Climate Change and Health: A Case Study of Pakistan

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Table of Contents

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Abbreviations and Acronyms

ADB : Asian Development Bank

AFIC : Armed Forces Institute of Cardiology

CC : Climate Change

CDM : Clean Development Mechanism

CGE : Computable General Equilibrium

CO_2 : Carbon Dioxide

CO_2e : Carbon Dioxide Equivalent

CVD : Cardio Vascular Disease

CVM : Contingent Valuation Method

EIA : Energy Information Administration

EPA : Environmental Protection Agency

EPI : Environmental Performance Index

GDP : Gross Domestic Product

GHG : Greenhouse Gases

IPCC : Intergovernmental Panel on Climate Change

MMT : Million Metric Tones

MWTP: Marginal Willingness to Pay

NOAA : National Oceanic and Atmospheric Administration

PIC : Punjab Institute of Cardiology

PPM : Parts per million

UN : United Nations

UNEP : United Nations Environment Program

UNFCCC: United Nations Framework Convention on Climate Change

VSL : Value of Statistical Life

WDI : World Development Indicator

WHO : World Health Organization

WMO : World Metrological Organization

WTP : Willingness to Pay

Abstract

This thesis analyzes the impact of climate change on health in two cities of Pakistan; i. e. Lahore and Rawalpindi. Lahore is relatively hotter and Rawalpindi is relatively colder. The data have been collected from selected hospitals of both cities. The study focuses on the nexus between GHG emission; rising temperature and health. We investigate what is the contribution of transport sector in GHG emissions and resultantly how the emissions (one of the indicators of temperature change) have caused temperature to rise and then estimate the relationship between temperature and health.

In this study the relationship between emissions from the transport sector and Pakistan's temperature has been tested empirically. Based on data of carbon dioxide from road transport sector, minimum and maximum emissions of carbon dioxide emissions from road transport sector and their damages in financial terms have been forecasted up till 2030.

The data of cardiovascular diseases (indicator of state of health) from different hospitals of Lahore and Rawalpindi have been collected to assess the relationship between health and temperature. The study has found inverse relationship between cardiovascular diseases and temperature for Lahore whereas this relationship has been found to be positive for Rawalpindi.

This study also calculated the direct and indirect cost of cardiovascular diseases (CVD). The findings of this study show that direct cost of CVD is much larger then indirect cost.

The study also uses the Contingent Valuation method to calculate the willingness to pay for a better traffic system and enhanced health program specifically for cardiovascular diseases in Lahore. The findings indicate that the people of Lahore are more conscious about their health as they are ready to pay more for improved health program as compared to better traffic system.

Chapter 1: Introduction

"Climate change presents a unique challenge for economics: it is the greatest and widest ranging market failure ever seen." [Stern, N. (2006)][1][2][3].

All the countries in the world, whether developed or developing, are struggling to achieve sustained economic development to eradicate poverty and to increase the welfare of society. Developing countries face difficult choices in balancing efforts to protect the environment and boosting economic growth. A key element, of such decisions, is an estimate of the social benefits that an improved environment will provide, which is generally absent. In developing countries like Pakistan, climate change is an additional burden because socioeconomic and ecological systems are already facing pressures caused by rapid population growth, industrialization and economic development. The annual presage estimated cost of environmental degradation and natural resource damages in Pakistan is about Rs 365 billion which is one billion rupees per day or six percent of GDP.(World Bank, 2006).

Economically and ecologically important regions are significantly damaged by the impacts of climate change, such as changes in atmospheric temperature. Consequently, many valuable economic functions are threatened by climate change. Climate change is projected to

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[1]"Climate is usually defined as the "average weather", or more rigorously, as the statistical description of the weather in terms of the mean and variability of relevant quantities over period of several decades (typically three decades as defined by WMO). These quantities are most often surface variables such as temperature, precipitation and wind, but in a wider sense the "climate" is the description of the state of the climate system." (IPCC glossary).

[2] For the purpose of this study we have taken only one variable, i.e. temperature as the main indicator of climate change.

[3]"A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."(IPCC Glossary).

impact the sustainable development of most developing countries in Asia [Stern (2007)]. Although developing countries are less responsible for the Greenhouse Gases (GHG)[4] emission, major factor behind recent climate changes, the adverse impacts are higher on them [Patz and Kovats (2002)]. For example, Pakistan has contributed very little to global GHG emissions which are responsible for climate changes but they are a major threat to individuals' lives and livelihood in Pakistan. It is an important issue that requires national and international cooperation to formulate effective economic and environmental policies[5] . Currently, Pakistan is actively participating in the meetings of the Intergovernmental Panel on Climate Change (IPCC)[6] and annual conferences of United Nations Framework Convention on Climate Change (UNFCCC) in order to find a solution to the problem.

Human activities, primarily the burning of fossil fuels, are very likely (with more than 90 percent probability) to be the main cause of climate change. According to the United States Geological Survey for Volcano Hazard Program, human activities emit more than 130 times of CO_2 than volcanoes. (Gerlach 1991)[7]. Human activities emit 27 billion tons of CO_2 every year. These human activities include fossil fuel combustion, cement production and gas flaring (Marland, et al. 2006).

Wealthy energy consuming nations are mainly responsible for global warming and poor nations are more at risk.(Patz and Kovats, 2002). Although developing countries are currently contributing less to the emissions but the international energy agency (IEA) estimates that by

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[4]Greenhouse gases absorb the infrared radiation and trap the heat in the atmosphere.

[5]If we see per capita emissions then Pakistan is at 132nd number in the world emitting 0.9 per capita in 2007 (Institute 2010).

[6]IPCC was established in 1988 by the United Nations Environment Program and the World Meteorological Organization to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.

[7]Volcanoes emit between 130-230 million tons of CO_2 per year (Gerlach 1991)

2020, 60 percent of gas emissions will come from developing countries and economies in transition (International Energy Outlook, 2003). According to US Energy Information Administration the highest growth in per capita primary energy consumption between 1980 and 2010 was seen in Asia i.e. 155 percent increase in the said period. While per capita world primary energy consumption has increased around 16 percent. If we take the case of Pakistan then around 75 percent of per capita primary energy consumption is seen in the corresponding period. In Europe there is only 2 percent increase. While according to British Petroleum Statistical Review of World Energy (2015), the highest average primary energy consumption between 2004 and 2014 was seen in Asia which is around 38 percent in the said period. While in Europe and Eurasia average primary energy consumption is around 25 percent and around 24 percent in North America in the corresponding period. It can be concluded that the developing world has the higher primary energy consumption as compared to Europe and North America.

According to the Energy Information Administration (2001), in the US anthropogenic (human induced) GHG emissions from fossil fuel combustion have resulted 82 percent from the carbon dioxide[8] , 9 percent from methane and 5 percent from nitrous oxide. Since carbon dioxide (82 percent) is the main component of the anthropogenic emissions and it is also evident that once emitted in the atmosphere, it remains there for more than 100 years so damages will continue to exist for long period of time. Thus the main focus of this study is on carbon dioxide emissions.

If carbon dioxide is broken down into its main contributors, then the main culprit is the transport sector contributing almost 34 percent of all carbon dioxide (Envirolink, 2011).

[8]Carbon dioxide is a colorless and odorless gas. It is heavier than the air and therefore can flow in low lying areas. According to the United States Geological Survey (volcano hazard program), if there is 5 percent CO_2 in the air, it will cause a perceptible increase in respiration, 6-10 percent causes shortness of breath, headaches, dizziness, sweating and general restlessness, 10-15 percent results in impaired coordination and abrupt muscle contractions, 20-30 percent results in loss of consciousness and convulsions, while over 30 percent can cause death (Hathaway et. al 1991)

According to the U.S. Energy Information Administration (various issues) the increase in the petroleum consumption of Pakistan is 277 percent between 1980 and 2010. The average of Asia in the petroleum consumption is around 159 percent while in North America the average increase of petroleum consumption is around 17 percent in the corresponding period. The world average shows around 39 percent increase in use of petroleum products. Since the transport sector contributes greatly to carbon dioxide emissions, the focus of this study is to analyze the pattern of emissions, damages, and forecasting, in this rapidly expanding sector in Pakistan. The growth rate of transport sector in Pakistan is around 1300 percent between 1980 and 2009. [see Figure 3.2.

As mentioned earlier, wealthy energy consuming nations are more responsible for climate change (International Energy Outlook, 2003). However, developing countries are more vulnerable and are immediately affected by climate change. Developed nations contributed greatly to combating climate change and are continuously accelerating towards the solutions. But developing countries, which are more vulnerable, are far behind. Thus, the topic of climate change and health needs to be researched especially in developing countries which are more vulnerable and are immediately affected, so that a viable solution may be found quickly in order to save human capital and to minimize the damages and losses in the future by devising the policies. A decision needs to be reached as to whether losses incurred by climate change should be borne today or in the future.

Human beings are the cause and effect[9] of climate change. The effects of climate change could be linked, directly and/or indirectly, with the health hazards faced by individuals. Healthy human beings have the capability to overcome the problems caused by climate change; however

[9] Human beings are cause because they are responsible for emissions of anthropogenic emissions and they are effect because they are facing damages especially health damages through climate change.

unhealthy humans face an exacerbation of the problems like workdays loss, absence from school, restrictive activity days etc. Therefore, this study focuses on impacts of climate change on human health. The study has been divided into four main parts. In the first part the transport sector's contribution to Pakistan's share of GHG emissions has been ascertained; in the second part the concentration of CO_2 and consequently its effect on climate change has been estimated. In the third part the relationship of temperature with the number of patients of cardiovascular disease, an indicator of health, in Lahore and Rawalpindi cities is examined. In the fourth part our objective is to find out the willingness to pay for improved health and better transport system. Climate change has the characteristics of a public good and market price is unavailable for evaluation of its impacts (Halsnæset al., 2007). Therefore, in the fourth part, the contingent valuation method has been applied to calculate the willingness to pay for a better traffic system and health program in Lahore city.

1.1 GHG Emissions and Temperature

From the literature, discussed in chapter two, it can be concluded, with 90 percent certainty, that anthropogenic emissions have caused the observed global warming after the industrial revolution. According to the IPCC the relationship between carbon dioxide emissions and temperature is positive (CDIAC 2007). According to IPCC the global average surface temperature has increased by approximately 0.65 °C over the last 50 years and between 1.0 to 1.7 °C since 1850. Moreover IPCC forecasts an increase in world average temperature by 2100 within the range of 1.4 – 5.8 °C (IPCC 2007). The National Research Council (NRC) report (2006) claims that rise in global average temperature has been higher during the last few decades as compared to any other period in the last 400 years. It is claimed that: "The risks of the worst impacts of climate change can be substantially reduced if greenhouse gas levels in the atmosphere can be stabilized between 450 and 550 ppm (parts per million) CO_2equivalent (CO_2e). The current level is 400 ppm CO_2e, and it is rising by 2ppm each year."(NASA, 2015). It is also forecasted that stabilizing at 550 PPM of CO_2 (double of the pre-industrial revolution level) will lead to temperature increase of 2.0 – 4.5°C by 2050 (IPCC 2007). According to Stern (2007):

"If no action is taken to reduce emissions, the concentration of greenhouse gases in the atmosphere could double as compared to its pre-industrial level as early as by 2035. It means virtually committing us to a global average temperature rise of over 2°C. In the longer term, there would be more than 50 percent chance that the temperature rise would exceed 5°C.".

How much it will cost to limit/control the GHG emissions? The literature gives different answers. For example, Stern review states that a cost of 1 percent of global GDP (0.630441 trillion US$ in 2010) WDI (2011) is required to limit 550 PPM of CO_2 by 2050. On the other hand, the International Energy Agency's World Energy Outlook estimates that around 550 billion US$ are required to be invested in energy efficiency each year, so that by 2030 the concentration of CO_2 will be limited to 450 PPM. IPCC believes that to limit the concentration of GHG to 450 PPM of carbon dioxide equivalent (CO_2e), we have to reduce CO_2 emissions by 60 percent by 2030.(IPCC 2007).

The effect of heat waves is greater in big cities. If we look at the regional climate change it is evident that most cities show a large heat effect. They exhibit an increment of around 5-11 °C as compared to the surrounding rural areas (Jonathan A. Patz, 2005). After reviewing the relationship of GHG and temperature globally we analyze the same relationship for Pakistan.

1.2 Trends of GHG Emissions and Temperature in Pakistan

According to the World Development Indicators, in 1971, almost 19 million metric tons of carbon dioxide emissions was recorded in Pakistan and per capita carbon dioxide emissions were 0.3 metric tons, which increased to a total of 114 million metric tons and 0.8 metric tons per capita in 2003. This shows an increase of almost 500 percent in total emissions and 167 percent in terms of per capita emissions of carbon dioxide from 1971 to 2003. CO_2 emissions have increased and the temperature has also increased in the corresponding periods from 0.2 to 1.0°C. There is a positive relationship between CO_2 emissions and temperature in Pakistan as shown in Figure 3.4[10]. This relationship is in accordance with the IPCC report and Stern Review Report of 2007. Consequently, it can be concluded that the same relationship, as observed globally, has been observed in Pakistan.

1.3 Climate Change and Health

The effects of global climate change can be potentially very detrimental for the next century. The possible aftereffects include regional increases in high-temperature events, outbreaks of diseases affecting human health and safety adversely, especially among poor communities with high population densities.

If we review history, top ten warmest years in the history (1880-2014) are between 1998 and 2014[11](NOAA, 2014). According to IPCC, climate change is likely to have a wide-ranging and mostly adverse impact on human health, accompanied by a significant loss of life.

[10]See Ch. 3 for the Figure 3.4

[11] See Appendix for Chapter 1 for the list of top ten warmest years.

By 2020, more than half of Asia's urban population will be at great risk from heat waves, pollution and diseases while straining infrastructure (ADB, 2008). One of the major health impacts of climate change is the increase of heart-related diseases especially cardiovascular diseases (McMicheal et al., 2006; Haines and Patz, 2004). The highest death rate in world is 26 percent of total deaths due to cardiovascular diseases in south Asia region (WHO, 2005). IPCC also concludes, "The range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time." (IPCC 2007)

It is further stated that the susceptibility of the human and natural system to climate change varies greatly from region to region (IPCC 2007). As urban areas and the population of urban areas increases, vulnerability to heat-related mortality seems likely to increase in future. More vulnerable regions are temperate latitudes, and regions around the pacific and Indian oceans [Patz, et al.(2005)].

There are several limitations to the available information. Foremost is that most empirical climate-health studies and national assessments of health risks from future climate change have been done in high-income countries. Most epidemiological studies of extreme temperatures have been done in Europe and North America [Basu, (2002); McGeehin, (2001)]. It has been observed that most of the studies have been conducted in Canada, USA and Europe and a couple of studies have taken place in Asia[12]. With respect to Asia, some research on this topic has been conducted in India; however, as far as I know, no study has been carried out in Pakistan. It has also been concluded that most of the effects of climate change are adverse effects. To estimate the health cost associated with climate change in developing countries, policy makers are often

[12]For detail see the chapter of Literature Review.

forced to extrapolate results from studies conducted in industrialized countries. These extrapolations, however, may be inappropriate.

1.4 Objectives of the Study

Following are the major objectives of the study:

1. To examine the relationship between expansion of transport sector and GHG emissions.
2. To study the linkage between GHG emissions and changes in temperature.
3. To analyze the impact of temperature change on health.
4. To calculate the willingness to pay for improved health and transport system.

1.5 Contribution to the Literature

Like most of the developing countries, in Pakistan also, there is dearth of studies examining the linkage between climate change and human life, particularly health. In order to bridge this gap, in this study, an effort is made to understand the link between GHG emissions, temperature rise and health. For this purpose the study is divided in following four parts:

1. In the first part, using the transport data, we examine the contribution of transport to GHG emissions.
2. In the second part, an effort is made to determine how the emissions have contributed to change in the temperature.
3. The third part is focused on the link between temperature change and health.
4. In the fourth part our objective is to find out the willingness to pay for improved health and better transport system.

It will help the policy makers to opt for strategies which will reduce the dependency on oil within the transport sector and reduce the emissions from transport sector. This can be done by inducting environmental friendly technologies and producing healthy human resource for the economy to achieve sustainable development in Pakistan.

1.6 Importance of the Study

Climate change is affecting almost every sector of economy such as human health, ecosystem, rainfall, water resource etc. Human beings are the cause and effect of climate change. Therefore human beings need to make an effort to limit climatic changes. Healthy human beings have the capability to overcome the problems caused by climate change; however unhealthy human beings face an exacerbation of the problems linked to climate change. That is why climate change’s health impacts analysis has been chosen for this study. Climate change is expected to increase the average temperature. Increased temperature is expected to increase morbidity and mortality especially for cardiovascular patients. It is also expected that climate change will affect the life in developing countries more than in developed ones. (Patz and Kovats 2002).

Most of the studies related to climate change and health have taken place in Europe and USA. They have shown a positive relationship between increased temperature and mortality. It has also been found that most of the mortalities occurred in people with pre-existing cardiovascular disease. It is also evident from most of the studies that people living in urban areas are at greater risk. This is due to the urban heat island effect.[13]

In Europe, abnormally high temperature (3.5C above normal) in the summer of 2003 was

[13] Inner urban environments, with high thermal mass and low ventilation, absorb and retain heat which amplifies and extends the rise in temperature.

associated with over 35000 more deaths than in the same period in previous years (P. S. Stott 2004). Climate change has already caused the deaths of 150000 people in 2000. In 1995, the Chicago heat wave caused 696 more deaths (whitman, 1997)and in 1999 a heat wave caused 119 deaths in Chicago (Palecki, 2001). Adaptation[14] to climate change can reduce the risks. This showed that developed countries are also vulnerable to increased temperature especially laborers who work outdoors.

It is imperative to estimate the health cost with reference to conditions in Pakistan. Additionally it is essential for Pakistan to initiate research about this important issue so that an estimation of the impact of climate change on health can be carried out. These steps are necessary in order to convey our stance in international debate and convey our subjective point of view; which will eventually lead to legislation of internal policies. It is crucial for Pakistan to take serious steps to avoid further increase in emissions especially carbon dioxide through transport. If preventive measures are not taken, increased temperature will lead to an increased health cost which will bring about a depletion of human resources. Every country needs mental and medical fitness of its human resources to achieve maximum prosperity and sustainable development.

The reason for choosing cardiovascular disease is that the patients of this disease are increasing and the impacts are very acute. Internationally, Asia has the highest death rate due to cardiovascular diseases (WHO, 2005). In all other diseases we have generally enough time to manage the treatment but not in the case of cardiac related disease. This indicates that the causes of cardiovascular disease need to be tackled urgently.

There is an acute shortage of environmental and health data in developing countries,

[14](Proper air conditioning in summer, proper heating in cold weather, improved health care facilities, public awareness etc.

especially in Pakistan. Due to financial and time constraint, it is very difficult to conduct this study for the whole country. Thus, a survey was conducted to collect information. In order to obtain primary data we have chosen Lahore city to study WTP for transport and health, for our analysis. Main reason for choosing Lahore as the subject for this study is that Lahore city is the second largest city and second biggest commercial area of Pakistan and the capital of Punjab province. The oldest and largest hospital of cardiology is situated in Lahore.[15] Another reason for choosing Lahore is that the incidence of cardiovascular disease is increasing in Lahore (see chapter four). The government of Punjab has provided the highest level of facilities for cardiovascular patients in Lahore as compared to other cities.

