbers. In the starting, there were no significant efforts to develop and use AQI in India. Therefore, some problems are facing for monitoring air quality. Two dimensions are related to this that translates the complex scientific and medical information into simple and precise knowledge and second is communicate with the citizen in the historical, current and futuristic sense. Air Quality Index is making to make decisions to prevent and minimize air pollution exposure and ailments induced by the exposure (CPCB, 2014, p.1). Central Pollution Control Board has initiated this project on National Air Quality to collect air quality information for public awareness and their participation in air quality management. The major objectives are related to the Air Quality Index such as for inform public regarding the overall status of air quality through parameters for easy to understanding, associated health impacts of air pollution exposure, and rank cities town for prioritizing actions based on a measure of AQI. Air pollution affects human health and some' pollutants are dangers of health, therefore, air quality index has developed the pollutant related health index and measure the air quality in terms of cubic meter for 24 hours.

4.3.2 Particulate Matter

Particulate matter in the air is a mixture of particles from primary sources (direct emissions to the atmosphere) and secondary sources (chemical transformation in the atmosphere). Basically, main sources of particulate matter in the atmosphere are vehicular emissions, construction industries, industrial combustion processes, vehicular emissions and commercial and residential combustion. Various types of short term and long term health effects generate by PM₁₀.⁶

⁶ According to national air quality index 2015, the break point concentration for various categories of particulate matter is 50 (good), 100 (satisfactory), 250 (moderate), 350 (poor), 430 (very poor) and 430+ (severe).

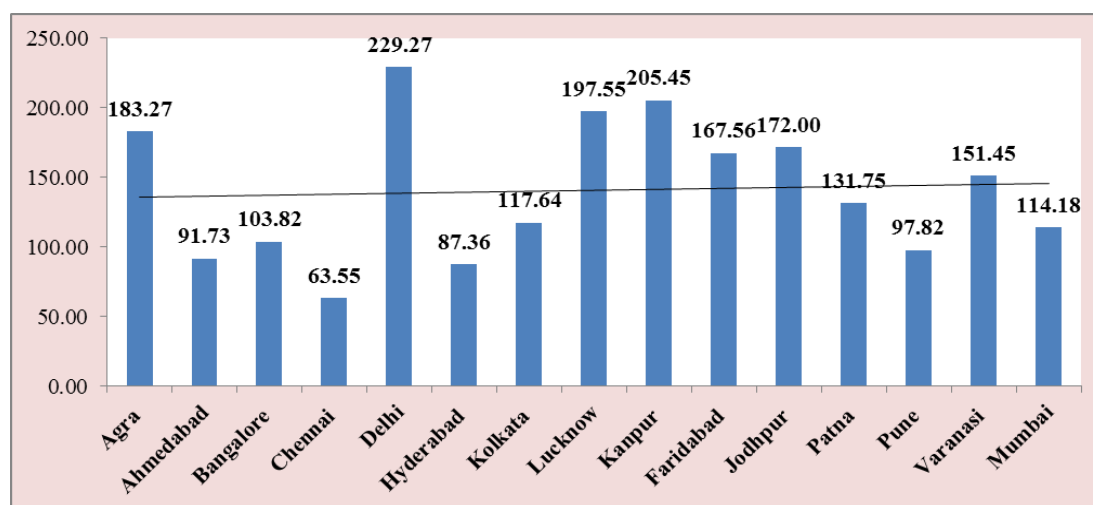
Table 4.2: Trend of PM10 of Major Cities in India From 2007 to 2017

Cities	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average
Agra	167	198	185	185	155	196	184	178	186	198	184	183.27
Ahmedabad	86	88	94	95	83	83	79	84	89	108	120	91.73
Bangalore	63	100	112	89	91	121	113	139	119	103	92	103.82
Chennai	37	63	73	59	92	57	75	57	59	65	62	63.55
Delhi	159	214	252	261	222	237	221	217	220	278	241	229.27
Hyderabad	77	85	81	79	74	79	90	95	93	100	108	87.36
Kolkata	99	103	126	99	113	135	159	122	105	113	120	117.64
Lucknow	187	190	197	204	189	211	192	174	169	214	246	197.55
Kanpur	193	212	212	203	183	215	201	199	201	217	224	205.45
Faridabad	146	150	154	164	174	184	196	199*	105	235	-	167.56
Jodhpur	-	176	140	181	168	189	176	190	152	168	180	172.00
Patna	123	120	146	181	158	166	-	-	-	4	156	131.75
Pune	109	103	88	82	113	93	88	92	99	107	102	97.82
Varanasi	114	106	125	127	127	138	145	139	145	256	244	151.45
Mumbai	92	127	117	97	116	117	117	96	107	119	151	114.18

Source: CPCB, 2018, <http://www.cpcbenviis.nic.in>

Table 4.2 shows the increasing trend of PM10 in major cities of India. According to the CPCB that eleven years air quality data is an increasing trend in terms of PM10 due to the increasing number of vehicles and re-suspension of natural dust. Figure 4.2 shows the average mean of the thirteen-year data to particulate matter. Delhi pollution is level highest as well most of the cities of Uttar Pradesh are pollution such as Agra, Kanpur and Lucknow. Figure 4.2 shows that the average of PM10 is continuously increased and it has crossed the trend line in some cities.

Figure 4.2: Average of PM10 of Major Cities in India from 2007 to 2017



Source: CPCB, 2018, <http://www.cpcbenvi.nic.in>

4.3.3 Sulphur dioxide (SO₂)

Basically, SO₂ from an industrial process and the burning of fossil fuels has been the main components of air pollution in many parts of the world level. It is rising due to natural sources such as volcanoes and man-made contribution like fossil fuels for domestic heating and for power generation. In recent years power generation is the main source for SO₂. Many health problems are created due to the SO₂ such as 10-minute exposure decreases pulmonary function, eye irritation and respiratory inflammation, like coughing, infections, asthma attacks, bronchitis (Hosamane N Sateesh, Dr, Desai.P.G, 2013, p.3739). Health effect due to SO₂ various categories found in the national air quality index⁷.

⁷According to national air quality index 2015, the break point concentration for various categories of sulphur dioxide is 40 (good), 80 (satisfactory), 380 (moderate), 800 (poor), 1600 (very poor) and 1600+ (severe).

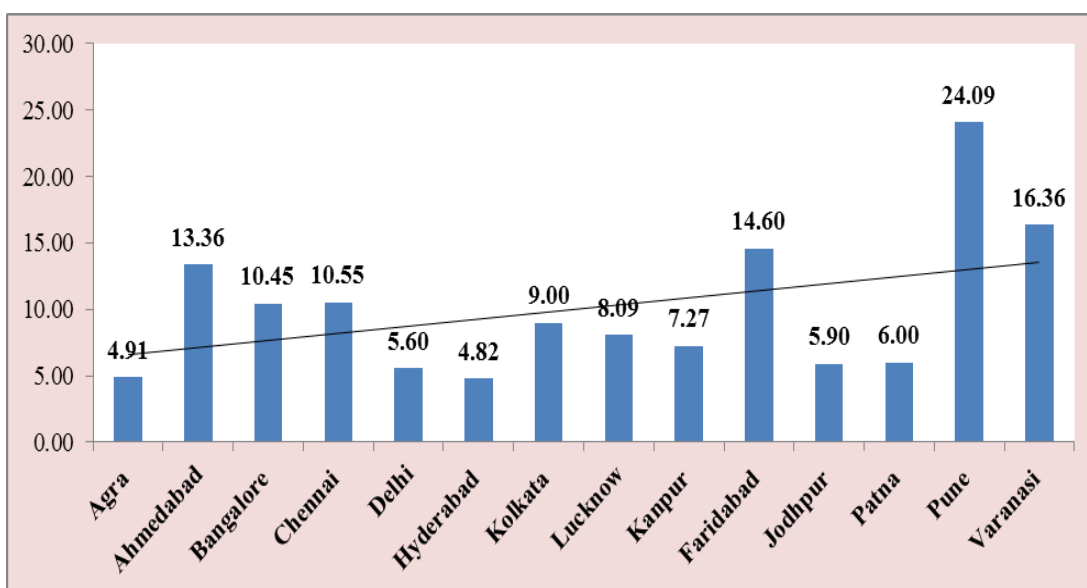
Table 4.3: Trend of SO₂ of Major Cities in India From 2007 to 2017

Cities	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average
Agra	6	6	6	5	3	5	5	5	4	5	4	4.91
Ahmedabad	12	12	16	15	14	12	12	13	13	14	14	13.36
Bangalore	17	15	14	14	4	14	13	13	6	3	2	10.45
Chennai	9	9	9	9	9	12	14	13	13	10	9	10.55
Delhi	BDL	6	6	5	6	5	4	5	5	7	7	5.60
Hyderabad	5	5	5	5	5	4	5	5	4	4	6	4.82
Kolkata	8	8	11	11	12	12	11	9	7	4	6	9.00
Lucknow	9	8	8	8	8	8	8	8	8	8	8	8.09
Kanpur	7	7	8	7	10	8	7	6	6	7	7	7.27
Faridabad	12	13	15	18	20	12	12	14	15	15	-	14.60
Jodhpur	-	6	6	6	5	6	5	7	6	6	6	5.90
Patna	10	7	5	7	4	6	-	-	-	4	5	6.00
Pune	20	22	25	29	32	22	20	23	23	28	21	24.09
Varanasi	16	16	17	18	17	18	19	19	19	11	10	16.36
Mumbai	11	9	6	4	5	5	3	4	4	6	3	5.45

Source: CPCB, 2018, <http://www.cpcbenviis.nic.in>

Table 4.3 shows the trend of SO₂ in major polluted cities of India. Due to this pollutant, Pune is the highest polluted and Ahmadabad is second. Data shows that from 2007 to 2017 the pollution level is increased in these cities. Figure 4.3 shows the average of SO₂ where most of the cities crossed the trend line that means it is continuously growing in India.

Figure 4.3: Average of SO₂ of Major Cities in India from 2007 to 2017



Source: CPCB, 2018, <http://www.cpcbenvi.nic.in>

4.4. Nitrogen Oxide (NO₂)

NO₂ level is rising all over India at level because of the continuously increasing vehicles and approximately 80 percent. NO₂ has risen by the motor vehicle in the cities. But, the other sources of this gas are patrol and metal refining, coal-fired and electricity generation. The health effect of nitrogen oxide has increased the likelihood of respiratory problems. It also reduces the lung function and causes bronchitis in asthmatic children and older people with heart disease is most at danger⁸.

⁸ According to national air quality index 2015, the break point concentration for various categories of nitrogen oxide is 40 (good), 80 (satisfactory), 180 (moderate), 280 (poor), 400 (very poor) and 400+ (severe).

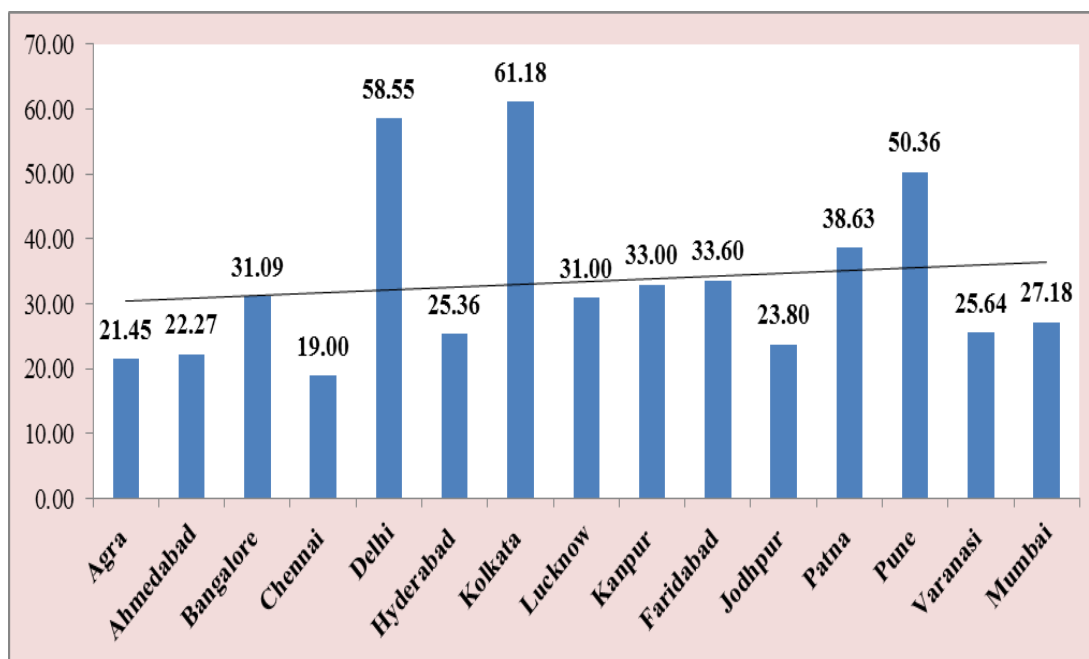
Table 4.4 Trend of NO₂ of Major Cities in India From 2007 to 2017

Cities	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average
Agra	23	23	21	20	23	23	21	19	22	22	19	21.45
Ahmedabad	20	20	21	21	25	24	17	20	21	27	29	22.27
Bangalore	39	41	37	31	28	28	26	30	20	31	31	31.09
Chennai	BDL	14	17	15	24	21	22	22	20	18	17	19.00
Delhi	36	57	50	55	61	59	66	61	65	66	68	58.55
Hyderabad	24	26	23	24	28	28	24	24	23	27	28	25.36
Kolkata	58	64	68	62	65	70	70	70	56	49	41	61.18
Lucknow	32	36	36	34	33	32	29	28	28	27	26	31.00
Kanpur	24	24	31	34	31	34	31	34	36	39	45	33.00
Faridabad	25	24	23	29	43	38	26	26	74	28	-	33.60
Jodhpur	-	24	23	22	23	24	23	31	24	23	21	23.80
Patna	50	39	37	40	36	36	-	-	-	32	39	38.63
Pune	45	37	40	39	58	44	41	45	62	78	65	50.36
Varanasi	19	19	20	20	20	21	28	32	33	32	38	25.64
Mumbai	40	40	41	19	33	20	13	20	25	30	18	27.18

Source: CPCB, 2018, <http://www.cpcbenviis.nic.in>

Figure 4.4 shows the average of NO₂ that is highest found Delhi, Kolkata and Pune due to the vehicular cities. Urbanization is the main cause to increase of this pollutant in these cities.

Figure 4.4: Average of NO₂ of Major Cities in India from 2007 to 2017



Source: CPCB, 2018, <http://www.cpcbenvi.nic.in>

Finally, it is found that the pollution level is increased in major cities during 2007 to 2017. Delhi, Kolkata, Pune, Kanpur, Lucknow, Ahmedabad and Varanasi are affected due to all pollutants. This is creating many health problems which are show by the World Health Organisation reports. If air pollution will increase continuously than it will convert in poor quality concentration that after it will create various types of health diseases among the population.⁹

Basically, the Central Pollution Control Board (CPCB) has been made the limit of air quality for health effects. it shows every remark and health effects of diseases by air

⁹ Air quality index pollution level and health statements shows the various categories such as 1-50 (good, minimal impact), 51-100 (satisfactory, Minor Breathing, discomfort to Sensitive People), 101-200 (moderate, Breathing discomfort to the people with lungs, asthma and heart disease), 201-300 (poor, Breathing discomfort to most people on prolonged exposure), 301-400 (very poor, Respiratory illness on long exposure), 401-500 (severe, Effects healthy people and serious impacts to those with existing diseases) found by the national air quality index 2015.

pollution. According to the NAQI was in very poor (301-400) category between November and February 2015 and severe condition in winter dates. The health impacts are described in the index, which is a very poor range related to the respiratory illness to the people on prolonged exposure. This is also more pronounced or converted in people with lung and heart diseases with the severe category.

4.5 Mechanism for Control of Air Pollution

Pollution Elimination Financing is a mechanism to increase and allocate revenue for the prevention and control of negative effects. There are three type of abatement measurement given by Rajah and Smith in 1993 where first is control measures established in production processes (end-of-pipe technology) represent classical cases of pollution reduction second relates to the investment with personal gain generates some revenue other than reduction in pollution for example by recovering useful materials from the garbage and third integrated technology options, which are primarily productive investments with the possibility of significant pollution reduction, for example new, for the older ones replaced by older technology To establish productive and less polluting alternatives, or energy-saving technologies (Lovei Magda, 1995, p.1). Basically, pollution charges exit in the various form such as emission, or effluent charge (on air, water, or soil), user charger (based on the domestic or industrial effluent treated), product charges (charges or taxes on product that are polluting in the manufacturing, consumption or disposal phase),¹⁰ and administrative charges (control and authorization fees and payment for administrative services such as licensing, registering) (Prevention, P., & Handbook, 1998, Pp.160-161).

OECD, 2004, p.11, report found that since 2000, ten air pollutants emitted by stationary sources have been subject to environmental charges such as particulate matter, carbon monoxide, nitrogen oxides, sulphur dioxide, chlorine, chloroprene, chromium oxide, formaldehyde, toluene and xylol. Basically, air is considered to be an external anomaly without an air quality management scheme. The cost of the pollutant must be imposed on the polluter rather than affected population otherwise this misallocation results affects the market mechanism. The effluent fee program

¹⁰ Product charges take the form of tax differentiation that creates more favorable market conditions for cleaner products and less favorable condition for polluting products.

monitored to reduce both the costs of pollution damage and abatement expenses (pollution control cost) by requiring the polluter. Therefore, the cost function of the polluter to abatement program is determined by the when marginal effluent damage equals the marginal control cost.

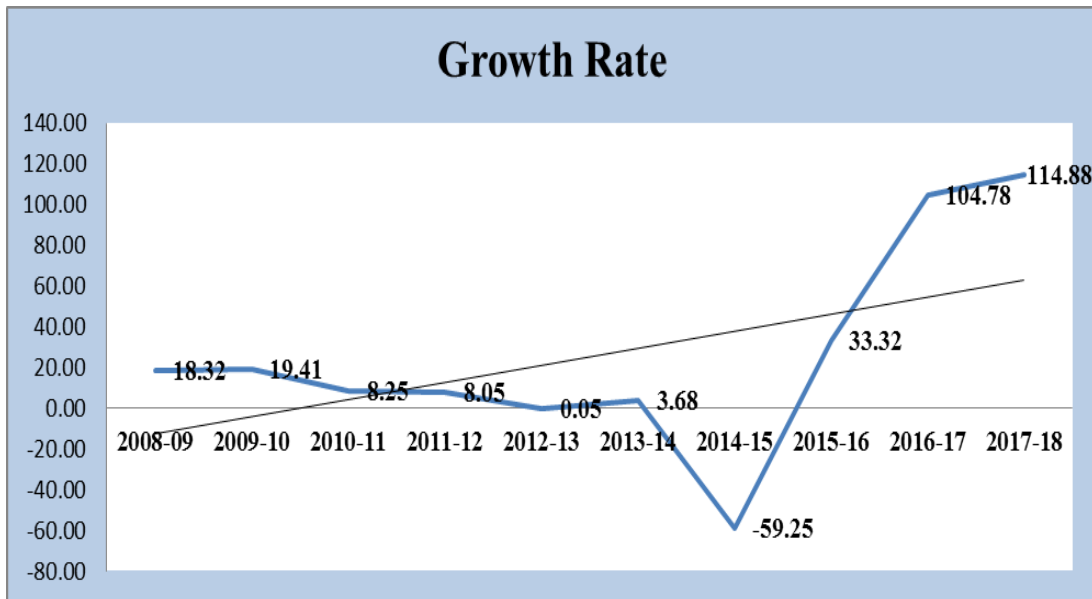
Many European countries have adopted the air or water pollution charge mechanism. These systems work primarily to generate revenue rather than discourage pollution, but a partial exception is the Affluent Charge Act adopted by the Federal Republic of Germany in 1976. For five pollutants, dischargers give a fixed fee for each increase of the actual emission (Stavins, R. N., & Whitehead, B., 1992, p.18). One another study is related to the marketable pollution permit. There are two concepts of permit first “pollution licenses” which defines allowable emissions in terms of pollutant concentration at a set of receptor points, and second “emissions licenses” that is confer directly the right to emit pollutants up to specified rate (Krupnick, A. J., et.al, p.233). In India, most of the environmental regulations are classified in terms of “Command and Control” instrument such as include technology mandates, bans on production processes and absolute emissions. Historically, it was suggested that transport-sector fuel and technology mandates have sometimes been effective in reducing pollution. But it was not always true. Environmental regulators across the country have said that plants install various types of air pollution control devices in case of the industrial sector (Greenstone, M., et.al., 2017, p.8.). These are the market-based mechanism while another system starts with the government to control air pollution such as a budgetary system for environmental pollution.

4.6 Budget Allocation for Environmental Protection in India

Basically, the Ministry of Environment and Forest coordinates the budgetary policy for sustainable development-related action plans, programs and other environmental activities. The government of India has been also taken many steps to control environmental air pollution such as the National Action Plan on Climate Change (NAPCC), 2008 etc. The important role of MoEF is to monitors the development process and perspective of sustainable development (Planning Commission, GOI, 2012, P.21). Central Pollution Control Board improve the infrastructure included additional zonal offices.

State Pollution Control Board and Pollution Control Committees (PCC) are mainly responsible for implementing the Air (Pollution Prevention and Control) Act, 1981. Therefore, the SPCB advocates the state governments ahead of budgetary proposals. Several recommendations for environmental protection funds are considered by the State Government, such as providing financial grants in accordance with the Water and Air Act (nominal grant). Budgetary support shows the work of SPCB in the Annual Plan. In order to improve air quality, science and technology activities are conducted by the Environmental Protection Agency. These improvements are related to the understanding of life cycle analysis through ozone, particulate matter, lead and sulfur dioxide nitrogen dioxide, air, and climate change and energy research program. Energy research programs are directly related to transportation, operations and effects on health and the environment, To know the health and environmental risks of transport, personal and population, to inform the chemical changes of air emissions and clean air management decisions, it is developing and evaluating new levels for air pollutants including air pollutants (EPA, 2018, P.1030). There was a provision of Rs. 23000 crore for the implementation for the Green India mission during the 12th plan. Some issues are related to this target such as it improved quality of degraded forest and tree cover on 2.5 m. ha area, improved ecosystems services, increased forest-based livelihood income and enhance annual carbon dioxide (CO₂) sequestration. The strategy of the National Action Plan on Climate Change was taken steps for adaptation and mitigation action. Where, mitigation is included the goal of a lower carbon while adaptation actions must reflect the needs and priorities of the States. The environmental budget allocation from 2008 to 2018 has collected with revenue, capital, plan and non-plan of the total budget. The budget allocation for environmental protection from 2008 to 2018 that is showing the fluctuating condition where the total budget was estimated Rs. 1707 crores in 2008 and Rs. 2250.34 in 2016-17. Their growth rate is lowest in 2014-15 and was highest in 2016-17 (Figure 4.5) (Table 4.3, A).

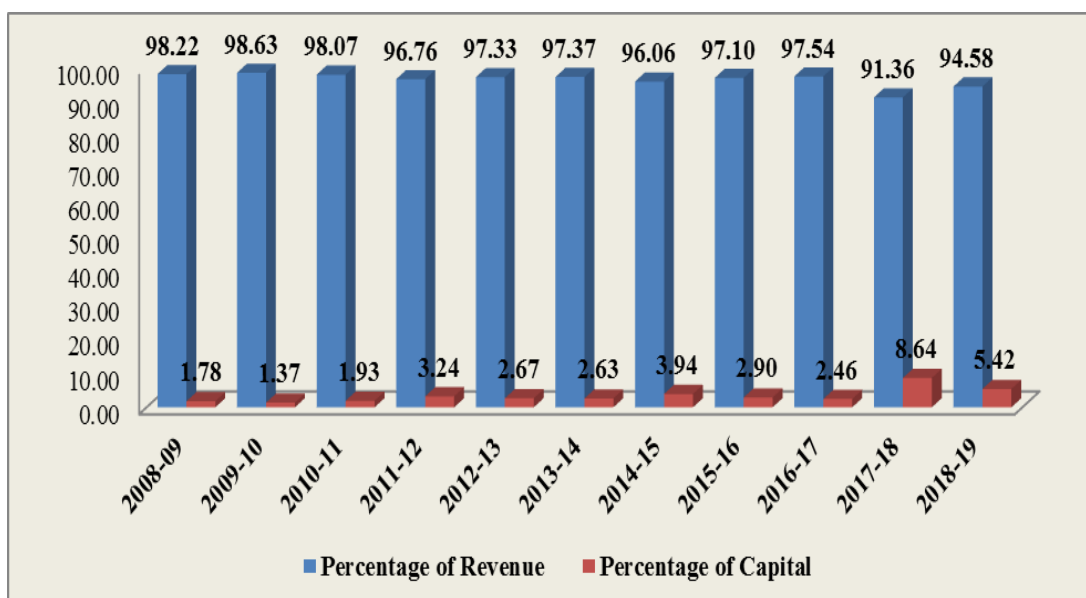
Figure 4.5: Total Environmental Budget Allocation From 2008-2018



Source: GOI, Budget Report, Various Years.

The graph (4.6) of revenue and capital are also showing the ups and down condition where revenue percentage is highest in 2008 to 2011 that is approximately 98 percent and capital is lowest in this time. The capital percentage is highest in 2017-18 that is 8.64 percent. Indian environmental is continuously damaging but the budget policy is showing fluctuating condition. The emissions fee can (carbon tax) support of the government in two purposes first it can improve incentives about pollution or reduce pollution and increase revenue for the related agencies for monitoring and enforcement (Austin, D., 1999, p.9). Generally, revenues are usually distributed for such functions as pollution abatement, financing of administrative costs, monitoring enforcement and educational. Cities that receive a federal grant for construction of sewer systems are required by the Water Pollution Control Act to recover their operating costs and part of the capital cost from their users through municipal sewage treatment user fees. Many states charge flat permits, which entitle the permit to the discharge of wastewater. For example, California charges a polluted discharge permit, which is based on the type and quantity of polluted pollutants (Helmer, R., Hespanhol, I., & World Health Organization 1997, Pp.163-168).

Figure 4.6: Percentage share of Revenue and Capital Expenditure of the Environmental Budget



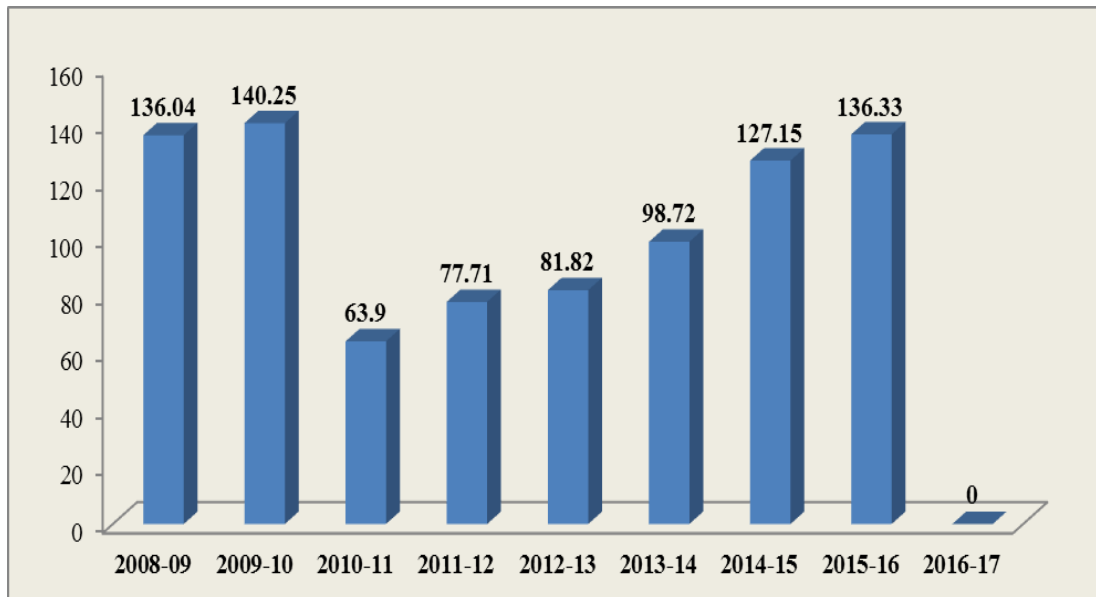
Source: GOI, Budget Report, Various Years.

4.6.1 Budget Allocation for Air Pollution

Ministry of Environment, Forest and Climate Change provide the budget for control air pollution in India that is known as prevention of air and water pollution budget. This includes many schemes for the budget such as prevention and control of water pollution (cess), Establishment of Environment Authorities and Environmental Commission & Tribunal, Central Pollution Control Board, Promotion of Common Effluent Treatment Plants, and other schemes.

Figure 4.7 shows the ups and down condition of air pollution budget where it was highest in 2008 and 2016 because National Action Plan on Climate Change was started in 2008, therefore, fund was highest in this year it was lowest in 2010 than after it is continuously increasing. But after 2015-16 there is not any particular budget for air pollution as well as climate change.

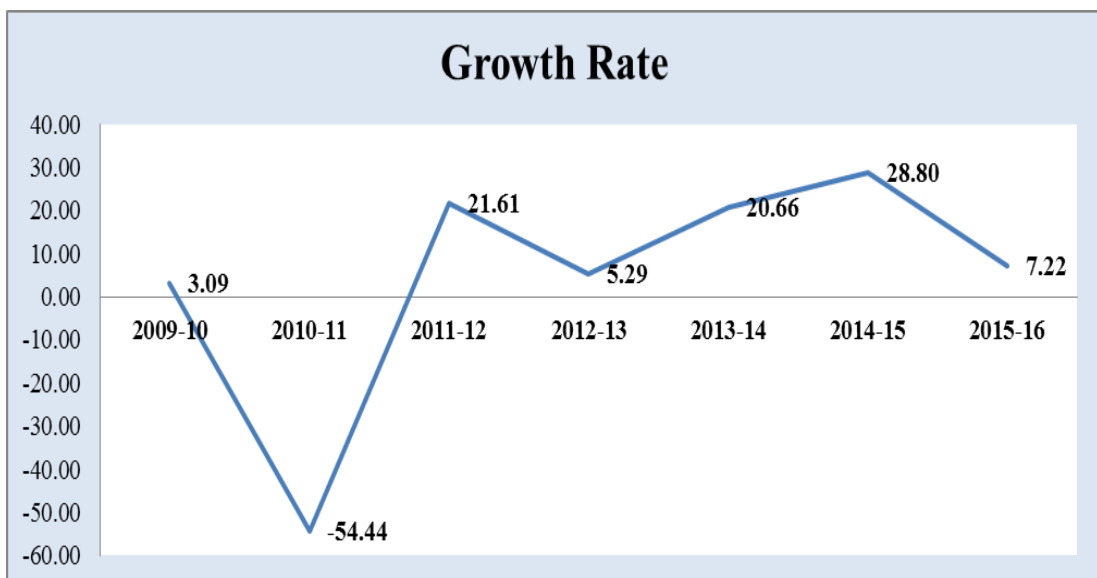
Figure 4.8: Air Pollution Budget Expenditure from 2008 to 2016 (In Crores)



Source: GOI, Budget Report, Various Years.

Figure 4.5 shows the growth rate of air pollution where it was highest in 213-14 and it was lowest in 2008-09 that is 3.09 percent. The growth rate was negative in 2009-10. In 2016-17 the air pollution budget is zero.

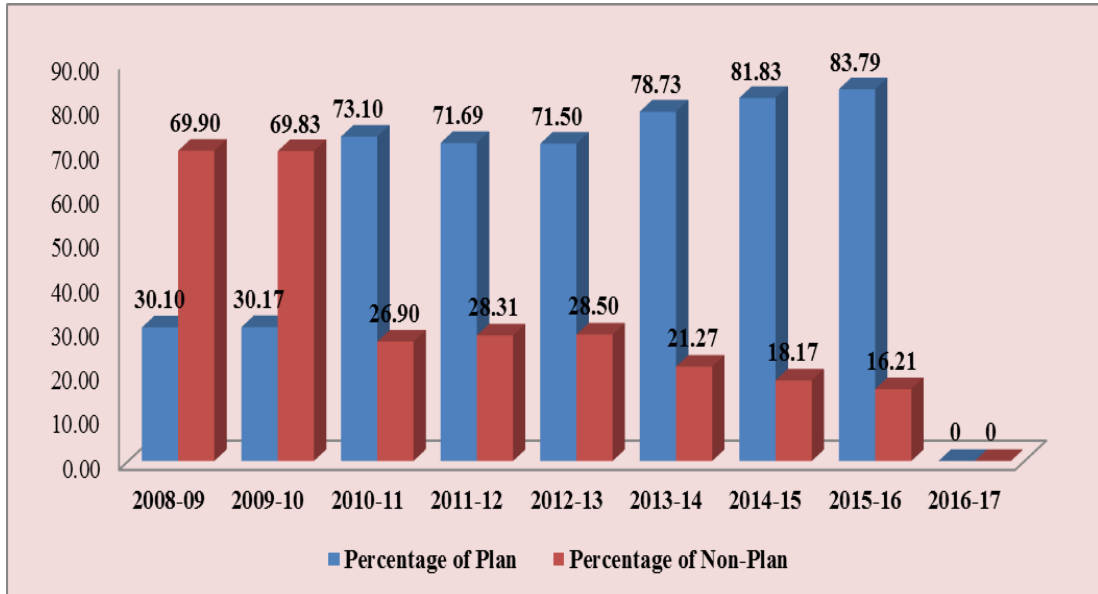
Figure 4.8: Growth Rate of Air Pollution Budget from 2008-2016

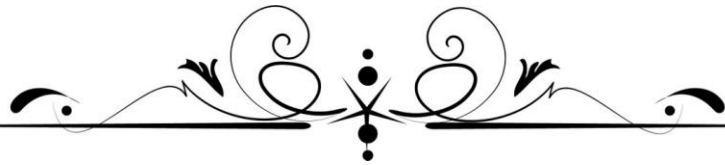


Source: GOI, Budget Report, Various Years.

Figure 4.9 represents the plan and non-plan budget for air pollution from 2008 to 2016. Where the plan budget is highest in 2015-16 than after it was zero as well as non-plan budget is highest in 2008-09 that is 69.90 percent of the total. There are many schemes has been started to control air pollution in India but the budget policy is fluctuating.

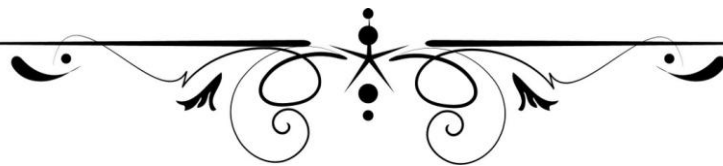
Figure 4.9: Plan and Non-Plan Budget Expenditure for Air Pollution





Chapter- 5

Health Cost Measurement in Surveyed Areas



5.0 Introduction

Air pollution is an important risk factor for disease in present time. Due to increment of outdoor air pollution, mortality, morbidity and shortens life expectancy are also rising at the world level. The Global Burden of Diseases (GBD) has estimated on burden of disease attributable to 79 risk factors in 195 countries from 1990 to 2015 (Cohen J Aaron, Brauer Micheal et al., 2017, p.1907). In low income and middle income countries, air pollution has been an important cause of global disease burden (Feigin L Valery, Roth A Gregory et al., 2016, p. 913).

Ambient air pollution always affects adversely on human health. It develops many risk factors for diseases such as respiratory system and particularly lung cancer, cardiovascular diseases and especially negative effects on children's health (Njee M. Robert, Melisfate Kees, et al., 2016, p. 83). According to International Agency for Research on Cancer (IARC, 2013) outdoor air pollution is hazardous to human because the particulate matter components of air pollution increases the cancer incidence especially lung cancer. The data indicates that there were 223000 deaths from lung cancer worldwide resulted in 2010 due to air pollution.

Air pollution is the main environmental cause of premature death in Europe. European Commission estimated that due to air pollution, approximately 400000 premature deaths asses in 2010 and 2012 in Europe and heart disease was the most common reason of the premature death. Air pollution increases the frequency of a wide range of diseases such as respiratory and cardiovascular diseases to the short and long effect on health (European Environmental Agency, 2014, p.13).

In low and middle income countries, there were 3.7 million deaths were estimated due to ambient air pollution (WHO, 2014, p.1) and 4.3 million deaths due to ambient air pollution and household air pollution respectively at a global level in 2012 (WHO, 2014, p.1). Basically, some guidelines has been given by WHO for the air pollutants which are the average annual for PM10 levels is 20 micrograms per cubic meter and this level has been exceeded in all major citites. Asian mega cities has also exceeded of this level such as Delhi and Lahore etc. Fine particles (PM_{2.5}) level is 10 micrograms per cubic meter and 25 micrograms per cubic meter for a 24 hour period. Most of the developing countries have been crossed this level. For example

Kathmandu's $PM_{2.5}$ levels is over 500 micrograms per cubic meter recorded (Wismans Jac, Grahn Maria & Denbratt, 2016, p.8).

Due to expansion of industrialization, urbanization and rise in income, the use of motor vehicles in India is showing a rapid growth and economic development. Mostly India's rural people are moving to the cities for the search of livelihood (CPCB, 2012, p.4). Basically, use of combustion of fossil fuels in urban areas are rising the transportation, power generation and industrial sector. Therefore, urban air pollution is increasing and adversely human health. In India, under the Prevention & Control of Pollution Act, 1981, the central government has the right to take necessary measures for the safety and improvement the quality. for the determination of standard emissions and discharge, some issues are included in terms of environment such as regulate the location of industries, management of hazardous waste, and protection of public health and welfare (Ambhore Shankar, et al., 2013, p.36).

Due to increment of air pollution, especially $PM_{2.5}$ pollutant, health problems continuously increase such as respiratory and, cardiovascular disease, chronic bronchitis in adults, acute bronchitis in children, asthma attacks have continuously increased. Basically, there are two links has been established between air pollution. First link related to the air pollution and health status and the second is related to the health status and its monetary equivalent. Willingness to pay and willingness to accept compensation (Freeman, 2014. p.190). Air pollution is the cause for a range of diseases and contributing to the Burden of Disease (BOD). Air pollution health impact also covers many significant financial and economic implications. Therefore, not only include the societal cost of mortality and morbidity but also add household, hospital and public budgets (OECD, 2015, p.11).

Air pollution affects health in the form of mortality and morbidity. Mortality directly refers to death and morbidity is the deterioration of physical or mental health due to an injury or sickness, known to the concerned person (Gunatilak, H.M.,2003, p.105). It can be also classified in many ways which are the duration of the condition such as chronic or acute disease and degree of injury or loss of activity and type of symptom (Freeman, 2014, p. 211).

Organisation for Economic Co-operation and Development (OECD, 2014, p.20) report has defined the nature of mortality and morbidity. Where mortality can be

termed as a singular and well-defined endpoint and morbidities entail a plurality of endpoints because of a very large range of endpoint, complicating task of eliciting, extent of severity and add an individual willingness to pay values. Therefore, the cost of mortality is directly linked to individual death and morbidity cost is a cost of suffering ill health of individual and many who are involved in the care of the one who is ill.

Basically, the economic cost of health impact of air pollution can be classified into three categories, which are resource costs, opportunity costs and disutility costs. Resource costs include all medical costs such as visiting doctor, ambulance, medicines etc. and nonmedical costs like childcare and housekeeping costs due to the affected person. An Opportunity cost refers to the indirect cost which is related to the loss or productivity or wages and loss of leisure time or days due to the health impact. Third, disutility costs refer to the pain, suffering and discomfort linked to the illness (OECD, 2014, p.22; A. Hunt, et al., 2016, p.42).

The aim of economic development is directly related to improved quality of life. Therefore, the socioeconomic status of any country plays an important role in development. In south-eastern Asian countries, rapid urbanization, increase of total population, standard of living, per capita income, educational progress, sex ratio, gross income women and child development indicate different status after 1990. In India, food, clothing, housing, travel, disease prevention and treatment, education, employment, information access and cultural enjoyment are the basic terms of quality of life and these are also the indicators of socioeconomic development in present time (Dhali, M.K., 2015, p.21).

In Lucknow, due to expansion of industrial and transport, the environment of the city is getting affected adversely on water, air, land-ecology and public health as well as damage to heritage property.

5.1 Demographic & Physical Profile of Uttar Pradesh

Uttar Pradesh is the largest state of India. The population of Uttar Pradesh were 16.49 (199,812,341, total population) percent of all India level and there are 155.11 million persons (77.7 percent) from rural area and 44.47 million persons (22.3 percent) from urban area respectively. In terms of geographical area their rank is fifth, which is 7.2

percent of India. The total area of Uttar Pradesh is 2,40,928 square kilometer. Basically, it is divided into 18 revenue divisions which are Agra, Aligarh, Allahabad, Azamgarh, Bareilly, Basti, Chitrakoot, Devipatan, Faizabad, Gorakhpur, Jhansi, Kanpur, Lucknow, Meerut, Mirzapur, Moradabad, Saharanpur and Varanasi. The structure of Uttar Pradesh is divided into four zones such as Eastern region, Western region, Central region and Bundelkhand region (National Skill Development Corporation, 2013, p.8). Lucknow is the capital of Uttar Pradesh and it is situated in the Central region.

Uttar Pradesh is one of the most populous states of the country. The decadal growth rate of population recorded to be 20.09 percent from 2001 to 2011, where the rural population is 18.0 percent while the urban population is 28.75 percent. It was 25.85 in 1991 to 2001.¹¹ The population density of Uttar Pradesh is continuously increasing due to increased urbanization. The density of population is as 250 per square kilometer in 1951 and 291 in 1961. It was again increased to 348 in 1971 to 839 in 2011.

¹²The sex ratio of Uttar Pradesh is highest in 2011, which was 912 and in rural area, it is 918 and in urban area this is 894. In 1951, it was 908 and it was same in 1971 and 1991 which was 876 while this ratio was increased in 2001 it was 898. In case of the child population, it includes 0-6 age group specific population also known as child sex ratio. There are many reasons to explain the low level of sex ratio in India such as high maternal mortality, neglect of the girl child resulting in their higher mortality at younger ages, sex selective abortion, female infanticide. In Uttar Pradesh, the total child population is 30,791,331 and in rural area, it was 25,040,583 and 5,750,748 was in an urban area. The child sex ratio was 902 and it was 906 in rural areas and 885 in urban areas (GOI, 2011).

Health is a measurement indicator of the socio economic development because the social and economic development of a nation is regularly reflected by the existing

¹¹ The number of person per unit of a km is expressed the population density. Therefore, it helps getting a better a better understanding of the distribution of population with the relation of land.

¹² Sex ratio represent number of females per thousand males in a population. It can also describe the age specific mortality rate and sex specific net migration rate from one area to another area.

infant and child mortality rates (Sahu Damoda, Nair Saritha, Singh Lucky et.al, 2015, 709). Mortality rate is most important indicator for determining the health status. In Uttar Pradesh, the infant mortality rate is 70 and crude birth rate 25 as well as crude death rate is 8.3 according to the national family health survey. In 2011, India's literacy was higher as compared than before last years which were 74.04 percent. But in Uttar Pradesh, the literacy rate shows increasing orders. It was 12.02 percent in 1951 and 32.65 percent in 1981. It was 40.71 and 56.27 percent in 1991 and 2001. In 2011 it was higher which recorded 69.72 percent is. In rural area the literacy rate was found 65.5 and in urban areas, it was noted 75.1 in Uttar Pradesh census.

Table 5.1: Demographic features of Lucknow Districts (Census, 2011)

Indicators	Lucknow	Uttar Pradesh
Demographic Status		
Total Population	4,589,838 (2.29)	199,812,341
Total Rural Population	1,550,842 (0.99)	155,317,278
Total Urban Population	3,038,966(6.82)	44,495,063
Male	2,394,476 (2.29)	104,480,510
Female	2,195,362 (2.30)	95,331,831
Decadal Growth from 2001 to 2011 (in Percentage)		
Total	25.79	20.09
Rural	16.9	17.81
Urban	30.9	28.75
Sex Ratio (Per thousand males)		
Total	917	912
Rural	906	918
Urban	923	894
Child Population 0-6 years (in number)		
Total	543,641	30,791,331

	(1.7)	
Rural	222,592 (0.13)	25,040,583
Urban	321,049 (5.6)	5,750,748
Girl Child Sex Ratio (per thousand male child)		
Total	915	902
Rural	928	906
Urban	902	885
Density (person per sq. Km.)	1815	829
Educational Status (in percent)		
Literacy Rate	77.3	67.72
Male	82.6	77.3
Female	71.5	57.2
Rural	67.8	65.5
Urban	81.9	75.1
Health Status (percent)		
Infant Mortality Rate	44 (person)	70
Crude Birth Rate	18.4	25
Crude Death Rate	6.5	8.4
Working Status (in percent)		
Total Workers	33.6	32.9
Main Workers	74.7	67.8
Marginal Workers	32.2	25.3
Category wise Occupation in percent (main+marginal)		
Total cultivators	11.4	29
Agricultural workers	13.2	30.3
Household industry workers	6.5	5.9
Other workers	69	34.8

Source: Primary Census Abstract of Lucknow, 2011, GoI, 2011 & Annual Health Survey Bulletin 2011-12, Uttar Pradesh.

5.2 Demographic Profile of Lucknow

The capital of Uttar Pradesh, Lucknow is situated in the central region. It is spread the 2528 sq.kms over an area of India. Lucknow is located between the parallel 26°30'

and 27°10' north latitude and 80° 12' east longitude. This city lies on the banks of the river Gomti which divides Lucknow city into two unequal halves which are southern part and northern part and the southern half being than the northern part (CPCB, p.26). As per census 2011, the total population of Lucknow city recorded 4,598,838 in 2011 as well as the share of urban population of this district is 3,038,996 and the rural population was 1,550,842. Due to rising population, the demand for housing, education, medical facilities transportation, drinking water, etc. are continuously increasing. The total male population recorded 2,394,476 as well as 2,195,362 female are there. The decadal growth rate of Lucknow city was registered 25.79 percent. In rural area decadal growth is 16.9 percent and in urban areas this is recorded 30.9 percent

In Lucknow city, population density was 1815 per.sq.kilometer and it was 1443 sq.kilometer in 2001. Industrial and tertiary activities are growing at a faster rate in this area because they represent the largest scale economies and its prevalence is focused on workforce mainly technologically and skilled fitted workers.

According to census 2011, the sex ratio of the Lucknow city is recorded 906 of the number of females per 1000 males. It was 888 in 2001. The child sex ratio includes 0-6 year old children and the child sex ratio in Lucknow 915 and it was in rural areas 928 and in urban areas it was 905. The total populations of these children were 543,641 in this city. It covers the 222,592 children of the rural areas and 321,049 child population of the urban areas. The total numbers of literate person in the city were recorded 3,226,214 and the literacy rate was 79.33 percent. The total male literate persons are registered 1,799,177 as well as total female literate persons are 1,427,037. There is 67.8 of literacy rate in rural area urban area respectively 81.9 percent.

The health status of Lucknow district is showing the poor condition. According to the National Family Health survey The infant mortality rate is 44 and crude birth rate is 18.2. The death rate of this city is recorded 6.5 percent.

Uttar Pradesh always gains first position in terms of food grain production at all the India level. The industrial sector also gains top second Position and provides the highly secondary level employment for the population. At present, small industries are also contributing to achieve economic growth and provide the employment. There

are four industrial areas in Lucknow area which are rural industrial estate Talkatora, UPSIDC industrial area Chinhat, Sarojini Nagar, Amausi (Micro, Small and Medium Enterprises, 2016). There are many categories of total worker of Lucknow city, where the total workers recorded 33.6 percent in census 2011 as well as main workers are 74.7 percent and marginal workers 25.3 percent. In 2011 census, it was found that there are 13.2 percent belongs to the total agricultural sector and 6.5 percent worker related to the total household industries.

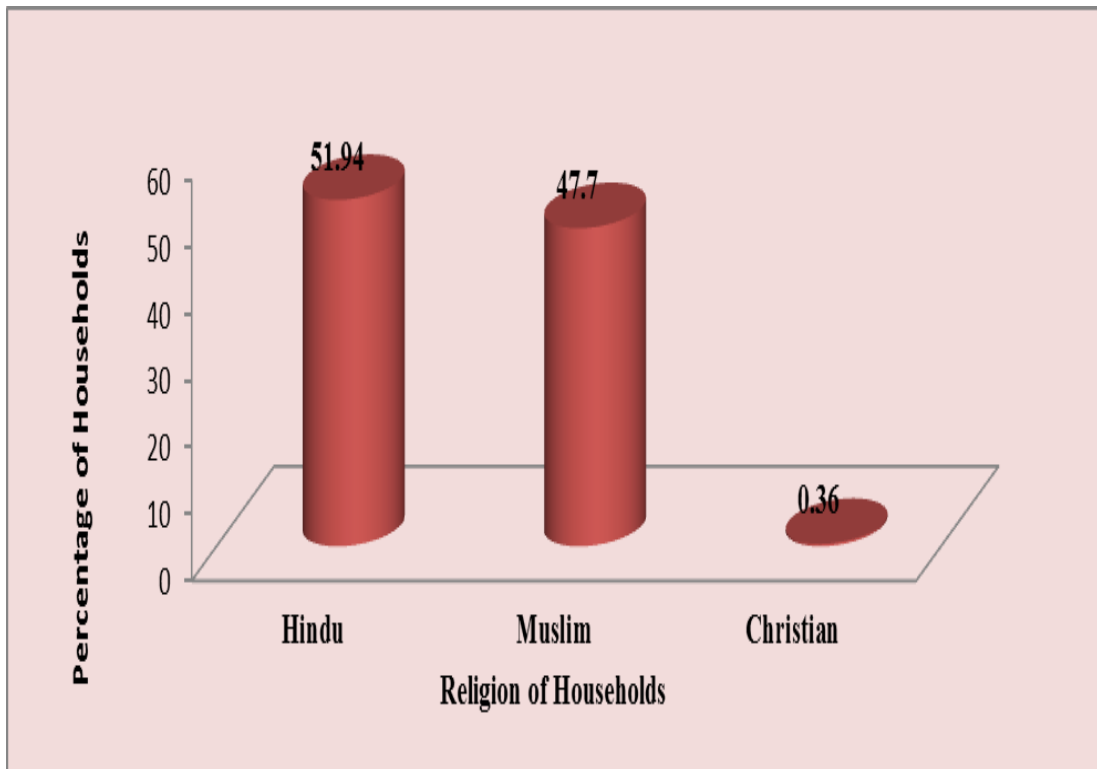
5.3 Socio-Economic Status of the Study Area

The study is conducted from Lucknow district of the Uttar Pradesh. There are two zone taken for the household survey. First is industrial area viz., Talkatora and second is commercial area viz., Sarai Mali khan (Chowk). There are 115 households survey from each with 230 households in total. The survey data was conducted during February 2017 to March 2017 from the study areas of Talkatora and Sarai Mali Khan in Lucknow

Talkatora area is situated in the center of the city which very congested residential area. Many types of industries exist in Talkatora viz., chemical, iron & steel industries, plastic industries, rubber industries, food processing, service station, aluminum industries, and engineering goods. Total 64 industries are situated in this area. However plywood industries are much wide spread in this area. Chowk is one of the oldest market in the city and it is biggest center of the commercial place. It is also famous for the chikan work and thousand of chikan industries do exist in this area.

5.3.1 Socio-Economic Status of the Household

Religion is the most important indicator to assess the socio-cultural and obviously demographic feature from the first census in 1872 till now. After independence, there are six major religion registered in India, which are Hindu, Muslim, Christian, Jain, Buddhist and Sikh and census also includes data on other religion faiths and denominators (GOI, 2011). But the study area mostly covers the Hindu, Muslim and Christian community. In the study Hindu and Muslims religion are dominated and their spoken language is Hindi.

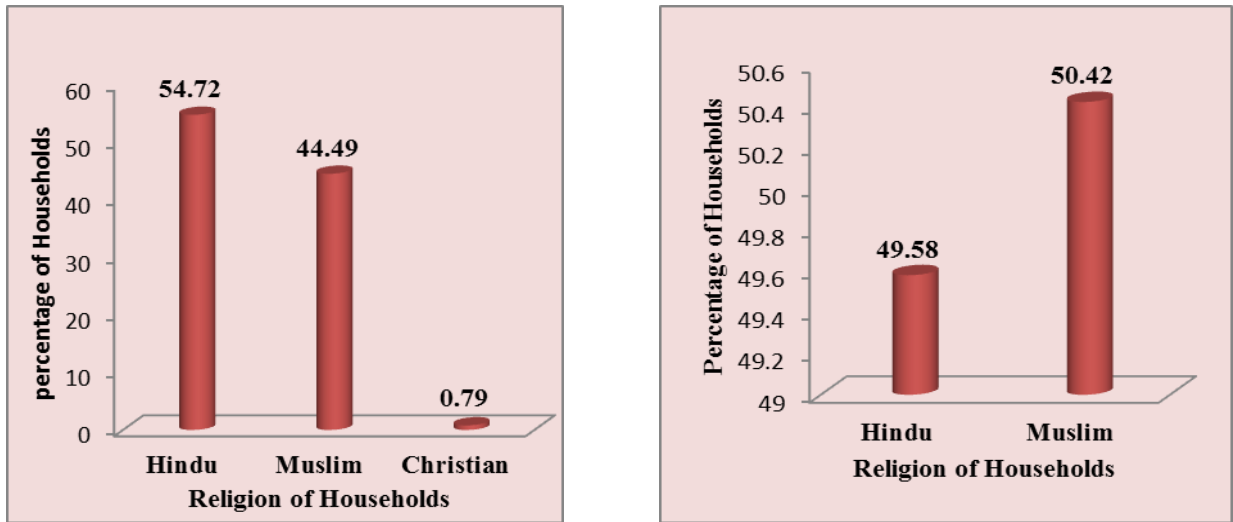
Figure 5.1: Religion Wise Household Profile

Source: Estimated from Primary Data

Figure 5.1 shows the percentage of religion wise household profile. Out of 230 households, 51.94 percent are from Hindu community and 47.70 percent from Muslim community and rest 0.36 percent are Christians. There is not enough difference in Hindu and Muslims. Households as Sarai Mali Khan is situated in Muslim denoted.

Figure 5.2, shows the zone wise percentage of religion wise household profile. The first zone is Talkatora where the total religions are divided into three categories viz., Hindu, Muslim and Christian. The total percentage of Hindu community is 54.72 percent, Muslim people are 44.49 percent and the total 0.79 percent Christians are found

Figure 5.2: Religion wise Household Profile of Talkatora & Sarai Mali Khan



Talkatora

Source: Estimated from Primary Data

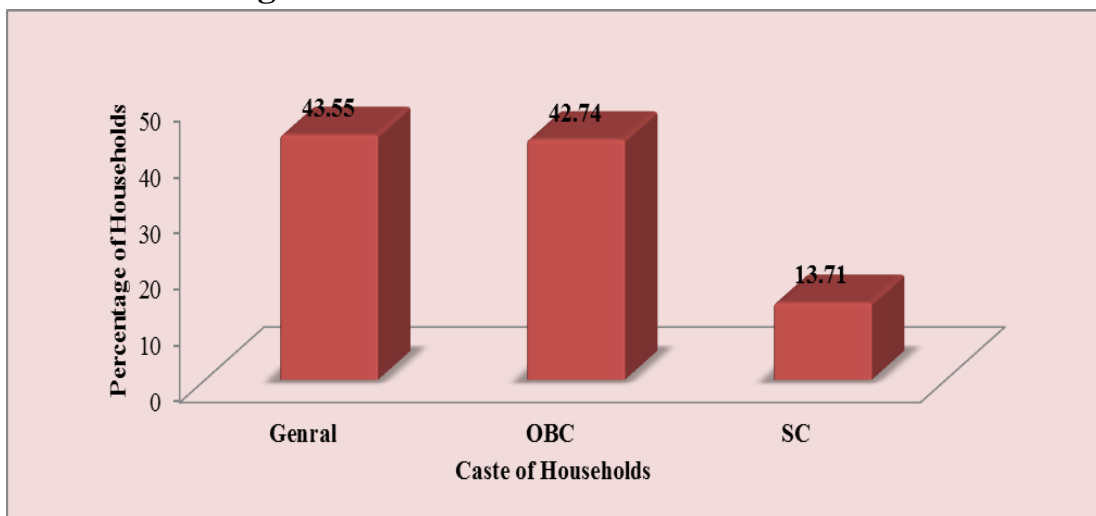
Sarai Mali Khan

There are two religions found in the Sarai Mali khan zone, viz., indu and Muslim religions. There are 49.58 percent people from Hindu community and the total population of the Muslim community is 50.42 percent. In both zones, there are 1109 members live in 230 households.