1.7 Organization of the Study

After the introduction, in chapter two history of climate change is discussed with special reference to Pakistan. Chapter three briefly reviews the literature related to studies of climate change, health and cardiovascular diseases. In chapter four, data collection and methodology are discussed. A brief history of the survey area is introduced and data collection techniques are discussed. Survey method, primary and secondary data collections techniques are also discussed in this chapter. Chapter four also deals with theoretical and econometric models. In chapter five the impact of emissions on temperature is discussed in detail. The issue of health cost is discussed in chapter six. For the patients of cardiovascular disease in Lahore per capita and total expenditures (minimum, maximum and average) are calculated for the year 2009. In chapter seven we have discussed the contingent valuation method. Willingness to pay for both sectors, transport and health, is assessed separately. Conclusions and recommendations are given in chapter eight. National/international policies for both sectors are also part of this chapter.

[15] There are other cardiology hospitals in Punjab but they are relatively smaller and newer as compared to Lahore's cardiology hospital. There are four more cardiology hospitals in Punjab located at Rawalpindi, Multan, Faisalabad and Wazirabad. Wazirabad's hospital is not yet operational.

Chapter 2: Literature Review

In 2007, Intergovernmental Panel on Climate Change (IPCC) reached on a consensus that anthropogenic emissions have caused climate change which in turn has affected life on globe especially with reference to human health. Urban areas are more vulnerable to climate change as compared to surrounding areas. Buildings absorb increased temperature more than trees and green fields. Consequently, people in cities are more at risk as compared to residents of rural areas. As mentioned earlier, in developing countries the research on impacts of climate change is not sufficient, but it is expanding at a high rate. Pakistan's atmospheric environment is very different and it has very different climatic conditions as compared to the rest of the world[16].

As mentioned in the previous chapter this study focuses on the relationship of emissions with climate change and the subsequent impact of climate change on human health and the willingness to pay for improvement in transport and health sectors. We have arranged the literature review on the same lines in the following manner. In the first portion a couple of studies related to CO_2 emissions, emissions from transport sector and climate change have been discussed. Then the relationship between climate change and health has been discussed. The second part is related to willingness to pay for improvement in health sector. At the end of the literature review we have quoted a couple of studies related to climate change and health from the point of view of policy making.

[16] In Pakistan, 12 locations are cooler, 22 are warmer. Globally, 2282 are cooler, 698 are warmer (World Climate 2010).

2.1 Literature on CO_2Emissions, Climate Change and Health

IPCC reports conclude that most of the observed warming over the last 50 years is attributed to human activities and these are likely to continue to change the climate during the 21^{st} century. By 21^{st} century the concentration of CO_2 in the atmosphere will be in the range of 490-1260 PPM and it will change atmospheric temperature by 1.4 – 5.8°C at the end of the 21^{st} century [Albritton (2001)]. Different studies have concluded that IPCC estimates regarding the temperature increase of between 1.4 – 5.8°C in 21^{st} century are likely to be conservative [see Andronova (2002), Knutti(2002), Stott and Kettleborough, (2002)]. In addition Cline (1992) has estimated that a doubling of CO_2e above preindustrial levels would increase global average temperature by 2.5°C. It will be achieved as early as 2025 under the scenario of "Business as usual". Albritton (2001) is of the view that 75 percent of anthropogenic emissions of CO_2 during last 20 years were due to the fossil fuel burning. Meehl (2004) reveals that the frequency of heat waves has been projected to increase the frequency and duration in Chicago and Paris by the end of the century (2080-2099). Ulph (1997) suggested that we must initiate an abatement process now rather than in the future on the basis of available information. Houghton (1990) quoted that IPCC has estimated that a reduction of emissions in CO_2 of over 60 percent is required for the stabilization of atmosphere concentration. Chichilnisky (1993) concluded that failure to understand the irreversibility of damages leads to understatement of the need for immediate reduction of GHG emissions.

Patz and Kovats (2002) have concluded that health effects of climate change affect poorer populations first. In this paper authors have reviewed the major findings of published reports by IPCC, the National Research Council, the World Health Organization and UN Environmental Programs. They found that developed nations are more responsible for the emissions of GHG and climate change but poorer nations are at a higher risk.

Andrew, et al. (2000) checked the health status in Africa, Asia and South America. They used secondary data. The health impacts were estimated from the number of people affected. Climate Variability is one of the factors which accounted for up to 26 percent of the anomalies in the case of highland hospitals which needs to be prioritized amongst many factors affecting human health and survival. Schwartz (2000) concluded that in U.S. the effect of emissions on daily deaths that occurred out of hospitals (outdoor) are greater than an increase in deaths taking place in hospitals. Mostly the health impacts of climate change come from temperature and precipitation [Jonathan A. Patz (2002)]. Pattenden (2003) concluded that higher temperature contributes approximately 1-4 percent to the mortality of the elderly in Europe. Stott (2004) reported that more than 35000 deaths in Europe in 2003 were due to the heat wave and it has been estimated that the probability of such events has doubled since preindustrial time. Patz,et al. (2005) have reviewed the climate-health relationships in many regions of the world. They concluded that the effect of heat waves has increased in big cities as compared to villages and small towns. As urban areas and population of urban areas have increased, vulnerability to heat-related mortality seems likely to increase in future. More vulnerable regions are temperate latitudes and regions around the Pacific and Indian oceans. McMicheal,et al. (2006) have focused largely on thermal stress, extreme weather events and infectious diseases.

Eurowinter (1997) concluded that daily deaths increased with falling temperatures in warmer areas. The effect of a cold day is larger in warmer cities then in colder cities. Robert D. Morris (1998) claimed that increased carbon dioxide reduces the flow of Oxygen in blood and causes serious cardiovascular effects. Braga (2002) has concluded that for cardiovascular deaths the hot day effect is five times smaller than the cold day effect. This refers to the fact that a fall in temperature affects cardiovascular patients more than a rise in temperature. They also concluded that the cold temperature effect continues for days, but high temperatures are associated with the actual death or the day before the actual death. In a report by McMichael A. J. et al (2003) it is observed that in South East Asia, change in the temperature in a range of 0 - 1°C is associated with 0 – 0.9 percent of cardiovascular cases and between 1 - 2°C temperature is associated with 0 – 1.3 percent of the cardiovascular cases. A serious side effect of increased temperature is related to premature deaths due to Cardiovascular, cerebrovascular and respiratory diseases Zell, (2004), Patz and A., (2004), McMicheal, et al. (2006) and there are some indirect effects of climate change through air pollution like asthma and allergies; as well as other acute and chronic respiratory disorders and deaths [Haines et al (2000)]. The World Health Organization, WHO, (2005), has suggested that in many temperate countries, death rates during the winter are higher, approximately 10-15 percent than during the summer season. Most deaths occur in people who are suffering from preexisting conditions such as cardiovascular and respiratory diseases. Park (2005), concluded that in San Paulo, Brazil, emergency room visits for cardiovascular problems were associated with traffic pollutants like CO_2. In a report presented by World Health Organization, WHO (2007) in Central Africa, in 1986, more than 1700 deaths took place due to carbon dioxide from Lake Nyos, a volcanic crater lake, which released this gas. Shannon, et al. (2007), Committee on Environmental Health, USA has tried to determine the main factors that affect children's health. They have concluded that we have to educate people about adverse health effects for children.

Arriaga-Salines, et al. (1980) examined the value of air quality, due to different emissions like CO_2, TPM etc., based on the differences in wages among cities. They used the two stage least squares. They concluded that the supply of labor to any city increases with real wage and air quality in the cities. It means that people give great weightage to real wages and air quality. Cropper, et al. (1997) used the daily mortality data for 1991-1994 to check the cost and benefits of air pollution control for cardiovascular and respiratory diseases in Delhi, India. They used the auto regressive Poisson model for deaths with causes. She concludes that air pollution impacts on mortalities due to cardiovascular and respiratory with respect to various ages are very different than those in developing countries as compared to US. In US, adverse effects were found in people whose age is 65 and above. In Delhi, these effects were observed in the age group between 15 and 44 years. It means that a death due to air pollution causes more life-years to be lost in a developing country then in a developed country.

The discussion in paragraphs given above revealed that the result is inconclusive. Some studies show a positive relationship between temperature and incidence of cardiovascular disease while others show a negative relationship. Moreover as mentioned earlier that most of the studies have taken place in the developed countries. Thus, there is a need to investigate this subject further especially in developing countries and in both of the areas i.e. cold and hot areas, in order to reach a conclusion. Therefore from Pakistan the cities of Lahore and Rawalpindi have been chosen for this study in order to reach a conclusion. Lahore is a hot area while Rawalpindi is a relatively cold area.

2.2 Literature on Willingness to Pay

As mentioned earlier the second part of this study is related to the willingness to pay for improvement in the traffic and health sectors. Thus, the following literature review is also related to the willingness to pay.

Cropper (1981) used the damage function approach to conclude that the willingness to pay is greater for acute illness than the benefits computed. She estimated that the value of a 10 percent reduction in pollution is only $3.60 ignoring the adjustments to pollution and therefore this value is understated. A study was conducted by Anna Alberini et al(1997), the objective of the study was to elicit Willingness to Pay (WTP) to avoid a recurrence of acute illness in Taiwan. Using survey based data for 864 people and applying Contingent valuation method and Log likelihood function the study shows that WTP increased with duration of illness, number of symptoms and with education and income. Kumar (2001) suggests that due to an improvement in the ambient air to meet the National and World Health Organization standards, households of Panipat are willing to pay an amount between the range of Rs. 12 to Rs. 53 per month. In another study Alan, et al. (2002) suggests that value of statistical life through willingness to pay was C$ 3.8 million in 1999 C$, for 1 in 10000 annual risk reduction and C$ 1.2 million for 5 in 10000 annual risk reduction or US$ 3.04 and US$ 0.96 million respectively. They also concluded that willingness to pay for 5 in 10000 risk reduction is C$ 657 and did not change up to age 70 and was around 30 percent lower for persons age 70 and above. Anna (2004) investigated the Willingness to Pay (WTP) for a reduction in probability of dying during the next 10 years in Canada and in USA. She used the survey based data for 930 residents of Hamilton, Canada and 1200 residents from USA. She used the Contingent valuation method and applied Maximum Likelihood technique for estimation. They found that in both countries the results are similar.

WTP is significantly greater for persons with high blood pressures than for those without it. Chronic respiratory and cardiovascular diseases have no statistically significant effect on WTP in either country. Alberini (2005) obtained estimates of the Value of a Statistical life in the context of the risk of dying of Cardiovascular and Respiratory illness. They collected primary data from three cities including PRAGUE (N=351), BRNO (N=296) AND OSTRAVA (N=307). They calculated the Value of Statistical Life (VSL) by applying the Maximum Likelihood technique. They concluded that mean VSL of€1.27 million at the current exchange rate is, €2.86 million at the PPP, while median VSL is 18.52 million. Value of Statistical life is higher among rich people and it declines with the age of the respondent. In another study by Anna Alberini (2006) it is concluded that delaying the time of risk reduction of mortality risk significantly reduces the willingness to pay. Respondents between ages 40 – 60 have less willingness to pay today for a risk reduction of mortality which is going to occur at age 70 then willingness to pay for a current risk reduction. In another study Alberini (2006) looked at the WTP for reduced mortality risk by analyzing the latency in the period from 10 years to 30 years. This was a survey based study for 930 residents of Hamilton, Canada and 1200 from USA. They concluded that delaying the time at which the risk reduction of mortality occurs significantly reduces WTP, at least for respondents in the 40-60 age groups. Gupta (2006), used both Household Surveys and Secondary Sources and applied the Poisson Regression Model and Tobit Model to show that the annual welfare gains of better health to a working individual from reduced air pollution are Rs. 164.82 and a total gain of Rs 212.82 million per annum for the population (2.7 million) of the city of Kanpur.

Haines et al (2000) analyzed direct and indirect health effects of climate change. Based on their analysis they suggested a change in the housing designs to enhance summer-time cooling, adding greenery to inner cities and early warnings of the weather. McMichael (2003) reviewed the quantitative estimates of the total health impacts due to climate change. He also laid out the steps necessary to further scientific investigation and develops strategies and polices to help societies adapt to climate change. A study by Patz (2004) investigates the impacts of thermal stress, floods and droughts, air pollution, etc. on health. They have concluded that if we make policies related to reducing GHG, efficient use of energy and early warning of climate changes then we can reduce the impacts of climate change on health. Ojha (2005) shows that a carbon tax policy that imposed heavy costs in terms of lower economic growth and higher poverty can minimize or can even prevent it if the emission tax revenues are transferred to the poor and the emission restriction targets are very mild. The study uses secondary data and applies the Computable General Equilibrium (CGE) Model to simulate alternative policy scenarios. The study finds that in different policy options, the best one is to sell the Carbon trade permit internationally instead of applying a carbon tax. If the carbon price is set at $6/ton then GDP will increase by 3.7 percent per year and poverty will be reduced by 19 percent by the year 2020. If the carbon price is set at $12/ton, GDP will increase by 5.7 percent and poverty will reduce by 57 percent by year 2020. McMicheal (2006) summarized the epidemiological evidence of how climate variations and trends affect health outcomes from some published materials. He concluded that the evidence and anticipation of adverse health effects will indicate priorities for planned adaptive strategies and strengthen the case for pre-emptive policies. Parry (2006) studied the externalities from automobiles and damages from transport like CO_2, fuel dependency, accidents etc. and calculation of these damages and presented methods to devise a policy for transportation. He used secondary data. He has shown that the total external cost is 176 cents/gallon of oil and from this 7 and 12 cents/gallon is attributed to greenhouse warming and oil dependency respectively. He has also shown that the US passenger car emissions standards (grams per mile) have decreased from 34 in 1970 to 4.2 in 2004-05.

Discussion in literature review revealed that most of the studies are from developed countries like Canada, USA and Europe. Only a few studies have been undertaken in Asia. From Asia, a few studies are available for India but no research has been conducted on this topic in Pakistan (according to my knowledge). It can also be concluded from the above discussion that climate change has adverse direct and indirect health effects. Moreover the discussion of section 3.1 concluded that some studies show a positive relationship between temperature and incidence of cardiovascular disease while others show a negative relationship. Most of the studies have been conducted in colder areas whereas some studies are from comparatively hotter areas. Therefore, it is imperative for Pakistan to initiate research on this important issue in order to assess the impacts of climate change on health and realize and suggest appropriate precautionary measures. Therefore, as mentioned earlier, there is a need to investigate this subject further especially in developing countries and in both of the areas i.e. cold and hot areas, in order to reach a conclusion. Therefore from Pakistan the cities of Lahore and Rawalpindi have been chosen for this study in order to reach a conclusion. Lahore is a hot area while Rawalpindi is a relatively cold area.

Chapter 3: History of Climate Change

3.1 Brief History of Climate Change:

Climate change has been taking place during the last few billion years. This has changed from a global ice ball to the world's global warming. Historically, scientists have concluded that climate change started taking place in the ICE AGE which was part of the global scenario 20000 years ago. They called it the "Last Glacial Maximum". It was a time when most of the North America and Eurasia were covered with the ice sheets. The sea levels were 400 feet lower than today. From this Last Glacial Maximum, scientists have started to observe an escalating trend in global temperature.

From the last ten thousand years, the scientists observed the global warming with some cooling episodes. But on the whole there was global warming. There have also been a population boom and technology breakthroughs which is also a cause of the global warming. The population of the world increased from five million to one billion by 1800 A.D.

The last 1000 years are denoted by the term "Little Ice Age". This is the period which encapsulates the time between the $16^{th}$and 19^{th} century. It is generally believed that three periods i.e. 1650, 1770 and 1885 can be separated from warm periods. IPCC [2007] claimed that this is not the appropriate term as this is not global climate change. There has been some increase with respect to glaciations in some parts of the world such as Alaska, New Zealand and Patagonia. Since glaciations have occurred in only some parts of the world, we can say that this is regional climate change and not global climate change.

The next stage comprises of the last 200 years. This is the era known as the industrial revolution. Human beings have started burning coal and oil in huge amounts, thus releasing Greenhouse Gases (GHG) into the atmosphere. These increased GHG have caused the global warming trend. IPCC was established in 1988 by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) to provide the world with a clear scientific perspective on the current scientific knowledge relating to climate change and its potential threats to environment and economy.

From 1990 onwards, the earth's temperature has shown drastic climatic changes. Researchers and policy makers from all over the world have presented various views/theories for controlling the GHG emissions. With the establishment of IPCC in 1988, the people have also become aware of the fact that the climate is changing rapidly. In 1997, the Kyoto Protocol was signed to reduce GHG emissions (by 5.2 percent on average with reference to the 1990 level during a period of five years (2008-2012)) [UNFCCC (1997)]. In 2005, scientists have presented major discoveries related to climate change. Greenland glaciers suddenly leaped; consequently large amounts of ice submerged with the sea. Studies from the last 50 years of hurricanes were shown to the public and revealed that the storms were getting more intense. Indian Ocean Tsunami of 2004, Hurricane Katrina of 2005 and the 2010 flood in Pakistan are some examples of these types of disasters.

3.2 Brief History of Climate Change in Pakistan[17]

In Pakistan, the met data, available from 11 stations, indicates that a cooling of 0.1 to 0.3^{O}C in rural towns' stations and a warming of 0.7^{O}C in the stations of cities is observed in the last four decades. In the last three decades, there has been a net decrease in temperature of Badin and Nokundi by 0.3^{O}C and 1.1^{O}C respectively whereas in last two decades the temperature of Islamabad has decreased by 0.6^{O}C. In the last decade, the decrease in temperature of Hyderabad and Jacobabad has observed by 0.2^{O}C and 0.1^{O}C respectively. There has also been observed a net increase in temperature in Karachi, Quetta, Gilgit, Peshawar and Lahore 0.7^{O}C, 0.5^{O}C, 0.2^{O}C, 0.3^{O}C and 0.6^{O}C respectively. All of these increases have been observed in the last four decades.

The mean maximum temperature also has different patterns. The mean maximum temperature in Badin decreased by 1.4^{O}C, in Hyderabad decreased by 0.7^{O}C, and in Jacobabad decreased by 0.3^{O}C in the last four decades. On the other hand in Karachi an increase of 0.6^{O}C, Nokkundi by 0.4^{O}C, Quetta by 0.4^{O}C, Gilgit by 0.7^{O}C, Islamabad by 0.4^{O}C has been observed between 1960 and 1990. In Lahore an increase of 0.2^{O}C was noted between 1960 and 1990 and a decrease of 0.1^{O}C was seen in the period between 1960 – 70, Peshawar exhibited an increase of 0.9^{O}C since four decades.

Based on data, reported in the Economic Survey of Pakistan (various issues), the temperature trends of major cities of Pakistan are shown in Figure 2.5A[18]. It shows slight fluctuation of temperature (mean of Maximum) in Pakistan's major cities from 1975 to 2002. While Figure 2.6A shows a significant increase in the temperature (mean of minimum) of Pakistan's major cities except for Quetta.