4.3.2 Caste Profile of Study Area

Figure 5.3 shows total caste wise data of household survey. It is observed 44 percent & 14 percent of households belong to genera, OBC and SC community.

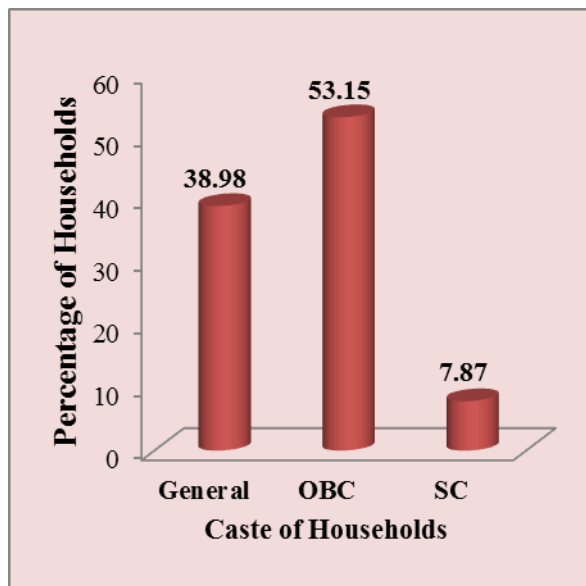
Figure- 5.3: Caste wise Household Profile



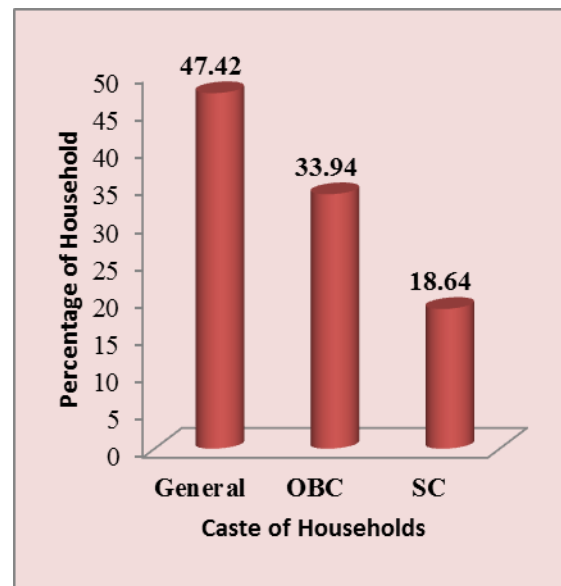
Source: Estimated from primary data

Figure 5.4 shows the caste wise percent of households profile. Household is divided into three categories viz., General, OBC and SC. In this zone, general, OBC & SC community are distributed with 39 percent, 51 percent & 8 percent respectively. Where as in Sarai Mali Khan area, the corresponding figures are 47 percent, 34 percent & 19 percent respectively.

Figure 5.4: Caste wise Household Profile of Talkatora & Sarai Mali Khan



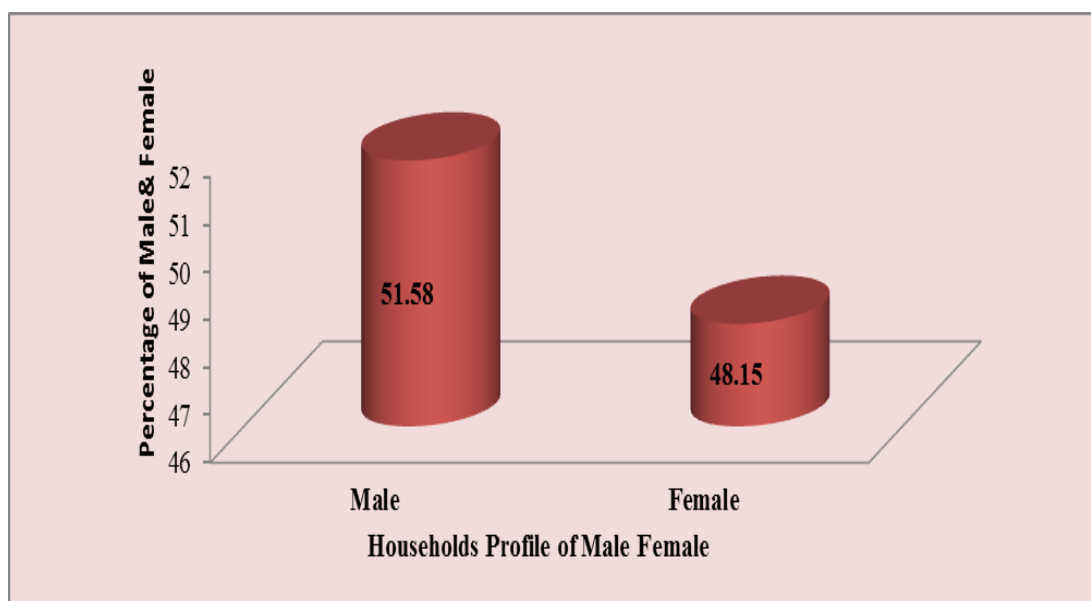
Talkatora



Sarai Mali Khan

4.3.3: Gender Profile of Households

Gender composition is one of the most important demographic characteristics and significant issue in India. It reflects more on mortality, morbidity and migration. India's male female population distribution pattern affects relative roles and economic relationship (GOI, 2011). The Indian census gives the information on various aspects of population on gender composition. It shows the equity between males and females in a society at a given point of time. Government of India has been already given the different plans, programs and policies for raising the economic, educational, health and political participation of women to match with the men.

Figure 5.5: Gender Composition of the Household

Source: Estimated from Primary Data

Figure 5.5 shows the sex ratio of the household in the study area. In the study area, there are 51.85 percent and 48.15 percent are males and females respectively.

5.4: Methods for Measuring Morbidity

Cost of illness is a method of economic valuation which determines the cost caused by illness. Therefore, it refers to the application of the health sector. The procedure is that a specific disease, or a risk factor (e.g. smoking or obesity), or a wider group of diseases or injuries, is specified. Basically the aim of cost of illness (COI) is described the economic burden of disease of people. It also measures the rising costs as a result of particular illnesses. There are two approaches can be adopted for costs of illness method. First, prevalence based COI method which measures the economic burden of disease to society during a period of time. This also produces lifetime cost estimates of a disease for predicting future costs. It can change the things in the health care sector and estimate the long term risks in the society. Second, incidence-based COI which is based on produce lifetime cost estimation. it can be directly incorporated in a cost-effectiveness analysis or disease model for predicting future cost (Tedisi Fabrizio, Parazzini Fabio, and Garattini Livo, 2000, p.3).

According to World Economic Forum Report, (2011, p.14) the cost of illness method can also include and accommodate non-personal health costs such as those related to research and public health education. Pain and suffering cost also considered in this method and find the monetary value of pain and suffering. Cost of illness method can complement epidemiology and include the useful information on the economic dimension which is related to the health problem. This provides the data of society which can use for the policy improvement (Bastida Lopez, Gonzalez Luis Montejo Angel, 2009, pp. 2-3). It is estimated that the cost of illness of chronic diseases and their risk factors ranges from 0.02 percent to 6.77 percent of the GDP in the various countries. The cardiovascular diseases in the United Kingdom has been estimated 18 percent of the total health care expenditure. There are many diseases and economic factors measured by the cost of illness method at the world level such as sick leave proportion of people due to mental disorders was 35 percent in Sweden and disability due to mental health problems varies from 44 percent in Denmark and 8 percent in the Russian Federation (The European Health Report, 2009, p. 79).

Cost of illness includes the direct cost and indirect costs. Direct cost cover two approaches, it is a top-down approach which is based on the aggregate costs of specific diseases. This is calculated by multiplying the total health care expenditures by the people of health care services used by the disease group. The second is a Bottom-up approach which is based on the individual units of service performed. Average costs estimate the total number of health care encounters related to the diseases and measure the health care costs of a disease. Indirect cost includes the societal costs of morbidity, disability and premature mortality. It also includes the non-medical costs of disease such as lost productivity, caregiver costs, loss of days or leisure, pain and suffering and quality of life. Indirect costs measure three approaches which are included a Human Capital Approach, Willingness to Pay (WTP) Approach and Friction Costs Approach (Sam Gnana Kishore, MA Kuriachan, et.al, 2009, p. 2).

This chapter attempts to analyse the morbidity effects of the air pollution in industrial and commercial area of the household. It includes all types of diseases such as acute illness for 14 days, sub-chronic illness for 14-90 days, chronic illness for 3 years. Morbidity effects are measured by using an individual preference approach or resource opportunity cost approach. The main objective of the chapter is to assess the impact on air pollution on health in the study area of Lucknow. Further, Contingent

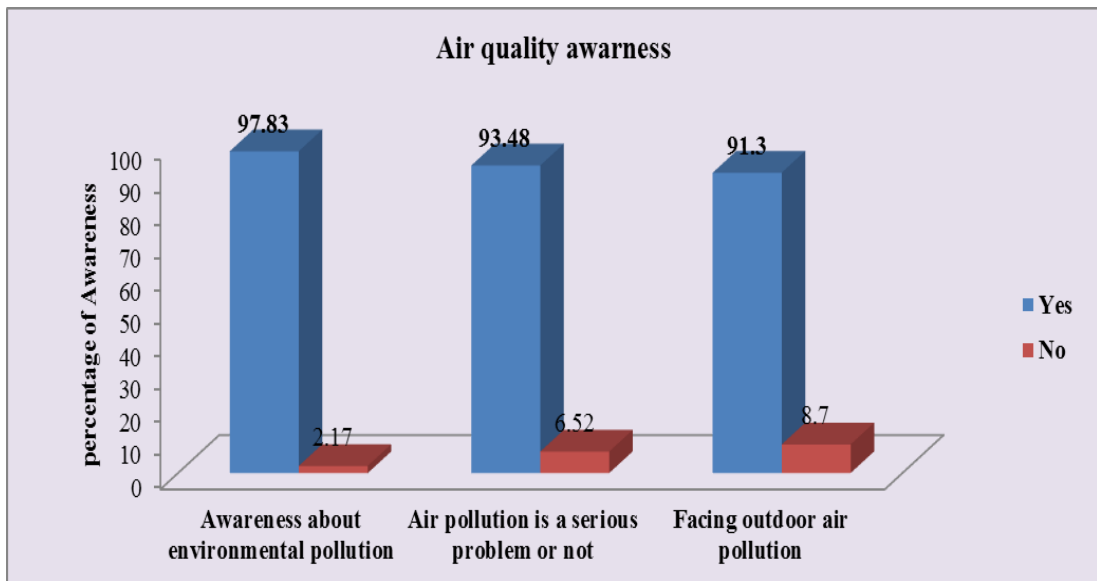
Valuation Method is used for measuring the individual preference approach and for measure of cost of illness (direct cost and indirect cost) used under the resources opportunity costs in this chapter. There are two section for measurement of cost of illness, first air quality perceptions by households and second health profile and health valuation in the study area. Air quality perceptions includes air quality problems, conditions, type of outdoor air pollution problems, Degree of problems and sources of problems in the study area.

Health profile includes awareness on air pollution as well as classification of diseases. There are three section of diseases such as respiratory diseases (Asthma, Shortness of breath, Respiratory allergy to dust & pollen, Cough with phlegm, Dry Cough, Bronchitis, Lung cancer), cardiovascular diseases (Heart Disease) and Infections (Eye, Nose, Throat Irritation, Skin infection). It is also describing the type of treatment such as allopathic, homeopathic Ayurveda, unani, and other typer of precautions. It is also describe the reasons if any household is not capable to taking any treatment. These causes are related to the shortage of money, The longest distance of hospital, Lack of awareness, Heavy work load and time problem and other reasons in the study area.

5.5: Perception of Air Quality in the Study Area

There are three industrial places in Lucknow city viz., Aishbagh, Amausi and Talkatora. Where, according to State Pollution Control Board (SPCB) report., Talkatora is highly polluted place. The major source of air pollution in this area is combustion activities, heavy traffic and many commercial activities (Verma A.K., Saxena A., et al., 2016, p. 274). Second, area is situated near of Chowk viz., Sarai Mali Khan. Chowk is a commercial as well as residential area. According to SPCB, there are four commercial places in the Lucknow city viz., Hazratganj, Sarai Mali Khan (Chowk), Gomti Nagar and Ansal. T.C, Chowk is the highest polluted place in case of particulate matter (PM10) (SPCB, 2015)). There are many sources of air pollution in this area such as tempo, two wheeler and passenger car (Indian Institute of Toxicology Research, 2008, p.8). Therefore, these places are highly affected by air pollution. The information about air pollution is collected by primary survey. Figure 5.6 shows the percentage share of awareness about environmental pollution.

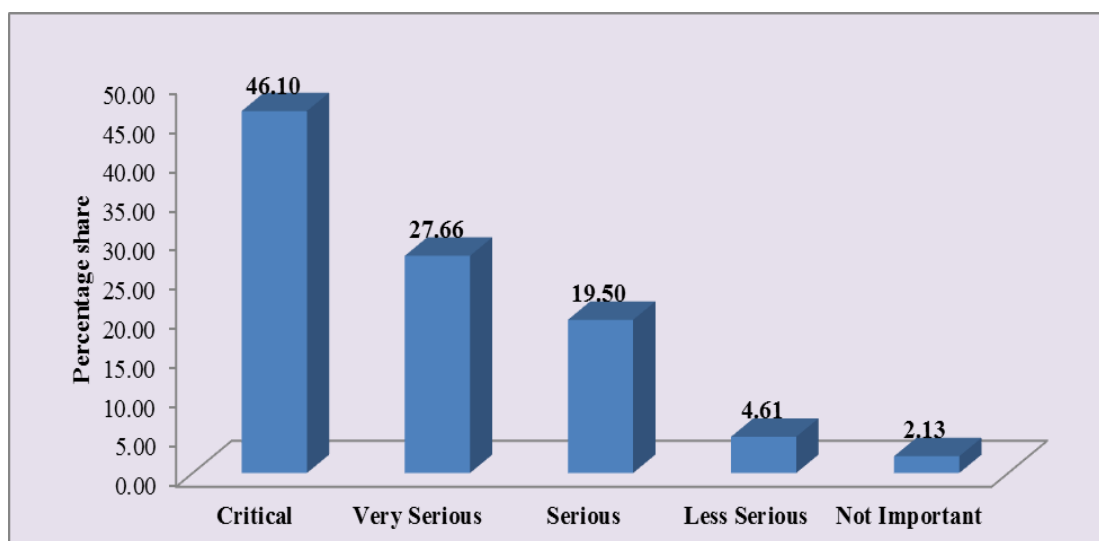
Figure 5.6: Awareness on Environmental Pollution in Study Area (in percent)



Source: Estimated from Primary Data

For the information about air quality awareness, 97.83 percent people are aware on environmental pollution and 2.17 percent are not aware. Approximately 93.48 percent agree for air pollution is a serious problem and 6.52 percent are disagree. Further, 91.3 percent people are facing outdoor air pollution and 8.7 percent are not facing problems in both the study area.

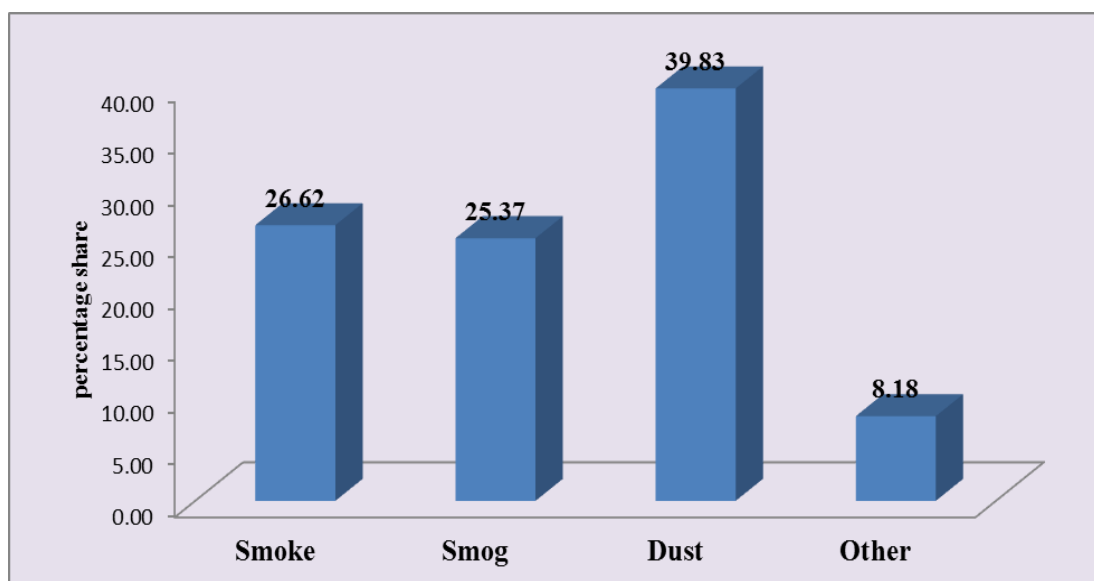
Figure 5.7: Condition of Air Pollution Problems in Study Area (in Percent)



Source: Estimated from Primary Data

Figure 5.7 shows the condition of air pollution problems in the study area. These problems are divided into five categories viz., critical, very serious, serious, less serious, not important. The percentage share of critical condition is 46.10 percent, which is representing highest and 27.66 percent population agree for very serious and only 2.13 percent person agrees only for not important. Therefore, it is found that study area is highly affected by air pollution and people are suffering from many problems. There are many causes responsible for increasing air pollution in Lucknow city such as vehicular emissions and rising private vehicles on road which are related to the transport related air pollution, industries surrounding the city, and the unconsciousness related problems of government and public (Saluja Geetika, 2017, p.1).

Figure 5.8: Nature of Outdoor Air Pollution Problems in the Study Area (in percent)

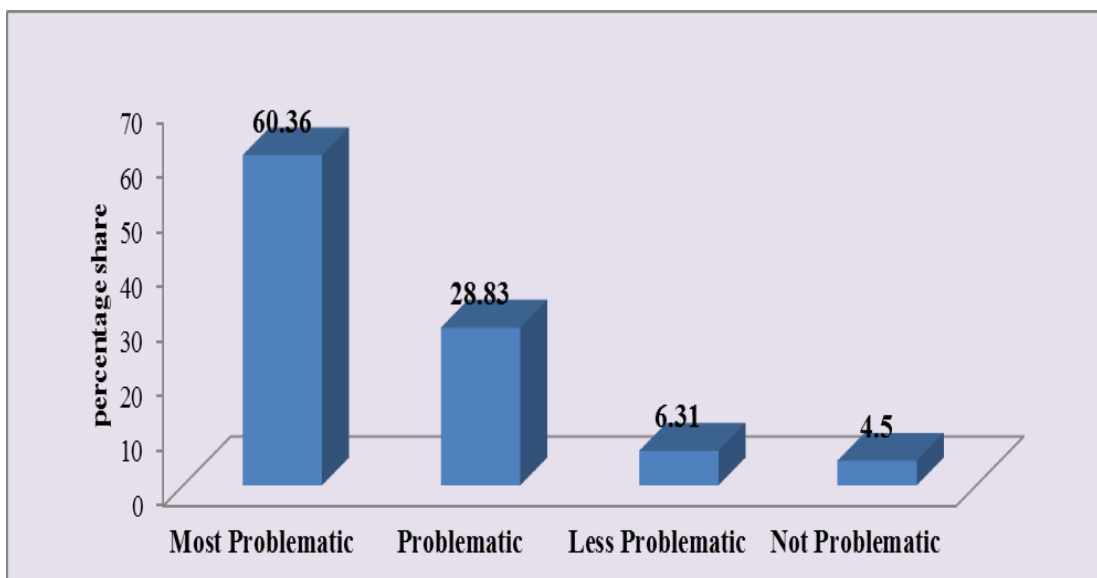


Source: Estimated from Primary Data

There are many problems related to the air pollution. Study area has been covered with industrial and commercial areas. Therefore, the nature of outdoor air pollution divided into four categories such as smoke, smog, dust and other problems. There are 26.62 and 25.37 percent of respondents suffering from smoke and smog induced air pollution problems respectively.

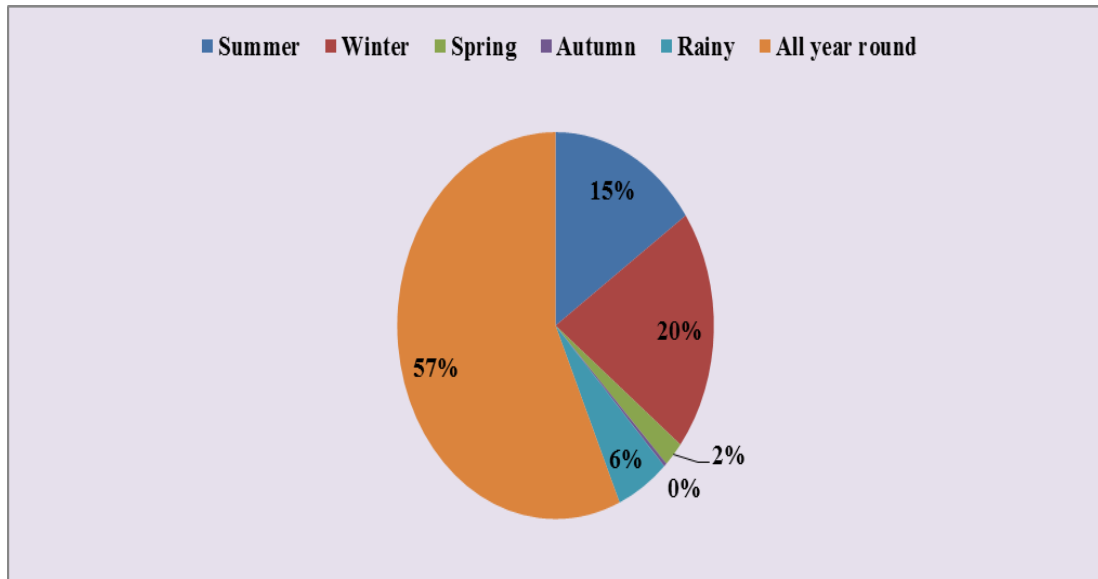
Generally, smoke can more easily enter and harm to children's lungs as well as it can also exacerbating life threatening diseases (Rees Nicholas, 2016, p.6). At the world level, every year nearly one million children's died due to the smoke in the home (Warwick Hugh & Doig Alison, 2004, p. 6). Smog is also a serious problem for environment. Thousands of people have died due to the high levels of sulphur dioxide (SO₂) and different diameter present in outdoor air. This adverse health impact of air pollution at population level is so called the Great Smog during December 1952 in London (Galicic.A., Zaletel Kragelj, et.al., 2015, p.36). Dust is also the common problem and 39.83 percent people are facing this problem. In industrial area, there are many causes responsible for air pollution such as increase of the automobiles on road and increase of the deforestation rate for the construction of highways.

Figure: 5.9 Degree of Outdoor Air Pollution related Problems in the Study Area (in percent)



Source: Estimated from Primary Data

Figure 5.8 shows the degree of problems. Degree of problems are related to many categories viz., most problematic, problematic, less problematic and not problematic. Approximately 61 percent of respondent agree for air pollution is most problematic and 28.83 percent are agree for problematic. Only 4.5 percent people do agree that the level of air pollution exist in that area is not problematic.

Figure 5.10: Seasons Wise Intensity of Air Pollution

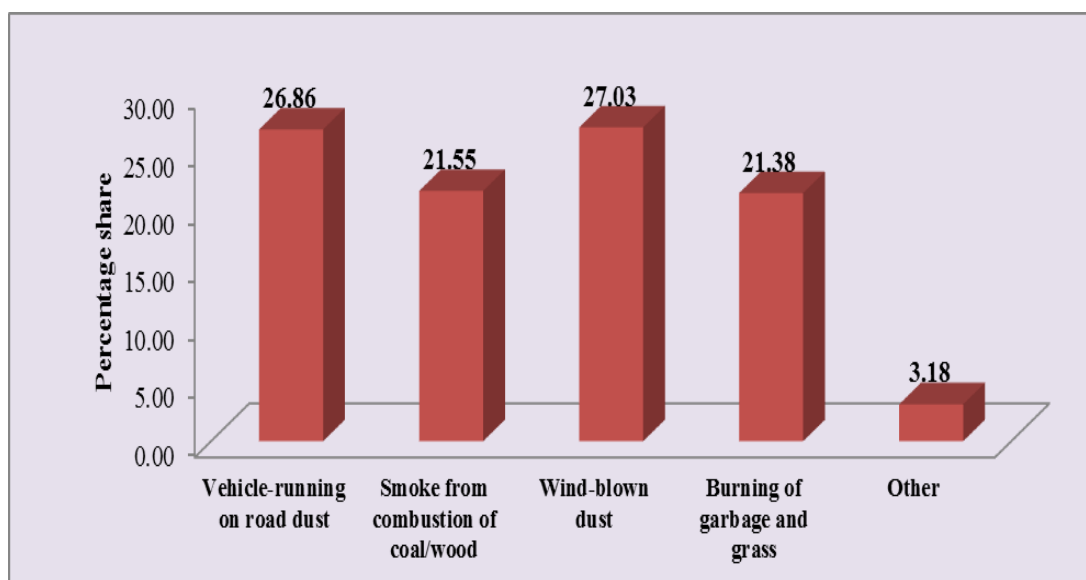
Source- Estimated from Primary Data

Season wise perception of the respondent on air pollution is divided into six groups such as summer, winter, spring, autumn, rainy, and all year round. Nearly 57 percent people agree for all year round which is very highest and 20 percent person is suggesting for winter season. Figure 5.10 shows that, in these areas, air pollution is very less in the rainy season which, is only 6 percent. Delhi is another big example of high air pollution in India. In Delhi and its adjoining areas, the level of pollution is high in the winter, because the temperature decreases and inversion. It traps the pollutants near the ground and does not allow dispersion (EPCA, 2018, p.5).

In the Lucknow city, major sources such as secondary sulphates, wood combustion, diesel and gasoline powered exhaust and road dust are responsible for the higher level of air pollutants in urban area especially of the particulate matter (Barman. S.C., et.al., 2010, p.913). Figure 5.11 shows the sources of outdoor air pollution in the study area. There are five sources responsible for air pollution which are vehicles running on road, smoke from combustion of coal/wood, windblown dust, burning of garbage and grass, and other. The first preference select for the graph percentage because all sources are responsible for air pollution and households were agreed for all options. the percentage share of windblown dust is highest which is 27.03 percent and it is highly responsible for air pollution, especially in industrial area (Talkatora) followed

by 26.86 percent of the vehicles entrained which is also high it is mostly found in a commercial area (Sarai Mali Khan) and other sources are very low which is only 3.18 percent.

Figure 5.11: Sources of Outdoor Air Pollution in the Study Area



Source: Estimated from Primary Data

5.6 Classification of Air Pollution Induced Diseases in Study Area

According to the WHO, air pollution is the largest environmental risk factor in the present time. Outdoor air pollutants affect human health in various ways, such as increased mortality and morbidity. In 2008, there are 1.3 million deaths estimated from ambient air pollution (WHO, 2016, p.1). PM10 is very dangerous to health because it block and inflame nasal and bronchial passages, and increase the respiratory related disease that leads to illness or death (UNICEF, 2016, p.20). There are three categories of disease related to the outdoor air pollution, such as respiratory, cardiovascular and Infections diseases. Respiratory disease covers the asthma attacks, shortness of breath, respiratory allergy to dust & pollen, cough with phlegm, dry cough, bronchitis, lung cancer. Cardiovascular disease refers to heart disease and infection is covering the eye, nose, throat irritation & skin infection. The intensity of diseases are divided into acute, sub chronic and chronic. Acute diseases related to the 0 to 14 days. Basically coughing, shortness of breath, tightness of the chest and irritation of the eyes are the main result of acute diseases (EPA, 2012). Sub chronic diseases are associated with 14 to 90 days and chronic diseases are covering 90 days

to 3 year related diseases such as reduced lung function, development of respiratory diseases in children and premature death of people with lung disease.

5.6.1 Cardiovascular Diseases

In mega cities and urban areas, ambient air pollution has become a matter of severe concern. Urbanization, population growth, transportation, economic development and increase in energy consumption are the major causes of air pollution in the large cities. There are many pollutants are found in the air of lucknow such as PM10, SPM, SO2, NOx and metals etc (Verma A. K., Saxena A, et.al, 2015, p.1176). In the survey area, cardiovascular related heart diseases are found in 15 people. Where, 14 cases are chronic disease and 1 case is to sub-chronic in nature. There are 5 people affected to general category, 8 people from OBC group and 2 people from SC category. Basically, the main sources of air pollution in developing countries are use of wood, coal and crop residue for domestic energy and the PM10 average annual level is exceeding 70 micrograms per cubic meter. The woods, coals and automobile pollution are the main sources of air pollution and average level of PM10 is exceed 180 micrograms per cubic meter. Further, both types of short term and long term exposure to PM can leads to risk of ischaemic heart disease, atherosclerosis and myocardial infarction ie. Basically, there are two mechanisms responsible for cardiovascular diseases. First is clotting hypothesis and second is neural hypothesis. Clotting hypothesis suggest that inhaled small particles can cause an inflammatory response which in turn may activate the clotting blood vessels and the neural hypothesis suggest that air pollutant effect neural receptors in the lungs, which can disturb the rhythm of the heartbeat. in developed countries, cardiovascular diseases are related to outdoor air pollution as well as active and passive smoking while there is a less information about developing countries and air pollution from household solid fuel uses constitutes a major hazard. Therefore, a very little information is available of the relationship between air pollution and cardiovascular diseases (Bbeigbe, 2008, p.1105).

Table 5.2 shows that age wise classification of the cardiovascular diseases in the study area. Where total 15 household are affected by the heart diseases and 40 percent people are affected from 60 to 69 year age group and 20 percent people are from above 70 year age group. It means that in the study area outdoor air pollution is highly

affecting to 30 to above 70 year old people. There are 6 person are from private sector employment and the main cause of death due heart disease is lack of income. Therefore, people are facing many problem such as treatment, awareness etc.

Table 5.2: Age wise Cardiovascular Diseases in the Study Area

Age Group	Percentage of Heart Diseases
(30-44)	3 (20.00)
(45-59)	3 (20.00)
(60-69)	6 (40.00)
(70-above)	3 (20.00)
Total	15 (100.00)

Source: Estimated from Primary Data

5.6.2 Respiratory Diseases

There are six types of respiratory disease found in the study area such as asthma attacks, shortness of breath, respiratory allergy to dust & pollen, cough with phlegm, dry cough, and Bronchitis as well as there is not any respondent affected by the lung cancer. Respondent with respiratory diseases are classified with two type such as person affected by one and person affected by two respiratory diseases at a particular time. Total 209 people are affected by respiratory diseases during last one year, and 183 person are suffering from single respiratory disease. Where 23.50 percent from asthma attacks, 39.34 percent from shortness of breath which is highest in the study area nearly 20.21 percent people are affected from respiratory allergy to dust and pollen. Further, 7.65 percent from cough with phlegm and same percent from dry cough and very lower share of the bronchitis disease which is only 1.64 percent of the study area.

Table 5.3: Degree of Respiratory Diseases 1&2

Degree of Diseases 1	No. of observation	Percentage
Acute	69	37.70
Sub Chronic	38	20.77
Chronic	76	41.53
Total	183	100.00
Degree of Diseases 2	No. of observation	Percentage
Acute	10	38.46
Sub Chronic	5	19.23
Chronic	11	42.31
Total	26	100.00

Source- Estimated from Primary Data

Table 5.3 shows the percentage share of respiratory degree of disease where two diseases found in a single person at point of time. Total 183 person are affected single diseases where 37.70 percent people are suffering from acute diseases and 20.77 are related to sub chronic diseases. The highest percentage share of the chronic diseases which is 41.53 percent of the total of the study area. Total 26 people are affected by two diseases. The highest percentage of chronic disease which is 42.31 percent and sub chronic degree of disease is 19.23 percent while acute disease percentage share is 38.46 percent in the study area. Therefore, it has been found that due to air pollution in the study area, people are suffering from long term diseases.

Table 5.4: Age Wise Respiratory Diseases in the Study Area

Age group	Asthma	Shortness of breath	Respiratory allergy to dust & pollen	Cough with phlegm	Dry Cough	Bronchitis	Total
(0-14)	0 (0.00)* (0.00)**	2 (33.33)* (2.78)**	2 (33.33)* (5.41)**	1 (16.67)* (7.14)**	1 (16.67)* (7.14)**	0 (0.00)* (0.00)**	6 (100.00)* (3.28)**
(15-29)	7 (28.00)* (16.28)**	13 (52.00)* (18.06)**	3 (12.00)* (8.11)**	1 (4.00)* (7.14)**	1 (4.00)* (7.14)**	0 (0.00)* (0.00)**	25 (100.00)* (13.66)**
(30-44)	10 (15.38)* (23.26)**	22 (33.85)* (30.56)**	17 (26.15)* (45.96)**	5 (7.69)* (35.71)**	9 (13.85)* (64.29)**	2 (3.08)* (66.67)**	65 (100.00)* (35.52)**
(45-59)	11 (20.75)* (25.38)**	25 (47.17)* (34.72)**	10 (18.87)* (27.03)**	5 (9.43)* (35.71)**	2 (3.77)* (14.29)**	0 (0.00)* (0.00)**	53 (100.00)* (28.96)**
(60-69)	14 (51.85)* (32.56)**	7 (25.93)* (9.72)**	4 (14.81)* (10.81)**	2 (7.41)* (14.29)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	27 (100.00)* (14.25)**
(70-above)	1 (14.29)* (2.33)**	3 (42.86)* (4.17)**	1 (14.29)* (2.70)**	0 (0.00)* (0.00)**	1 (14.29)* (7.14)**	1 (14.29)* (33.33)**	7 (100.00)* (3.83)**
Total	43 (23.50)* (100.00)**	72 (39.34)* (100.00)**	37 (20.22)* (100.00)**	14 (7.65)* (100.00)**	14 (7.65)* (100.00)**	3 (1.64)* (100.00)**	183 (100.00)* (100.00)**

Source: Estimated from Primary Data

Note: *Row percentage ** Column percentage

Table 5.4 shows the age wise respiratory diseases and their frequency distribution. The percentage share of respiratory diseases in 0 to 14 year children is 3.28 percent and 13.66 percent share of the 15 to 29 years old people. Most of the population in the study area is working on private sector, especially in industries and they are highly affected by air pollution Because of that the highest share i.e. 35.52 percent has been found in this age group 30-44 and mostly person are affected by shortness of breath disease. There is 28.96 percent share of the 45 to 59 years old person which is also high and 14.25 percent of the 60 to 69 years old. Approximately 3.83 percent share of

the 70 and above population because of live in highly air pollution affected area in long duration. Diseases wise percentage share is 23.50 percent of the asthma patient and 39.34 percent of the shortness of breath which also highest in the study area. There are 20.22 percentage share of the respiratory allergy to dust and pollen diseases. In the industrial area, there is not any health facilities for workers.

Table 5.5: Education wise share of Respiratory Diseases (in percent)

Educational Pattern	Asthma attacks	Shortness of breath	Respiratory allergy to dust & pollen	Cough with phlegm	Dry Cough	Bronchitis	Total
Illiterate	7 (25.76)* (39.53)**	23 (34.85)* (31.94)**	15 (22.73)* (40.54)**	4 (6.06)* (28.57)**	6 (9.09)* (42.86)**	1 (1.52)* (33.33)**	66 (100.00)* (36.07)**
Primary	11 (19.64)* (25.58)**	23 (41.07)* (31.94)**	10 (17.86)* (27.03)**	6 (10.71)* (42.86)**	5 (8.93)* (35.71)**	1 (1.79)* (33.33)**	56 (100.00)* (30.60)**
Secondary	5 (14.29)* (11.63)**	16 (45.71)* (22.22)**	6 (17.14)* (16.22)**	4 (11.43)* (28.57)**	3 (8.57)* (21.43)**	1 (2.86)* (33.33)**	35 (100.00)* (19.13)**
Higher Secondary	4 (33.33)* (9.30)**	6 (50.00)* (8.33)**	2 (16.67)* (5.41)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	12 (100.00)* (6.56)**
Diploma/Certificate	3 (60.00)* (6.98)**	1 (20.00)* (1.39)**	1 (20.00)* (2.70)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	5 (100.00)* (2.73)**
Graduate	3 (50.00)* (6.98)**	1 (16.67)* (1.39)**	2 (33.33)* (5.41)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	6 (100.00)* (3.28)**
Post Graduate	0 (0.00)* (0.00)**	1 (50.00)* (1.39)**	1 (50.00)* (2.70)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	2 (100.00)* (1.09)**
Other	0 (0.00)* (0.00)**	1 (100.00)* (1.39)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	1 (100.00)* (0.55)**
Total	43 (23.50)* (100.00)**	72 (39.34)* (100.00)**	37 (20.22)* (100.00)**	14 (7.65)* (100.00)**	14 (7.65)* (100.00)**	3 (1.64)* (100.00)**	183 (100.00)* (100.00)**

Source: Estimated from Primary Data

Note: *Row percentage ** Column percentage

Table 5.5 shows the education wise percentage share of respiratory diseases. These diseases are highly founded in the illiterate category and their percentage share is estimated 36.07 percent of the total. They are highly affected because of the lack of awareness and less income. These people are living in near by industries and road side due to poverty. Same with the primary education related person their percentage is

30.60 percent. There are 19.13 percent people of secondary education is suffering from respiratory education. In the study area, due the increasing the level of education, the percentage share of diseases is fallen. It is found that due lack of education, the awareness of health is low.

Table: 5.6 Occupation Wise Share of Respiratory Diseases (in percent)

Occupational Pattern	Asthma attacks	Shortness of breath	Respiratory allergy to dust & pollen	Cough with phlegm	Dry Cough	Bronchitis	Total
Government Sector	3 (42.86)* (18.75)**	1 (14.29)* (2.22)**	2 (28.57)* (8.70)**	1 (14.29)* (12.50)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	7 (100.00)* (6.93)**
Private Sector	10 (14.93)* (62.50)**	28 (41.79)* (62.22)**	16 (23.88)* (69.57)**	5 (7.46)* (62.50)**	8 (11.94)* (100.00)**	0 (0.00)* (0.00)**	67 (100.00)* (66.34)**
Self Employed	3 (11.11)* (18.75)**	16 (59.26)* (35.56)**	5 (18.52)* (21.74)**	2 (7.41)* (25.00)**	0 (0.00)* (0.00)**	1 (3.70)* (100.00)**	27 (100.00)* (26.73)**
Total	16 (15.84)* (100.00)**	45 (44.55)* (100.00)**	23 (22.77)* (100.00)**	8 (7.92)* (100.00)**	8 (7.92)* (100.00)**	1 (0.99)* (100.00)**	101 (100.00)* (100.00)**

Source: Estimated from Primary Data

Note: *Row percentage ** Column percentage

Table 5.6 shows the occupation wise percentage share of respiratory diseases. There are three types occupation in the study area such as government sector, private sector and self employed sector. Basically, employment is also divided into two categories such as indoor work (office, shop keeping and factory workers) as well as outdoor work (labour in constructional side, labour in transport sector and field job). In the study area, most of the people work in open space in private sector population are highly affected by respiratory diseases and their percentage share is 66.34 percent. There are 26.73 percent and 6.93 of workers work in closed space especially self employed and regular job holders in public ssector office respectively suffer various

respiratory diseases. Due to limited wage, households economic condition was weak. Therefore, they are unable to take health facilities.

5.6.3 Infectious Diseases

In developing countries, acute respiratory infections are the leading cause of the global burden of diseases and cause more than 6 percent mortality worldwide. From 1997 to 1999, there are 4 million deaths were taken place due to acute lower respiratory infections (Chauhan & Johnston, 2003, p. 97). In the study, many infectious diseases such as eye, nose, throat and skin infection are found.

Table 5.7: Frequency Distribution of Infections Diseases 1

Type of Infectious	Frequency Disease & Percentage
Eye	72 (59.50)
Nose	9 (7.45)
Throat Infectious	10 (8.26)
Skin Infectious	30 (24.79)
Total	121 (100.00)
Degree of Diseases	Frequency & (Percentage Share)
Acute	47 (97.92)
Sub Chronic	1 (2.08)
Total	48 (100.00)

Source: Estimated from Primary Data

Table 5.7 shows the frequency distribution of infectious diseases in the study area. There are mainly four types of infectious diseases found in the study area, which are eye infection, nose infection, throat infection and skin infection etc. There are 121 people are affected by infectious diseases due to air pollution. In Talkatora zone the situation is worse because most of the people are working in wood industries. Therefore, eye and skin infection are very high and their percentage share is 59.50 and 24.79 percent of the total respectively. Sarai Mali Khan zone is also highly affected by vehicular pollution. Therefore, nose infection is very high in this area.

Approximately 8.26 percent is the share of throat infection and 7.45 percent of the nose infection.

Table 5.8: Degree of infectious Diseases 1

Degree of Diseases	Frequency Disease & Percentage
Acute	105 (86.78)
Sub Chronic	8 (6.61)
Chronic	8 (6.61)
Total	121 (100.00)

Source: Estimated from Primary Data

Basically, available mortality and morbidity statistics indicates that respiratory infections and chronic conditions are widespread in Indian cities, which are the most polluted cities in the world. Due to air pollution, three type of acuteness may result such as inhalation of gases and vapors are asphyxiation, irritation of respiratory organs and harcosis, other effects such as stuffy or runny nose, sinusitis, sore throat, wet cough, head cold, fever and burning or red eyes (A. Gautam, M. Mahajan & S. Garg, 2009, p. 2). In the study area mostly people are affected by acute diseases and the percentage share is 86.78 percent. While, only 6.61 percent people are affected from the sub chronic and chronic diseases (Table 5.8).

Table 5.9: Frequency Distribution of Infectious Diseases 2

Type of Infectious	Frequency Disease- 2
Eye	2 (4.17)
Nose	21 (43.75)
Throat Infection	3 (6.25)
Skin Infection	22 (45.83)
Total	48 (100.00)

Source: Estimated from Primary Data

Table 5.9 reflects on the frequency distribution of respondents having two infectious diseases at a time. The higher percentage share of the skin infection because 22 people are suffering from two diseases and their percentage share is also high which is 45.83 percentage. There are 97.92 percent suffering from acute diseases and only 2.08 percent of sub chronic diseases.

Table 5.10: Compare Age Wise Intensity of Infectious Diseases (in percent)

Age group	Percentage share
(0-14)	7.44
(15-29)	24.79
(30-44)	34.71
(45-59)	26.45
(60-69)	5.79
(70-above)	0.83
Total	100.00

Source: Estimated from Primary Data

Table 5.10 shows age wise intensity of infectious diseases where 30 to 44 year old population is highly affected by the infection and the percentage share is 34.71 percent of the total than after the maximum share of the 45 to 59 which is 26.45 percent because of their working condition. There are 24.79 percent share of the 15 to 29 year old people and the less share of 60 to 69 which is 5.79 percent and they are not highly affected by outdoor air pollution. Therefore, it is estimated that working population age group is highly affected by the skin infectious diseases.

Table 5.11: Occupation wise Intensity of Infectious Diseases (in percent)

Occupation	Percentage Share
Government Sector	9.85
Private Sector	49.30
Self Employed	40.85
Total	100.00

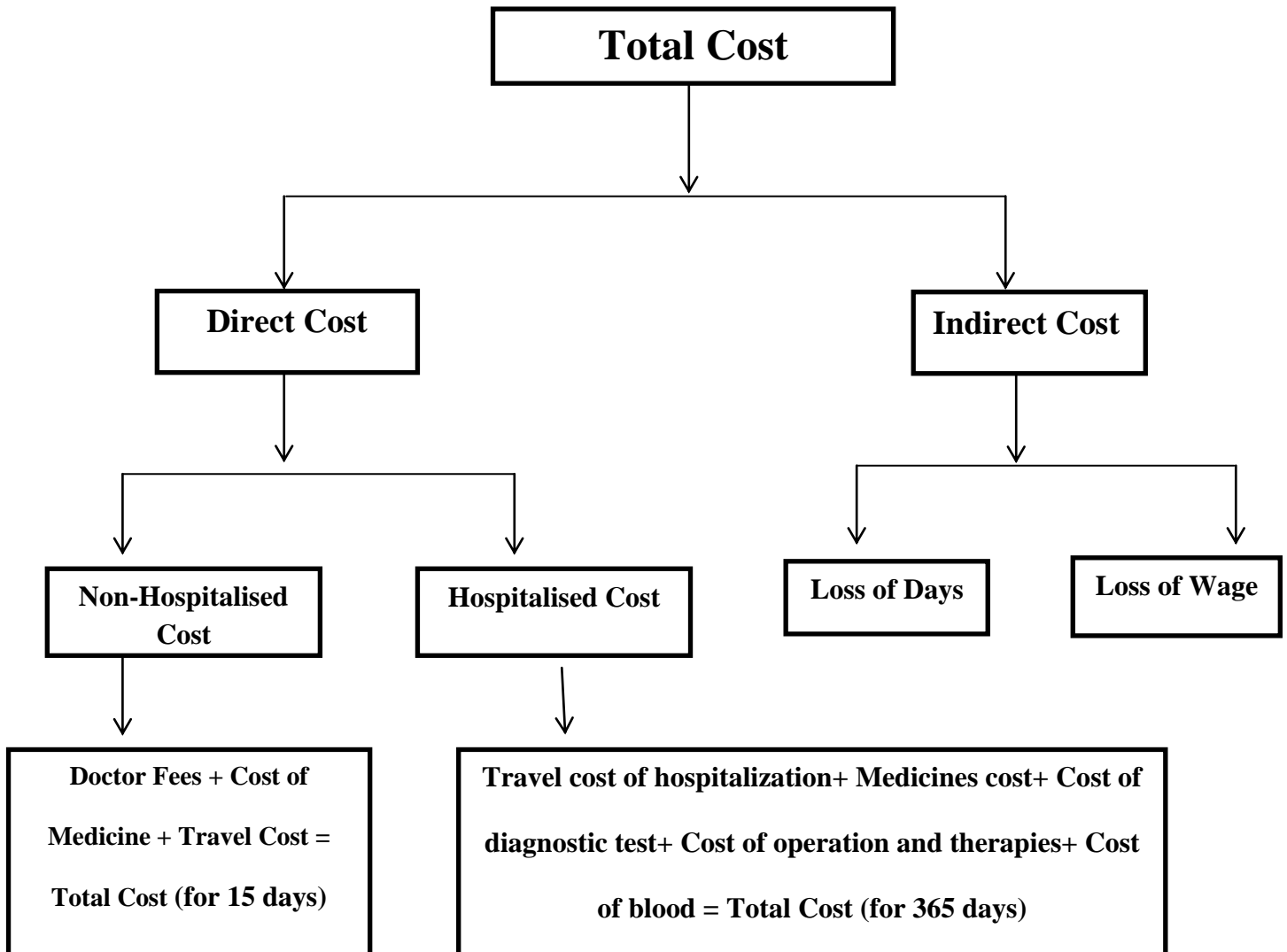
Source- Estimated from Primary Data

Table 5.11 shows the occupation wise infection diseases. It is estimated that the highest percentage share of the private sector, which is related to the outdoor employment sector and their percentage is 49.30 percent people are affected by the infection diseases and self employed percentage share is also same which is 40.85. There are only 9.85 percent people are affected by this disease because they are working in indoor employment sectors such as office work etc. it is observed that those people who are working in the industries and open spaces places, highly affected by the infectious diseases. In the study area, households were not serious for infectious diseases therefore, mostly people suffering from chronic diseases.

5.7: Cost of Illness of Households

Cost of illness describes the economic burden of a disease in the society. It can also measure the costs of treating a particular disease due the illness (Tediosi Fabirizio, Parazzini Fabio, Garattini Livio, 2000, p.14). Cost of illness approach is used for estimating of the economic costs of health care and lost of output up to recovery or death. Air pollution causes human morbidity, therefore the valuation of illness is actually important for assessing the social costs of air pollution and cost-benefit analysis of control measures (Lvovsky Kseniya, 1998, p.15).

Figure 5.12: Structure of Health Cost



This figure shows the structure for the measurement of cost of illness. Cost of illness cover the direct and indirect cost. Direct cost includes the medical expenditure and indirect cost includes the loss of days and loss of wages. Further direct cost divided into two categories Non-hospitalised cost and hospitalized cost. According to both round of National Sample Survey Organisation (NSSO) round 60 (2004, p.7), there are two categories of treatment first is non-hospitalisation and second hospitalization. Non-hospitalisation treatment is known for the 15 days and hospitalization treatment is related to the 365 days. In the study area, the non-hospitalisation cost is covering the doctor fee, cost of medicine and travel cost. And hospitalization cost is covered the travel cost of hospitalization, medicines cost, cost of diagnostic test, cost of operation and therapies, and cost of blood.

Table 5.12: Summary of Non- Hospitalisation & Hospitalisation Cost of Households

Type of Fees	Mean	Maximum	SD
Non- Hospitalisation Cost			
Doctor fees	12.45	800	63.12
Medicine fees	45.39	3000	197.63
Travel fees	4.68	200	21.81
Hospitalisation Cost			
Medicine fees	212.32	25000	1326.91
Travel fees	52.78	5000	281.51
Cost of diagnostic test	72.55	5000	418.35

Source- Estimated from Primary Data

Table 5.12 shows the non-hospitalized costs and hospitalized costs of the households in the study area. Non-hospitalised cost includes to the doctor fee, medicine fee and travel cost which is based on the 0 to 14 days where people are mostly affected to the acute diseases. Mean of the doctor fees of non-hospitalisation cost is Rs.12.45 and the maximum fee is Rs. 800 per month, which is very high because people are earning low income. The standard deviation of the doctor fee is 63.12, which is showing the high variation with the mean value and it is found that the cost of illness is more in the study area. Mean of the medicine cost is Rs.45.39 and the maximum cost is Rs. 3000 and the travel cost is Rs. 200 per month for the non-hospitalised costs.

Hospitalized costs which includes travel cost, medicines cost, cost of diagnostic test, operation and therapies and cost of blood. This is covered to the above 90 days to 3 year illness and related to the chronic diseases. The maximum cost of medicine is Rs.

25000 and the mean is Rs. 212.32 per month. The mean of the travel costs is 52.78 and maximum cost is Rs. 5000 and diagnostic test cost is also 5000 Rs. per month. Both costs are related to the direct costs of the cost of illness of the study area.

Table 5.13: Total Cost of the Households

Statistics	Direct Cost	Indirect Cost	Total Cost
Mean	406.45	90.27	496.71
Standard Deviation	1930.25	311.02	2049.37
Annual			
Mean	4877.36	1083.14	5960.50
Standard Deviation	23162.95	3732.15	24592.39

Source- Estimated from Primary Data

Basically, in the study area poor health condition of the individual is a poses a great economic burden to them because they are spending a huge share of their income for the treatment of the these diseases as well as loss of their productivity. Most of the individual is working in private job, especially in the form of industrial worker and shopkeeper and they are unable to go to work because of their poor health or due to ill health of their family person. This increases to loss of their productivity and wages. Therefore, they are facing low economic condition and suffering from many problems. Direct cost of illness refers to hospitalized and non-hospitalised costs of the household and indirect cost of illness includes the loss of number of working days and loss of wages due to own illness or illness of any family member. Non-hospitalisation cost is includes 1 to 14 days cost while hospitalization cost is includes after 15 days cost of the treatment. Table 5.13 shows the direct cost, indirect cost and total cost. The direct cost of the study area is Rs. 406.45 per month and the indirect cost is Rs. 90.27. Therefore, total cost of the study area is Rs. 496.71 per month.

Table 5.14: Inequality Cost of Treatment of the Households based on Socio-Economic Characteristics

Caste Wise Cost	Total Cost	Total Direct Cost	Total Indirect Cost
General	500.56	389.51	111.06
OBC	501.27	418.87	82.41
SC	470.27	421.58	48.69
Average	496.71	406.45	90.27
Gender wise Cost			
Male	489.15	367.33	121.83
Female	504.86	448.58	56.28
Average	496.71	97.38	399.34
Occupation wise Cost			
Government Employees	1323.48	906.09	417.40
Private Employees	478.73	346.75	131.98
Self Employed	900.76	596.97	303.80
Average	615.80	431.51	184.29
Income wise Cost			
Lower Income Group	427.19	340.76	86.44
Middle Income Group	644.40	435.80	208.60
Upper Income Group	1696.67	996.39	700
Average	614.20	430.39	183.81

Source: Estimated from Primary Data

Table 5.14 represents the socio economic characteristics wise cost of treatment of the households which is related to caste, gender, occupation and income.. Caste wise cost divided into three categories such as General, OBC, and SC. The total cost is highest in the OBC category, which Rs. 501 per month and lowest in SC group which is Rs. 470.27 per month. Total direct cost is highest in the SC category which Rs.421.58 per month and lowest in general which is estimated only Rs. 389.51 per month. Indirect cost is related to the loss of wage and loss of days and this cost is highest in the general group which is Rs. 111.06 and lowest in SC category that is Rs. 48.69 per month. The total cost is Rs. 614.20 and direct cost is Rs. 430.39 and indirect cost is

Rs. 183.81 per month in the study area and it has been found that SC category spend highest for the treatment of diseases.

Gender wise analysis shows that female workwer spend more than male workers for treatment of disease in the household. Direct cost is higher for the female category because they are living near of industrial area which and female cost is Rs. 367.33 per month and Indirect cost is high for male categories per month in the study area. Occupation wise cost is divided into three categories such as government employees, private employees and self employed. In the government categories, the total cost is highest which Rs. 1323.48 and also highest in terms of direct and indirect cost which is Rs. 906.09 and Rs. 417.40 cost per month. In the private sector, total cost is Rs. 478.73 and direct cost is lower that is Rs. 346.75. Self employed person are also spend high cost for treatment where their total cost is Rs. 900.76 and direct cost is Rs. 596.97 and indirect cost is Rs. 303.80. Therefore, it is found that total cost is high as well as direct cost is also increasing with the chronic diseases in the study area.

There are three categories of income wise cost which are lower income group, middle income group and upper income group. Upper income group cost is highest in all categories, which is Rs. 1696.67 of total cost, Rs.996.67 is direct cost and Rs.700 is indirect cost . In the middle income group, the direct cost is estimated Rs. 435.80 and Rs. 208.60 found indirect cost. There is Rs. 427.19 cost estimated in the lower income group. Economically the total cost of all income groups is estimated very high which is Rs. 614.20 per month and direct cost is Rs. 430.39 and Rs. 183.81 is indirect cost in the study area. Therefore, it is found that for the better treatment, upper income group is pay high cost of illness.