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[17]The figures of Pakistan temperature have been taken from a study by Dr. Mirza Arshad Ali Beg (Former Director General, PCSIR) entitled "Climate Change in Pakistan; is it Related to Global Warming". This study is available at http://www.energy.com.pk/Climatechange percent20in percent20Pakistan.doc

[18]See Appendix for Figure 2.5A and 2.6A

3.3 Situation Analysis

Anthropogenic emissions are the main cause of climate change. So to develop the argument, it is necessary to look very briefly at Pakistan's demographic situation. Pakistan has a total area of 0.796096 million square kilometer. Pakistan's total population increased from 33.75 million in1951 to around 162 million in 2008 showing annual growth rate of 2.75 percent. In terms of population change at city level, the largest increase has been seen for Karachi (761 percent) followed by Quetta (574 percent), Peshawar (549 percent) and Lahore (506 percent) from 1951 to 1998. This increase in population shows a rising trend of urbanization.

The literacy rate (10 years and above) of Pakistan is 56 percent (2007-08). At provincial level, the highest literacy rate is in Punjab which is 59 percent followed by Sindh 56 percent, N.W.F.P. 49 percent and Balochistan 46 percent. Life expectancy at birth in Pakistan is 65 years [Economic survey of Pakistan (2007)]. Total number of hospitals in Pakistan in 2008 was 948 while the total beds for patients in hospitals were 0.103 million (which include all the health centers as well). This means that the population per bed is 1575. Total number of vehicles on Pakistan's roads was 8.88 million in 2007-08.

3.4 Environmental Situation Analysis:

Pakistan is at the 124th number out of 149[19] countries in the Environmental Performance Index (EPI)[20] scoring 58.7. Pakistan is at the 39th number out of 178 nations emitting cumulative carbon dioxide of 2192 million metric tons from 1980 to 2007 (World Resource Institute 2010). These are 0.35 percent of the world's total emissions of carbon dioxide. If we see per capita emissions then Pakistan is at the 132nd number in the world emitting 0.9 per capita emissions in 2007. In 2007,

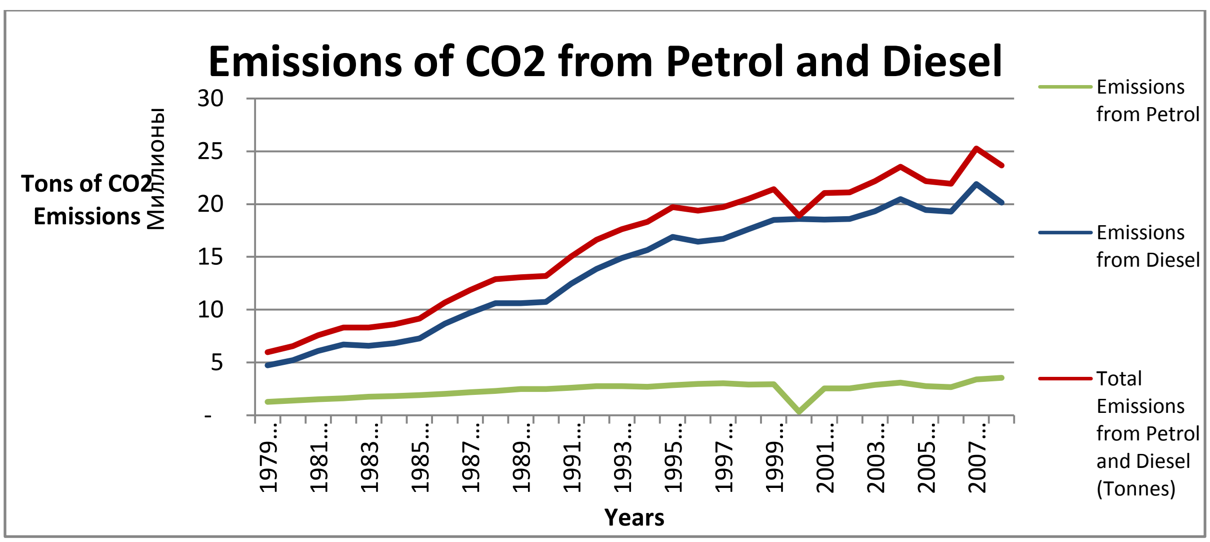
[19]Complete list is attached in the Appendix

[20]EPI is developed by Yale University and Columbia University with the Collaboration of World Economic Forum, Switzerland and Joint Research Center of the European Commission, Italy.

Pakistan's position was 32nd in the world, emitting 148.9 million metric tons of carbon dioxide. The table 2.1A[21] shows the total emissions in different years (World Resource Institute 2010). Average and total growth rates of CO_2 emissions of Pakistan from 1980 to 2007 are 6.4 percent and 431.3 percent respectively. Average and total growth of CO_2e emissions of Pakistan is shown in Table 2.2A [Institute (2010)]. With respect to just transport, Pakistan emitted 32.5 million metric tons in 2007 and ranked 30th. These emissions are 0.58 percent of the world's CO_2 emissions. While per capita emissions in transport are 0.2 and ranked 110th number in the world [Institute (2010)].

For the purpose of this study, the emissions from road transport sector have been calculated separately from petrol and diesel consumption. These were 22.18 million metric tons in 2006 and increased to 23.67 million metric tons in 2009. The emissions from road transport sector from 1980 to 2009 are shown in Figure 3.1.

Figure 3.1 Emissions of CO_2 from petrol and diesel in Pakistan



Source: Author's calculations

[21]See Appendix for Table 2.1A and 2.2A

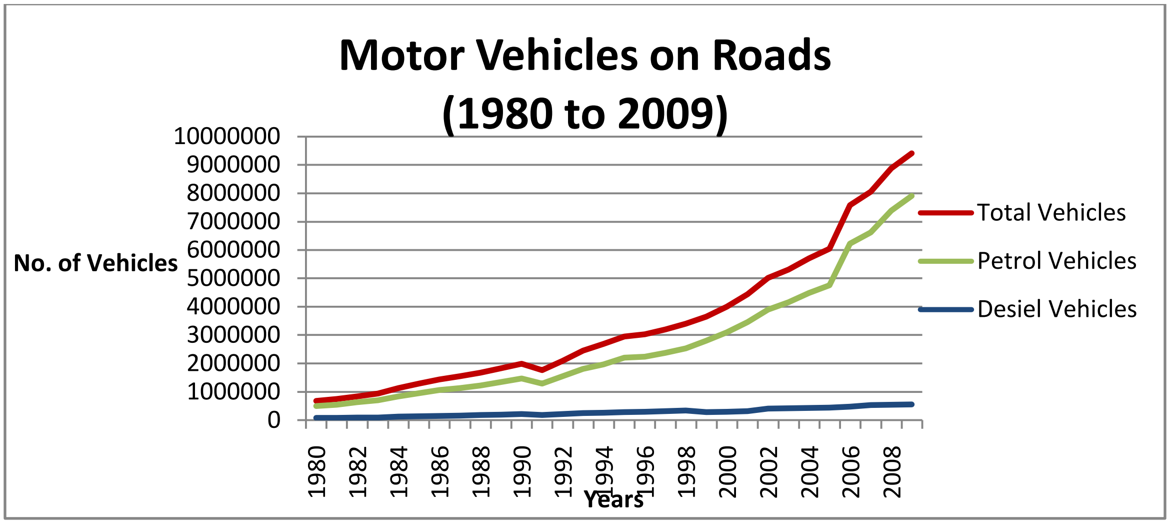
Figure3.1 shows that total emissions from petrol and diesel were around 6 million tons in 1979-80 and reached around 24 million metric tons in 2008-09 which shows an increase of 300 percent from 1980 to 2009. The emissions from petrol alone were around 1.3 million metric tons in 1979-80 and reached 3.5 million metric tons in 2008-09 which shows an increase of 169 percent from 1980 to 2009. The emissions from diesel alone were 4.7 million metric tons in 1979-80 and increased to 20 million metric tons in 2008-09 which shows an increase of 326 percent. Figure 2.2A[22] shows the total carbon dioxide emissions from the consumption of petroleum products for Pakistan between 1980-2005. The Emissions calculated by the Energy Information Administration (EIA) have been shown in Figure 2.2A. It shows that total emissions from petroleum were around 14 million tons in 1980 and reached around 52 million metric tons in 2005. The difference between author's calculation and EIA's calculation is because EIA has calculated the emissions from total transport sector while author has calculated emissions only from the road transport excluding agricultural, railway and aviation transport.

3.5 Transport Trends:

After calculation of emissions from transport, Pakistan's vehicular trends have been examined to check out why there is huge increase in the emissions. Figure 3.2 shows that the total numbers of vehicles were 0.68 million in 1980 which increased to 9.4 million in 2009. This shows an increase of around 1300 percent. Vehicles which use petrol have increased by 1500 percent and vehicles which use Diesel (excluding tractors) have increased by 560 percent.

[22]See Appendix for Figure 2.2A

Figure 3.2 Growth of motor vehicles in Pakistan

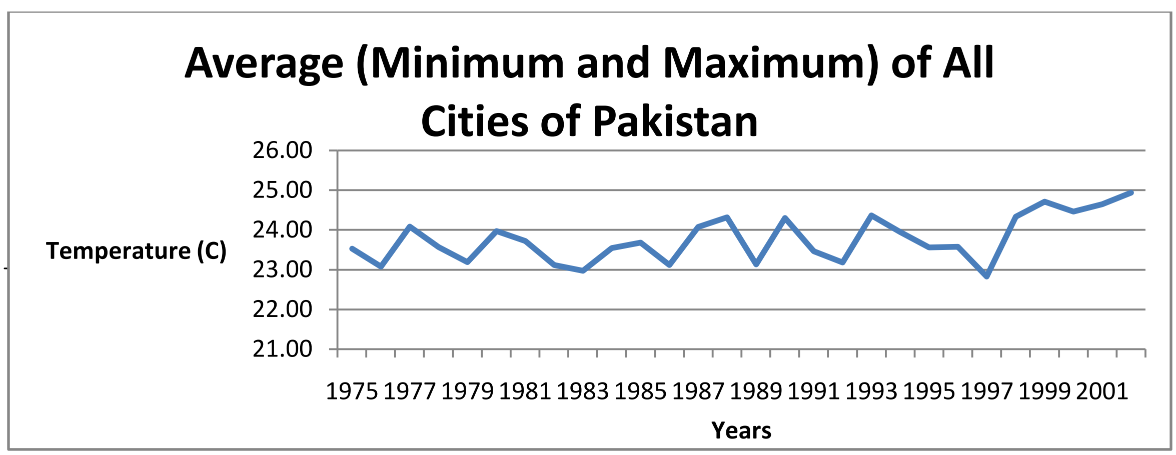


Source: Transport department

3.6 Temperature Trends

Historical temperature of Pakistan from 1970 to 2004 revealed that temperature has changed from 0.2 to 1.0 C°. Figure 3.3 clearly shows an upward trend of temperature of Pakistan.

Figure 3.3 Average temperature of Pakistan



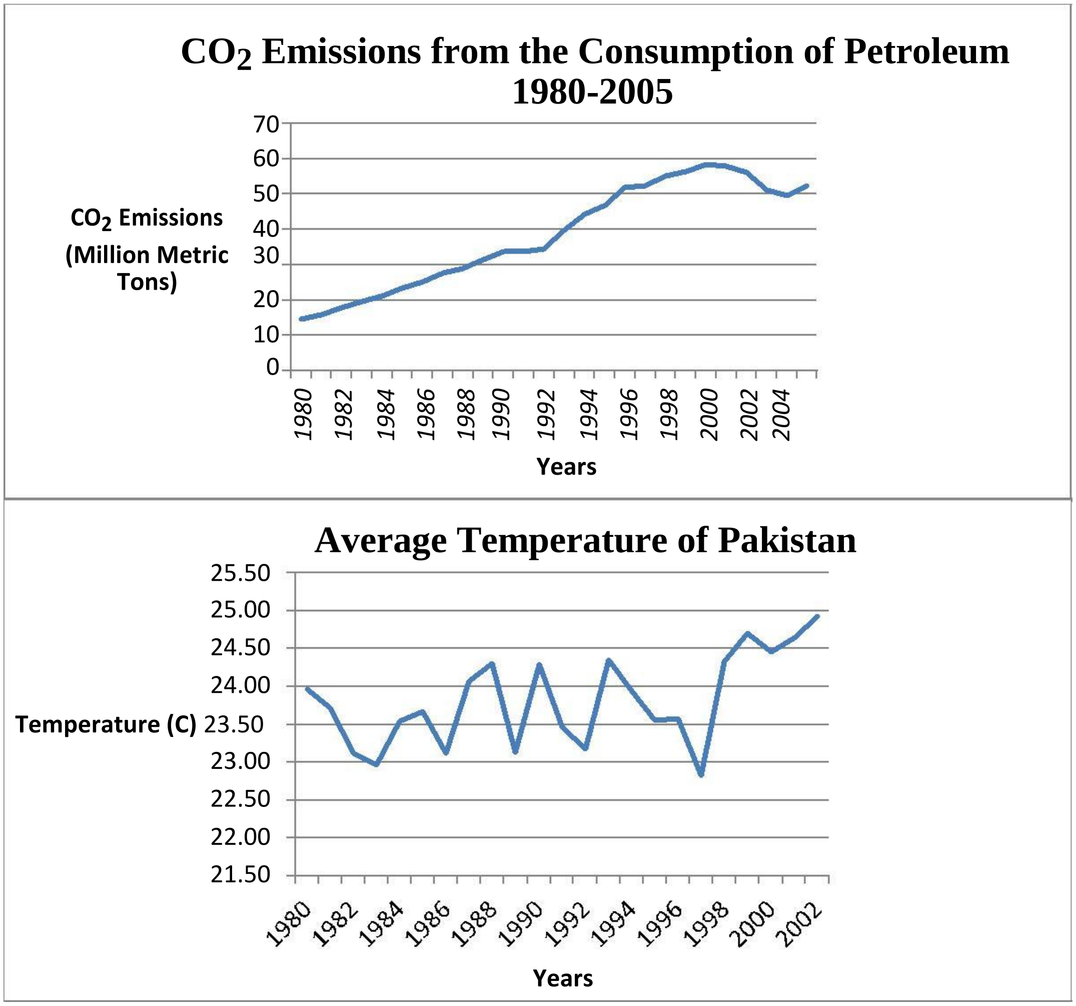
According to the Economic Survey of Pakistan the temperature trends of major cities of Pakistan are shown in Figure 2.5A[23]. It shows slight fluctuation of temperature (mean of Maximum) in Pakistan's major cities from 1975 to 2002. While Figure 2.6A shows a significant increase in the temperature (mean of minimum) of Pakistan's major cities except for Quetta.

3.7 Relationship of GHG and Temperature in Pakistan

After looking briefly at the emissions and temperature trend in Pakistan, we have examined the relationship of CO_2 and temperature in Pakistan. Figure 3.4 clearly shows a positive relationship between CO_2 emissions and temperature in Pakistan. CO_2emissions have increased from 1980 to 2002 and the temperature has also increased in the corresponding periods. This relationship is in accordance with the IPCC report and Stern Review. So it can be concluded that in Pakistan the relationship is the same as observed globally.

[23]See Appendix for Figure 2.5A and 2.6A

Figure 3.4 CO_2emissions of petroleum and average temperature in Pakistan



The analysis given above shows that there is a significant increase in Pakistan's population and in the major cities. This has caused a significant increase in mode of transportations from 1980 to 2009 which is around 1300 percent. From this massive increase in transport the emissions of carbon dioxide also increased by 300 percent in the corresponding period. This may have changed the temperature significantly in different cities of Pakistan. Consequently, this may have significant impacts on human health. For this purpose, the impacts of climate change on human health are ascertained. We use primary and secondary data for this study[24]. Primary data is collected from hospitals and secondary data is collected from Pakistan's various meteorological and transport departments. Finally, household survey is conducted to calculate the willingness to pay for better environmental and health facilities.

[24] Detailed data description is given in chapter four.

Chapter 4: Data Collection and Methodology

In this chapter data collection techniques and description of different data sets have been explained briefly. The study has been divided broadly into four main sections. In the first part the transport sector's contribution to Pakistan's share of GHG emissions has been computed; in second section the concentration of CO_2 and consequently its effect on climate change has been estimated. In the third section the relationship of temperature with the number of heart patients of cardiovascular disease, an indicator of health, in Lahore and Rawalpindi cities is examined. In fourth section our objective is to find out the willingness to pay for improved health and better transport system. For the first two sections, annual data is required, because as mentioned in the previous chapters, climate change is a long run phenomenon encompassing decades [Parry (2007)]. Therefore, initial analysis is based on annual data. Daily data is required for the third part as the effect of temperature is visible after an interval of three to seven days. The fourth part of the study is based on the use of the contingent valuation method (CVM). For this purpose a household survey of Lahore city has been conducted. CVM was first proposed by the S. V. Ciriacy-Wantrup in 1947 for evaluation of non-market goods. It was first applied by Davis in 1963 to estimate the value tourist placed for wilderness areas. But it gained popularity in 1989 after the assessment of the Exxon Valdez Oil Spill, which took place on March 24, 1989 in Prince William Sound, Alaska. Economists used the CVM to find the willingness to pay to prevent another oil spill. After this estimation the method is being used worldwide.

A lot of criticism was aimed at this method. In 1993, the National Oceanic and Atmospheric Administration (NOAA) commissioned a Blue Ribbon Panel to look into the criticism. The panel consisted of many experts, including two Nobel prize winners, viz., Kenneth

Arrow and Robert Solow. They heard the arguments put forth by advocates and critics of CVM. In their final report, the panel concluded that the CVM can produce reliable results provided researchers meet a high standard of proof.

The primary objective of the thesis is to calculate the health cost of the people of Lahore, and willingness to pay for an improved transport and health system. Other objectives are to quantify the losses of the economy due to adverse health effects through climate change and to help policy makers to develop the policies for sustainable development and to avoid the adverse impact of climate change. For this purpose two data sets were required. One was related to climate change (temperature) and other was related to health. The data sets were collected from two sources. The First data set was obtained from the meteorological department and various hospitals to check the relationship between climate change and health and to calculate the health cost. The second data set was collected from a household survey in Lahore city to ascertain the willingness to pay for improvement in transport and health services.

Generally secondary data sets on environmental indicators and their economic value are not available. For this study, we have collected data from different hospitals situated in Lahore and one hospital located in Rawalpindi. Other than this some secondary data sets, if available, have been used. To compile a second data set, a household survey of Lahore city has been conducted to estimate people's WTP for health. Description of different data sets and their collection procedure is given below.

4.1 Meteorological Data[25]

The Meteorological Department Karachi provided the Lahore's daily temperature data from 1980 to 2008. This included the maximum and minimum temperature of Lahore city based on a monthly average. Daily temperature of 2009 & 2010 is available online at the meteorological department of Pakistan. Historical temperature of Pakistan[26] from 1970 to 2004 revealed that temperature changes from 0.2 to 1.0 C°. The Figure 2.3 in chapter two clearly shows rising trend in Pakistan's temperature.

4.2 Energy and Emission Data[27]

The yearly data with respect to petroleum energy products' consumption by fuel mix is taken from Pakistan Energy Yearbook (various issues) from 1972 to 2008. Carbon dioxide emission data is taken from the World Development Indicators (World Development Indicators 2007) and from Energy Information Administration, USA for the years 1980 – 2005. Figure 2.1 in chapter two depicted that emissions of CO_2 from petrol and diesel have increased over time.