5.8 Dummy Variable Analysis

It is already found that variables such as gender, education, occupation pattern, and age have a significant effect on cost of illness. The effects of such variables are analysrd through dummy variable models.

Impact of Education on Cost of Illness

Model 1

Cost of Illness = f (Education)

$$Y_i = \alpha + \beta_1 D_{1i} + \mu_i$$

Where,

α = intercept

β_1 = slope coefficient

D_{1i} = 1 if the education of the individual is above secondary

= 0 otherwise, i.e., if the education of the individual is up to secondary

Table 5.15: Results of Dummy Regression for Cost of Illness and Education

Dummy Variable	Coefficient	Cost of Illness	t-value	Level of significance
Total Cost of Illness				
α (Base Category)	566.69	566.69	7.91	0.000*
D1i 1= above secondary 0= Otherwise	-265.76	300.93	-1.90	0.057***
Direct Cost of Illness				
α (Base Category)	470.29	470.29	6.97	0.000*
D1i 1= above secondary 0= Otherwise	-242.49	227.8	-1.84	0.065***
Indirect Cost of Illness				
α (Base Category)	96.39	96.39	8.86	0.000*
D1i 1= above secondary 0= Otherwise	-23.28	73.11	-1.10	0.273(NS)

Note: * 1 percent level of significance, **5 percent level of significance, ***10 percent level of significance

Source: Estimated from Primary Data

Model 1 shows the dummy result of the cost of illness on the basis of education. The mean of illness of up to secondary education category is Rs. 566.69 per month and this is also showing the β_1 value and coefficient value. D_{1i} is showing the above secondary education related cost of illness and the coefficient is -265.76. The calculated cost of illness is Rs. 300.93 the mean cost of illness of above secondary education group. Direct cost also significant at a 10 percent level of significance and mean of illness up to secondary level is high but in case of indirect cost the model is not significant because above secondary level have much educational knowledge therefore, they are less suffering from loss of wage. Finally, it is found that all people are suffering from air pollution related problems, but due to lack of awareness and education, up to secondary school educated people are paying high costs of illness as compare to above secondary group and approximately 80 percent population are under this group and rest 20 percent populated is cover the above secondary group and they are taking some precautions to save their life as well as aware of the air pollution. Therefore, they are spending less cost of illness due to various illness.

Model 2

Cost of Illness = f (**Occupation**)

$$Y_i = \alpha + \beta_1 D_{1i} + \mu_i$$

Where,

α = intercept, β_1 = slope coefficient, $D_{1i} = 1$ if the occupation of the individual is in Private Sector/ self employed, = 0 otherwise, i.e., if the occupation of the individual is Government sector

Table 5.16: Results of Dummy Regression for Cost of Illness and Occupational Category

Dummy Variable	Coefficient	Cost of Illness	t-value	Level of significance
Total Cost of Illness				
α (Base Category)	1323.48	1323.48	4.48	0.000*
D _{1i} 1= Private Sector 0= Otherwise	-752.65	570.83	-2.47	0.014**
Direct Cost of Illness				
α (Base Category)	906.09	906.09	3.63	0.000*
D _{1i} 1= Private Sector 0= Otherwise	-504.74	401.35	-1.96	0.051***
Indirect Cost of Illness				
α (Base Category)	417.39	417.39	4.47	0.000*
D _{1i} 1= Private Sector 0= Otherwise	-247.92	169.47	-2.57	0.010*

Note: * 1 percent level of significance, ** 5 percent level of significance, *** 10 percent level of significance

Source: Estimated from Primary Data

Table 5.16 shows the dummy result of the cost of illness on the basis of occupation. Two categories of occupation which are government sector employees and private employees. Further, it cover the outdoor jobs and indoor jobs for the measuring the effect of air pollution in the study area. D_{1i} (Dummy) is showing 0 & 1 values. Cost of illness is the dependent variable. Model and variable both are significant at the 5 percent level of significance. The constant coefficient (α) and cost of illness of the government employees is Rs. 1323.48 per month and the coefficient value of the private employers is Rs. -752.65 and their cost of illness is less Rs. 570.83 per month. The main cause of less cost of illness of the private employer is lack of income and lack of health facilities. While government employees can takes good health facilities and guidance by the doctor. Private employees is not capable to paying the doctor fees and health facilities. Therefore, occupation wise cost of illness is high of government sector employees and their direct and indirect cost is also high in the study area.

Model 3

Cost of Illness = f (Age)

$$Y_i = \alpha + \beta_1 D_{1i} + \mu_i$$

Where, α = intercept, β_1 = slope coefficient, $D_{1i} = 1$ if the individual is above 15 age group

= 0 otherwise, i.e., if the individual is below 15 age group

Table 5.17: Results of Dummy Regression for Cost of Illness and Age Groups

Dummy Variable	Coefficient	Cost of Illness	t-value	Level of significance
Cost of Illness				
α (Base Category)	33.92	33.92	0.26	0.794 (NS)
D _{1i} 1= above 15 age group 0= Otherwise	594.03	627.95	4.03	0.000*
Direct Cost of Illness				
α (Base Category)	29.23	29.23	0.24	0.812 (NS)
D _{1i} 1= above 15 age group 0= Otherwise	484.19	513.42	3.48	0.001*
Indirect Cost of Illness				
α (Base Category)	4.69	4.69	0.24	0.811(NS)
D _{1i} 1= above 15 age group 0= Otherwise	109.84	114.53	4.93	0.000*

Note: * 1 percent level of significance, ** 5 percent level of significance, *** 10 percent level of significance

Source: Estimated from Primary Data

Table 5.17 shows the dummy result of the cost of illness on the basis of age. The analysis result is showing the air pollution related cost of illness on the basis of age group. Where D_{1i} (Dummy) is representing the 0 & 1 values, 1 represent above to 15 age group people and they are covered the working population as well as 0 is represent below to 15 age group person and they are non- working person of the

study area. The constant coefficient (α) and cost of illness of below 15 age group people is Rs. 33.92 per month and the coefficient value of above 15 years old people is Rs. 594.03 and their cost of illness is less which Rs. 627.94 per month. The effect of air pollution is very less of the children's group. Because, mostly working people are affected chronic diseases and children are affected by the infections and other acute diseases. Therefore, cost of illness of below to 15 age group is less as compared to working age group and model is insignificant.

Model 4

Cost of Illness = f (Income)

$$Y_i = \alpha + \beta_1 D_{1i} + \mu_i$$

Where,

α = intercept, β_1 = slope coefficient, $D_{1i} = 1$ higher income group individuals, = 0 otherwise, Lower income group individuals

Table 5.18: Results of Dummy Regression for Cost of Illness and Income

Dummy Variable	Coefficient	Cost of Illness	t-value	Level of Significance
Total Cost of Illness				
α (Base Category)	581.39	581.39	7.91	0.000*
D1i 1=Higher Income Group 0= Otherwise	904.32	1485.71	2.34	0.020
Direct Cost of Illness				
α (Base Category)	414.59	414.59	6.67	0.000*
D1i 1=Higher Income Group 0= Otherwise	435.41	850	1.33	0.183(NS)
Indirect Cost of Illness				
α (Base Category)	635.72	635.72	5.37	0.000*
D1i 1=Higher Income Group 0= Otherwise	-468.92	166.8	-3.89	0.000*

Note: * 1 percent level of significance, ** 5 percent level of significance, *** 10 percent level of significance

Source: Estimated from Primary Data

Model 4 shows the dummy result of the cost of illness on the basis of individual income. There are two dummy category of the income group which are higher income group and lower income group D_{1i} (Dummy) is showing 0 & 1 values. Where 1 represent the higher income group and 0 represent the lower income group category. In this analysis, model and variable both are significant at the 1 percent level of significance. The mean cost of illness on the basis of income is Rs. 1485.71 per month of the higher income group mean and mean expenditure of lower income group is Rs. 581.39 per month. Due to increase income of the household, they are capable of paying the high cost for the better treatment and their income is above 15,000 to 70,000 per month of the individual while lower income group earns only below to 15,000 per month and these people can not afford high cost for the treatment because their economic condition is not good and they are facing many financial problems. Further, 90 percent working population is under the lower income group. Therefore, it can be said that cost of illness is very high for both groups but higher income group spending high cost of illness and lower income group is spending less cost of illness in the study area.

5.9 Binary Logistic Analysis for Cost of Illness

In this section, how the health status of people due to air pollution get determined by various socio-economic factors is assessed. The dependent variable is affected people of the study area. There are two categories of air pollution affected people, first those who are affected and the second is those who are not affected. The employment pattern of individuals, education level and income level and age group are considered as independent variables. An empirical model is executed to find the factors affecting health of people in the study. The estimation of logit model is based on the cumulative logistic distribution function or cumulative logistic probability function and it specifies as:

$$L_1 = \text{Ln} (p_1/1-p_1) = \beta_1 + \beta_2 X_i + \mu_i$$

Where L_1 determines independent variables, P is the probability of success when explanatory variable has the value X . Logit model are explained using Odds and Odds ratios (Ali, J., 2011, p.245). X_i is the vector of independent variables.

The logit link has the form:

$$\text{Logit (P)} = \text{Log [P / (1-P)]}$$

Where $(P_i/1-P_i)$ is odd ratio. Odd ratio is a popular measure of the strength of association between exposure and diseases. It is expressed as the ratio of the number of cases to the number of non-cases in the exposed and unexposed groups (Hailpern M. Susan, Visintainer P, 2003). Based on descriptive statistics, an empirical model has been developed to identify the factors affecting air pollution, as follows:

$$\text{Log } \lambda_i = \beta_1 + \beta_2 \text{ EDU} + \beta_3 \text{ OCU} + \beta_4 \text{ AGE} + \beta_5 \text{ INC} + \mu_i$$

Where λ_i represent the health of affected people, EDU means education which is divided into three categories, OCU represent the occupation or employment pattern, age is the main factor for measuring health effect as well as INC denotes the income level in the study area.

Table 5.19 shows the binary logistic regression analysis results which are covering significance level value, z value and odd ratio value as well as coefficient value. All independent variables such as education, occupation, age, and income have statistically significant impact on health. The regression result of educational pattern has two categories creating for the regression analysis. It reflect, where 1 represent graduate and post graduate and 0 represent below to secondary education. Where negative coefficient indicates that those who are illiterate and below to secondary, highly gets affected as compare to above secondary education due to air pollution and their probability is also high. While, both categories are statistically significant at the 5 percenta and 1 percent level of significance.

Occupational pattern significantly by affect the dependent variable. There are three occupational categories government employees, private, and self employees. The negative coefficient indicates that those person who are working in outdoor areas such as industries, labour in constructional side, labour in Transport Sector as well job field, the adverse health impact chances more compare to government employees. This is mainly because they work in indoor such as office therefore; they are less affected due to air pollution.

There are two categories of age group, which includes 16 year & above (working group) and non-working group include children below to 15 year. The regression result is statistically significant in case of age. While negative coefficient means due to outdoor air pollution, the adverse impact on health of children and old age person is high and they are suffering many diseases especially chronic diseases. Working people are also affected but as compare to old age and children, they are less affected in the study area.

Table 5.19: Results for Binary Logistic Regression Analysis of Health Effect

Variables	Description	Coefficient	Z	P>Z	Odd Ratio
β_1 Base Category	Other Autonomous effects	1.317	2.20	0.027**	
Educational Pattern	Higher secondary and above = 1 Otherwise = 0	-.548	- 2.08	0.037**	.577
Occupational Pattern	Government Employees = 1 Otherwise = 0	-1.55	- 2.04	0.041**	.211
Age	Working Group = 1 Otherwise = 0	-1.106	- 2.02	0.043**	.330
Income	Higher Income Group = 1 Otherwise = 0	1.749	2.77	0.006*	5.754

Note: * 1 percent level of significance, ** 5 percent level of significance, *** 10 percent level of significance

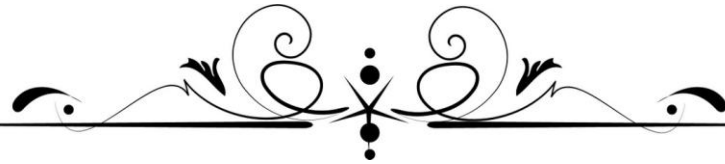
Log likelihood = -227.25693

LR chi² (6) = 33.73

Pseudo R² = 0.0691

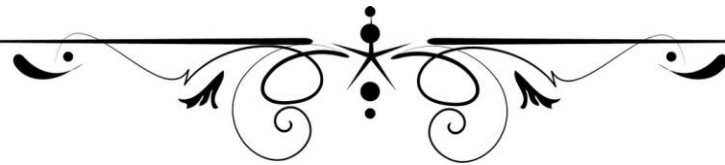
Prob> Chi² = 0.0000

The co-efficient of income is positive significant in this regression. There are two categories of the income pattern, higher income group include above Rs. 19000 income per month and lower income group include below to Rs. 19000 per month. Positive co-efficient implies higher income of people, the chances of not getting affected by diseases. If the family income is more than Rs. 19000 per month, the probability of not getting affected by air pollution diseases increases by 5.75 time than the people with low income less than Rs. 19000.



Chapter-6

Willingness to Pay for Reduction of Health Cost in Surveyed Area



6.0. Introduction

In developing countries, air quality is usually poor and air pollution is a significant health and economic burden on billions of people. The major environmental health problem air pollution is affecting everyone. Annually 3 million people are dying by the air pollution and it is affecting all region of the world where South East Asia and Western Pacific are the most affected (WHO, 2016, p.49). High level of air pollution is a cause of negative impact on a variety of economic outcomes including infant mortality. For the benefit of environmental regulations, the health impact of air pollution and consumer Willingness to pay for clean air is an important component (Barwick Jia Panle, et al. 2017, p.2). However, a large economic burden of air pollution does not necessarily mean that existing environmental regulations are not optimal. Optimal environmental regulation means those individuals who want to improve the air quality that is call their willingness to pay for clean air. For clean air, willingness to pay (WTP) is a key parameter which considers the trade-off between economic growth and environmental regulation (Greenstone and Jack, 2015, p.26).

6.1. Economic Valuation of Environmental Goods

The welfare of each individual depend not only consumption but also flow of resources related to quantities and qualities each receivers of nonmarket goods and service viz., health, visual amenities and opportunities for outdoor recreation. Therefore, it mentions the measures of the economic value of changes in environmental system resources and their effects on human welfare (Freeman, 2014, p.7). Basically, the standard economic theory was based on the purpose of interpreting changes in the prices and quantities of goods purchased in market before 40 years. But, today it is based on the public goods and other nonmarket services such as environmental quality and health, where, people know their preference, which is related to the property of substitutability market and non-market goods. Substitutability means for increase in the quantity of the second element due to the decrease in that of first element. It also shows the tradeoff ratio between pairs of goods that matter to people. The individual choice model is related the analyzed and predict a wide variety of economic behavior of markets. This is also included individual behaviors related to environmental and health concerns, participation in outdoor recreation activities, choices jobs with degrees of risk of fatal accident, and

choices of where to live and work. Market goods are expressed and purchase in monetary units. But nonmarket value measurement is based on substitutability and it can express in terms of either willingness to pay (WTP) or willingness to accept the compensation (WTA).

6.2. Willingness to Pay (WTP)

WTP refers to individual willing to substitute for the goods being value which is derived by money. The preference revelation is sought, i.e., by asking people how much they are willing to pay. It is the maximum sum of money where the person will want to pay instead of a better in some kind of environmental amenity. An individual's willingness to pay is use for reducing mortality risk which is conventionally estimated by multiplying the change in the probability of death by an estimate of the individual's marginal rate of substitution (marginal rate of substitution is described as the value of statistical life) between wealth and death risk (Eeckhoudt and Hammitt, 2001, p.262). Another method of willingness to pay is applied in empirical studies of valuation, which measure the welfare changes of individuals and preferences over non-market goods and services and considered behavioral methods (Gaviria Carlos and Martinez Daniel, 2014, p.160). For reduction of air pollution, individual's willingness to pay is strongly related to general health risk and the impact of the current level of air pollution on the environment (Carlsson and Martinsson, 2001, p.17). Basically, there are various methods for estimating willingness to pay for reducing mortality and morbidity risk. First approach measure WTP is to conclude the value from compensating wage differentials in the labour market and second approach measure WTP is to ask people that what they would pay to reduce their risk of dying; which is referred to as the contingent valuation method (Lee Jin Yong. et al., 2011, p.604).

6.2.1. Contingent Valuation Method (CVM)

Contingent valuation (CV) is a stated preference method of estimating value of non-market environmental goods through survey question that bring out individuals preferences regarding such goods (Haq, et al., 2007, p.1139). CV is a survey-based methodology for eliciting values people place on goods, services and amenities. It involves the use of sample surveys (questionnaires) to elicit the willingness to pay for

hypothetical projects of program (Portney, 1994, p.3). Contingent valuation method uses survey questions to elicit people's preferences for public goods for finding that what they would be willing to pay for specified improvement in them (Mithchell and Carson, 1989, p.2). It mainly asks people how much they are willing to pay for a benefit and it includes devising various forms of 'biding games' eliciting 'yes/no' response to questions and statements about maximum willingness to pay. This approach is use for valuing nonmarket resources such as recreation, wildlife and environmental factors which, is used with bidding method in case of air pollution. Contingent valuation method is a useful tool to control air pollution affected many aspects of a society, such as human health, agricultural yield and industrial production. It can obtain a monetary value for an intangible good that does not have a market price (Wang Yan and Zhang Yi-Sheng, 2007, p.1022). Contingent valuation method is used to determine the proportion valuation. It includes a wide range of techniques such as experimental, household substitution, and bidding (Stoll R. John, 1983, p.120).

There are many methods for eliciting the contingent valuation method such as open-ended method, iterative bidding method, contingent ranking method, dichotomous-choice method, and payment card method. In open ended method, the maximum willingness to pay for the good that is being valued asked by the respondent. Bidding approaches to valuation are by far the most important recognized form of CVM. Initially, a bidding format was used to elicit willingness to pay but mostly dichotomous choice questions are estimate the willingness to pay. There are two categories of dichotomous-choice techniques, viz., single bound dichotomous which relates to the person answer 'yes' otherwise 'no' and double bounded dichotomous choice which is related to two rounds of bidding where higher or lower depending on the response to the first question (Hanemann Michael, Loomis John & Kanninen Barbara, 2017, p.1255).

6.2.2 Willingness to Pay and Air Pollution Studies

Wang Yan & Zhang Yi-Sheng (2008) has estimated the air quality assessment by contingent valuation method in China. Energy consumption especially coal consumption is the main sources of air pollutants such as particles, SO₂, and NO₂. Due to air pollution, many aspects of a society can affected such as human health,

agricultural yield etc. contingent valuation method can gain a monetary value for an intangible good and non-market goods. The correlation between air pollution and health is significantly positive influences of respondent's decision of pay in case of income, treatment cost education and opinions. The study find out that approximately 60 percent respondent are agree to positive willingness to pay and more than 40 percent respondent were thinking that air quality improvement is a government responsibility.

Vlachokostas Christos et.al (2011) attempt to willingness to pay for reducing the risk of premature mortality attributed to air pollution with using contingent valuation method for Greece. The study has calculated the value of life year (VOLY) with using willingness to pay for increasing life expectancy as well as it is estimate year of life loss (YOLL) in case of unwillingness to pay. For describing WTP relationship with socio-economic (age, gender, education, and monthly income) characteristics and air pollution awareness probit model is used and it is found that approximately 80 percent of respondents were able to express their willingness to pay for improving air quality because economic value can increased life expectancy by saving one YOLL.

Pierre Leger Thomas (2001) has been worked on the willingness to pay for improved in air quality Canadian context by borrowing largely from the production function approach. This study examining the relationship between ozone levels and the visits of doctors and found that the average estimated willingness to pay (associated with the cost of illness) for a 50 percent reduction of ozone is \$1.50 per year per individual. Most common evaluation methods are hedonic pricing, contingent valuation, and cost of illness and health method used for evaluation and willingness to pay method used for improved air quality

Ito Koichiro and Zhang Shuang (2016) aspect is related to the willingness to pay for clean air and evidence from air purifier markets in China. There is using defensive investment method for reducing indoor air pollution which provides valuable information for the valuation of willingness to pay for air quality improvements. Air purifier is the High Efficiency Particulate Arrestance (HEPA) product attributes which provide both type of information consumers and econometricians of the purifier's effectiveness to reduce indoor particulate matter. It also provides improvement in health, including asthma symptoms, lower marker levels of

information, heart disease, and reduced incidences of invasive aspergillosis among adult. Revealed preference estimate of willingness to pay for clean air is used in developing countries.

Quah Euston and Boon Liam Tay, (2003) worked on estimating the economic cost of particulate air pollution health in Singapore. The damage function/dose response approach, the mortality and morbidity effects of particulate air pollution on the population of Singapore has used in this paper. Their results show that the cost of particulate air pollution (PM10) is substantial both in absolute and relative terms, which is show the relationship between environmental and economic valuation relationship of PM10 pollution in Singapore.

Carlsson Fredrik and Martinsson Peter, (2001) has explained the willingness to pay for reduction in air pollution in Sweden. It is related to the multilevel model data with using contingent valuation survey of individual's willingness to pay for reduction in the level of air pollution. Open ended method is used for survey and binary logistic model is applied. Individual's WTP for reduction in air pollution is strongly related to health risks and the impact of the current level of air pollution on the environment. The primary data used with hierarchical structures which use for multilevel models where individuals are clustered into geographical region. The results suggest that most variations are among individuals. It is explained by homogeneous preferences for a reduction in air pollution among individuals living in the same households or region with the similar level of air pollution.

In this chapter, willingness to pay method is used for avoid cost of illness. This is based on the primary data and cover with socioeconomic parameters of the household.

6.3. Willingness to Pay in Study Area

Basically, contingent valuation method (CVM) solves the problems of using environmental valuation analysis. In this study area, i.e, Talkatora and Sarai Mali Khan, contingent valuation method is used for collecting the information. The information conducted through direct questions asked to the respondents through face to face interview which is based on the questionnaire. There are two sections of contingent valuations survey, where first is related to air pollution related health valuation and illness which is described in many section such (a) name of diseases,

(b) number of sick days, (c) medical visit and expenditure as well as loss of days and wages and (d) restrictions in daily activities and the related cost.

Second section is related to the economic valuation and willingness to pay. This section elicits information of household marginal willingness to pay for a clean air. The respondents are asked how much they would be willing to pay to completely avoid illness. There are three common preference such as Open-ended questions, bidding games and dichotomous choices to elicitation formats of Contingent Valuation Method (Wang Guizhi, Song Yingxi, et.al., 2016, p.1023). For knowing their answers, the question used the double bounded dichotomous choice method (DBDC). In this method, respondents are asked with a 'follow-up' questions in addition to the "yes" or "no" options of the single bounded dichotomous choice (SBDC) method. The respondents required to answers yes or no when asked if he or she is willing to pay a given amount (bid) for public goods.

Bid design is an important feature to find out the efficiency of the estimators. In the study area bids are design in three patterns which is based on the monthly cost of illness. The amount of first bid decided after the pilot survey. Therefore, the minimum cost of first bid is based on the minimum medicine cost and travel fare. The minimum cost of medicine is Rs. 60 and per person fares is Rs. 40 minimum and the total cost is Rs. 100 (60+40=100). There are three bids are design for the study area such as 100, 200, 300 which are based on the double bounded dichotomous choice method.

Yearly willingness to pay bid design is also based on the pilot survey of the study area. It is included monthly house area, health cost and travel cost. In the study area, the housing condition is related to the property value (own/rented), rent (per month), year of living and location of the house. Therefore, it indicates to the social facilities such as public and environmental facilities. Housing condition WTP questions are relate, if some scheme or government policies are provide extra facilities near the house and area such as public goods (park), plantations and other facilities.¹³

¹³ In both study area minimum house rent and house tax is Rs. 700 per month and medical cost (doctor fees + fares) is Rs.100 per month. Transport cost is different in both areas where Talkatora transport cost is found minimum Rs. 10 per day and Rs. 300 per month. In Sarai Mali khan, transport cost is Rs. 40 per day and Rs. 1200 per month.

Table 6.1 Cost Estimation for Bidding in the Study Area

Area	Housing Cost	Health	Transport Cost	Total Cost (in Rs.)
Chowk Zone (Monthly)	50 (700/12)	100	1200 (40*30)	1350
Talkatora Zone (Monthly)	50	100	300 (10*30)	450

For cost estimation for bidding in the study area, the minimum average of bidding design is Rs. 450 from Talkatora zone and maximum average is Rs. 1350 from Chowk zone. Double bounded dichotomous method is used for willingness to pay in the study area. Therefore, Rs. 500 is the lowest bound and Rs. 1500 is the upper bound for the yearly willingness to pay. As well as Rs. 250 is also using for not acceptable condition for WTP.

Table 6.2 shows the three bidding in the study area which is based on the willingness to pay. Minimum bidding is Rs. 100 per month on the basis of medical expenditure per month found in Pilate survey and maximum bid is Rs. 700 per month. Willingness to pay is conducted from household where first house bid start at Rs. 100 and second bid is stated from Rs. 200 well as third bidding starts from Rs. 300 per month. It is also based on the monthly income of the respondent. There are two bids of the yearly willingness to pay Rs. 500 is the minimum bid and Rs. 1500 is the maximum bid.

Table 6.2: Monthly and Yearly Bidding Design in the Study Area (in Rs.)

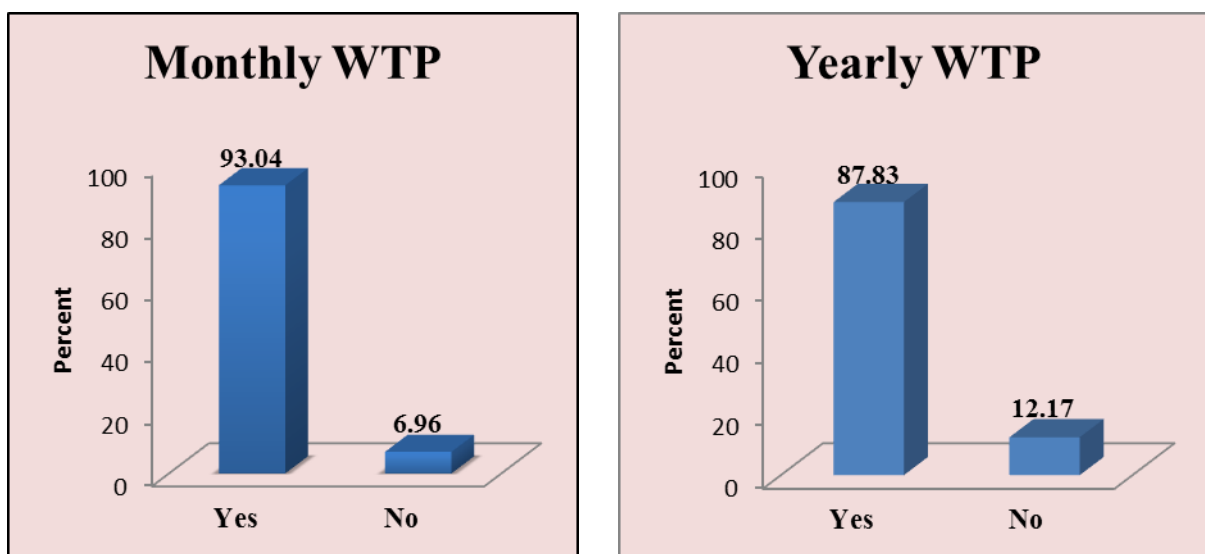
Monthly Bid Design		
Bidding I	Bidding II	III Bidding III
100	200	300
200	300	400
300	400	500
400	500	600
500	600	700
Yearly Bid Design		
Bidding I	Bidding II	Bidding III
500	1000	1500
1000	1500	-

Source: Estimated from Primary Data

Figure 6.1 shows the perceptions of monthly and yearly willingness to pay in the study area. This is related to the how many person are want to willing to pay for reducing air pollution in the study area. Total 230 household found in the study area where 214 agree for monthly WTP and 16 are disagree further 202 household are agree for yearly WTP and 28 are disagreed. There are two categories of the perception which are yes and no. Approximately 93.04 percent households are agreed for willingness to pay to save their life and 6.96 percent people are disagreed for willingness to pay. As well as yearly willingness to pay is 87.83 percent and 12.17 percent households are disagree for reduction of health cost and air pollution. It is found that there are many causes for disagreement such as less income, not affected by air pollution, government responsibility and other.

WTP is depend on their conditions such as if the WTP is low for clean air, than current level of air pollution can be optimal because social planner is prioritizing economic development on environmental regulation. While, if WTP is high, the hardness of the regulations can be decrease form optimal. Therefore, for clean air, WTP is a critical parameter when it is considered among the trades between economic regulation and environmental regulation (Ito, K., & Zhang, S., 2018, p.2). Therefore, with the high WTP, respondent will face less problems on the other hand, with low WTP respondents with a family member suffering allergies or respiratory illness (Filippini, M., & Martínez Cruz, A. L., 2016, p.3).

.Figure 6.1: Perceptions of Monthly &Yearly Willingness to Pay in the Study Area (in percent)



Source: Estimated from Primary Data

Table 6.3 represents the percentage share of bid wise total willingness to pay in the study area. Monthly bids are divided into four rang categories. Bid1 covers 50 to 100 Rs. to give WTP and bid2 is covering 200 to 300 Rs. to give the willingness to pay as well as bid3 is related to the 400 to 500 Rs. WTP and bid4 is covered the amount of 600 to 700 Rs. per month in the study area. This is categories for, those household who are suffering from air pollution, what is their highest bidding percent for WTP with the limited income in the study area.

Table 6.3: Bid Wise Monthly & Yearly Willingness to Pay (WTP) in the Study Area

Monthly WTP	
Bids	Frequency & Percentage
Bid1 (Rs. 50-100)	77 (35.98)
BidII (Rs. 200-300)	85(39.72)
BidIII (Rs. 400-500)	47 (21.96)
BidIV (Rs. 600-700)	2 (2.34)
Total	214 (100.00)
Yearly WTP	
Bid1 (Rs. 250-500)	65 (32.18)
BidII (Rs. 750-1000)	61 (30.20)
BidIII (Rs. 1250-1500)	76 (37.62)
Total	202 (100.00)

Source: Estimated from Primary Data

In the study area, there are 214 household agree to willingness to pay and the highest percentage share is found in bidII where 39.72 percent people want to pay for air pollution reduction. Because, mostly population of the both study areas are working in the industries and open areas liken shops. They are highly affected by air pollution therefore they wanted to pay second bid for avoiding heath cost because their income is limited. The same percentage shares of the bid1 which 35.98 percent of the total. As well as very lower percentage share of the bidIV and this is only 2.34 percent. Therefore, it is found that due to lack of income and employment, mostly people want to willing Rs. 100 to 300 per month. Total 202 households are agreed to yearly

willingness to pay and yearly bids are divided into three categories. Year wise mostly households want to pay for bidIII. The main cause of highly percentage share of bidIII is that mostly people belong to the upper income group and they are aware to air pollution problems. Therefore, they want to pay extra amount to save their life. Monthly and yearly bidding has taken because costs of illness diseases are categories in three terms viz., acute, sub chronic and chronic. Therefore, to avoid the health cost monthly WTP include diseases as well as yearly WTP included diseases and other policies for a year. This is based on the household perception.

Table: 6.4: Income-Wise Response of WTP to avoid Cost of Illness

Monthly WTP					Yearly WTP				
Income Groups	BidI	BidII	BidIII	BidIV	Total	Bid1	BidII	BidIII	Total
Lower Income Group	43 (51.81)* (55.13)**	28 (33.73)* (32.94)**	11 (13.25)* (23.91)**	1 (1.20)* (20.00)**	83 (100.00)* (38.79)**	38 (46.91)* (58.46)**	25 (30.86)* (40.98)**	18 (22.22)* (23.68)**	81 (100.00)* (40.10)**
Middle Income Group	27 (27.55)* (34.62)**	48 (48.98)* (56.47)**	20 (20.41)* (43.48)**	3 (3.06)* (60.00)**	98 (100.00)* (45.79)**	20 (22.22)* (30.77)**	31 (34.44)* (50.82)**	39 (43.33)* (51.32)**	90 (100.00)* (44.55)**
Upper income Group	8 (24.24)* (10.26)**	9 (27.27)* (10.59)**	15 (45.45)* (32.61)**	1 (3.03)* (20.00)**	33 (100.00)* (15.42)**	7 (22.58)* (10.77)**	5 (16.13)* (8.20)**	19 (61.29)* (25.00)**	31 (100.00)* (15.35)**
Total	78 (36.45)* (100.00)**	85 (39.72)* (100.00)**	46 (21.50) (100.00)	5 (2.34)* (100.00)**	214 (100.00)* (100.00)**	65 (32.18)* (100.00)**	61 (30.20)* (100.00)**	76 (37.62)* (100.00)**	202 (100.00)* (100.00)**

Source: Estimated from Primary Data

Note: *Row Percentage **Column Percentage

Table 6.4 shows the income-wise frequency share of response of willingness to pay to avoid cost of illness. There are three categories of income group i.e., lower income group, middle income group and upper income group. The range of lower income group is Rs. 1000 to 5000 per month per household and Rs. 6000 to 15000 of the middle income group and above 15000 of the upper income group. There are 214 households agree to give monthly willingness to pay, where the highest percentage share of the middle income group is 45.79 percent while upper income group is agree to the very less percentage share which is only 15.42 percent. Year wise 202 households are agree for WTP and this is also high in middle income group because people are agree to give approximately Rs. 1000 per year. Therefore, it is found that upper income group mostly working in the public group sector and they can afford many facilities to avoid air pollution, while lower income group suffer highly by the air pollution and their willingness to pay percentage is 38.79 percent of the total.

Table 6.5: Education-Wise Response of WTP to avoid Cost of Illness

Educational Categories	Monthly WTP					Yearly WTP			
	BidI	BidII	BidIII	BidIV	Total	BidI	BidII	BidIII	Total
Illiterate	30 (47.62)* (38.46)**	26 (41.27)* (30.59)**	7 (11.1)* (15.22)**	0 (0.00)* (0.00)**	63 (100.00)* (29.44)**	31 (49.21)* (47.69)**	18 (28.57)* (29.51)**	14 (22.22)* (18.42)**	63 (100.00)* (31.19)**
Primary	32 (46.38)* (41.03)**	27 (39.13)* (31.76)**	10 (14.49)* (21.74)**	0 (0.00)* (0.00)**	69 (100.00)* (32.24)**	24 (36.92)* (36.92)**	21 (32.31)* (34.43)**	20 (30.77)* (26.32)**	65 (100.00)* (32.18)**
Secondary	4 (10.00)* (5.13)**	18 (45.00)* (21.18)**	17 (42.50)* (36.96)**	1 (2.50)* (20.00)**	40 (100.00)* (18.69)**	4 (10.53)* (6.15)**	11 (28.95)* (18.03)**	23 (60.53)* (30.26)**	38 (100.00)* (18.81)**
Higher secondary	7 (43.75)* (8.97)**	7 (43.75)* (8.24)**	2 (12.50)* (4.35)**	0 (0.00)* (0.00)**	16 (100.00)* (7.48)**	4 (30.77)* (6.15)**	4 (30.77)* (6.56)**	5 (38.46)* (6.58)**	13 (100.00)* (6.44)**
Diploma/certificate	1 (16.67)* (1.28)**	1 (16.67)* (1.18)**	4 (66.67)* (8.70)**	0 (0.00)* (0.00)**	6 (100.00)* (2.80)**	0 (0.00)* (0.00)**	2 (40.00)* (3.28)**	3 (60.00)* (3.95)**	5 (100.00)* (2.48)**
Graduate	3 (18.75)* (3.85)**	5 (31.25)* (5.88)**	6 (37.50)* (13.04)**	2 (12.50)* (40.00)**	16 (100.00)* (7.48)**	2 (14.29)* (3.08)**	4 (28.57)* (6.56)**	8 (57.14)* (10.53)**	14 (100.00)* (6.93)**
Post-graduate	0 (0.00)* (0.00)**	1 (50.00)* (1.18)**	0 (0.00)* (0.00)**	1 (50.00)* (20.00)**	2 (100.00)* (0.93)**	0 (0.00)* (0.00)**	1 (50.00)* (1.64)**	1 (50.00)* (1.32)**	2 (100.00)* (0.99)**
Others	1 (50.00)* (1.28)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	1 (50.00)* (20.00)**	2 (100.00)* (0.93)**	0 (0.00)* (0.00)**	0 (0.00)* (0.00)**	2 (100.00)* (2.63)**	2 (100.00)* (0.99)**
Total	78 (36.45)* (100.00)**	85 (39.72)* (100.00)**	46 (21.50)* (100.00)**	5 (2.34)* (100.00)**	214 (100.00)* (100.00)**	65 (32.18)* (100.00)**	61 (30.20)* (100.00)**	76 (37.62)* (100.00)**	202 (100.00)* (100.00)**

Source: Estimated from Primary Data Note: *Row Percentage **Column Percentage

Education is an important factor for analyzing socio-economic aspects for value measurement of natural resources like safe air. There are eight educational categories in the study area which are Illiteracy, Primary, Secondary, Higher secondary, Diploma/certificate, Graduate, Post-graduate and others. Table 6.5 shows the education wise monthly and yearly frequency of willingness to pay for avoiding illness and other air pollution related problems. Monthly WTP is highest in primary education category than that of illiteracy category, further it is lowest for the post-graduation group of people. In the study area, illiterate and primary educated people are highly prone to air pollution and facing many health problems due to more exposure to industry and roadside activity. Therefore, they want to pay more for save their life and their highest contribution rang is bidII which Rs. 200 to 300 per month. Yearly WTP is also highest in primary category while bidIII is also highest as compare to other bidding. But this is lowest in post graduate people and other group people because they feel that controlling air pollution is purely responsibility of government.

Table 6.6: Caste-Wise Response of WTP to avoid Illness

Monthly WTP						Yearly WTP			
Caste	Bid1	BidII	BidIII	BidIV	Total	Bid1	BidII	BidIII	Total
General	35	36	15	2	88	28	21	33	82
	(39.77)*	(40.91)*	(17.05)*	(2.27)*	(100.00)*	(34.15)*	(25.61)*	(40.24)*	(100.00)*
	(44.87)**	(42.35)**	(32.61)**	(40.00)**	(41.12)**	(43.08)**	(34.43)**	(43.42)**	(40.59)**
OBC	32	38	27	2	99	28	32	33	93
	(32.32)*	(38.38)*	(27.27)*	(2.27)*	(100.00)*	(30.11)*	(34.41)*	(35.48)*	(100.00)*
	(41.03)**	(44.71)**	(58.70)**	(40.00)**	(46.26)**	(43.08)**	(52.46)**	(43.42)**	(46.04)**
SC	11	11	4	1	27	9	8	10	27
	(40.74)*	(40.74)*	(14.81)*	(3.70)*	(100.00)*	(33.33)*	(29.63)*	(37.04)*	(100.00)*
	(14.10)**	(12.94)**	(8.70)**	(20.00)**	(12.62)**	(13.85)**	(13.11)**	(13.16)**	(13.37)**
Total	78	85	46	5	214	65	61	76	202
	(36.45)*	(39.72)*	(21.50)*	(2.34)*	(100.00)*	(32.18)*	(30.20)*	(37.62)*	(100.00)*
	(100.00)**	(100.00)**	(100.00)**	(100.00)**	(100.00)**	(100.00)**	(100.00)**	(100.00)**	(100.00)**

Source: Estimated from Primary Data

Note: *Row Percentage **Column Percentage

Table 6.6 shows the caste wise response of willingness to pay to avoid illness due to air pollution. There are three categories overesered in the study area which are general, OBC and SC, the highest percentage found of the OBC category which is 46.26 percent of the total and 41.12 percent share of the general categories. Their financial and economic condition is better compared to schedule caste category because SC percent share of WTP is very low which only 13.18 percent. They are mostly working in the industry on contractual and temporary basis and shops therefore they are getting Rs. 3000 to 6000 per month and they are facing many economical and financial problems.

Table 6.7: Occupation-Wise Response of WTP to avoid Cost of Illness

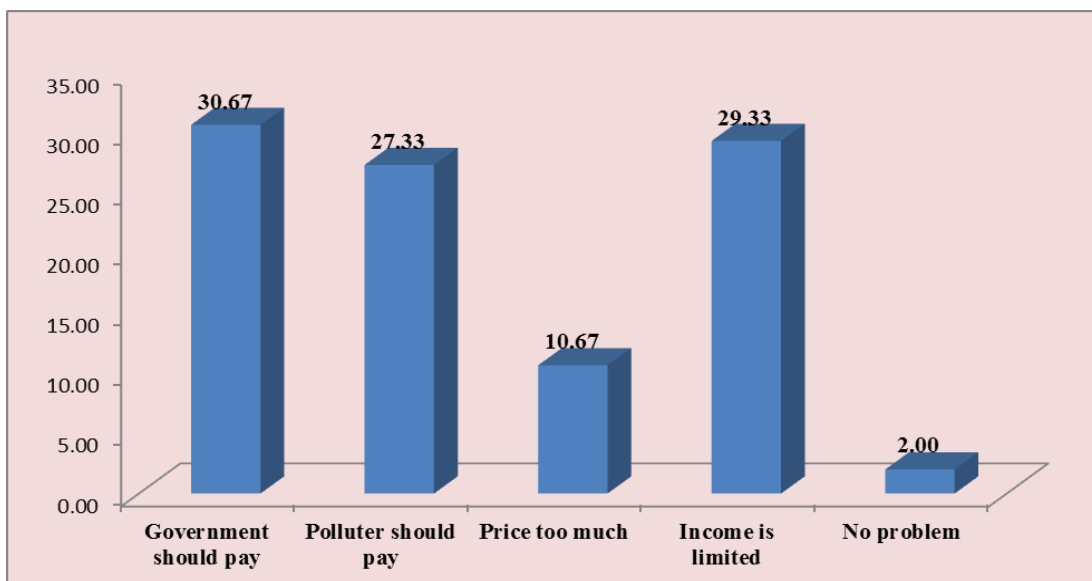
Occupational Groups	Monthly WTP					Yearly WTP			
	Bid1	BidII	BidIII	BidIV	Total	Bid1	BidII	BidIII	Total
Public Sector	6 (25.00)* (7.69)**	6 (25.00)* (7.06)**	11 (45.83)* (23.91)**	1 (4.17)* (20.00)**	24 (100.00)* (11.21)**	4 (18.18)* (6.15)**	4 (18.18)* (6.56)**	14 (63.64)* (18.42)**	22 (100.00)* (10.89)**
Private Sector	57 (40.43)* (73.08)**	57 (40.43)* (67.06)**	24 (17.02)* (52.17)**	3 (2.13)* (60.00)**	141 (100.00)* (65.89)**	46 (34.85)* (70.77)**	46 (34.85)* (75.41)**	40 (30.30)* (52.63)**	132 (100.00)* (65.35)**
Self Employed Sector	15 (30.61)* (19.23)**	22 (44.90)* (25.88)**	11 (22.45)* (23.91)**	1 (2.04)* (20.00)**	49 (100.00)* (22.90)**	15 (31.25)* (23.08)**	11 (22.92)* (18.03)**	22 (45.83)* (28.95)**	48 (100.00)* (23.76)**
Total	78 (36.45)* (100.00)**	85 (39.72)* (100.00)**	46 (21.50)* (100.00)**	5 (2.34)* (100.00)**	214 (100.00)* (100.00)**	65 (32.18)* (100.00)**	61 (30.20)* (100.00)**	76 (37.62)* (100.00)**	202 (100.00)* (100.00)**

Source: Estimated from Primary Data

Note: *Row Percentage **Column Percentage

Basically, there are three categories of occupation such as public sector, private sector and self-employment in the study area. Most of the public sector employees are working in indoor environment or offices also and they are less exposed to air pollution and their health illness cost is also less. Therefore, their percentage share for willingness to pay is only 11.21 percent. While private sector employees are continuously working in the outdoor environment such as industry and road side shops. They are highly affected by air pollution and especially respiratory diseases and skin infections. Their working hours is also ranges from 8 to 12 hours per day. Therefore, they are highly agreed for willingness to pay and their percentage is also high which 65.89 percent of the total is. Self-employed percent is 22.90 estimated in the study area (Table 6.7). The percentage share of the private sector employees are estimated high in all bids as compare to all other occupational groups.

Figure 6.2: Causes of Unwillingness to pay to Control Air Pollution



Source: Estimated from Primary Data

Figure 6.2 shows the reasons of unwillingness to pay in the study area. There are many causes of no WTP such as government should be pay, polluter should pay, price is higher, and income is limited and not known. Among 230 households, there are 16 (6.96 percent) households are not agree for monthly WTP and 28 (12.17 percent) households are not ready for yearly WTP. For their unwillingness to pay in the study area, the highest percentage share is government should pay and limited income. Because upper income group people understand that to reduce air pollution is the

responsibility of government and lower income group people cannot afford because they are earn limited income and economically they are weak. In the industrial area, mostly people understand that polluter should be pay because they are responsible for air pollution as well as some people agree to price is higher because WTP price is higher and they do not have extra money to their safety and other benefits.

Table 6.8: Socio-Economic Characteristics Wise Mean WTP for Reduce Air Pollution

Income-Wise Mean WTP for reduce Air pollution				
Income Groups	Monthly Mean of WTP (Rs.)	SD of Monthly WTP (Rs.)	Yearly Mean of WTP (Rs.)	SD of Yearly WTP (Rs.)
Lower Income Group	186.75	153.04	777.78	484.13
Middle Income Group	256.64	148.29	1050	456.24
Upper income Group	309.09	177.86	1137.1	486.65
Average	237.62	160.47	954.21	492.56
Education-Wise Mean WTP for reduce Air pollution				
Illiterate	176.19	125.68	769.85	494.53
Primary	205.08	145.82	865.39	488.29
Secondary	313.75	136.81	1223.68	388.99
Higher secondary	206.25	143.62	980.77	450.25
Diploma/certificate	375	178.19	1300	273.87
Graduate	343.75	199.07	1196.43	418.09
Post-graduate	450	353.56	1250	353.56
Other	550	70.72	1500	0
Average	237.62	160.47	954.21	492.56
Caste-Wise Mean WTP to reduce Air pollution				
General	222.16	154.79	954.27	507.84
OBC	255.56	162.08	959.68	485.24
SC	222.23	171.72	935.19	488.29
Average	237.62	160.47	954.21	492.56
Occupation-Wise Mean WTP to reduce Air pollution				
Government Sector	325	178.77	1181.82	437.68
Private Sector Employees	219.15	155.79	895.84	484.54
Self Employed	247.96	152.39	1010.42	510.42
Average	237.62	160.47	954.21	492.56

Source: Estimated From Primary Data

Table 6.8 shows the mean willingness to pay of the socio-economic characteristics such as income, education, caste, and occupation for reduction of health cost due to air pollution in the study area. Mean and SD are calculated by income categories of the households. First the average WTP of the lower income group is Rs. 180.46 per month which is also supported by SD with (153) rupees. The highest mean WTP found in the upper income group which is Rs. 304.412 per month and SD also fluctuate the mean value. Similarly yearly bases WTP is also explain all three groups. Where lower income group average WTP Rs. 777.78 and SD (484.13) rupees and upper income group mean is Rs. 1137.1 respectively. Therefore, it is clear that people want to pay for reducing air pollution and thinking to avoid cost of illness. It is also analyses that income has direct relationship with WTP. Therefore, income is an important determinant of WTP for reduction of health cost.

Education of the respondents also influence for WTP. Where, monthly and yearly WTP is Rs. 176.19 and Rs. 769.85 for illiterate category. Due to awareness, highest WTP is found for post graduate and other categories people. Education wise monthly average WTP is Rs. 237.62 and as well as yearly WTP is Rs. 954. Therefore, it is suggested that WTP is continuously increased with rising literacy and people want to pay maximum amount for reducing air pollution.

The average of WTP general category is Rs. 222.16 per month and same is for the SC category which is Rs. 222.23 per month. The WTO for the OBC category is Rs. 255.56 per month, Which is highest. Same condition shows for the yearly WTP, where OBC category wants to pay highest amount. Therefore, it is found that caste wise willingness to pay does not direct relationship. The maximum mean WTP is Rs. 700 for OBC people and SC people and minimum mean amount Rs. 50 found in all categories.

The mean WTP for public and private sector is observed an employee in industrial sector is Rs. 325 & Rs.219 respondent. The same situation is true for yearly WTP in the study area, where government employees want to pay more amounts and due to lack of income private sector worker want to pay less amount. It observed that public sector employees earn more income than private sector employees. Therefore, their WTP is high. This is also show the direct relationship between employment and WTP.

This is found that there is a direct relationship between willingness to pay and socio economic characteristics in terms of income, education, occupation. Income is the main indicator to observing WTP. When income is rises, than education, employment as well as WTP is also rises.

6.4. Dummy Variable Analysis

It is observed education has direct relations with WTP. It suggests that higher the educational qualification, higher is the WTP. Therefore, dummy variable is used to understand the significance of education on WTP to control adverse impact of health due to air pollution.

6.4.1. Impact of Education on Willingness to Pay

Model 1: Monthly Willingness to Pay = f (Education)

$$y_i = \alpha + \beta_1 D_i + \mu_i$$

Where,

α = {intercept}

β_1 = {slope coefficient}

D_{1i} = {1 if the education of head of the household is illiteracy

0 otherwise,

D_{2i} = {1 if the education of the households is upto primary

0 otherwise,

D_{3i} = {1 if the education of the households is upto secondary/higher secondary

0 otherwise,

Table 6.9: Results of Dummy Regression for Willingness to Pay

Dummy Variable	Coefficient	Willingness to Pay	t-value	Level of significance
β_1 (Base Category)	(375)	375	12.97	(0.000)*
D1i				
1= illiterate	(-198.80)	176.19	-5.78	(0.000)*
0= Otherwise				
D2i				
1= primary	(-169.93)	205.07	-5.01	(0.000)*
0= Otherwise				
D3i				
1= secondary/higher secondary	(-91.97)	283.03	-2.63	(0.009)*
0= Otherwise				

Note: * signifies 1 percent, ** signifies 5 percent, *** is 10 percent.

Source: Estimated from Primary Data

Table 6.9 shows the results of dummy regression for willingness to pay. The dependent variable is willingness to pay and independent variable is educational qualification of respondent. There are four dummy categories viz., illiterate, primary, secondary/higher secondary and others (base category).

The values of co-efficient suggest that as educational level increases, willingness to pay of the households will also increases and vice versa. All independent variables are statistically significant. The mean value for illiterate category is 176.19, primary category 205.07, secondary to higher secondary 283.03 and others 375. It is clear that higher the educational qualification higher the WTP. Statistical value of P is 0.000 that means the model is significant at 1 percent level of significance.

6.4.2 Interaction Effect Using Dummy Regression Analysis

The effect of education, caste and income can be observed as follows:

$$Y_i = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \beta X_i + \mu_i$$

It has analyse the interaction between two qualitative variables. Therefore, their effect on mean Y is not simply additive but multiplicative in nature which is as follows.

$$Y_i = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_4 (D_{2i} D_{3i}) + \beta X_i + \mu_i$$

Model 2: Monthly Willingness to Pay = f (Education, Caste, Income)

$$Y_i = \alpha_1 + \alpha_2 \text{EDU} + \alpha_3 \text{Caste} + \alpha_4 (\text{EDU} * \text{Caste}) + \beta \text{INC} + \mu_i$$

Where,

Y_i = Willingness to Pay

α_1 = intercept

α_2 = differential effect of being an illiterate

D_{1i} = {1 if the education of head of the households is illiterate

0 otherwise,

α_3 = differential effect of being a OBC

D_{2i} = {1 if the caste of the households is OBC

0 otherwise,

α_4 = differential effect of being an illiterate under OBC

D_{2i} = {1 if the education of head and caste of the household are illiterate and OBC respectively

0 otherwise,

INC = Income of the households

Table 6.10: Results of Multiplicative Dummy Regression for Willingness to Pay

Dummy Variable	Coefficient	t-value	Level of significance
β_1 (Base Category)	(193.83)	8.70	(0.000)*
(Educational Pattern)			
D1i			
1= illiterate	(-63.97)	-2.05	(0.041)**
0= Otherwise			
(Caste)			
D2i			
1= OBC	(43.99)	1.77	(0.078)***
0= Otherwise			
(Edu & Caste)			
D3i			
1= illiterate and OBC	(-7.44)	-0.16	(0.871)NS
0= Otherwise			
Income	(.005)	3.75	(0.000)*

Note: * signifies 1 percent, ** signifies 5 percent, *** is 10 percent.

Source: Estimated from Primary Data

This Model 2 explains the multiplicative dummy regression for willingness to pay. Where, education and caste are qualitative and income is a quantitative variable. The model shows the differential effect of education and caste. OBC category is having higher but illiterate people have lesser willingness to pay. This is analysed by interaction dummy model. There are two aspects first, if the mean willingness to pay is higher for educated people than illiterate whether they are OBC or not. Second is if the mean willingness to pay is higher for OBC than otherwise whether they are educated or illiterate.

In this model, there are two dummy of educational categories such as illiterate and otherwise. It is statistically significant and their coefficient value is negative that means educated people are paying higher than that of illiterate people. As well as, two

dummy for caste 1 is for OBC and 0 is for otherwise. It is also statistically significant and the coefficient value is positive association indicates OBC statistically significance relationship with WTP.

Income is also statistically significant and their coefficient value is positive which means when income increases, willingness to pay also increases and vice versa. P value is statistically significant at 1 percent level of significance.

6.5 Analysis of Willingness to Pay for Avoiding Cost of Illness

Here, the likelihoodness on probability of WTP for avoiding health cost due to air pollution based on socio-economic factors is estimated by using Logit and Probit regressions, which are as follows. Basically, contingent market responses are consistent with expectation concerning relationship socio-economic characteristics such as education, occupation, income, and environmental group membership (Blomquist C.G & Whitehead J.C, 1998, p.190).

6.5.1. Willingness to Pay & Binary Logistic Analysis

In this model, the dependent variable is Willingness to Pay (WTP). There are two categories of willingness to pay, i.e., those who are those who are willing to pay and others are not for avoiding cost of illness. Education is considered as independent variable. An empirical model is developed to understand the probability of WTP when socio-economic factors such as education, caste, income and occupation are affecting if.

$$\text{Log } \lambda_i = \alpha + \beta_1 \text{EDU} + \mu_i$$

Model 3: *Monthly Willingness to Pay = f (Education, Caste, Occupation, Income)*

$$\text{Log } \lambda_i = \alpha + \beta_1 \text{EDU} + \beta_2 \text{Caste} + \beta_3 \text{Occu} + \beta_4 \text{Inc} + \mu_i$$

Where λ_i represents willingness to pay, EDU means education which is divided into two categories. Occu is the occupational pattern, where two categories of occupation public or government sector and private sector. Inc is the income pattern, categories

in upper income group and lower income group. There are two categories of caste, general and OBC or SC.

Table 6.11: Results for Binary Logistic Regression Analysis of Willingness to Pay

Variables	Description	Coefficient	Z	P>Z	Odd Ratio
β₁ (Base Category)	Other Autonomous	(3.5)	6.67	(0.000)*	32.9
	Effects				
Educational Pattern	Illiterate = 1	(-1.0)	-1.89	(0.059)***	.36
	Otherwise = 0				
Occupational Pattern	Government = 1	(-2.6)	-1.69	(0.092)***	.07
	Otherwise = 0				
Caste	General =1	(-.97)	-1.77	(0.077)***	.37
	Otherwise = 0				
Income	Upper Income = 1	(3.06)	1.71	(0.087)***	21.35
	Otherwise = 0				

Note: * signifies 1 percent, ** signifies 5 percent, *** is 10 percent.