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[25] I am thankful to **the Director** of Climatological Data Processing Centre, Karachi for providing me the daily data of temperature for different cities from 1980 to 2008. Daily temperature data is available on payment. For the students they provide limited data sets without any payment. Otherwise everybody have to purchase the data. Due to financial constraints, the only data which was provided (without payment) was used in this study i.e. temperature.

[26] For detailed discussion about temperature see chapter 2, section 2.6

[27] For detailed discussion about petroleum and emissions see chapter 2, section 2.4

4.3 Survey Area[28] (Lahore City)[29]

Lahore city is the second largest city and second biggest commercial area of Pakistan. It is also the capital of Punjab province. The main reason for choosing Lahore as the focal area for survey is that it has the oldest and largest hospital of cardiology. There are other cardiology hospitals in Punjab but all of them are relatively smaller and newer as compared to hospitals in Lahore. There are four more cardiology hospitals in Punjab which are located in Rawalpindi, Multan, Faisalabad and Wazirabad.[30]

Lahore is situated on the world atlas as 31°15´ and 31°45´ north latitudes and 74°01´ and 74°39´. Lahore's total population was 6 million in 2008 and the average growth rate is 3.46 percent while Pakistan's total population was 162 million in 2008 and has an annual growth rate of 2.75 percent (from 1951 to 2008). There are more than 500 primary, secondary and tertiary health care centers in Lahore.

Inadequate management of transport sector poses serious threats to the health of people and the environment of Lahore. Two air quality monitoring stations were installed in Lahore in April 2007. One is situated at Town Hall which is heavily crowded and has a busy traffic area while the other is installed at Township which is a commercial area. The data for air quality is being recorded since April 2007 in these two areas i.e. residential and commercial areas.

The transport system has contributed greatly to Lahore's insalubrious environmental situation. The main source of environmental degradation in Lahore's transport system which

[28] Due to time and monetary constraint we have conducted the survey only in Lahore.

[29] The total geographical area of Lahore consists of 1772 sq. km. The river Ravi flows in the west side of the district and it touches the district Sheikhupura on the west. On the South side it touches the Kasur district and Indian border is on the East and North-East side.

[30] Wazirabad's hospital is not operational as yet.

includes two stroke rickshaws, old vehicles and a poor examination system of motor vehicles. The congestion of traffic in Lahore is another major cause which exacerbates the environmental condition. (Figure 3 and 4 in Appendix).

Following six environmental quality labs are operational in Lahore. Despite these labs, the environmental quality of Lahore city is not at acceptable level due to ineffective measures to control air pollution. According to the report by World Health Organization (WHO 2011), Lahore had 200 mcg/m^3 level of PM10 in 2003-04, while WHO guidelines shows that the safe exposure is 20 mcg/m^3 annual mean and 50 mcg/m^3 24-hour mean.

- Pakistan Environmental Protection Agency
- Solution Environmental & Analytical Laboratory (SEAL)
- ECTECH-Environment Consultants &APEX Environmental Laboratory
- Global Environmental Lab (Pvt) Limited
- Analytical Laboratory, Institute of Chemistry, University of Punjab\
- GS Pakistan.

Lahore experiences all four seasons. May and June are considered to be the hottest months while December and January are thought to be the coldest months. The temperature of Lahore city ranges from 1.2 °C to 46 °C. Lahore’s seasons can be divided into four categories according to the temperature.

- Summer [June – September]
- Autumn [October – November]
- Winter [December – February]
- Spring [March – May]

Lahore is divided into 9 towns and 150 union councils. Lahore's map is shown in the Appendix.

4.4 Survey Data

A household survey has been conducted to estimate the willingness to pay for improvement in transport and health sectors. For this purpose a questionnaire was developed with the consultations of the experts in this field. It took around three months in finalizing the questionnaire. A team of highly qualified and experienced people was formed to conduct the survey[31]. Data authentication is the primary responsibility of this study which is why a highly qualified and experienced data collection team was developed.

Two day training was conducted at Pakistan Institute of Development Economics, Islamabad based on survey methodology. The principal investigator and research team conducted the household interviews. The Survey started in the second week of April 2010 and was completed in the first week of June 2010. There were five main sections in the questionnaire. The first section was related to demographic information i.e. information related to area, age, occupation, marital status, family members etc. The second part was related to information about traffic system like problems of emissions and traffic system, improvement in traffic system and the willingness to pay for improvement in traffic system etc. The third part of the questionnaire was related to health such as the respondent's physical condition as well as his/her family members, history of health problems, information regarding different facets of the health system such as the relationship between temperature and different diseases especially cardiovascular disease, medical insurance, type of treatment (public or private), improvement and willingness to

[31] There were five members of the survey team who were highly qualified and had a minimum M. Sc level education in Economics/Environmental Economics. One member has an M. Sc Economics; two are doing M. Phil/MS in economics and environmental economics while two other members are PhD candidates in environmental economics.

pay for improvement of health system etc. The fourth part of the questionnaire was related to information about mitigating activities like treatment by a private doctor or public hospital, number of days of medication, cost of hospital/doctor, traveling time to hospital etc. Last section of the questionnaire was related to the income of the household, averting behavior like use of air conditioning, private or public transport, socio-economic status etc. Questionnaire is attached in the Appendix.

Due to financial and time constraints a target of 500 questionnaires were set. Out of 500 households only 322 responded returned the completed questionnaires. The number of questionnaires to be delivered in different parts of Lahore was decided according to the population of each of Lahore's towns. Each town has been given weights according to the town's population. As mentioned earlier there are nine towns in Lahore (see Lahore's map in Appendix).

The number of completed questionnaires received from each town is reported in Table 4.1.

Table: 4.1 Numbers of completed questioners from each town

Serial Number	Name of the Town	Number of Completed questionnaire
1	AllamaIqbal	67
2	Aziz Bhatti	15
3	Data GanjBaksh	32
4	Gulberg	49
5	Nishtar	30
6	Ravi	28
7	Samanabad	34
8	Shalimar	18
9	Wahga	18
	Cantt& DHA	31
	Total	**322**

Source: Survey conducted by Author

- NOTE: Cantt& DHA are not included in any town and is separately mentioned in Lahore's map.

The average age of the respondent is 30 years. Minimum age of the respondent was 16 years while the maximum age was 76 years. Out of 322 respondents, the numbers of male respondents are 207 while 115 are female. Out of these respondents 148 are married, 169 are unmarried and 3 are divorced.

The educational level of the respondents has been reported in Table 4.2.

Table: 4.2 Educational levels of the respondents

Educational Level	Number of Respondents	Percentage Share
Illiterate	15	4.66
Primary	6	1.86
Up to Metric	67	20.81
Up to Intermediate	37	11.49
Up to Graduation	76	23.60
Up to Masters	108	33.54
Above Masters	13	4.04
Total	**322**	**100.00**

Source: Survey conducted by Author

Out of the sample 75 persons are the head while the other relations of respondents to the head of household are reported in Table 4.3. The Table shows that majority of the respondents are either sons, or daughters or brothers. This is expected to improve quality of data significantly.

Table: 4.3Relationships of respondents with the head of the family.

Relationship	Number
Head	75
Brother	16
Cousin	3
Daughter	83
Daughter in Law	7
Husband	3
Sister	6
Son	111
Uncle	3
Wife	15
TOTAL	**322**

Source: Survey conducted by Author

Out of our sample, 246 respondents have their own conveyance while 75 do not have personal conveyance (one respondent did not answer the question). Out of our sample, 273 respondents (85 percent) are not satisfied with the current traffic system of Lahore, while only 49 (15 percent) are satisfied with this system.

The respondents were asked to rank the main problems and their solutions for the traffic system. Then the question related to improvement in the traffic system was asked. Out of the total respondents, 83 (26 percent) were **NOT WILLING TO PAY** for the improvement of traffic system of Lahore and 229 (71 percent) were **WILLING TO PAY** for the improvement of traffic system. Only 10 respondents did not answer this question. Out of 229, who were WILLING TO PAY, 156respondents showed the positive amount while the remaining said that they were willing to pay but could not specify the exact amount.

In the health section, respondents were asked about the relationship between temperature and health, namely whether temperature effects health or not? Out of 322 respondents 303 (94 percent) replied that they were aware of this relationship while 19 (6 percent) were unaware of the relationship. Among the 245 respondents, 64 (26 percent) respondents replied that there is strong relationship (between cardiovascular disease with the temperature), 78 (32 percent) replied that there is a moderate relationship, 49 (20 percent) replied that there is a weak relationship while the remaining 54 (22 percent) said that there is no relationship between temperature and Cardiovascular disease.

The respondents were then asked if there was any cardiovascular problem in their family. Out of the total respondents, 104 (33 percent) reported positively while the remaining did not have this problem. The respondents were then asked if they would be willing to participate/contribute to any improvement in the health system. Out of total respondents 80 (25 percent) were **NOT WILLING TO PAY** for improvement in the Health system and 230 (71 percent) were **WILLING TO PAY** for improvement in the health system. About 12 (4 percent) respondents did not answer this question. Out of 230, who are WILLING TO PAY, 162 (70 percent) reported a positive amount while the remaining said that they were willing to pay but could not specify the amount at the moment.

During the course of the survey, the respondents revealed that they were willing to pay an even higher amount for an improved health system but due to lack of confidence in the government's part, they did not reveal their true willingness to pay. The majority of respondents told us that if they were guaranteed that their money would be appropriated in the right direction then they would pay even more.

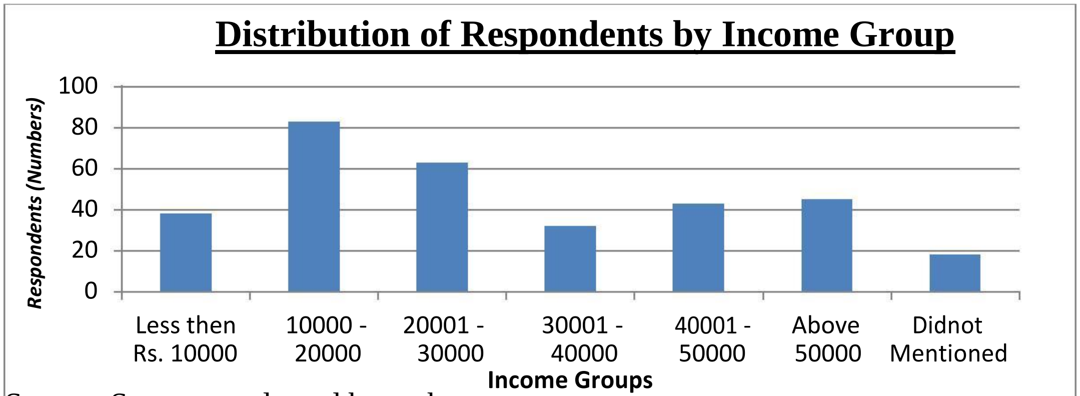
Respondents were asked about the mitigating activities and the averting behavior. In mitigating activities, different questions were asked such as number of sick days, travel cost to a hospital, doctor’s fees, medicine expenditure, number of days absent from work, wages lost etc.

In averting behavior questions such as use of A/C in summer, A/C cars, exhaust fans etc. were asked.

In the last section, respondents were asked about the monthly household income. The respondents were divided according to their household income and thus seven groups were created according to the income range.[32]The income groups of the respondents are shown in Figure 4.1:

[32]Group 1 (income less than Rs. 10000), Group 2(Income between Rs. 10000 – 20000), Group 3 (Income between Rs. 20001 – 30000), Group 4 (Income between 30001-40000), Group 5 (Income between 40001 – 50000), Group 6 (Above Rs. 50000), Group 7(Reluctant to mention the income)

Figure: 4.1Division of respondents according to their income group



Source: Survey conducted by author

The majority of the respondent's household income is in group 2, Followed by group 3, group 6, group 5, group 1, group 4 and group 7.

4.5 Data From Hospitals[33]

As mentioned earlier that the effect of temperature on cardiovascular disease (CVD) is visible in three to seven days therefore daily data of cardiovascular diseases from three hospitals of Lahore and one hospital from Rawalpindi is collected. The names of the hospitals are as following:

- Punjab Institute of Cardiology, Lahore.
- Jinnah Hospital, Lahore.
- Sir Ganga Ram Hospital, Lahore.
- Armed Forces Institute of Cardiology, Rawalpindi.

Punjab Institute of Cardiology (PIC) is the main hospital for cardiology cases. The major problem in collecting the data was that no hospital had computerized records of the data. All the records were written in registers. After obtaining permission from the hospital's Medical

Superintendent (M.S.), the related department was contacted. The survey team acquired the records manually from registers on the predefined performa and then transferred the data to computers. The head nurse and store keeper were very cooperative and helpful in overcoming any problems faced while reading the registers. At times, the doctors and registrar's help was also sought. The survey team also conducted many interviews with Professors, Associate Professors, Assistant Professors, Consultants and doctors of the respective departments to get further information regarding cardiovascular diseases and their symptoms.

Collection of data from different hospitals started in the first week of March, 2010 and was completed in the last week of May, 2010 from the three hospitals of Lahore mentioned

[33] It is also worth mentioning here that it took around three months to collect data from hospitals. Due to time constraint and problems mentioned in this chapter, we were able to collect the data only for four years.

above. In Rawalpindi, data has been collected in December 2010. Same team collected data from hospitals and households. Data authentication is the primary responsibility of this study which is why the same team of highly qualified and experienced members was hired. Following is a brief description of the data collected from hospitals.

4.5.1 Punjab Institute of Cardiology (PIC):

Daily data of cardiovascular diseases from PIC emergency department was collected from 2005 to 2009. The data was so large that its collection required more time. Time and resource constraints especially financial constraints forced us to limit the time period to 2005 - 2009. Other then, the hospital staff did not have spare time to assist us in obtaining all the data from the storeroom’s registers. Nevertheless, they gave registers belonging to different months of various years. Monthly data was available at the computer department. However, the data was categorized according to ward not type of disease. Monthly data of different wards was also collected in order to ascertain the percentage share of cardiovascular cases in the total number of emergency cases. This helped us to estimate the daily data which was not given by the emergency ward. The daily data which was collected from the registers and monthly data provided by the computer department were helpful in estimating the missing daily data. Weight was given to the daily data collected from the registers. The missing data was estimated by applying this weight to the monthly data provided by the computer department. For example a weight has been assigned to the daily data of June 2007 by dividing the daily data of June 2007 with the monthly data of June 2007 and this weight was applied to missing data for June of different years. By doing so the missing values were estimated.

The formula which was used to convert the monthly data into daily data is as under.

$$\mathrm{W}DD_{mi} \ = \ DDR_{mi}/MD_{m}$$

Where

WDD = Weight of Daily Data

DDR = Daily Data from registers

MD = Monthly Data from Computer Dept.

m = jan, feb, mar …….dec (month)

i = 1,2,3,……….31 (no of days)

Then this calculated weight was applied to other months whose daily data was not available but monthly data was available. In short the following formula was applied.

$$DD = WDD_{mi} * MD_{m}$$

Where DD = Daily Data

4.5.1.1A Brief Description of Punjab Institute of Cardiology (PIC) Data:

The daily data of PIC which was collected is from January 1, 2005 to April 17, 2010. The total number of cardiovascular patients in this period was 42710.This is the total numbers of emergency cases available in the computer department for 2007, 2008 and 2009 only. The figure for 2005 and 2006 was not available. Hospital authorities clarified that they started compilation of emergency cases in 2007. Before 2007 they had data for different wards but not for the emergency ward. For 2010 the data was still not compiled. Consequently, the data was collected from the emergency ward's registers. The breakup of the monthly total emergency cases, cardiovascular cases and the percentage of the cardiovascular cases to total emergency cases are reported in Table 4.4.

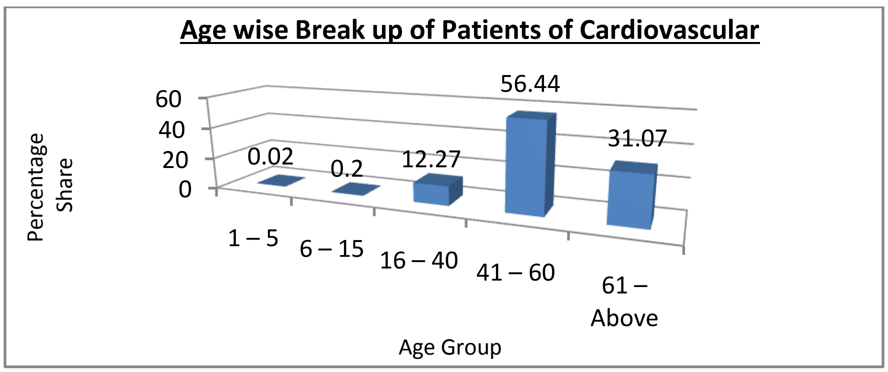
Table: 4.4Emergency cases at Punjab Institute of Cardiology, Lahore

	2005			2006			2007			2008			2009			2010	
	Total # of Emer Gency Cases	# of CV Cases	perce Ntage of CV Cases	Total # of Emer gency Cases	# of CV Cases	perce ntage of CV Cases	Total # of Emergency Cases	# of CV Cases	Perce Ntage of CV Cases	Total # of Emer gency Cases	# of CV Cases	perce ntage of CV Cases	Total # of Emer Gency Cases	# of CV Cases	perce ntage of CV Cases	Total # of Emer gency Cases	# of CV Cases
Jan	N/A	712		N/A	935		5839	1081	19	6295	1163	18	7080	1219	17	N/C	820
Feb	N/A	594		N/A	654		5738	711	12	6414	778	12	7946	854	11	N/C	681
Mar	N/A	643		N/A	740		6360	770	12	6190	812	13	6671	924	14	N/C	672
Apr	N/A	577		N/A	590		5977	711	12	6236	644	10	6921	730	11	N/C	433
May	N/A	605		N/A	571		6014	662	11	6246	629	10	6939	763	11		
Jun	N/A	510		N/A	516		5665	601	11	6263	573	9	7088	669	9		
Jul	N/A	525		N/A	496		5905	545	9	6573	548	8	7237	664	9		
Aug	N/A	577		N/A	601		5830	662	11	6404	609	10	7684	706	9		
Sep	N/A	635		N/A	576		5141	556	11	6069	537	9	7233	545	8		
Oct	N/A	596		N/A	529		5769	532	9	6792	523	8	7232	613	8		
Nov	N/A	592		N/A	606		5930	659	11	6686	602	9	6528	595	9		
Dec	N/A	791		N/A	714		6638	635	10	6569	651	10	7495	744	10		
Avg		**613**			**627**		**5901**	**677**	**11**	**6395**	**672**	**11**	**7171**	**752**	**11**		**652**

Source: Hospital sources

Out of the total number of cardiovascular cases, 73.82 percent were male while 26.18 percent were female. In PIC the patients came from 93 cities in this period. Out of the total number of cardiovascular patients, 72.78 percent belonged to Lahore city and the remaining 27.22 belonged to other cities. The patient's age ranged from 4 years to 120 years. The largest number of patients fell in the age group of 41 – 60 years. The Figure 4.2 shows the breakup of the patients according to age.

Figure: 4.2 Age groups of patients at PIC.