Log likelihood = -52.379577

LR chi2 (6) = 11.40

Pseudo R₂ = 0.0981

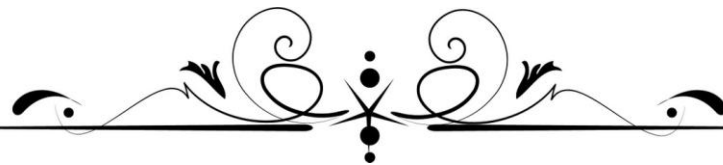
Prob> Chi2 = 0.0224

Source: Estimated from field data.

The logistic regression results for willingness to pay shows that education level, occupation, and caste have negative association with WTP but the otherwise category is positive, while income has positive association with WTP. All independent variables are statistically significant at a 10 percent level of significance. It implies that that as income of household increases, the WTP also increases. The probability of WTP for upper income category is 21.35 times higher than that of lower income category for WTP.

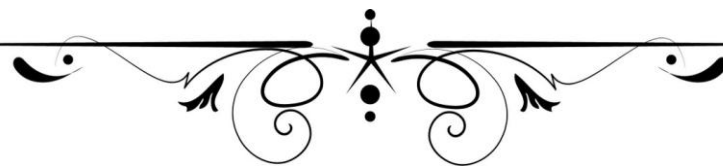
6.6 Willingness to Pay and Public Policy Studies

It is already mentioned that during the last decade, an increase in air pollution level raises public morbidity rate. Therefore, willingness to pay for reduction of health cost and clean air is also a key parameter when considering the tradeoff between economic growth and environmental regulations. For economic losses, air pollution has serious cause therefore, investment in pollution control technology is increasing due to public pressure on local government to take immediate mitigation action to reduce pollution levels (Akhtar, S., et al., 2017, p.280). A case study of Lera-Lopez Fernando, et.al, (2013, p.135) has suggested the willingness to pay to reduce the main externalities attributed to road transportation for air pollution and noise pollution. Environmental problems caused by road transportation positively impact the WTP to reduce air pollution. Another concept is related to the WTP, where to improve any plan related to air pollution, households have to pay the increase in annual household assessment tax directly to the government from their pocket for a fixed period (Masahina Sarabdeen, et al., 2012, p.13). For manufacturing workers, with the help of WTP, local government can develop more effective and practical approaches to improve current air pollution and public health in the future (Liu, R., et al., 2018, p.2). Government policies play an important role to reduce air pollution and with the help of willingness to pay it can be easy.



Chapter- 7

Major Findings & Conclusion



7.0 Introduction

The environment is affected by human and natural causes and creates environmental degradation condition. Natural causes are heavy rain, floods, storms, earthquakes, volcanoes, etc. However, anthropogenic causes are highly responsible for environmental problems in recent decades. Due to human-induced activities such as industrial process, deforestation, heavy transport system, chemical effluents, change land use patterns cause an increase in gases like SO₂, CO₂ consequently pollution level increases at the global level. The relationship between economic development and environmental degradation has been a source of great controversy for quite a long time. Environmental pollution denotes to the contamination of the earth's ecological balance with materials that interfere with human health, quality of life or the natural functioning of the ecosystems. Therefore, environment and pollution relationship have become a subject of intense public debate on sustainable development. Air pollution is a major global public health risk as well as it is one of the highest-ranking environmental health challenges in the world. In India, air pollution has rapidly increased due to amplified use of fossil fuel, industrialization and large use of vehicles. Therefore, the health problems are rising by air pollution especially outdoor air pollution.

The study has made an attempt to understand the impact of air pollution at global level. Firstly, how economic development linked to environmental degradation based on theoretical and conceptual development. Second, how economic theories linked with the environment based on a review of the literature. Third, how carbon dioxide emission deteriorates the environmental quality and the impact of carbon dioxide emission and economic development with the empirical analysis. Forth, how air pollution is increased in India and extends & dimension of Indian air pollution with its institutions, acts, mechanisms and budget policy. Fifth, how air pollution affects human health and intensity of health cost with the livelihood pattern. Finally, how people are willingness to pay for any reduction of pollution health cost. The study has used primary as well as secondary data to analyse the various objectives of the study. Secondary data is used to analyse the impact of economic growth on carbon dioxide emission (1990-2014) at the global level. Check the trend and mean of the pollutant viz., particulate matter, sulphur dioxide, nitrogen oxide during 2007-2017 in India.

Lastly, analyse the Indian budget allocation during 2008-2018 for the environment and especially air pollution. Primary data is used to analyse the health cost and willingness to pay of surveyed areas.

7.1 Major Findings of the Study

Chapter one entitled “**Economic Development and Environmental Degradation: Theoretical and Conceptual Development**” is based on the linkage between environmental degradation and economic development. First, it shows the natural and anthropogenic causes for environmental degradation. Further, denotes its results such as pollution, loss of biodiversity, animal extinction, deforestation and global warming and health challenges.

Second, related to the historical background of the linkage between economic development and environmental degradation. Environmental Kuznets Curve (EKC) defines the relationship between economic development and environmental degradation based on the model stages and shape of the curve. Where, the model is linked with different indicators for economic development and environmental degradation in developed and developing countries. It suggests the pollution level to global concern.

Third, described the concept of sustainable development which is related to the concept of global climate change and greenhouse gas emission. Where, the impact of climate change increases the frequency of drought, more floods, more storms and heat waves with the increasing process of economic development. Further, it is a big challenge to development. Carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and several fluorinated gases are as indicators of GHG emissions and the highest share of the CO₂. The increasing rate of vehicles and road-based transportation are mostly responsible for GHG emissions.

Forth, shows concepts, composition and courses of the air pollution. Where, many types of air pollutant viz., particulate matter, nitrogen oxides, sulfur oxides carbon oxides, hydrocarbons, ozone, and air toxics exists in the atmosphere. Air pollution is also responsible for an increasing number of mortality and morbidity cases. Because,

due to air pollution, approximately 4.2 million die every year and exposure to PM_{2.5} is the fifth among all risk factors alone.

Fifth show a selection of the study area based on the national and state level air pollutants are among the top. There are four cities of Uttar Pradesh viz., Lucknow, Kanpur, Agra, and Varanasi, which included in the seventeen highest polluted cities in India. Where, respirable suspended particulate matter (RSPM) is highest found in the Lucknow city. Therefore, this is selected for the survey. After the analyse data of particulate matter (PM₁₀) by SPCB, Talkatora and Sarai Mali Khan zone also select for the surveyed area of Lucknow. It is also found that vehicles are the most important cause of air pollution in Lucknow.

Chapter two entitled “**Air Pollution and Economic Development: Review of Literature**” based on the review of literature of air pollution and its measurement. First, many case studies linked to air pollution and the environment. In India, outdoor air pollution is mainly to urban areas due to large scale automobiles with a concentration of industries and thermal power plants in major industries and some other areas. Industries (toxic gases), thermal power plants (fly ash and sulphur dioxide), and motor vehicles (carbon monoxide, particulate matter, hydrocarbons and oxides of nitrogen) are the major sources of air pollution in India.

Second, shows the air pollution and health status studies with World Health Organisation estimation report and Global Burden Diseases reports. It shows the health effect due to the particular pollutants and number of death separately. Major concerns for human health by exposure with PM₁₀ include effects on breathing and respiratory system, loss of lung tissue, cancer and premature death.

Third, shows the literature of the economic cost of air pollution. Economics of air pollution is directed to measure the cost for individuals and society on a large extent. Economic activity generates air pollution, which imposed its biophysical effects (morbidity and mortality) on economic cost. The purpose of health economics is to determine the cost of any disease, which is different from the mortality rates of people associated with morbidity.

Forth, air pollution and willingness to pay described the non-market valuation method. Where, contingent valuation method is created a hypothetical market. Because CVM is a useful tool to deal with this type of issue because it can obtain a monetary value for an intangible good that does not have market value. Individual's willingness to pay (WTP) for a specific reduction in air pollution is strongly related to general health risks and the impact of the current level of air pollution on the environment. This also concluded the many studies of air pollution and willingness to pay in different countries.

Chapter three entitled “**Extent, Dimensions and Negotiation of Carbon Dioxide Emission at Global Level**” based on global level analysis of economic development and environmental degradation. First, the concentration of atmospheric carbon dioxide rises from 288 parts per million (ppm) approximately 200 years ago (before the Industrial Revolution began) to 391 ppm in 2010. World CO₂ emission is rising mostly by the use of fossil fuel in the energy sector and from some part of land use change. The key sectors of the economy use energy are industry, residential, commercial buildings, and transportation.

Second, shows the empirical analysis of the Environmental Kuznets Curve based on secondary data of GDP and carbon dioxide emission (1990 to 2014) in five developed and developing countries. This shows the trend of CO₂ emissions, panel data analysis of EKC based on fixed effect model and random effect model, and regression results. The shape of EKC is depended on the sign of the different β parameters related to GDP. Data has proved that developed countries follow the EKC model hypothesis but individual country level data is not significant that means its emission increase due to economic development. Therefore, N-shaped found in the graph. Developing countries highly responsible for carbon emissions in the present time especially BRICS nations. The analysis also found a positive relationship between carbon emissions and economic development.

Third, covers the theoretical framework of climate change and sustainable development. Where, three issues are related to climate change, scientific approach of climate change, economic approach to understand climate change and international treaties on global climate change. International treaties on global climate change

cover the scenario and negotiations of climate change from 1979 to 2018. This also shows the flexible mechanism for controlling climate change.

Forth, it is found that climate change is continuously increased while many rule, agenda, and target decided after the Kyoto protocol. Due to CO₂ emissions, global warming increasing day to day that is dangers for human health. Developed and developing countries are committing but no control of GHGs emission especially carbon dioxide emissions. Because in the Bali conference it was recommended that cut in carbon emissions 25 to 40 per cent in the advanced industrial countries by 2020 and total world emission reduction of 50 percent by 2050.

Chapter four entitled “**Air Pollution in India: Acts, Institutions, Mechanisms & Budgeting**” related to the scenario of the air pollution of India. First, related developments of air pollution act in India. Many enactments are linked to health, pollution and environment in India viz., The Air (Prevention & Control of Pollution) Act, 1981, motor vehicle act, 1988.

Second, described the administrative structure for air pollution protection in India. Various institutes are working at centre and state level under the government of India. Where, the Ministry of Environment & Forest was established in 1985 by the government of India for environmental protection for is making planning, promotion, co-ordination and overseeing the implementation of environmental and forestry programs and policies. Central pollution control board and its functions are measured the air quality data and prepared the air quality index.

Third, related to the air quality index. This has developed the pollutant related health index and measures the air quality in terms of cubic meter for 24 hours. Secondary level data analysis is based on the pollutant and finds the average from 2007 to 2017. First is particulate matter, the analysis is found that most of the cities that cross in the trend line. Delhi pollution is level highest as well most of the cities of Uttar Pradesh are pollution such as Agra, Kanpur and Lucknow. Second sulphur dioxide, due to this pollutant, Pune is the highest polluted and Ahmadabad is second. Third, nitrogen oxide that is highest in Delhi, Kolkata and Pune due to the vehicular cities. Urbanization is the main cause to increase of this pollutant in these cities.

Fourth, budget allocation for the environment covers a two-part budget for environment and budget for air pollution. The budget allocation for environmental protection from 2008 to 2018 that is showing the fluctuating condition where the total budget was estimated Rs. 1707 crores in 2008 and Rs. 2250.34 in 2016-17. Their growth rate is lowest in 2014-15 and was highest in 2016-17. While, the air pollution shows the fluctuating trend, it was highest in 2008 and 2016. The growth rate of air pollution where it was highest in 213-14 and it was lowest in 2008-09 that is 3.09 percent. The growth rate was negative in 2009-10. In 20016-17 the air pollution budget is zero.

Chapter five entitled “**Health Cost Measurement in Surveyed Areas**” related to the air quality, socioeconomic condition and cost of illness of the study area. There are two zones has been taken for the household survey. First is the industrial area which is Talkatora and second is a commercial area which is Sarai Mali khan (Chowk). There are 115 household samples has been collected by each zone from each section of the society.

First, the socio-economic condition, there are 230 households, 51.94 percent found from the Hindu community and 47.70 percent from Muslim community and rest 0.36 percent from the Christian group. Caste wise analysis is 43.55 percent of General category, OBC 42.74 percent and SC 13.71 percent. Gender wise classification is 51.85 percent males and 48.15 females analysed.

Second, related to perception about the air quality in the study area. Where, air quality awareness, 97.83 percent people are aware of environmental pollution and 2.17 percent are not aware. Approximately 93.48 percent agree for air pollution is a serious problem and 6.52 percent disagree as well as 91.3 percent people are facing outdoor air pollution and 8.7 percent are not facing in both the study area. The condition of air quality shows that the percentage share of the critical condition is 46.10 percent, which is representing the high rank and 27.66 percent population agree for very serious and only 2.13 percent person agrees only for not important. Therefore, it is found that the study area is highly affected by air pollution and people are suffering from many problems. There are four categories of the nature of air pollution such as smoke, smog, dust and other problems. There are 26.62 and 25.37 percent of respondents suffering from smoke and smog-induced air pollution problems

respectively. Dust is also a common problem and 39.83 percent people are facing this problem. Season-wise nearly 57 percent people agree for all year round which is very highest and 20 percent person is suggesting for the winter season and 6 percent of the rainy season. There are five sources responsible for air pollution which are vehicles running on the road, smoke from combustion of coal/wood, windblown dust, burning of garbage and grass, and other. The percentage share of windblown dust is highest which is 27.03 and 26.86 percent of the vehicles entrained which is also high it is mostly found in a commercial area (Sarai Mali Khan) and other sources are very low which is only 3.18 percent.

Cost of illness is also high in the study area. The direct cost of the study area is Rs. 406.44 per month, as well as the indirect cost, is 90.26 Rs. Therefore, the total cost of the study area is Rs. 496.70 per month. All models are significant and logit analysis is also significant.

The Chapter six entitled “**Willingness to Pay for Reduction of Health Cost in Surveyed Area**” willingness to pay method is using to reduce the probability of death. This refers to an individual’s own risk. To estimate the environmental health field, contingent is a common method for asses quantifies a person's willingness to pay for better environmental services. In the study area, the results show that most of the respondent is willing to pay to reduce the health problem which they are facing. Where Approximately 93.04 percent person agrees to give monthly the willingness to pay to save their life and 6.96 percent people are disagree for willingness to pay in the study area. As well as the percentage of yearly willingness to pay is 87.83 percent for agreeing and 12.17 percent people disagree for reducing health cost and air pollution.

Second is socio-economic condition wise willingness to pay. Where, the average WTP of the lower income group is Rs. 180.46 per month. The highest mean WTP found in the upper-income group which is Rs. 304.412 per month. It is also analyses that income has a direct relationship with WTP. Therefore, income is an important determinant of WTP for a reduction of health cost.

Education of the respondents also influences for WTP. Where, monthly and yearly WTP is Rs. 176.19 and Rs. 769.85 for the illiterate category. Due to awareness, the highest WTP is found for postgraduate and other categories people. Education wise

monthly average WTP is Rs. 237.62 and as well as yearly WTP is Rs. 954. Therefore, it is suggested that WTP is continuously increased with rising literacy and people want to pay the maximum amount for reducing air pollution.

Category wise, the average of WTP general category is Rs. 222.16 per month and same is for the SC category which is Rs. 222.23 per month. The WTO for the OBC category is Rs. 255.56 per month, which is the highest. The same condition shows for the yearly WTP, where OBC category wants to pay the highest amount. Therefore, it is found that caste wise willingness to pay does not a direct relationship.

Occupation wise the mean WTP for the public and private sector is observed an employee in the industrial sector is Rs. 325 & Rs.219 respondent. The same situation is true for yearly WTP in the study area, where government employees want to pay more amounts and due to lack of income, private sector worker want to pay less amount. It observed that public sector employees earn more income than private sector employees. Therefore, their WTP is high. This also shows the direct relationship between employment and WTP.

It is observed that there is a direct relationship between willingness to pay and socio-economic characteristics in terms of income, education, occupation. Income is the main indicator of observing WTP. When income rises, along with better education and employment, the WTP rises. Various models is used to check the probability of willingness to pay and it is found that educational qualification, employment patter as well as income are important indicators for increase WTP and reduction of health cost.

7.2 Conclusions

In most of the countries, is observed the N-shaped relationship between CO₂ emissions and economic development and some countries follows the inverted N-shaped relationship. That is not followed the EKC hypothesis because that was based inverted U-shaped curve. Trend of the data analysis is showing decreasing trend after 2012. This is mainly due to temperature is increasing continuously after 2010 due increment of CO₂ emissions in the environment by the developed nations. Basically, time duration in data analysis is same for developed and developing nations as well as

pollution and economic development is showing same curve. Therefore, it is found that the pollution level is totally dependent on the economic growth not on the condition of developed and developing nations.

Further, most of the cities especially Delhi, Kanpur, Lucknow, Pune, Ahmadabad and Kolkata are most polluted cities by different pollutants. The mean of pollutants are high in these cities during 2007 to 2017. While the budget allocation shows increasing growth rate in the same time period. However, the rising budget allocation on environment is based on market price but not the constant price. Further, the allocation of budget reflects that substantial proportion, i.e, nearly 97 percent is spent on the category of revenue expenditure and 2.5 percent is spent of capital account. Therefore, the growth in terms of institutional development is poor and insufficient.

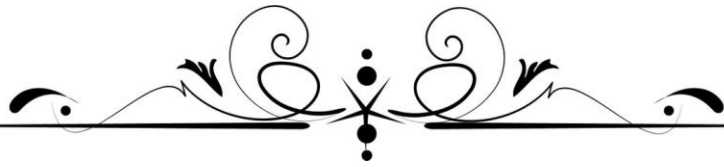
Chapter five concluded that in the study area, it is found that there is no government regulations implemented for industries. They have not provided the medical facilities at the industrial level for the occupational induced disease. They also take more working hours and because of the arbitrariness of the contractors, they are forced to work at low wages. Therefore, workers economic condition is substantially poor and facing many health problems caused by their occupation. Due to availability of air borne pollutants cause to high health cost. The prevalence of high health cost is due to more working hours, low wage rate and poor health protection by the employment.

Chapter six concluded that most of the workers in private and public working regularly on temporary willingness to pay. While the WTP is highest found by the government employees because they are earn more income. Therefore, it is conclude that the willingness to pay increases where the high educational qualification, better occupation and high income is involved. For the cleanliness of air and good health of the area, government should impose the taxes for clean air and provide some facilities such as plantation, public park, and subsidiary tools like mask for good health.

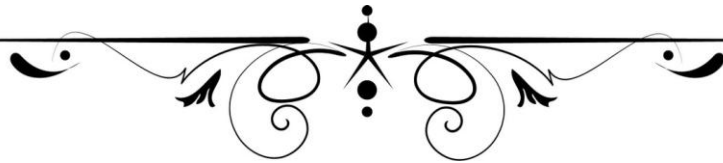
7.3 Policy Implication

Some of policy implications are important to reduce air pollution, health risk as well as better socio economic condition in India as well as Lucknow city of Uttar Pradesh.

1. To control the carbon emission, firstly reduce the pollution of vehicles, commercial/transport vehicles, taxis and autos over 15 years running on traditional fuels, including diesel-driven city buses, should be banned. As well as new vehicles must tighten emissions standards on a large scale. The frequency of public transportation to be increased.
2. The budget allocation needs to increase further especially in the category of capital expenditure. More budget provision for plantation, Public Park and constructing instrument for clean air.
3. In the study area, regular monitoring mechanism needs to develop to act as per minimum wage act & child labour act. Steps should be taken to develop new sanitary landfill sites to convert garbage into manure.
4. Substantial health facility packages needs to provide t to the workers in the industries.



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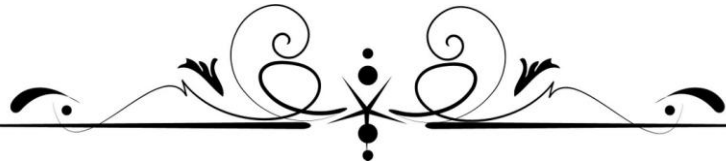
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Appendices

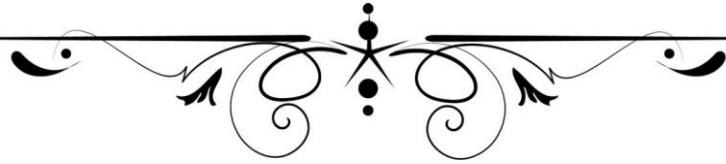


Table: 1.1 Major Air Pollutants

Pollutants	Compositions	Primary or Secondary
Particulate Matter 1. Dust 2. Lead 3. Sulfuric Acid	PM Variable Pb H ₂ SO ₄	Primary Primary Secondary
Nitrogen Oxides Nitrogen dioxide	NO ₂	Primary
Sulfur Oxide Sulfur dioxide	SO ₂	Primary
Carbon Oxides Carbon monoxide Carbon dioxide	CO CO ₂	Primary Primary
Hydrocarbons Methane benzene	CH ₄ C ₅ H ₆	Primary Primary
Ozone	O ₃	Secondary
Air Toxics Chlorine	Cl ₂	Primary

Source: Greer, Ny, and Fisman, 2008

Table 1.2: RSPM & NO₂ in Cities in India

Cities	NO₂ (µg/m³)	RSPM (µg/m³)
Agra	20	185
Ahmedabad	21	95
Bangalore	31	89
Chennai	15	59

Delhi	55	261
Hyderabad	24	79
Kolkata	66	99
Lucknow	34	204
Kanpur	34	203
Faridabad	29	164
Jodhpur	22	181
Patna	40	181
Pune	39	82
Solapur	35	66
Varanasi	20	127
Jharia	38	237
Mumbai	19	97

Source: CPCB, 2010

Table 1.3: PM10 from October 2015 to October 2016

Month	Hajratganj	Mahanagar	Aliganj	Sarai mali khan	Talkatora	Ansal	Gomti nagar
October	167.2	152.7	161.7	169.9	177.3	143.1	153.3
November	171.3	159.7	174	177.8	182.9	149.4	161.7
December	214.42	201.1	192.63	205.11	222.12	200.8	202.6
January	252.8	263.8	232.5	259.7	262	234.6	244.6
February	274	266.8	249.3	286.7	288.8	277.8	280.9
March	254.7	218.6	283.6	244	252.1	215.8	241
April	231.9	228.1	309.5	290.2	269.9	271.8	276.3
May	172.2	192.7	206.8	194.1	207.3	228.5	176.9
June	140.9	129.9	124.9	145.7	144.5	166.3	144.6
July	84.6	84.7	69.6	74.6	80.5	66.5	75.4
August	83.6	96.8	61	90	100.3	70.5	57.7
September	148.3	85.4	82.3	112.8	115.4	87.7	77.6
October	277.7	161.6	223.8	225	209	211.2	261.1

Source- State Pollution Control Board, Lucknow , 2016

Table 1.4: Sulphur Dioxide From October 2015 to October 2016

Month	Hajratganj	Mahanagar	Aliganj	Sarai mali khan	Talkatora	Ansal	Gomti nagar
October	7.7	7.3	7.6	7.8	8.1	7.1	7.2
November	7.9	7.7	8	8.2	8.4	7.5	7.6
December	11	10.17	9.26	10.7	33.4	10.2	9.8
January	11.9	12.59	12.58	12.92	12.64	13.17	11.58
February	10.2	8.9	8.1	10.5	11.6	9.5	10.7
March	7.7	7.4	7.2	7.5	7.8	6.8	7.7
April	6.8	7	6.9	7.1	8.2	6.3	7.2
May	7.6	6.5	6.4	6.5	7.5	6	5.9
June	7	6.8	6.1	7.1	6.9	6.5	6.6
July	5.9	5.4	4.6	6.2	5.8	5.3	5.4
August	6	6	5.5	6	6.5	5.1	5.6
September	6	6.5	6	6.4	6.1	6	5.7
October	7	6.9	6.3	8.2	8	6.3	7

Source- State Pollution Control Board, Lucknow , 2016

Table 1.5: Nitrogen Oxide from October 2015 to October 2016

Month	Hajratganj	Mahanagar	Aliganj	Sarai mali khan	Talkatora	Ansal	Gomti nagar
October	27.3	25.9	26.9	27.8	28.1	24.9	25.5
November	28	27.2	28.5	28.7	30	26.5	26.8
December	35.06	32.13	30.74	33.3	33.4	32.13	32.64
January	35.54	37.27	37.65	38.82	39.19	36.29	35.54
February	30.3	27.9	26.4	31	33.6	28.9	30.6
March	27.6	30.3	26.5	28.4	32.2	29.4	31.1
April	28.2	28.1	25.6	28.6	30.4	27.2	29.1
May	28	26.9	26.9	25.9	27.9	25.7	26.2
June	27.2	25.7	24.4	26.5	26.2	24.6	25.1
July	22.3	21.3	20.1	23.1	21.7	21.1	20.8
August	21.9	23.1	21.3	21.8	23.3	20	21.6
September	22	23	20.7	23.1	22.1	21.2	20
October	26.9	25.8	24.1	27.6	27.3	24.6	26.5

Source- State Pollution Control Board, Lucknow, 2016

Table 3.2: Country Wise GDP and Carbon Dioxide Emissions in Developed Nations during 1990 - 2014

Year	USA		Canada		Australia		Japan		European Union	
	GDP	CO ₂	GDP	CO ₂	GDP	CO ₂	GDP	CO ₂	GDP	CO ₂
1990	23954.5	19.3234	20019.8	15.6591	17358.2	15.4613	19229.6	8.85798	14774.2	8.61214
1991	24405.2	19.0622	19974	15.1493	17804.3	15.1339	20466.7	8.87568	15327	8.66139
1992	25493	19.1456	20352.5	15.4493	18197.4	15.3226	21052.3	9.03976	15721.8	8.57246
1993	26464.9	19.3635	21147.3	15.4566	19136.4	15.706	21536.8	8.89902	16081.4	8.50808
1994	27776.6	19.3766	22364.9	15.6965	20061.9	15.5813	22109.7	9.394	16906.2	8.38457
1995	28782.2	19.2957	23263.1	15.9272	20962.1	15.601	22921.5	9.4369	16020.7	8.17424
1996	30068.2	19.5279	23827.6	16.1589	22016.3	16.506	23888.6	9.58522	16670.7	8.52134
1997	31572.7	19.7143	25000.6	16.4937	22935.4	16.5166	24626.4	9.53044	17532.8	8.32157
1998	32949.2	19.6152	26090.9	16.7435	24218.7	16.94	24328.8	9.16756	18447	8.18291
1999	34620.9	19.7478	27584.8	16.9009	25268.5	17.1922	24606.9	9.45956	19353.4	7.99124
2000	36449.9	20.2076	29075.9	17.3705	26331.7	17.2025	25938.2	9.61388	20863	7.93128
2001	37273.6	19.6562	29936.9	16.985	27384.1	16.7351	26559.5	9.45491	21801.9	8.2131
2002	38166	19.6392	30630.7	16.5594	28685.3	17.3723	27241.1	9.54706	22960.3	8.22678
2003	39677.2	19.5762	32019.3	17.4639	29684.6	16.9062	27941.2	9.6881	23726.5	8.53194
2004	41921.8	19.6836	33594	17.2636	31309.6	17.0303	29377.3	9.85691	25136.3	8.54196
2005	44307.9	19.6103	35973.5	17.4261	32559.5	17.1744	30441.3	9.68611	26348.5	8.448
2006	46437.1	19.1161	37822.3	16.8936	34310.1	17.2939	31790.7	9.62737	28943.9	8.49046
2007	48061.5	19.2375	39226.3	17.0519	36539.2	17.467	33313.9	9.77148	30999.3	8.47928
2008	48401.4	18.4892	40108.3	16.3662	37479.3	17.7041	33495.2	9.42296	32428.7	8.21925
2009	47001.6	17.1924	38709.1	15.0891	40205	17.6318	31857.4	8.59862	31320.1	7.55899
2010	48374.1	17.4848	40055.3	14.5891	39118.7	16.7109	33740.5	9.12718	32174.5	7.89024
2011	49781.4	16.97346	41567.4	15.6398	41763.1	17.5389	34315.8	9.317427	33629	7.5969
2012	51456.7	16.30429	42280.8	14.8906	41763.1	17.0661	35598.09	9.638628	33964.23	7.254178
2013	52980.0	16.31435	43033.1	14.7120	43098.7	16.0835	36223.34	9.780815	34480.00	7.034807
2014	54629.5	16.49061	44057.2	15.1172	43306.5	15.3701	36426.3	9.538706	35367.71	6.757751

Source: World Bank Data, (2016), <https://data.worldbank.org>

Table 3.3: Country Wise Data on GDP and Carbon Dioxide Emissions in Developing Nations during 1990 - 2014

Year	China		India		Brazil		Russian Federation		South Africa	
	GDP	CO ₂	GDP	CO ₂	GDP	CO ₂	GDP	CO ₂	GDP	CO ₂
1990	979.979	2.1677	1146.03	0.793218	6644.22	1.38894	8012.8	13.3061	6698.48	9.0851
1991	1091.45	2.2459	1172.56	0.830434	6854.15	1.43431	7844.09	12.8466	6711.18	9.25661
1992	1260.16	2.31421	1240	0.864498	6867.09	1.42043	6854.09	14.0013	6578.77	8.38966
1993	1453.16	2.4428	1303.9	0.880821	7245.01	1.46211	6416.17	13.0703	6675.91	8.56878
1994	1659.31	2.56599	1393	0.917598	7674.84	1.511	5736.16	11.4681	6887.39	8.81787
1995	1859.83	2.75575	1500.68	0.957509	8055.57	1.58734	5611.66	11.0147	7093.94	9.03524
1996	2060.03	2.84431	1612.53	1.02342	8253.06	1.72279	5515.99	10.9058	7368.26	8.96594
1997	2265.31	2.82057	1674.87	1.04622	8544.82	1.7901	5697.32	10.336	7515.28	9.07314
1998	2446.15	2.67675	1764.88	1.05461	8534.88	1.83143	5460.35	10.1465	7457.41	8.88357
1999	2649.75	2.64865	1915.39	1.10572	8575.39	1.84908	5914.3	10.42	7568.32	8.64409
2000	2915.41	2.69686	1998.49	1.12642	9017.79	1.86581	6825.41	10.6286	7868.31	8.37751
2001	3205.93	2.74212	2105.84	1.12311	9203.42	1.89124	7367.61	10.673	8097.48	8.07716
2002	3527.35	2.88523	2182.24	1.1253	9492.03	1.83527	8029.12	10.7199	8406.85	7.63369
2003	3933.6	3.51225	2361.33	1.15658	9661.95	1.75149	9253.58	11.0957	8716.23	8.25569
2004	4422.65	4.08014	2576.54	1.19718	10349.3	1.81513	10231.4	11.1265	9243.44	9.09042
2005	5053.38	4.44115	2860.89	1.23315	10880.6	1.84269	11822.4	11.2577	9912.54	8.27512
2006	5836.83	4.89273	3172.71	1.29454	11527.6	1.82313	14916.2	11.6716	10643.2	8.80247
2007	6807.11	5.15356	3523.04	1.36579	12409.4	1.88403	16648.6	11.6774	11354.9	9.06333
2008	7569.68	5.31115	3677.72	1.49789	13152.5	1.99043	20163.6	12.0191	11780.6	9.50648
2009	8290.09	5.77814	3963.23	1.61905	13091.3	1.86652	19386.6	11.0261	11521.4	9.5455
2010	9238.75	6.17249	4362.85	1.58487	14117.3	2.11341	20498	12.1984	11842.4	8.95715
2011	10274.5	7.241515	4685.86	1.476686	14830.9	2.211587	22569.8	12.33488	12290.9	9.004033
2012	11214.8	7.424751	4948.3	1.598099	15220.2	2.34357	24063.4	12.78498	12596.7	8.845033
2013	12196.1	7.557211	5301.8	1.591438	15726.5	2.488417	25032.9	12.39356	12866.7	8.673963
2014	13206.4	7.543908	5700.7	1.73	15838.0	2.594388	25635.9	11.85753	13046.2	8.980119

Source: World Bank Data, (2016), <https://data.worldbank.org>

Figure 4.1: List of Regional Offices of the Ministry of Environment & Forest

Regional Offices	Area
I/C Chief Conservator of Forests (C), Ministry of Env. and Forests, Regional Office(SZ), Kendriya Sadan, IVth Floor, E&F Wings, 17th Main Road, Koramangala Bangalore-560034 (Karnataka)	Andhra Pradesh, Goa, Karnataka, Kerala, Tamil Nadu, Pondicherry and Lakshadweep
Chief Conservator of Forests (C), Ministry of Env. and Forests, Regional Office(EZ), A/3, Chandrasekharapur, Bhubaneswar-751023	Orissa, Andaman & Nicobar, Island, Bihar Jharkhand and West Bengal
Chief Conservator of Forests (C), Ministry of Env. and Forests, Regional Office(WZ), E-5, Kendriya Paryavaran Bhawan, E-5 Arera Colony, Link Road-3, Ravishankar Nagar, Bhopal-462016	Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Dadra & Nagar Haveli, Daman & Diu
Chief Conservator of Forests (C), Ministry of Env. and Forests, Regional Office(NEZ) Uplands Road, Laitumkhrah, Shillong-793003	Arunachal Pradesh, Assam, Manipur, Meghalaya, Tripura, Nagaland, Mizoram and Sikkim
Chief Conservator of Forests (C), Ministry of Env. and Forests, Regional Office(CZ), Kendriya Bhawan, 5th Floor, Sector “H”, Aliganj, Lucknow-226020	Uttar Pradesh, Uttarakhand and Rajasthan
Conservator of Forests (C), Ministry of Env. and Forests, Regional Office(NZ), Bays No. 24-25, Sector 31 A, Dakshin Marg, Chandigarh-160030	Haryana, Himachal, Pradesh, Punjab, J&K, Chandigarh and Delhi

Source: <http://www.moef.nic.in/> 2019

Figure 4.1: List of Zonal Offices

S. No	Offices
1	Bengaluru
2	Kolkata
3	Shillong
4	Bhopal
5	Lucknow
6	Vadodara
7	Agra

State Pollution Control Board

1	Andhra Pradesh State Pollution Control Board
2	Arunachal Pradesh State Pollution Control Board
3	Assam State Pollution Control Board
4	Bihar State Pollution Control Board
5	Chhattisgarh Environment Conservation Board
6	Goa State Pollution Control Board
7	Gujarat State Pollution Control Board
8	Haryana State Pollution Control Board
9	Himachal Pradesh State Pollution Control Board
10	Jammu & Kashmir State Pollution Control Board
11	Jharkhand State Pollution Control Board
12	Karnataka State Pollution Control Board
13	Kerala State Pollution Control Board
14	Madhya Pradesh State Pollution Control Board
15	Maharashtra State Pollution Control Board
16	Manipur State Pollution Control Board
17	Meghalaya State Pollution Control Board
18	Mizoram State Pollution Control Board
19	Nagaland State Pollution Control Board
20	Odisha State Pollution Control Board

21	Punjab State Pollution Control Board
22	Rajasthan State Pollution Control Board
23	Sikkim State Pollution Control Board
24	Tamil Nadu State Pollution Control Board
25	Telangana State Pollution Control Board
26	Tripura State Pollution Control Board
27	Uttar Pradesh State Pollution Control Board
28	Uttrakhand State Pollution Control Board
29	West Bengal State Pollution Control Board

Source: <http://cpcb.nic.in>

Figure 4.1: List of State Control Committee

1	Delhi Pollution Control Committee
2	Puducherry Pollution Control Committee
3	Chandigarh Pollution Control Committee
4	Daman & Diu and Dadra & Nagar Haveli Pollution Control Committee
5	Andaman & Nicobar Islands Pollution Control Committee
6	Lakshadweep Pollution Control Committee

Source: <http://cpcb.nic.in>

Figure 4.1: Areas Divided Under Different Circles and Regional Offices

Name of the Circle	Regional Offices Under Different Circles	Districts Under Different Regional Offices
Circle-1	<ol style="list-style-type: none"> 1. Ghaziabad 2. Gautam Budh Nagar (Noida) 3. Greater Noida 	<ol style="list-style-type: none"> 1. Ghaziabad. 2. Gautam Budh Nagar (Noida) 3. Greater Noida

Circle-2	<ol style="list-style-type: none"> 1. Kanpur Nagar 2. Ramabai Nagar (Kanpur Dehat) 3. Jhansi 4. Banda 5. Prayagraj 6. Sonebadra 	<ol style="list-style-type: none"> 1. Kanpur Nagar, Farrukhabad 2. Kanpur Dehat, Kannauj, Auraiya 3. Jhansi, Jalaun, Lalitpur, Orai 4. Banda, Hamirpur, Chitrakoot, Mahoba 5. Prayagraj, Fatehpur, Kaushambi 6. Sonebadra, Mirzapur
Circle-3	<ol style="list-style-type: none"> 1. Meerut 2. Saharanpur 3. Muzaffar Nagar 	<ol style="list-style-type: none"> 1. Meerut, Bagpat, 2. Saharanpur 3. Muzaffar Nagar, Shamli
Circle-4	<ol style="list-style-type: none"> 1. Agra 2. Mathura 3. Aligarh 4. Firozabad 5. Bulandshahar 	<ol style="list-style-type: none"> 1. Agra 2. Mathura 3. Aligarh, Etah, Mahamaya Nagar (Hathras) 4. Firozabad, Mainpuri, Etawah 5. Bulandshahar
Circle-5	<ol style="list-style-type: none"> 1. Lucknow 2. Unnao 3. Raebareli 	<ol style="list-style-type: none"> 1. Lucknow, Barabanki, Lakhimpur Khiri, Sitapur 2. Unnao, Hardoi 3. Raebareli, Sultanpur, Chhatrapati Sahuji Maharaj Nagar(Amethi), Pratapgarh
Circle-6	<ol style="list-style-type: none"> 1. Gorakhpur 2. Faizabad 3. Azamgarh 4. Basti 5. Varanasi 	<ol style="list-style-type: none"> 1. Gorakhpur, Deoria, Maharajganj, Kushi Nagar 2. Faizabad, Bahraich, Gonda, Ambedkar Nagar, Shravasti 3. Azamgarh, Ballia, Mau 4. Basti, Siddhartha Nagar, Balrampur, Sant Kabir Nagar 5. Varanasi, Sant Ravidas Nagar, Jaunpur, Chandauli, Ghazipur
Circle-7	<ol style="list-style-type: none"> 1. Moradabad 2. Bijnaore 3. Bareilly 	<ol style="list-style-type: none"> 1. Moradabad, Rampur 2. Bijnore, J P Nagar 3. Bareilly, Shahjahanpur, Pilibhit, Badaun

Source: <http://www.uppcb.com>

Figure 4.1: U.P. Pollution Control Board, Regional Office

1.	Agra : 14, Sector-3 B, Avas Vikas, Sikandra Yojna, Agra
2.	Aligarh : J-1, Gyan Sarovar Colony, Ramghat Road, Aligarh
3.	Prayagraj : Sector-10, Yojna No.-3 Avas Vikas Parishad Colony, Jhusi, Prayagraj
4.	Azamgarh : 159, Raodpur Colony,
5.	Bareilly : E-1219/1, E-Block Rajendra Nagar, Avas Vikas Colony, Post-Izzat Nagar, Bareilly
6.	Banda : A-39, Avas Vikas Colony, Chilla Road, Banda-210001
7.	Basti : Block Road, Buddha Puram, Basti
8.	Bijnor : 108/11, Avas Vikas Colony, Bijnor
9.	Bulandsahar : F-5, Jamuna Puram Colony, Bulandsahar
10.	Ayodhya : 1/17/104, Ram Nagar Colony, Parikrama Marg, Faizabad
11.	Firojabad : H.No. 77 Gali No. 2 Mahaveer Nagar, Firojabad
12.	Gautam Buddha Nagar(Noida) : E-12/1, Sector 1, Noida, Gautam Buddha Nagar
13.	Greater Noida: A1-First Floor, Shopping Complex, Sector - BITA-2, Greater Noida, Gautam Buddha Nagar
14.	Ghaziabad : 2 I.N.S. Sector-16, Vasundhra, Post-Prahalad Garhi, Ghaziabad
15.	Gorakhpur : Jharkhandi Mahadev, Avas Vikas Colony, Kuda Ghat, Dooria Road, Gorakhpur
16.	Jhansi : Avas Vikas Colony, Talpura Yojna, Kanpur Road, Jhansi
17.	Kanpur : 243, Avas Vikas, Phase-III, Sadbhavna Nagar, Kalyanpur, Kanpur-17
18.	Kanpur Dehat : 844, Fetehpur Roshnai, Rania Kanpur Dehat
19.	Lucknow: Pickup Bhawan B-Block, 4th Floor, Vibhuti Khand, Gomti Nagar, Lucknow-226010
20.	Mathura : 65, Baldevpuri, Maholi Road, Post-Krishna Nagar, Mathura

21.	Meerut : Pocket-T, C-3/2, Pallav Puram, Phase-II, Modi Puram, Meerut
22.	Moradabad : 1-A/I.N.S.-1, Avas Vikas Colony, Buddha Vihar, Delhi Road, Moradabad
23.	Muzaffarnagar: Kamal Cinema Building, Railway Road, Muzaffarnagar
24.	Raebareli : C-Block, Avas Vikas Colony, Indira Nagar, Raebareli
25.	Saharanpur : 33/18, kapil Vihar, Near Vishwa karma Chowk, Saharanpur
26.	Sonebhadra: House No. 162, Uttar Mohal Robertsganj, Sonbhadra – 231216
27.	Unnao : B-16, Avas Vikas Colony, Unnao
28.	Varanasi : Avas Vikas Office cum-commercial Complex Jawahar Nagar, Bhelupur, Varanasi

Source: <http://www.uppcb.com>

Table 4.1: National Ambient Air Quality Standards (NAAQS)

Pollutant	Time Weighted Average	Concentration in Ambient Air		
		Industrial Area	Residential, Rural and other Areas	Sensitive Area
Sulphur Dioxide (SO₂)	Annual Average*	80 µg/m ³	60 µg/m ³	15 µg/m ³
	24 Hours Average**	120 µg/m ³	80 µg/m ³	30 µg/m ³
Oxides of Nitrogen as NO₂	Annual Average*	80 µg/m ³	60 µg/m ³	15 µg/m ³
	24 Hours Average**	120 µg/m ³	80 µg/m ³	30 µg/m ³
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m ³	140 µg/m ³	70 µg/m ³
	24 Hours Average**	500 µg/m ³	200 µg/m ³	100 µg/m ³

Respirable Particulate Matter (Size less than 10µm) (RPM)	Annual Average*	120 µg/m ³	60 µg/m ³	50 µg/m ³
	24 Hours Average**	150 µg/m ³	100 µg/m ³	75 µg/m ³
Lead (Pb)	Annual Average*	1.0 µg/m ³	0.75 µg/m ³	0.50 µg/m ³
	24 Hours Average**	1.5 µg/m ³	1.0 µg/m ³	0.75 µg/m ³
Carbon Monoxide (CO)	8 Hours Average**	5.0 mg/m ³	2.0 mg/m ³	1.0 mg/m ³
	1 Hour Average	10.0 mg/m ³	4.0 mg/m ³	2.0 mg/m ³
Ammonia (NH₃)	Annual Average*	0.1 mg/m ³		
	24 Hours Average**	0.4 mg/m ³		

Source: CPCB, 2009

* Annual Arithmetic mean of minimum 104 measurements in a year twice a week 24 hourly at a uniform interval

** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

Table 4.2: National Ambient Air Quality Standards (NAAQS)

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial Area Residential, Rural & other Areas	Ecologically sensitive area (Notified by Central Govt)
Sulphur Dioxide (SO₂)	Annual Average*	50.0 µg/m ³	20.0 µg/m ³
	24 Hours Average**	80.0 µg/m ³	80.0 µg/m ³
Oxides of Nitrogen as NO₂	Annual Average*	40.0 µg/m ³	30.0 µg/m ³
	24 Hours Average**	80.0 µg/m ³	80.0 µg/m ³
Particulate matter (size less than 10µm)	Annual Average*	60.0 µg/m ³	60.0 µg/m ³
	24 Hours Average**	100.0 µg/m ³	100.0 µg/m ³
Particulate matter (size less than 2.5 µm)	Annual Average*	40.0 µg/m ³	40.0 µg/m ³
	24 Hours Average**	60.0 µg/m ³	60.0 µg/m ³

Lead (Pb)	Annual Average*	0.50 µg/m ³	0.50 µg/m ³
	24 Hours Average**	1.0 µg/m ³	1.0 µg/m ³
Carbon Monoxide (CO)	8 Hours Average**	2.0 mg/m ³	2.0 mg/m ³
	1 Hour Average	4.0 mg/m ³	4.0 mg/m ³
Ozone	8 Hours Average**	100.0 mg/m ³	100.0 mg/m ³
	1 Hour Average	180.0 mg/m ³	180.0 mg/m ³
	24 Hours Average	60.0 mg/m ³	60.0 mg/m ³
Ammonia (NH₃)	Annual Avg*	100.0 mg/m ³	100.0 mg/m ³
	24 Hours Average**	400.0 mg/m ³	400.0 mg/m ³
Benzene	Annual Avg*	5.0 ng/m ³	5.0 ng/m ³
Benzo(a) pyrene	Annual Avg*	1.0 ng/m ³	1.0 ng/m ³
Arsenic	Annual Avg*	6.0 ng/m ³	6.0 ng/m ³
Nickel	Annual Avg*	20.0 ng/m ³	20.0 ng/m ³

Source: MoEF, 2009 (<http://www.moef.nic.in>)

* Annual Arithmetic mean of minimum 104 measurements in a year twice a week 24 hourly at a uniform interval

** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

Table 4.3: Environmental Budget Allocation from 2008-2018

Year	Budget Allocation (in Crores)			
		Plan	Non-Plan	Total
2008-09	Revenue	1481.95	194.72	1676.67
	Capital	18.05	12.28	30.33
	Total	1500	207	1707
2009-10	Revenue	1616.46	375.61	1992.07
	Capital	13.51	14.17	27.68
	Total	1629.97	389.78	2019.75
2010-11	Revenue	2169.07	136.67	2305.74
	Capital	30.93	14.49	45.42

	Total	2200.00	151.16	2351.16
2011-12	Revenue	2234.50	176.79	2411.29
	Capital	65.50	15.18	80.68
	Total	2300.00	191.97	2491.97
2012-13	Revenue	2375.37	183.91	2559.28
	Capital	54.63	15.50	70.13
	Total	2430.00	199.41	2629.41
2013-14	Revenue	2367.38	193.75	2561.13
	Capital	62.62	6.45	69.07
	Total	2430.00	200.2	2630.20
2014-15	Revenue	2381.34	205.55	2586.89
	Capital	98.66	7.45	106.11
	Total	2480	213	2693
2015-16	Revenue	1404.58	228.23	1632.81
	Capital	42.02	6.77	48.79
	Total	1446.6	235	1681.6
2016-17	Revenue	1944.75	250.34	2195.09
	Capital	55.25	0.00	55.25
	Total	2000.00	250.34	2250.34
2017-18	Revenue	-	-	3690.00
	Capital	-	-	349.00
	Total	-	-	4039.00
2018-19	Revenue	-	-	5675.00
	Capital	-	-	325.00
	Total	-	-	6000.00

Source: Union Budget, GOI

Vandana Ahirwar

Department of Economics

Research Scholar

BBA, University, Lucknow.

Date-.././....

Sl. No.....

Place- Lucknow, Uttar Pradesh

Interview Schedule

Section A: *General Profile*

1. Name of Head of the Household:

2. Education of Head the Household:

3. Name of the Respondent:

4. Relation with Head of HH:

5. Districts:

6. Block/Tehsil:

7. Religion:

1. Hindu 2. Muslim 3. Christian 4. Other

8. Caste

1. General 2. OBC 3. SC 4. ST

9. Family Status:

1. Joint 2. Nuclear

10. Sector:

1. Rural 2. Urban

Section B: Household Profiles

13. Household Detail

S.No	Name	Age	Gender	Marital Status	Education	Occupation	Monthly Income
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Codes:

Gender: Male- 1, Female 2

Marital Status: Married- 1, Unmarried- 2, Widow- 3, Divorced- 4.

Education: illiterate, 1 Primary, 2 Secondary, 3 Higher secondary, 4 Diploma/certificate course, 5 Graduate, 6 Post-graduate, 7 Other, 8.

Occupation: Government Sector, 1 Private Sector, 2 Self Employed, 3, Other, 4.

14. Expenditure Pattern (Annual expenditure of the Households)

Household Consumption Expenditure		
	Items Group	Last one Month Expenditure (in Rs.)
1	Non-Durables (a) Food grains (b) Non-foodgrains Total	

	Items Group	Last one year expenditure (in Rs.)
2	Clothing and Footwear	
3	Education	
4	Medical Expenses	
	Hospitalisation	
	Childbirth	
	Others	
5	Durable goods	
6	Other non-food items (conveyance, amusement, sundry articles etc)	
	Total	

Section C: Household Characteristics

15. Ownership of the House

Property value	Rent (Per Month)	Year of the living	Location of house

Codes:

Ownership: Own=1, Rented=2)

Location of House (Industrial Area=1, Constructional Area=2, Commercial/Market Areas=3

Residential Areas=4.

16. Distance from Daily working activities

Distance from market/Shopping Mall (In Kilometers)	Distance from medical clinic/Hospital (In Kilometers)	Distance from School/College/Other Place (In Kilometers)	Distance from Bus Stand/Railway station (Kilometers)	Distance from Industry/factory/Business Center/Other (In Kilometers)

17. Health and recreational facilities

A. Are you doing any exercise or morning walk Yes- 1 No- 2

B. If yes, where are you doing Garden- 1 Park- 2

22. Are you facing outdoor air pollution related problems? Yes-1 No- 2

23. If yes, what is the condition of air pollution in your area?

- | | |
|------------------|--------------------------|
| 1) Critical | <input type="checkbox"/> |
| 2) Very serious | <input type="checkbox"/> |
| 3) Serious | <input type="checkbox"/> |
| 4) Less serious | <input type="checkbox"/> |
| 5) Not important | <input type="checkbox"/> |

24. Which type of problem are you facing by the outdoor air pollution

Type of outdoor Pollution problems	Degree of the problems	Time of the year the Pollution occurs

Code

1. Problems (Smoke=1, Smog= 2, Dust= 3, Other= 4)
2. Degree (Most problematic= 1, Problematic= 2, Less problematic= 3, Not problematic= 4)
3. Time of the year (Summer= 1, Winter= 2, Spring= 3, Autumn= 4, Rainy= 5, All year round= 6)

25. **What are the sources of outdoor air pollution in your area?**

- | | |
|--|--------------------------|
| 1) Vehicle-entrained road dust | <input type="checkbox"/> |
| 2) Smoke from combustion of coal/ wood | <input type="checkbox"/> |
| 3) Wind-blown dust | <input type="checkbox"/> |
| 4) Burning of garbage and grass | <input type="checkbox"/> |
| 5) Other (specify) | <input type="checkbox"/> |

26. Do you have any idea which types of problems are caused by outdoor air pollution?

- | | |
|--|--------------------------|
| 1) Increase illness | <input type="checkbox"/> |
| 2) Premature death on a long term effect | <input type="checkbox"/> |
| 3) Low yield of crop | <input type="checkbox"/> |
| 4) Damage to vegetation and animals | <input type="checkbox"/> |
| 5) Reduces recreational outdoor activities | <input type="checkbox"/> |
| 6) Other (Mention the name): | <input type="checkbox"/> |

Section E: Health Profile

27. Are you aware about air pollution cause illness? Yes -1 No -2

28. If yes, are you facing any type disease related to the air pollution?

Name	Age	Respiratory Diseases	Cardiovascular Diseases	Infections	Degree of Diseases

Code

1. Respiratory Disease (Asthma attacks=1, Shortness of breath=2, Respiratory allergy to dust & pollen=3, Cough with phlegm=4, Dry Cough=5, Bronchitis=6, Lung Cancer= 7)
2. Cardiovascular Diseases (Heart Disease= 8)
3. Infections (Eye=9, Nose=10, Throat Irritation= 11, Skin infection=12)
4. Degree of Diseases (Acute=1, Sub Chronic=2 Chronic= 3)
(Acute- 14 days, Sub Chronic 14-90 days, Chronic -3 years)

29. Are you taking treatment of theses disease Yes, 1 No, 2

30. If yes, which type of treatment
Allopathic=1, Homeopathic=2, Ayurveda=3, Unani=4, Other=5

31. If no, what are the reasons?

- 1) Shortage of money
- 2) The longest distance of hospital
- 3) Lack of awareness
- 4) Heavy work load and time problem
- 5) Other

31. Section F: Health Valuation

Name	Disease symptom code as mentioned	Number of sick days	Medical expenditure								Loss of days and wages	
			Non hospitalized cost			Hospitalized cost					Days	Wage
			Doctor fee	Medicine cost	Travel cost	Travel cost of hospitalisation	Medicines cost	Cost of diagnostic test	Cost of operation and therapies	Cost of blood		

Code :

Total Cost (Direct Cost+Indirect Cost)

Direct Cost (Non hospitalized+Hospitalised)

Non Hospitalisation (Doctor Fees + Cost of Medicine = Total Cost) for 15 days

Hospitalisation (Travel cost of hospitalization+ Medicines cost+ Cost of diagnostic test+ Cost of operation and therapies+ Cost of blood = Total Cost) for 365 days

Indirect Cost (Loss of Days +Loss of wage)

32. Have any household member died in last few years?

Name of household	Age	Name of Disease symptom code as mentioned	Causes of Death

Code:

Causes of Death (Lack of awareness=1, Money Problem=2, Distance and conveyance problem=3, other=4)

Section G: Economic Valuation

This section elicits information of household marginal willingness to pay for a clean air.

Due to some activities such as market, vehicles, industries, and construction work, air pollution problem has continuously increased. Suppose a government policy or any program is introduced in your area, which can reduce smog, smoke, dust and other harmful pollutants.

As a result, it will help in reducing your pain and suffering, your medical expenditure; the time spent visiting medical practitioners, hindrances in your daily working activities and missed work days (loss in wages), and most importantly chronic disease.

33. Are you willing to pay some amount for saving your life (long life)?

(Yes, 1 No, 2)

34. If yes, Will you agree to pay R..... for clean air?

- 1) Rs.
- 2) Rs.
- 3) Rs.
- 4) Rs.
- 5) Rs.

35. If no, Will you agree to pay R..... for clean air?

- 1. Rs.
- 2. Rs.
- 3. Rs.
- 4. Rs.
- 5. Rs.

36. If you are facing air pollution problems in your area. Can you pay extra amount to reduce this problem?

(Yes, 1 No, 2)

37. If yes, which type of scheme, you will willingness to pay?

- 1) Public goods (Park)
- 2) Plantations
- 3) Constructing instruments for clean air
- 4) Subsidiary tools (Mask, other)

38. For these schemes, will you pay Rs.....?

- 1. Rs.
- 2. Rs.

39. What is the most important reason why you would be willing to pay?

- 1) For better air quality

- 2) It will improve environmental quality
- 3) It will reduce health problems caused by air pollution
- 4) It is not costly
- 5) Do not know
- 6) Other

40. What is the most important reason why you would not be willing to pay?

- 1) Government should pay
- 2) Polluters should pay
- 3) Price is too much
- 4) Income is limited
- 5) No problem with the Environmental air quality
- 6) Other