Source: Hospital sources

As shown in the Figure 4.2 the major portion of the patients fall in the age group of 41-60 years. This age group is the main concern for two reasons. The first concern is that this is a major portion and the second concern is that a higher fraction of population in this age group is economically active population. In addition, in this age group we have experienced human capital. The majority of people retire after this age. It is imperative to make a policy which places focus on this specific age group, in order to benefit from their experience and knowledge.

Most of the patients at PIC, 72.78 percent are from Lahore. Other than Lahore, major cities whose major cases have been moved to PIC are reported in Table 4.5.

Table: 4.5 List of cities and their percentage share of cardiovascular patients in PIC, Lahore.

City	percentage of Cardiovascular Cases
Kasoor	13.48
Sheikhupura	12.67
Gujranwala	6.58
Narowal	5.91
Nankana Sahib	5.25
Sahiwal	4.08
Pakpattan	4.04
Sargodha	3.97
Okara	3.82
Gujrat	3.05
Sialkot	3.05
Hafizabad	2.76
Bahawal Nagar	2.72
Faisalabad	2.65
Others (78 cities)	25.97
	100.00

Source: Hospital sources

NOTE: **A complete list of cities names is attached in the Appendix**

4.5.2 Jinnah Hospital:

Daily data of cardiovascular diseases was collected from Jinnah hospital. This data was taken from the outpatient department from 2005 to 2010. The hospital management gave registers belonging to different months of various years. Monthly data was available in the computer department. But it was total number of patients of cardiology and related to inpatient cases and not separate for the cardiovascular disease. The authorities in the outpatient department said that they had misplaced the registers of years 2006 and 2007.

4.5.2.1A Brief Description of Jinnah Hospital Data:

The daily data collected from Jinnah hospital is from May 1, 2005 to January 25, 2010. Total number of cardiovascular patients in this interval was9164. Total number of outpatient cases with reference to cardiology was available for 2005, 2006, 2007, 2008 and 2009 only. For 2010 the data has not been compiled yet. Earlier data was available in registers but the hospital authorities refused to bring the old data from store. The breakup of the monthly total outpatient cases of cardiology is reported in Table 4.6.

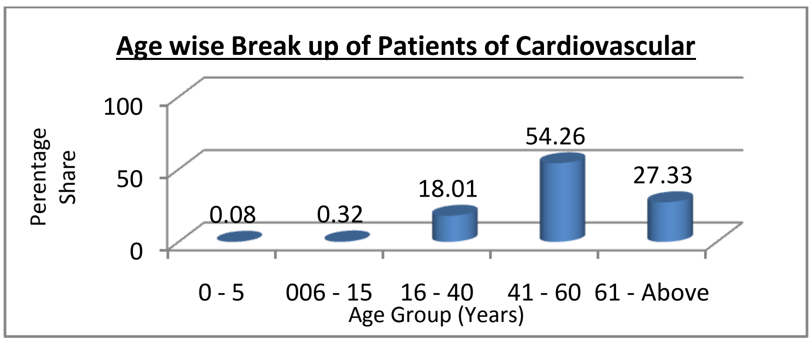
Table: 4.6Numbers of cases of cardiology at Jinnah hospital, Lahore

	2005	**2008**	**2009**
January	N/A	N/A	256
February	N/A	N/A	261
March	N/A	325	262
April	N/A	312	265
May	313	271	293
June	253	206	325
July	224	252	438
August	231	218	730
September	252	168	562
October	214	208	497
November	164	206	338
December	140	209	420
Total	**1791**	**2375**	**4647**

Source: Hospital sour
N/A = Not Available

Out of the total cardiovascular cases in Jinnah hospital in the reported period, female patients have a share of 49.76 percent while male cases are 50.2 percent. The age of the patients ranges from 4 to 106 years. As shown in the Figure below the major portion (54.26 percent) of the patients lies in the age group of 41-60 years. This age group is our main concern for the reasons as explained in section 4.5.1.1. The age wise frequency distribution of the patients is given in Figure 4.3.

Figure 4.3 Age groups of patients at Jinnah hospital, Lahore.



Source: Hospital sources

As shown in the Figure given above the major portion of the patients lies in the age group of 41-60 years. It is so in the PIC case as well. Consequently, the policy and implications of Jinnah hospital data are the same as mentioned in the PIC category.

4.5.3 Sir Ganga Ram Hospital:

Daily data of cardiovascular diseases was collected from Sir Ganga Ram hospital. This data was taken from the inpatient department from 2006 to 2009. They gave patients files pertaining to different months of various years. Monthly data was available in the computer department. However, the information was related to the total number of patients in each block; as such it was not divided according to the wards or cardiovascular cases. In 2009 they started compiling monthly data according to wards. Currently they hold monthly data for all cardiology patients. Nevertheless, it is of prime importance to compile the data separately according to the different diseases of cardiology like cardiovascular disease.

4.5.3.1 A Brief Description of Sir Ganga Ram Hospital Data:

The daily data of Sir Ganga Ram hospital was collected from January 1, 2006 to December 31, 2009. The total number of cardiovascular patients in this period was 951. Data has been collected from the inpatient department's files. Earlier data was available in files but hospital authorities refused to bring the old data from store. The breakup of the monthly total inpatients cases of cardiovascular patients is shown in Table 4.7.

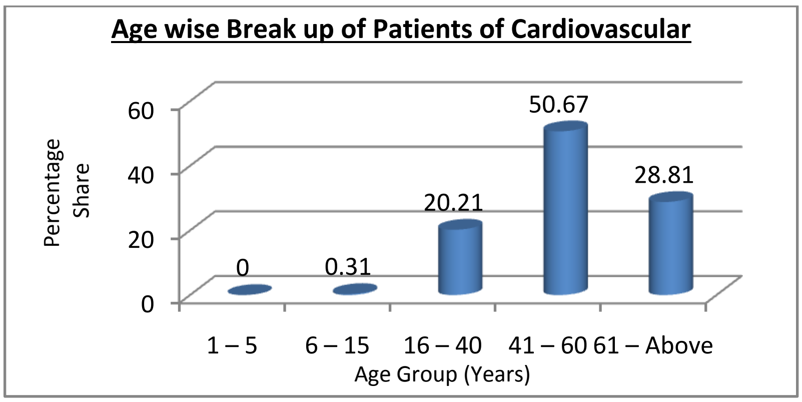
Table: 4.7 Number of cases of cardiovascular patients at Sir Ganga Ram hospital, Lahore

Months	2006	2007	2008	2009
January	29	15	19	26
February	23	21	18	20
March	18	19	17	5
April	10	18	27	13
May	11	19	15	18
June	14	17	16	12
July	17	22	25	26
August	25	34	27	21
September	27	18	24	18
October	23	23	21	15
November	26	24	9	22
December	24	14	23	23
Total	**247**	**244**	**241**	**219**

Source: Hospital sources

Out of the total number of cardiovascular cases in Sir Ganga Ram hospital during the reported period, female patients hold a share of 32.62 percent while male cases have a share of 67.38 percent. The age of the patients ranges from 13 years to 92 years. The patient's age frequency distribution is given in Figure 4.4.

Figure 4.4 Age groups of patients at Sir Ganga Ram hospital, Lahore.



Source: Hospital sources

As shown in the Figure given above the major portion of the patients falls in the age group of 41-60 years. This is the same for PIC and Jinnah hospital.

Most of the patients in Sir Ganga Ram hospital are from Lahore which are around 92.46 percent. Other than Lahore the other major cities from where cases were registered are shown in Table 4.8.

Table: 4.8 List of cities and their percentage share of cardiovascular patients in Sir Ganga Ram hospital, Lahore.

City	Percentage of Cardiovascular Cases
Narowal	0.83
Kasoor	0.62
Okara	0.52
Sheikhupura	0.52
Others (30 cities)	5.05

Source: Hospital source

NOTE: A complete list of city names is attached in the Appendix

4.5.4 Armed Forces Institute of Cardiology (AFIC) Rawalpindi:

The daily data of cardiovascular diseases was not available in this hospital. Therefore, monthly data was utilized instead of daily data. The data was taken from the computer department from January 2007 to November 2010. Unfortunately there was no extra information available in the computer department except for total number of patients. Thus, for comparative purposes (to compare with Lahore), only monthly data has been used while excluding all other information.

4.5.4.1 A Brief Description of AFIC Data:

AFIC's monthly data has been collected from January 2007 to December 2010. Total number of cardiovascular patients in this period was 143951. Data has been collected from the computer department. The breakup of the monthly total inpatients cases of cardiovascular diseases in AFIC is shown in Table 4.9.

Table: 4.9 Number of cases of cardiovascular patients at AFIC, Rawalpindi.

Months	2007	2008	2009	2010
January	2879	1800	1490	5355
February	3183	1734	1632	5936
March	3462	2095	1909	5037
April	3226	2149	2084	3711
May	3484	1869	2222	6229
June	3179	2018	1966	5925
July	3343	1844	1966	5321
August	3256	2085	1769	4887
September	3000	1610	2042	6201
October	2853	1717	2284	4246
November	3062	2014	1866	7045
December	3056	1975	1935	N/A
Total	**37983**	**22910**	**23165**	**59893**

Source: Hospital sour
N/A = Not Available

4.6 Theoretical Model:

The primary objective of this study is to focus on the health sector. We have used the health production function which was originally developed by the Grossman (1972). Then different economists have used the health production function with some variation. For example Cropper (1981) introduced a pollution variable in her model, Harrington and Portney (1987) included the pollution variable to check the willingness to pay for a reduction in pollution etc. In this study climate change (proxied by temperature) variable is used to check the relationship of climate change and health.

Household health production function is implicit in the utility maximizing behavior of an individual and is as follows:

$U = f\,(X, L, H, A, M)$ ……………………………………………(1)

Where

X = Consumption of marketed goods

L = Leisure time

H = Number of patients in hospital/no of days of illness

A = Averting behavior

M = Mitigating activities

Household health production function:

$$H= f\ (Cc\ (Temp\ (CO_2)), A, M, Z) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Where,

H: Work days lost due to morbidity/no of days of illness

Cc = Climate change

Temp = Temperature

CO_2 = Carbon dioxide

Z: Vector of other health indicators and household characteristics

Now substituting equation 2 into 1

$$U = f\ (X, L, H\ (Cc\ (Temp\ (CO_2)), A, M, Z), A, M) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The individual maximizes utility subject to the following budget constraint:

$$Y= w\ (T-L-H) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where,

Y = Income

W = Wage rate

(T-L-H) = Time spent at work

C = X + PaA + Pm M……………………………………………………….(5)

Pa = Price of averting behavior

Pm: Price of mitigating activity

Price of X is numerarie.

Equating the income and cost equations to get the budget constraint:-

Y = C ………………………………………………………………….(6)

So

w (T-L-H) = X + PaA + PmM ……………………………………………(7)

The consumer faces the following problem:

max U = ƒ (X, L, H (Cc (Temp (CO_2)), A, M, Z), A, M)…………………(8)

s.t

w (T-L-H) = X + PaA + PmM……………………………………………..(9)

By applying the Lagrange Function, demand function for mitigating activities and averting behavior have been obtained.

$£ = f(X, L, H (Cc (Temp (CO_2)), A, M, Z), A, M) + \lambda (w (T-L-H) - X - PaA - PmM$...(10)

The first order conditions for maximization are as under:-

$Lx = Ux - \lambda = 0$ ……………………………………..…..…….……….(a)

$L_A = U_H H_A + U_A - \lambda(P_A + WH_A) = 0$………………………….……..………..(b)

$L_M = U_H H_M + U_M - \lambda(wH_M + P_M) = 0$……………………….………….(c)

$L_L = U_L - \lambda w = 0$…………………………………………………………(d)

$L \lambda = w (T-L-H) - X - PaA - PmM = 0$……………………………..……(e)

Rearranging the averting behavior equation (b) yields following utility maximization equation:-

$(U_H H_A + U_A)/ \lambda = P_A + WH_A$……………………………………………(11)

The above equation of averting behavior shows that the marginal benefits of averting behavior are equal to the marginal cost of averting behavior. Consumers will continue the averting behavior until the marginal benefit of averting behavior is equal to its marginal cost.

Likewise rearranging the equation for mitigating activities (c) for utility maximization, we get the following:

$(U_H H_M + U_M)/ \lambda = wH_M + P_M$ …………………………………………(12)

The above equation of mitigating activities shows that the marginal benefits of mitigating activities are equal to the marginal cost of mitigating activities. Consumers will continue the mitigating activities until the marginal benefits of mitigating activities are equal to their marginal costs.

First order conditions can be derived for the demand functions for mitigating activities and averting behaviors. The resulting demand functions are as follows.

$M^* = m (Pm, W, H, Z)$…………………………………………………….(13)

$A^* = a (Pa, W, H, M, Z)$……………………………………………………..(14)

Similarly demand functions of all variables of objective function can be obtained.

Substitution of optimal values of all variables into the objective function (utility function) yields the indirect utility function:-

$V = V(P_A, P_M, W, H, M)$…………………………………….……………..(15)

The above indirect utility function is non-increasing in prices i.e. if P' >= P, then V'<=V. likewise it is non-decreasing in W i.e. if W'>=W, then V'>=V. It is non-increasing in H and homogeneous of degree zero.

Totally differentiating the indirect utility function:-

$dV = V_{PA}dP_A + V_M dP_M + V_W dW + V_M dM + V_H dH$………………………….(16)

Taking the total derivative of the mitigating activities, we get:

$dV/dM = V_H(dH/dM) + V_M$…………………………………….…………..(17)

Holding utility constant, the marginal value of a change in mitigating activities is given as:

$\boldsymbol{WTP = dH/dM = - v_{M/H}}$…………………………………….……………….(18)

At the optimal values, first order condition can be interpreted as the marginal utility of mitigating activities:-

$VM = U_H H_M + U_M – \lambda(wH_M + P_M) = 0$ ………………………………………(19)

First order condition for averting behavior is:

$L_A = U_H H_A + U_A – \lambda(P_A + WH_A) = 0$ ………………………………………(20)

Rearranging the above equation we get the following:-

$U_H = (\lambda(P_A + WH_A)- U_A)/H_A$…………………………………………………..(21)

Putting the value of U_H (21) into equation 19 and simplifying, we get the following:-

$MWTP = P_A(H_{M/A}) – U_A(H_{M/A})/ \lambda +U_M/ \lambda -P_M$

Where

MWTP = Marginal willingness to pay

The marginal willingness to pay is equal to the difference between the marginal value of averting behavior in joint production function of health incorporating mitigating and averting activities and its marginal utility of averting behavior from joint production function plus the difference between marginal utility from mitigating activities and its value.

If marginal utility of mitigating activity is equal to its value then marginal value and marginal utility of averting behavior in joint production function determine the marginal willingness to pay and if the marginal value of averting behavior in joint production function is equal to its marginal utility then marginal willingness to pay becomes zero.

If marginal value of averting behavior is equal to its marginal utility in joint production function then the difference between marginal utility from mitigating activities and its value determine the marginal willingness to pay.

We have to estimate the health production function and the demand function simultaneously in order to get the marginal willingness to pay.

4.7 Household Health Production:

Since the dependent variable is not a continuous variable but it is a discrete variable indicating the incidence of cardiovascular disease. The data collected from the hospitals gives us the count types of events of health cases related to cardiovascular disease. In this case, the appropriate regressions model is Poisson model because it accounts for the discrete nature of dependent variable and least square does not consider this type of variable. So for estimation purpose in this study Poisson regression model has been used.

$$\text{Prob}(Y=y/x) = \mu^{Y} e^{-\mu} / Y! \qquad Y=0,1,2,\ldots\ldots\ldots$$

Where variable Y is the count variable i.e. number of patients/visits of hospitals and it takes non-negative integer values and Y! is the Y factorial.

The resulting regression will be nonlinear in parameter. By taking the log we will obtain the following regression which is linear in parameters.

$$\text{Ln } \mu_i = \beta_0 + \beta_1 X_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots\ldots \beta_{ni} X_{ni}$$

Where X's are some of the variables that affect the mean value of our dependent variable i.e. number of visits of hospital.

There are two important points in the Poisson regression. First, an important assumption is that the events occur independently over time. Second, a unique feature of the Poisson distribution is that its variance is equal to its mean value.

$$\text{Var}(Y) = \mu$$

This chapter concludes with the technique used for estimation based on the type of data collected. As mentioned earlier in this chapter that dependent variable is discrete type so it is concluded that the best technique for this type of data is Poisson regression technique. In chapter six the author has estimated the effect of an increase in temperature on the mean value of number of patients in hospitals by using the Poisson regression model.

Chapter 5: Impact of CO_2 Emissions on Temperature

In this chapter the impact of emissions of CO_2 on temperature has been estimated using the Ordinary Least Square (OLS) method. Previous literature links the concentration of CO_2 to atmospheric temperature. As mentioned earlier that there is no study in Pakistan related to the relationship of emissions of CO_2 and concentration of CO_2. So initially the relationship of global emissions of CO_2 on global concentration of CO_2 in the atmosphere has been estimated and compared with other studies to verify these results. Then the same relationship with respect to Pakistan has been checked. Additionally, the relationship of the concentration of CO_2 on temperature has been estimated on global data and for Pakistan separately. Then the same relationship has been estimated for the emissions of CO_2 from transport sector of Pakistan. Finally using regression analysis and dynamic forecast, emissions of CO_2 from transport sector and their potential damages have been predicted up to the year 2030. For this purpose data on emissions of carbon dioxide from road transport and atmospheric temperature is needed. Due to the immense shortage of environmental data sets in developing countries the emissions of CO_2 from road transport were not available at city level. The other way to calculate the emissions of Lahore city is to look at the consumption of petrol/diesel in Lahore city. Unfortunately, both data sets are not available in any department's data base. So before looking at the impact of emissions of carbon dioxide on temperature, the emissions of carbon dioxide from transport sector excluding agricultural transport, railway and aviation have to be estimated. For this purpose yearly consumption of petrol/diesel has been used. This data set has been taken from Pakistan Energy Yearbook (McMicheal, et al. 2006). Motor Spirit, HOBC and HSD data has been taken which is currently being used in road transportation. In order to calculate the emissions from petrol (Motor Spirit & HOBC) and diesel (HSD), the formula, developed by the EPA, USA has been used. To calculate emissions of carbon dioxide, the carbon emissions are multiplied by the ratio of the molecular weight of carbon dioxide, which is 44, to the molecular weight of carbon, which is 12. i.e. 44/12. These calculations are based on each gallon of petrol consumed. The complete formulas for emissions calculation from a gallon of gasoline/diesel are as under:-

Carbon dioxide emissions from a gallon of gasoline = 2421(grams) x 0.99(44/12)

Carbon dioxide emissions from a gallon of diesel = 2778(grams) x 0.99(44/12)

For oil and oil products, the oxidation factor is 0.99(99 percent of carbon in fuel is oxidized, while 1 percent is not oxidized). This oxidation factor is used in calculating the emissions from oil products. Multiplying the above formulas with the total consumption of petrol and diesel gives us the total emissions for a year. The above emissions are in grams which are then converted into million metric tons.

This chapter has two main parts. In the first part we check how globally and specifically Pakistan's GHG emissions and concentration of CO_2 and change in temperature are related to each other. The second part consists of estimated and predicted emissions and damages (1972-2030) to health from emissions of transport sector of Pakistan. For this purpose we need the annual data because as mentioned in the previous chapters that climate change is a long run phenomenon (M.L. Parry 2007) spreading over decades. Thus, the initial analyses are based on annual data.

5.1 Relationship of Emissions and Concentration of CO_2

Before going into a detailed analysis it is essential to ascertain the relationship between carbon dioxide emissions and the concentration of the carbon dioxide in the air. Since concentration is related to atmospheric temperature; concentration can be calculated in Parts Per Million (PPM). Pakistan's contribution in terms of PPM is not available. Pakistan's contribution in terms of PPM can be calculated by first estimating the relationship of global PPM and emissions of CO_2 and by assuming that the same relationship can be applied to Pakistan. For this purpose global PPM data has been taken from the carbon dioxide Information Analysis Center (Keeling, et al. 2009). PPM data is collected from 1980 to 2008. However, data has been used in analysis only for up to 2006 because the carbon dioxide Emissions data was available only up to 2006. The global data for carbon dioxide emissions was taken from energy information administration (Griffin 2008). Carbon dioxide emissions are taken as Million Metric Tons (MMT). The Period covers from 1980 to 2006. The graphs of both the series i.e. CO_2 Emissions and concentration are shown in Figure 5.1A.[34]

To check the relationship of PPM and MMT OLS method has been used. The regression results of PPM on MMT are as follows:

Table 5.1 Regression results of emissions and concentration

Dependent Variable: PPM			
Variable(s)	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
C	321.3087	2.426878	132.39(0.0000)
MMT	0.000928	0.000137	6.7594(0.0000)
@TREND	1.284891	0.052040	24.690(0.0000)
R-Squared 0.998093			
DW-statistic 1.668214			

Where

PPM = Parts per million of carbon dioxide concentration in the atmosphere.

MMT = Million metric tons of emissions of carbon dioxide

[34]See Appendix for Figure 5.1A.

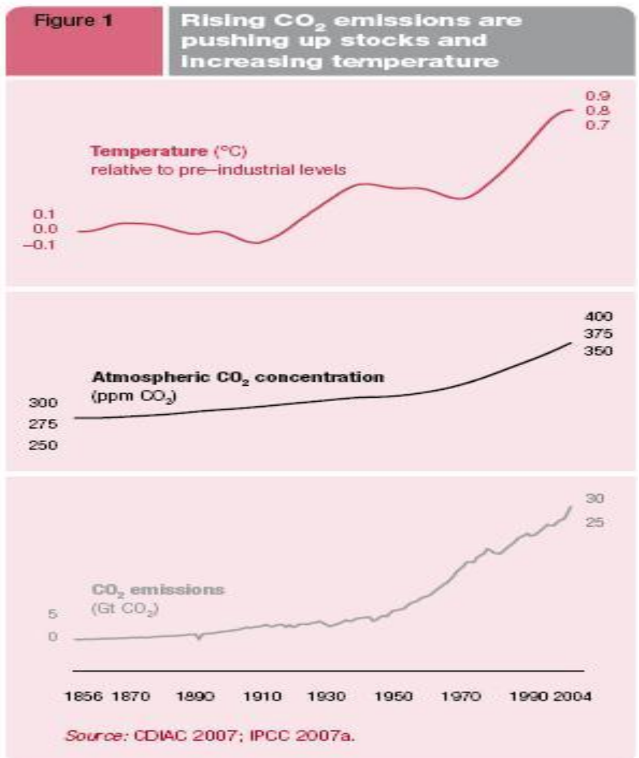
The results show that the coefficient of MMT is positive and statistically significant. It indicates that with an increase of one million metric tons of carbon dioxide emissions in the atmosphere the concentration of the carbon dioxide increases, on average, by 0.000928 parts per million in the atmosphere.

According to the Energy Information Administration (Griffin 2008) the total global emissions of carbon dioxide were 29195.4221 million metric tons in 2006 and the aggregate carbon dioxide emissions were 603,221.68 million metric tons from 1980 to 2006. The concentration of the carbon dioxide is 388 PPM as of 2009 (Keeling, et al 2009). According to the climate scientists the safest limit is 350 PPM of carbon dioxide which we have already crossed (Hansen, et al. 2008). So we have to either bear the losses due to climate change now, which could increase in future, or face heavy losses in the future?

5.2 Relationship of CO_2Emissions and Climate Change

Next the relationship between global temperature and concentration of CO_2 (PPM) of the world has been checked. According to the IPCC the relationship of carbon dioxide and temperature is positive as shown in Figure 5.1.

Figure 5.1 Relationships of emissions of co_2, concentration of co_2 and temperature as shown in IPCC 2007a.



The data for the global temperature is taken from the carbon dioxide Information Analysis Center (Keeling, et al. 2009). The estimated relationship is reported in Table 5.2 below.

Table 5.2 Regression results emissions and climate change

Dependent Variable: TEMP			
Variable(s)	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
C	10.44512	0.535840	19.49297(0.0000)
PPM	0.010764	0.001497	7.192418(0.0000)
R-Squared 0.683088			
DW-statistic 1.832950			

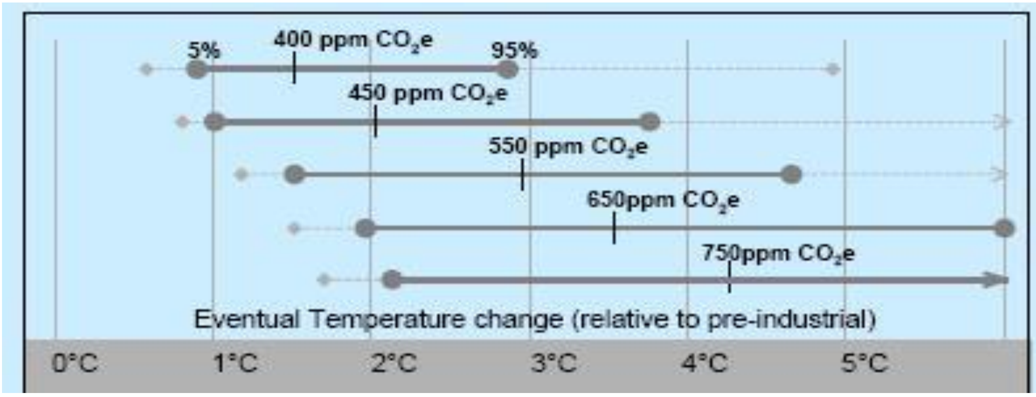
Where

Temp = Temperature of world (degree celsius)

PPM = Parts per million of carbon dioxide concentration

The estimated results, reported in Table 5.2, show positive and statistically significant impact of changes in PPM on temperature. If there is an increase of one unit in carbon dioxide concentration i.e. one PPM of carbon dioxide then, on average, the global temperature rises by 0.011 Celsius or we can say that if there is an increase in the carbon dioxide of around 1078 million metric tons then the global temperature will be increased by 0.011C^{o}. Alternatively, we can say that 98098 million metric tons of carbon dioxide emissions are associated with one degree Celsius increase of global temperature. These calculations are based on the data collected from the carbon dioxide Information Analysis Center (Keeling, et al. 2009). To confirm our calculations we compared them with the findings of The Stern review on the economics of climate change. The review reports that almost 100 PPM are associated with one degree Celsius increase as shown in the figure 5.2. (Stern 2007)

Figure 5.2 Relationship of concentrations of co_2 and temperature as shown in stern review on the economics of climate change



Source: Stern Review

Table 5.3 Comparison of PPM calculation:

Author's Calculations	Stern Review
91 PPM = 1°C	100 PPM = 1°C

Comparison of estimates reported in Table 5.3 reveals that there are minor differences in the two estimates. This confirms that the author's calculations are comparable to estimates in other studies.

5.3 Relationship of CO_2 Emissions and Transport in Pakistan

Next the above analysis has been repeated for the transport sector of Pakistan. First of all it has been ascertained whether transport is affecting the emissions of CO_2? For this purpose a time series data of total vehicles of Pakistan have been taken from the transport sector and total emissions have been calculated for Pakistan from 1980 to 2009. The results are reported in Table 5.4 below.

Table 5.4 Regression results emissions and transport

Dependent Variable: MMTP			
Variable(s)	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
C	5.829455	2.163312	2.694690 [0.0127]
TVEH	3.03E-06	1.05E-06	2.883324 [0.0082]
MMTP(-1)	0.865584	0.064612	13.39661 [0.0000]
R-Squared 0.994993			
DW-statistic 2.940772			

Where

MMTP = Million metric tons of co_2in Pakistan

TVEH = Total number of vehicles in Pakistan

The results, reported in Table 5.4, show positive and statistically significant impact of rise in number of vehicles on the emissions of carbon dioxide. It means if there is an increase of 3.3 lakh vehicles in Pakistan then, on average, carbon dioxide emission will increase by 1 million metric tons provided every vehicle consumes 1074 litters/vehicle using fuel (as in 2009).

5.4 Relationship of Emissions and Concentration of CO_2 in Pakistan

After looking at the relationship of both series for the whole world (see Table 5.1), the emissions of CO_2 and the PPM for Pakistan has been estimated. Assuming the same global relationship, the PPM for Pakistan has been calculated by multiplying the coefficient of MMT (Table 5.1) with the emissions of carbon dioxide of Pakistan. Pakistan has around 0.45 PPM of cumulative carbon dioxide concentration from 1980 to 2008 in the transport sector alone. The relationship of both the series in Pakistan is also the same as the global relationship as shown in Figure 5.2A[35].

[35]See Appendix for Figure 5.2A

After calculating the emissions and concentration, the relationship of carbon dioxide emissions with the concentration of carbon dioxide has been examined. The data for carbon dioxide emissions is taken from World Development Indicators (World Development Indicators 2007). The results are shown in Table 5.5, given below.

Table 5.5 Regression results of emissions and concentration

Dependent Variable: PPMP			
Variable(s)	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
C	0.000724	0.001714	0.4222 [0.6770]
MMTPWDI	0.000862	2.23E-05	38.569 [0.0000]
R-Squared 0.985427			
DW-statistic 2.079649			

Where

PPMP = Parts per million of carbon dioxide concentration for Pakistan

MMTPWDI = Million metric tons of carbon dioxide for Pakistan (WDI)

The results show positive and statistically significant impact of emissions on the concentration of carbon dioxide. It means if there is an increase of one unit of emissions (one million metric ton) then, on average, concentration of carbon dioxide will increase by 0.000862 units (Parts per million) in the atmosphere.

Next the relationship between Pakistan's temperature and the concentration of carbon dioxide has been estimated. The data of temperature is taken from the Compendium on Environment (Compendium on Environment Statistics of Pakistan 2004). A problem arose with respect to serial correlation in the estimation so the AR (1) process was included to remove the serial correlation. The results are reported in Table 5.6 below.

Table 5.6 Regression results of temperature and concentration of carbon dioxide

Dependent Variable: AVG			
Variable(s)	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
C	22.3979	0.0209	1071.632
PPMP	0.09174	0.0226	4.0514
AVG_{t-1}	-0.358723	0.2374	-1.5110
R-Squared 0.7626			
DW-statistic 1.7705			

Where

Avg= Average temperature (degree celsius) in Pakistan

PPMP = Parts per million of Pakistan

The result show positive and statistically significant impact of concentration of carbon dioxide on the temperature. It means that if there is an increase of one unit in PPM in Pakistan then there will be, on average, an increase of 0.092 degree celsius in the temperature. Similarly, we can say that if there is an increase of around 11 PPM of carbon dioxide then there will be an increase in the temperature by 1 degree celsius. In other words we can say that increase of 12760 million metric tons of carbon dioxide can be associated with one degree celsius increase in average temperature.

5.5 Damages of CO_2Emissionsfrom Transport Sector

According to the author's calculations, Pakistan contributed around 24 million metric tons of carbon dioxide from transport sector in 2009. To confirm these calculations we have compared these calculations with two other authentic calculations. The First is the World Resource Institute and the second is Compendium on Environment (Statistics of Pakistan). In 2006 the World Resource Institute (World Resource Institute 2006) estimated that the 26.9 million metric tons of CO_2 emissions were from transport sector of Pakistan. While for this study 22.18 million metric tons of CO_2 emissions have been calculated for the same year i.e. 2006.

When compared with the Compendium on Environment Statistics of Pakistan (2004) (Compendium on Environment Statistics of Pakistan 2004), it was found that the total emissions from transport in 1987-88 were 10.25 million metric tons and this study calculated 11.86 million metric tons in the corresponding year. The 1997-98 Compendiums showed the 18.99 million metric tons of carbon dioxide emissions from transport while in this study 19.73 million metric tons have been calculated for the same period. Table 5.2 displays the comparison of the CO_2 emissions from transport for different years.

Table 5.7 Comparison of co_2 emissions from transport sector of Pakistan in different years (million metric Tons)

Years	Author's Calculations	World Resource Institute	Compendium on Environment (Statistics of Pakistan)
1987-88	11.86	12.8 (35)	10.25
1997-98	19.73	23.8 (33)	18.99
2006	22.18	26.9 (32)	N/A
2007	21.94	32.5 (30)	N/A

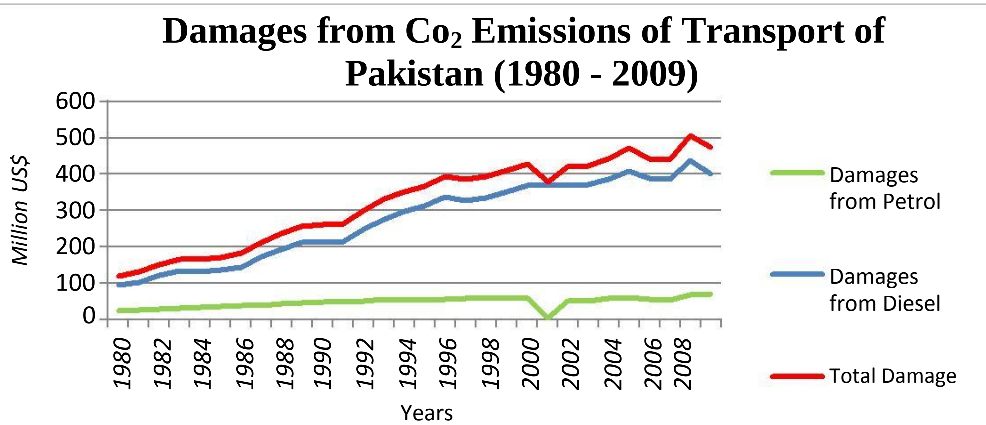
NOTE: (figures in parenthesis show the Pakistan's rank in world)

N/A = Not Available

Comparison of the Table 5.7 shows that there are minor differences in the three references i.e. author's calculations, statistics of Pakistan and World Resource Institute. The difference could be due to exclusion of agricultural transport, railway and aviation transport by the author.

Total damages from one ton of carbon dioxide emissions are US$20 as estimated by the World Bank (1995 $) (World Development Indicators 2007). The total damages from the transport sector of Pakistan are calculated which are equal to 473 million US$. Figure 5.3 displays the historical total damages from the transport sector.

Figure 5.3 Damages from co_2emissions of transport of Pakistan (1980-2009)



Source: Author's calculations

Damages from emissions of petrol vehicles are estimated to be around 70 million US$ and around US$ 400 million from diesel in 2009. To see this huge difference between damages from petrol vehicles and diesel, we have examined the total number of petrol vehicles and diesel vehicles in Pakistan with their emissions separately. The time series data of motor vehicles in Pakistan and total emissions from the transport in Pakistan have been reproduced from the second chapter of this study and shown in figure 5.4

Figure 5.4 Vehicles and emissions of $co_2$from petrol and diesel.

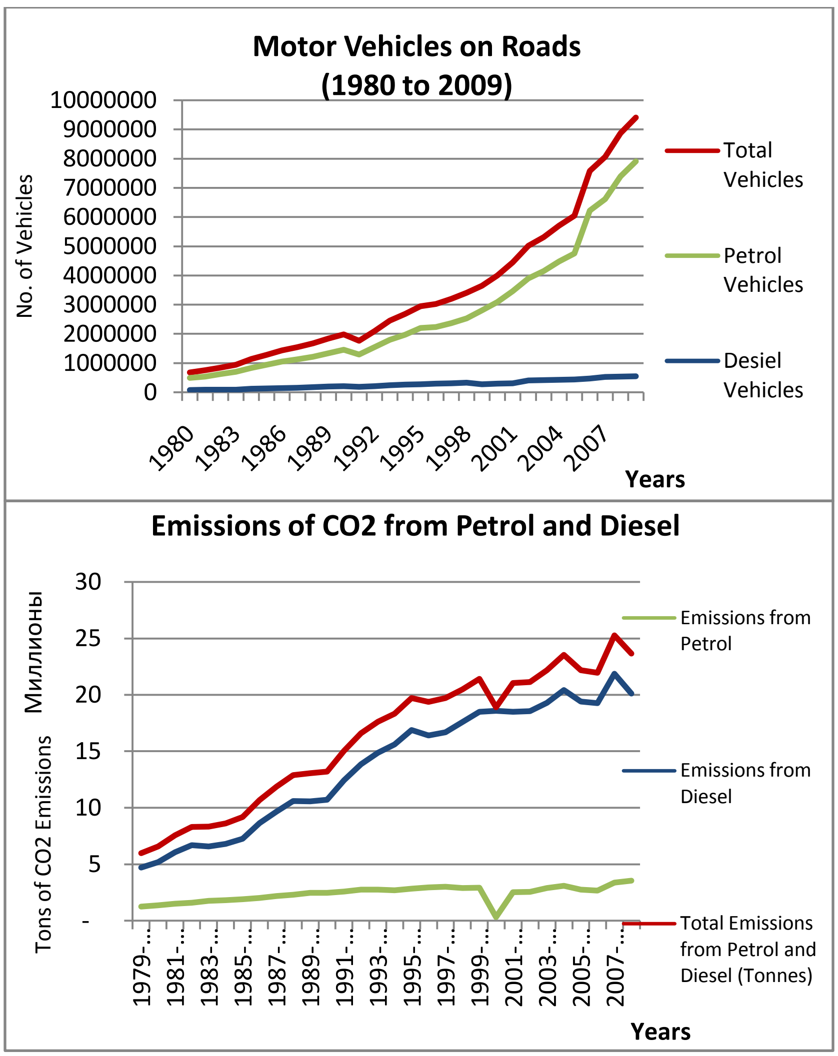
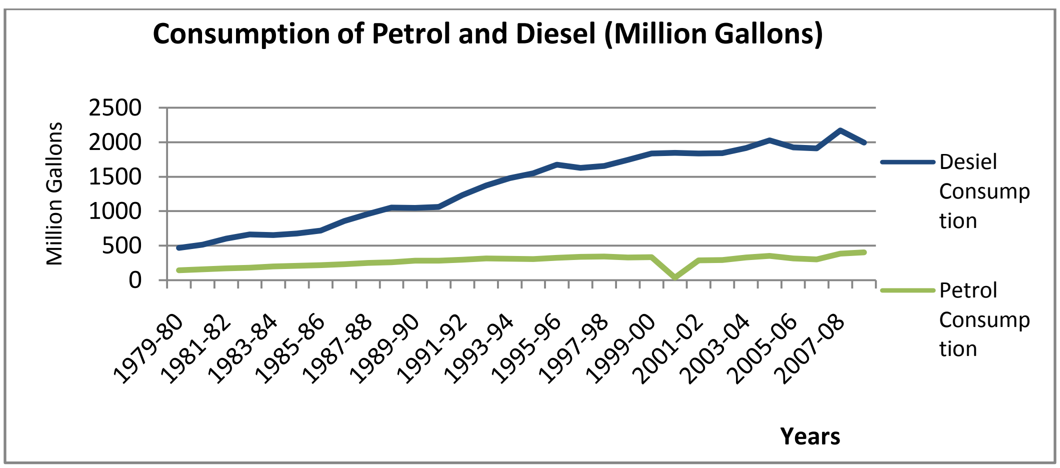


Figure 5.4 shows that increase in total vehicles has been recorded around 1300 percent in Pakistan from 1980 to 2009 and there is an increase of 300 percent in total emissions produced by transport sector in Pakistan between 1980 and 2009. The emissions from Petrol alone showed an increase of 169 percent from 1980 to 2009 while the emissions from diesel have increased by 326 percent in this period. To see the reason that why the emissions of diesel have recorded a larger increase then the emissions of petrol when the diesel vehicles growth (around 600 percent) is much less then petrol vehicles (around 1500 percent). The consumption of petrol and diesel have been examined and shown in figure 5.5

Figure 5.5 Consumption of petrol and diesel



The figure 5.5 shows a higher increase in consumption of diesel then of petrol. The consumption of diesel was 1995 million gallons in 2009 and had increased by 326 percent from 1980 to 2009 while the consumption of petrol was 403 million gallons and had increased by 182 percent from 1980 to 2009 in Pakistan. Consequently, we have to be very careful in future about our transport sector. Either we have to control our energy consumption, decrease our growth of transport or we have to encourage/support green transport system.

5.6 Actual and Predicted Emissions of CO_2 from Transport Sector of Pakistan

Next the CO_2 emissions from transport sector of Pakistan have been predicted. The AR model for prediction has been used. The equation for prediction of the emissions is as follows:

Table 5.8 Regression results of actual and predicted emissions

Dependent Variable: MMTPT			
Variable(s)	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
C	1.360675	0.907176	1.499903 [0.1429]
T	0.650132	0.039049	16.64917 [0.0000]
AR(1)	0.624393	0.138552	4.506572 [0.0001]
R-Squared 0.983432			
DW-statistic 2.144517			

On the basis of the above regression and using the dynamic forecast, predicted values show that the maximum emissions for year 2030 will be around 42 million metric tons of the CO_2 from the transport sector of Pakistan and the minimum value for the same year will be around 36 million metric tons. Maximum emissions (predicted) have been calculated as follows:

MMTPTFMAX = MMTPTF + 1.96*MMTPTSE ………………………(1)

Where

MMTPTFMAX = Predicted maximum value of co_2 emissions (million metric tons)

MMTPTF = Predicted co_2 emissions (million metric tons)

MMTPTSE = Predicted standard error of co_2 emissions (million metric tones)

Likewise minimum emissions (predicted) have been calculated as follows:

MMTPTMIN = MMTPTF - 1.96*MMTPTSE ……………………………(2)

Where

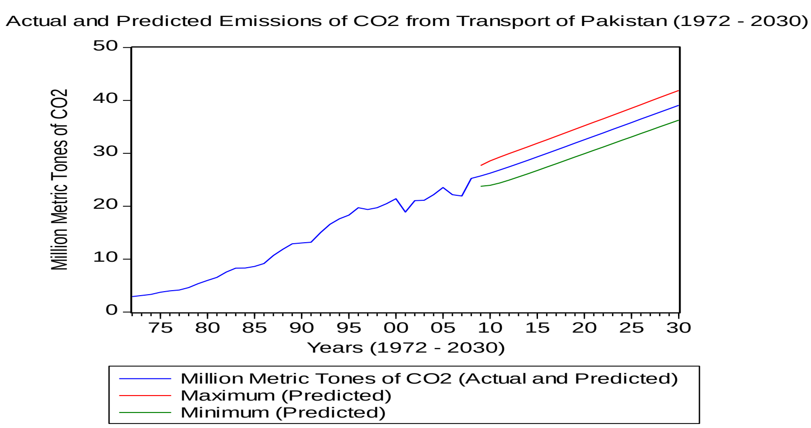
MMTPTMIN = Predicted minimum value of co_2 emissions (million metric tones)

MMTPTF = Predicted co_2 emissions (million metric tons)

MMTPTSE = Predicted standard error of co_2 emissions (million metric tones)

The standard errors have been added in predicted emissions to calculate the maximum emissions while subtracting standard errors to calculate the minimum emissions. Now there is a surety factor of around 95 percent that the range of emissions will be between these predictions. The range for, maximum predicted and minimum predicted emissions is shown in Figure 5.6

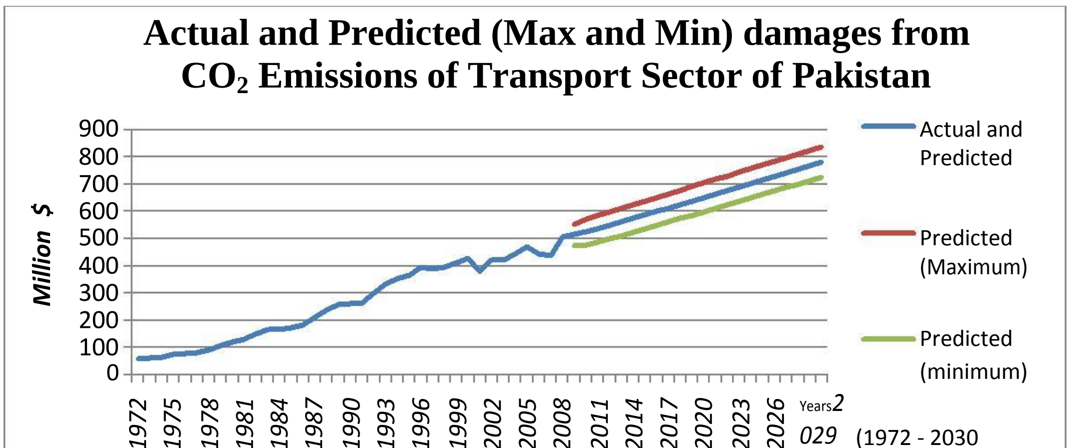
Figure 5.6 Actual and predicted emissions of $co_2$from transport sector in Pakistan (1972-2030)



5.7 Actual and Predicted Damages from CO_2Emissions of Transport Sector of Pakistan

On the basis of the predictions given above, total damages from transport sector of Pakistan have also been predicted for the corresponding period. Total damages (max and min) from CO_2 emissions from transport sector are shown in Figure 5.7

Figure 5.7 Actual and predicted damages from emissions of co$_2$from transport sector in Pakistan (1972-2030)



Source: Author's calculations

Total damages from one ton of carbon dioxide emissions are US$20 as estimated by the World Bank (1995 $). The total damages can be predicted from the transport sector of Pakistan by multiplying the total tonnes with 20 US$ (World Development Indicators 2007). It can be said safely that the range of damages perpetrated by Pakistan's transport sector will be between US$ 720 million to US$ 840 million in 2030.

In this chapter, we have examined the relationship of emissions and concentration of carbon dioxide in the atmosphere by using the global data and then making use of this data for Pakistan. There is a positive and significant relationship exists between both variables. Then, in the second step, we have examined the relationship of concentration and climate change by putting in to use the global data and then using the data for Pakistan. Again, we found a positive and significant relationship between the two variables. At the end, we have calculated the total emissions (see Table 5.7) and total damages (see Figure 5.3) from the emissions of transport sector in Pakistan. Finally, we also predicted the total emissions from transport sector in Pakistan (see Figure 5.6) and total damages from transport (see Figure 5.7) sector up to year 2030. We have calculated both the maximum and minimum damages.

Chapter 6: Impact of Climate Change on Health and Health Cost

In the previous chapter it was demonstrated how the emissions of carbon dioxide affect the temperature. In this chapter focus is on analysis of the health sector particularly the health of cardiovascular patients. As mentioned earlier, secondary data in developing countries with respect to health indicators is insufficient. So the data have been collected from the following three hospitals in Lahore and one hospital in Rawalpindi.

1. Punjab Institute of Cardiology, Lahore.
2. Jinnah hospital, Lahore.
3. Sir Ganga Ram Hospital, Lahore.
4. Armed Forces Institute of Cardiovascular, Rawalpindi

For the estimation purpose, in this study, the daily total numbers of patients of cardiovascular disease in each of Lahore's hospitals are used and regressed against the daily maximum temperature in Lahore (the data was collected on a daily basis). When the response variable is count type or discrete type, then the more appropriate method is the Poisson method which is used here. The estimated results are as follows.

6.1 Aggregates of Three Hospitals of Lahore

The results of the regression are as follows:

$$\text{Log}(Y) = \beta_0 + \beta_1 X$$

Table 6.1 Regression results of impact of temperature on CVD

Dependent Variable: patagg			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	4.027867	.0333842	120.65 [0.000]
Maxagg	-.0141384	.0010648	-13.28 [0.000]
Pseudo R-Squared 0.0325			

Where

Patagg= Daily aggregate number of patients of three hospitals of Lahore city.

Maxagg = Daily maximum temperature of Lahore city.

The results, reported in Table 6.1, indicate that in Lahore, the relationship between the number of cardiovascular patients and the maximum temperature is negative. It means that if there is an increase in the temperature the number of heart patients of cardiovascular decreases. The results of Table 6.1 can also be written in the following form:

$$\text{Patagg} = e^{4.03} \times e^{-0.014(\text{Max})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The equation given above is also useful in calculation of the relative risks with reference to the number of cardiovascular patients which increases as a result of the change in the maximum temperature. For example the relative risk of the 30 degree celsius with the increase to 31 degree celsius can be calculated as follows:

$$e^{-0.014(30)} / e^{-0.014(31)} = 1.014 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The negative sign of the coefficient coincides with the opinions expressed by heart specialists during their interviews. They suggested that in Lahore the relationship of the number of cardiovascular patients and the maximum temperature is negative. In developed countries it is positive. The temperature-mortality relationship varies considerably by latitude and climatic zone. People in warmer cities are affected by colder temperatures, and people in colder cities are more affected by warmer weather. (Curriero FC, Temperature and mortality in 11 cities of the eastern United States 2002). For example in the UK and other northern high latitude countries, seasonal mortality rates and incidence of illness are higher in summer then in winter (Huynen, et al. 2001; Keatinge, 1997; Aronowand Ahn, 2004; Keatinge and Donaldson, 2004; Weerasinghe, et al. 2002).

The actual data of daily number of cardiovascular patients against the daily temperature of Lahore is plotted in Figure 6.2A[36]. Then to check the robustness of the results given above, the same method has been applied in each hospital of Lahore separately (see Tables 6.2, 6.3 and 6.4 reported below). The results are the same as above and it has been concluded that the relationship is negative in Lahore and the doctors' opinion from each hospital is consistent with these results. There may be some other damages of increased temperature on health but this is not the case with reference to cardiovascular disease in Lahore. Thus, more research needs to be conducted in order to ascertain other impacts of climate change on health.

6.2 Punjab Institute of Cardiology (PIC)

The remaining results are as follows. The results of Punjab Institute of Cardiology are as follows:

$$\text{Log}(Y) = \beta_0 + \beta_1 X$$

Table 6.2 Regression results of impact of temperature on CVD of PIC

Dependent Variable: pat			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	3.6549	.0211831	172.54 [0.000]
Maxpic	-.0195557	.0007011	-27.89 [0.000]
Pseudo R-Squared 0.0557			

[36]See Appendix for Figure 6.2A

Where

Pat = Daily number of patients in the Punjab institute of cardiology

Maxpic = Daily maximum temperature of Lahore city.

The results show that in PIC the relationship of number of cardiovascular patient is negative with the maximum temperature. It means that if there is an increase in the temperature the number of patients of cardiovascular diseases will be lower.

The results of Table 6.2 can also be written in the following form:

$$Pat = e^{3.66} \times e^{-0.02(Max)} \quad \ldots\ldots(3)$$

The equation given above is also useful to calculate relative risks about the number of patients of cardiovascular diseases due to change in the maximum temperature. For example the relative risk of the 30 degree celsius with an increase to the 31 degree celsius can be calculated as follows:

$$e^{-0.02(30)} / e^{-0.02(31)} = 1.020 \quad \ldots\ldots(4)$$

In the last five years, the total numbers of cardiovascular patients in PIC are as shown in Table 6.3A[37].

[37] See Appendix for Table 6.3A

From the Table 6.3A we can observe that total number of cardiovascular patients is increasing over time. The graph of the number of daily patients at PIC and daily maximum temperature is shown in Figure 6.3A[38].

6.3 Sir Ganga Ram Hospital

Next the relationship of number of cardiovascular patients from Sir Ganga Ram Hospital with the maximum daily temperature of Lahore city was estimated. The results are as follows.

$$\text{Log}(Y) = \beta_0 + \beta_1 X$$

Table 6.3 Regression results of impact of temperature on CVD of Ganga ram

Dependent Variable: patganga			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	.4570476	.1023668	4.46 [0.000]
Maxganga	-.0067861	.0033125	-2.05[0.040]
Pseudo R-Squared 0.0012			

Where

Patganga= Daily number of cardiovascular patients at Sir Ganga Ram Hospital

Maxganga = Daily maximum temperature of Lahore city.

The results show that in Sir Ganga Ram Hospital the relationship of number of cardiovascular patient is negatively related to the maximum daily temperature. It means that if there is an increase in the temperature the number of cardiovascular patients will be decrease.

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[38]See Appendix for Figure 6.3A

The results of Table 6.3 can also be written in the following form.

Patganga = $e^{0.46} \times e^{-0.007(Max)}$ …………………………..…………………(5)

The equation given above is also useful in calculation of relative risks with reference to the number of patients of cardiovascular diseases due to change in the maximum temperature. For example the relative risk of the 30 degree Celsius with the 31 degree Celsius can be calculated as follows:

$e^{-0.007(30)} / e^{-0.007(31)} = 1.007$………………………………………………(6)

Table 6.4A[39] shows the total number of heart patients in the last five years. The graph of the number of daily patients at Sir Ganga Ram Hospital and daily maximum temperature is shown in Figure 6.4A[40].

6.4 Jinnah Hospital

Next the relationship between the number of cardiovascular patients from Jinnah hospital and Lahore's maximum daily temperature has been estimated. The results are as follow.

$Log(Y) = \beta_0 + \beta_1 X$

Table 6.4 Regression results of impact of temperature on CVD of Jinnah hospital

Dependent Variable: patjin			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	2.648153	.0582195	45.49 [0.000]
Maxjin	-.0031647	.0018343	-1.73 [0.084]
Pseudo R-Squared 0.0006			

[39]See Appendix for Table 6.4A

[40]See Appendix for Figure 6.4A

Where

Patjin = daily number of cardiovascular patients at Jinnah hospital

Maxjin =daily maximum temperature in Lahore city.

The results show that in Jinnah hospital the relationship between the numbers of cardiovascular patients is negatively related to the maximum daily temperature of Lahore. It means that if there is an increase in the temperature, the number of patients of cardiovascular diseases will decrease.

The results of Table 6.4 can also be written in the following form.

$$Patjin = e^{2.65} \times e^{-0.003(Max)} \quad \ldots\ldots(7)$$

The equation given above is also useful in calculation of relative risks of the number of heart patients due to change in the maximum temperature. For example the relative risk of the 30 degree Celsius with an increase to the 31 degree Celsius can be calculated as follows:

$$e^{-0.003(30)} / e^{-0.003(31)} = 1.003 \quad \ldots\ldots(8)$$

Table 6.5A[41] shows the total number of cardiovascular patients in the last five years. The graph of the number of daily patients at Jinnah hospital and daily maximum temperature is shown in Figure 6.5A[42].

[41]See Appendix for Table 6.5A

[42]See Appendix for Figure 6.5A

6.5 Summary of Results:

The following Table shows the summary of results of all hospitals separately and on aggregate level.

Table 6.5 Summary of regression results

Variable(s)	Patagg (Z)	Pat (Z)	Patganga (Z)	Patjin (Z)
C	4.027867 (120.65)	3.6549 (172.54)	.4570476 (4.46)	2.648153 (45.49)
Maxagg	-.0141384 (-13.28)	-	-	-
Maxpic	-	-.0195557 (-27.89)	-	-
Maxganga	-	-	-.006786 (-2.05)	-
Maxjin	-	-	-	-.0031647 (-1.73)
Observations	614	1826	1461	614
Pseudo R^2	0.0325	0.0557	0.0012	0.0006

The results show negative and statistically significant impact of climate change on the cardiovascular disease. It means when there is rise in the temperature then, on average, there is decrease in the number of patients of cardiovascular patients and vice versa.

6.6 Cost of Cardiovascular Disease:

In Lahore all public hospitals are currently providing medical services free of charges to the cardiovascular patients. Therefore patients do not have to bear any cost. For analytical purposes, hospital authorities were asked about the cost incurred on cardiovascular patients. Unfortunately, the cost of cardiovascular disease was not available separately. The cost of cardiovascular disease was calculated from our survey conducted in Lahore in 2010. The summary of the cost is as follows:

Table 6.6: Minimum, maximum and average cost/day/person

	Cost of Medicine/ per day (Pak Rs.)	Total Cost/day (Medicine+ Doctor +Travel) (Pak Rs.)	Wages Lost/day (Indirect Cost) (Pak Rs.)
Minimum	8	30	100
Maximum	4000	9833	4000
Average	270	1464	856

Source: Calculations based on survey conducted by author

Apparently, minimum cost is very low. However, the fact is that this represents the cost which the destitute would have incurred on the treatment who can't afford to go to a specialist doctor or a hospital which is situated far away from their homes. In order to save time and travelling cost they go to the doctors nearby and often these doctors are unregistered practitioners.

The total number of cardiovascular patients in three hospitals of Lahore was 14848 in 2009. The cost given above has been used as the total expenditures[43] of cardiovascular patients, in three hospitals of Lahore in 2009, as shown in the following Table:

Table 6.7: Total (min and max) and average expenditure for year 2009

	Expenditure (Million Pak Rs.)	Indirect Cost (Million Pak Rs.)
Minimum Total Expenditures	0.45	1.49
Maximum Total Expenditure	146.00	59.39
Average Expenditure	21.74	12.71

Source: Calculations based on survey conducted by author

[43] Assuming that every patient has stayed in hospital for one day.

6.7 Armed Forces Institute of Cardiovascular (AFIC)[44]

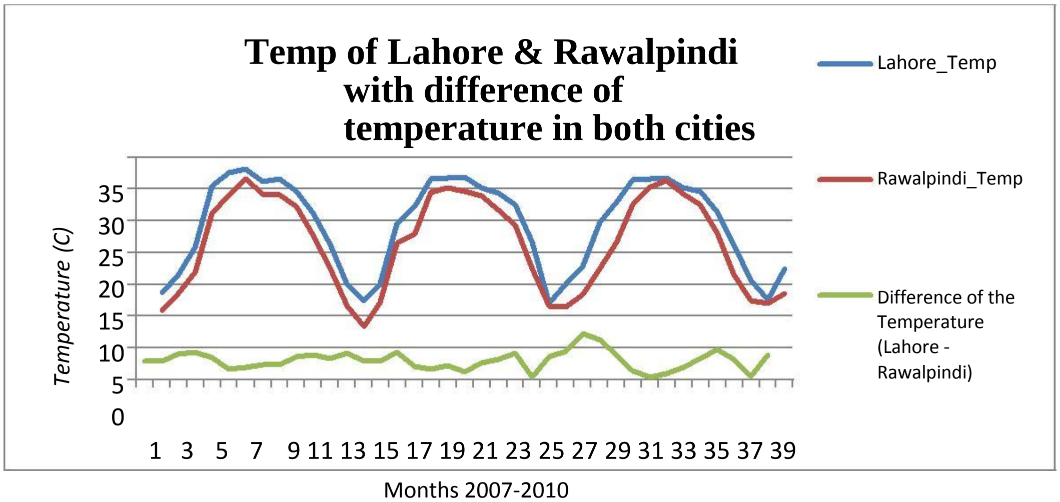
As we have seen in the case of Lahore that the relationship of maximum daily temperature and number of cardiovascular is negative while in most studies (see chapter 2) of the Europe and America it is positive. To check the robustness of our results, another city was chosen for the same analysis. For this purpose, Rawalpindi[45] was chosen as the secondary city in view of the fact that it is colder then Lahore. The maximum temperature of Lahore has been 3°C hotter than Rawalpindi in the last four years. In the last four years, on average the maximum monthly temperature of Lahore city was 33.17°C while in Rawalpindi it was 31.55°C. Likewise the minimum temperature in Lahore was 11.98°C and in Rawalpindi it was 8.30°C. In Figure 6.1, the average differences[46] in temperature, of both cities, are shown. It shows temperature in Lahore is consistently higher than temperature in Rawalpindi.

[44]Armed Forces Institute of Cardiovascular is in the Rawalpindi City.

[45]I am very thankful to Mr. Mehdi Hassan (Senior Observer) of Meteorological Department, Rawalpindi for providing me the monthly temperature data for last two years i.e. 2009 and 2010 for Rawalpindi City.

[46]The difference is based on Lahore's temperature minus Rawalpindi's temperature.

Figure 6.1 Temperature of Lahore and Rawalpindi along with difference of temperature in both cities.



Unfortunately the daily data for patients in AFIC was not available. They have only monthly data of patients. There is no other available information, regarding the patients, except for the number of monthly admissions of cardiovascular patients. Consequently, we relied on this data and the analysis was carried out on the basis of the available information.

$$\text{Log}(Y) = \beta_0 + \beta_1 X$$

Table 6.8 Regression results of temperature impact on CVD of AFIC

Dependent Variable: patrawal			
Variable(s)	**Coefficient**	**Standard Error**	**Z [Prob]**
C	7.654615	.0118994	643.28 [0.000]
Maxrawal	.0119955	.0003891	30.83 [0.000]
Pseudo R-Squared 0.0278			

Where

Patrawal =Monthly number of patients in the AFIC

Maxrawal = Monthly maximum temperature of Rawalpindi city.

As seen the relationship between maximum temperature and number of patients of cardiovascular disease is positive. The results are consistent with previous studies. As mentioned earlier in this chapter, the temperature-cardio, especially cardiovascular disease, relationship varies by latitude and climatic zone. This confirms that rise in temperature leads to rise in incidence of cardiovascular disease in Rawalpindi.

The results of Table 6.8 can also be written in the following form.

Patrawal = $e^{7.66} \times e^{0.012(Max)}$……………………………………………(9)

The equation given above is also useful in calculating relative risks with reference to the number of cardiovascular patients due to change in the maximum temperature. For example the relative risk of the 30 degree Celsius with an increase to the 31 degree Celsius can be calculated as follows:

$e^{-0.012(30)} / e^{0.012(31)} = 1.01$………………………………………………….(10)

We can conclude from this chapter that in Lahore the relationship of cardiovascular disease is inversely related to the Lahore's temperature. When the temperature decreases, on average, the number of patients of cardiovascular increases. While in Rawalpindi, which is colder than Lahore city, the results are the opposite. In Rawalpindi, the relationship between cardiovascular disease and temperature is positive. This supports the finding of some studies reported earlier that residents of colder regions are affected more by the rise in temperature as compared to residents of warmer regions. However, this may not be a linear relationship that needs to be tested in future studies.[47]

[47] One of the external referees suggested to test the non linear relationship between temperature and heart diseases. However this is not tested in this study and we have taken this point for future studies.

Chapter 7: Estimation of Willingness to Pay[48] for Health and Transport Sectors– A Contingent Valuation Approach

In the previous chapter, after analyzing the relationship between temperature and health, health cost is estimated. However, the estimated cost is only part of the total cost; as there are additional costs as well such as productivity loss, cost incurred by the caretaker and psychic cost etc. which are difficult to estimate. For example, psychic cost includes tension, pain, disturbance etc. during the disease. If these costs are high, people will be willing to pay more and vice versa for improved health services. For this purpose people are asked how much they are willing to pay to reduce the total cost. Thus, cost and willingness to pay are assumed to be directly proportional; the higher the cost is, the more the people will be willing to pay. In this chapter we have asked people how much they are willing to pay for the improvement of Lahore's traffic and for better health systems and applied the contingent valuation method to estimate average WTP of respondents.

For estimation purpose, contingent valuation method has been applied i.e. people were directly asked how much they would be willing to pay for better health and transport systems. The data, collected through a household survey, has already been discussed in chapter 4.[49].

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[48] Basically there are many methods to estimate the willingness to pay. For example. 1. The differences in wages that workers must be paid to take riskier jobs. 2. Examines behaviors where people weigh costs against risks (revealed preference) and this is indirect approach of obtaining the willingness to pay.(as mentioned by reviewer) 3. Contingent valuation surveys where respondents are directly asked how much they are willing to pay (stated preference) and this is direct approach of obtaining the willingness to pay.

I have applied the third approach and in literature many authors have applied the third approach like Anna Alberini et al(1997), Kumar (2001), Alan, et al. (2002), Anna (2004) etc have applied the third approach.

[49]Questionnaire is attached in the appendix.

7.1 Transport Sector

In this section, willingness to pay for improvement in transport system has been estimated. Since the variable 'willingness to pay' is continuous, it is better to use the OLS method. But before doing this it is better to check for the problem of heteroscedasticity? To check and confirm this White's heteroscedasticity test have been applied. The following regression has been estimated.

$$
\begin{aligned}
WTP\_AMOUNT = {} & \beta_1 + \beta_2*AGE + \beta_3*EXP\_OF\_CONV + \beta_4*PHD + \beta_5*MASTER + \\
& \beta_6*GRAD + \beta_7*METRIC + \beta_8*MIDDLE + \beta_9*PRIMARY + \\
& \beta_{10}*HAV\_CONV + \beta_{11}*HHSIZE + \beta_{12}*INDOOROUTDOOR + \\
& \beta_{13}*MARITAL\_STATUS + \beta_{14}*PARTICIPATION + \beta_{15}*SEX + \\
& \beta_{16}*INC\_2 + \beta_{17}*INC\_3 + \beta_{18}*INC\_4 + \beta_{19}*INC\_5 + \beta_{20}*INC\_6 + \\
& \beta_{21}*POLLU\_RED4 + \beta_{22}*POLLU3 + \beta_{23}*POLLU4 + \beta_{24}*POLLU2 + \\
& \mu
\end{aligned}
$$

Where

WTP_amount = Willingness to pay for improvement of Lahore's traffic system [in Rs.]

EXP_OF_CONV = Expenditure on conveyance (in Rs.)

PHD = Doctor of Philosophy

MASTER = Master's degree (16 years of education)

GRAD = Graduation (14 years of education)

METRIC = Metric (10 years of education)

MIDDLE = Middle (8 Years of education)

PRIMARY = Primary (5 Years of education)

HAV_CONV = Have own conveyance (if Yes = 1, otherwise = 0)

HHSIZE = Household size

INDOOROUTDOOR =Working area (indoor or outdoor) (if indoor = 1, otherwise = 0)

MARITAL_STATUS = if married = 1, otherwise = 0

PARTICIPATION = Willing to participate in betterment of traffic system (if yes = 1, otherwise = 0)

SEX = Sex (male = 1, female =0)

INC_2 = Income group (Rs. 10001 – 20000 per month)

INC_3 = Income group (Rs. 20001 – 30000 per month)

INC_4 = Income group (Rs. 30001 – 40000 per month)

INC_5 = Income group (Rs. 40001 – 50000 per month)

INC_6 = Income group (Rs. 50001 and above per month)

POLLU_RED4 = Pollution reducing technology (if less important = 1, otherwise = 0)

POLLU3 = Major changes required for pollution problem (if required = 1, other wise 0)

POLLU4 = Complete overhauling is required for pollution problem (if required = 1, other wise 0)

POLLU2 = Minor changes required for pollution problem (if required = 1, otherwise = 0)

By estimating the above regression, the residuals are obtained and then the auxiliary regression has been estimated, as suggested by White i.e. regressing the squared residuals on a constant, all explanatory variables, their squared and cross products. The heteroscedasticity problem was found in the test because the p value is less than 0.05. To remove the problem, instead of simple OLS method, White's heteroscedasticity-consistent variances and standard errors method has been applied. By applying this method the problem of the heteroscedasticity was also removed. White's heteroscedasticity-corrected standard errors are also known as robust standard errors. The following results show that the heteroscedasticity is removed. Because the P value is greater than 0.05.

Table 7.1 White heteroscedasticity test:

F-statistic	0.671947	Probability	0.992322
Obs*R-squared	182.9017	Probability	0.926575

The estimated regression results are reported in Table 7.2.

Table 7.2 Estimated parameters of WTP for improvement of traffic system (CVM).

Dependent Variable: WTP_AMOUNT			
Variable(s)	**Coefficient**	**Standard Error**	t-Statistic **[Prob]**
C	-9.573676	162.2945	-0.058 [0.953]
AGE	-5.567490	2.458666	-2.264 [0.024]
EXP_OF_CONV	0.020407	0.006266	3.256 [0.0013]
PHD	126.2479	172.2992	0.732725 [0.4643]
MASTER	151.7343	83.83159	1.809990 [0.0713]
GRAD	173.9455	85.57825	2.032590 [0.0430]
METRIC	95.50890	68.22596	1.399891 [0.1626]
MIDDLE	-8.409772	62.43609	-0.134694 [0.8929]
PRIMARY	132.9054	83.62173	1.589365 [0.1130]
HAV_CONV	85.51342	47.81120	1.788565 [0.0747]
HHSIZE	-9.899096	13.52955	-0.731665 [0.4650]
INDOOROUTDOOR	-113.9801	65.90832	-1.729374 [0.0848]
MARITAL_STATUS	-85.40914	57.91308	-1.474781 [0.1413]
PARTICIPATION	269.3020	42.71679	6.304359 [0.0000]
SEX	74.05455	61.61508	1.201890 [0.2304]
INC_2	-54.40893	69.10951	-0.787286 [0.4317]
INC_3	10.65278	79.52073	0.133962 [0.8935]
INC_4	236.7696	107.3949	2.204664 [0.0282]
INC_5	136.5305	110.8875	1.231252 [0.2192]
INC_6	-20.95879	97.27249	-0.215465 [0.8296]
POLLU_RED4	-140.4452	51.07261	-2.749912 [0.0063]
POLLU2	153.9866	119.6292	1.287199 [0.1990]
POLLU3	187.9689	91.43882	2.055679 [0.0407]
POLLU4	169.7297	97.93100	1.733156 [0.0841]
R-Squared 0.222579			
D-Watson 1.875371			

The results given above show that age is negatively related to the willingness to pay (WTP) this implies that the youngers have higher marginal utility for improved traffic system than olderones since the model shows that higher willingness to pay reflects higher marginal utility. The improvement in traffic system increases the welfare of the youngers more than the olders. The youngers are more willing to contribute to improvement of traffic system and thus the reduction in CO_2. The increase in CO_2 is one of the major causes of climate change. The negative sign of the age shows one additional year of age contributes on average Rs. 5.57/- less for the improvement of traffic system.

The expenditure on conveyance is positively related to willingness to pay. One additional rupee on conveyance contributes to around Rs. 0.02/- increase in willingness to pay for improvement of traffic system. This is because when people are stuck in the traffic their expenditure and cost of time increases. So to save these expenditures and time they are willing to pay more for improvement in the traffic system.

Education positively affects the willingness to pay for the improved traffic system. It means that educated people are more conscious about a good traffic system and clean environment. If a person is a graduate (14 years of Education), then he/she is willing to pay around Rs 174/- more than an illiterate person. Likewise if a person has a master's degree (16 years of education), then his/her willingness to pay is around Rs 152/- more as compare to an illiterate person. PhD, metric, middle and primary are insignificant in our sample survey.

Those people who have their own conveyances are willing to pay on average around Rs 86/- more than those who do not have conveyance. Because of traffic congestion system their expenditure on conveyance and time increases rapidly. Consequently, they are willing to pay more to save expenditure and time. The negative sign of the indoor/outdoor category shows that those people who are working indoor, are willing to pay on average Rs. 114/- less than the people who are working outdoors. This implies that the marginal utility from one additional unit of traffic improvement for persons working outdoor is higher than for persons working indoor. The reason may be that people working outdoor are more vulnerable to traffic pollution. Another reason may be that those who are working outdoor may want to work more on the site and minimize the time stuck in the traffic in order to increase their income by working more hours. Therefore they are willing to pay more for improvement in the traffic system. The variable participation is highly significant. Those people who are willing to participate in the improvement of traffic system are willing to pay, on average, Rs. 269/- more than those who do not want to participate. The individuals who are participating in improvement of traffic system derive higher marginal utility from one additional unit of traffic system improvement because their willingness to pay is higher than those who are not participating.

The income has been categorized into six different groups according to the income level instead of taking the income as continuous variable. By doing this we can pin point that which income group is willing to pay more amount for improvement in traffic and health sectors. These income groups are shown in Table 7.6.Regarding the income, only category four is significant. It means that those people whose income lies between Rs. 30 – 40 thousands per month are willing to pay Rs. 237/- more than the people whose income is less than 10 thousands per month. All other income categories, lower and upper, are insignificant. It can be concluded that only the middle class is willing to pay for improvement in traffic system.

Regarding the mitigating activities, when asked about the problems and solutions of the traffic system of Lahore, only one problem is significant and that is the pollution. Pollution can be classified into two categories. Pollution3 shows the major changes (for example replacing the old vehicles with green technological vehicles, greening the cities etc.) are required and pollution4 shows that complete overhauling is required with reference to pollution. Those who view major changes positively are willing to pay Rs.188/- more than those who are not concerned about the problems posed by pollution. Those who support complete overhaul of the traffic system to control the pollution are willing to pay Rs. 170/- more than those who are not in favor of a complete overhaul. When asked about the solutions for the pollution. With respect to solutions for the problems created by pollution, people are in favor of the induction of various pollution reducing technologies. The negative sign shows that the people who consider technologies to be less important are willing to pay Rs. 140/- less than those who give more importance to pollution reducing technologies.

By looking at the results given above, the lower bound of the willingness to pay has been calculated for the whole city of Lahore. The initial step in this process was the calculation of population of Lahore. The population of Lahore city was available only for few years and it was last updated in 1998 Census. The total population of Pakistan was 132 million in 1998 and the total population of Lahore in the same year was 5 million. So the share of Lahore's population in Pakistan was around 3.8 percent.

Pakistan's total population is available for each year in the Economic Survey of Pakistan (Pakistan 2010). Lahore's share in the population was calculated by using Lahore's population in 1998 as a correlative and assuming that the ratio was the same in 2009. Total population of Pakistan in 2009 was around 167 million. So by multiplying the share of Lahore population in 1998 with 167 million; the population of 2009, the population of Lahore has been calculated. By this method the total population of Lahore was around 6.4 million in 2009.

The same method has been applied to calculate the enrollment of colleges and universities in Lahore. The level of enrollment in Lahore was calculated by taking Lahore's share of population and the enrollment level of colleges and universities in Pakistan (Pakistan 2010). College level enrollment means that the students have definitely completed metric level education and university level enrollment means that the students have definitely completed graduation.

In order to calculate the total willingness to pay according to the level of education, the total numbers of metric people and graduates have been multiplied with their corresponding coefficient of education according to the regression given above. Total number of students who passed metric was 40812 and total number of graduates in Lahore was 31069 in 2009. Total willingness to pay according to the level of education is reported in the Table 7.3. [50]

Table 7.3 Total WTP for education.

WTP for education	Metric (10 years Completed)	Graduates (14 years Completed)	Net Effect of 4 Years of Education at Higher level.
Willingness to pay For year 2010 (Lahore)	47 (Million Rs.)	64.87 (Million Rs.)	17.87 (Million Rs.)
Willingness to pay For year 2010 (Pakistan)	1237.25 (Million Rs.)	1677.7 (Million Rs.)	440.45 (Million Rs.)

Source: Calculations based on survey conducted by author

Table 7.4 reports distribution of respondents based on the working conditions (Indoor/Outdoor).

Table 7.4 Distribution of respondents according to working condition.

Indoor/Outdoor	Number of Respondents	Percent
Outdoor	97	30.12
Indoor	225	69.88
Total	322	100.00

Source: survey conducted by author .

[50] Due to non-availability of data of master level education completion, only up to graduation level willingness to pay has been calculated. If data of higher education completion had been available then the willingness to pay could also be calculated for higher education.

By looking at the above Table, the total population of Lahore who are working outdoor can be calculated. The total population of Lahore who is working outdoor is 1.93 million. From the regression results it is clear that the people who are working outdoor are willing to pay Rs. 114/- more than those who are working indoor. Total willingness to pay for outdoor workers will be Rs. 220/- million per month more than those who are working indoor.

(Total population of Lahore) X (percent of people who Works Outdoor) X (WTP in Rs.)

(6.4 million) X (0.3012) X (Rs. 114/-) = Rs. 220/- million per month

Willingness to pay per year = 220 X 12 = Rs. 2640/- million

The Table 7.5 represents the number of people who view improvement of Lahore's traffic system positively and would like to participate in the process.

Table 7.5 Distribution of respondents who want to participate or not in improvement of the traffic system.

Participation	Number of Respondents	Percent
No	60	18.63
Yes	262	81.37
Total	322	100.00

Source: survey conducted by author

According to our sample, 81.37 percent population wants to participate in the improvement of traffic system. Our regression results show that these persons are willing to pay Rs 269/- more than those who are not willing to participate. If this population percentage is multiplied with Lahore's total population and the resulting figure is multiplied with Rs.269; the resulting sum will be an approximation of how much more the people who want to participate are willing to pay than those who are not so eager about involvement. The equation for the people exhibiting willingness to pay with respect to Lahore is given as under

(Total Population of Lahore) X (percent of people who wants to participate) X (WTP in Rs.)

(6.4 million) X (0.8137) X (Rs. 269/) = Rs. 1401/- million per month

Willingness to pay per year = 1401 X 12 = Rs. 16812/- million

With reference to the income groups, it is shown in our regression results that only category 4 is willing to pay for improvement of traffic system of Lahore. The willingness to pay for this group is Rs. 237/- more as compared to group one. Six income groups have been defined in Table 7.6

Table 7.6 Distribution of respondents according to income groups.

Income Group	Number of Respondents	Percent
1 (Less than Rs. 10000)	39	12.11
2 (10001 – 20000)	87	27.02
3 (20001 – 30000)	70	21.74
4 (30001 – 40000)	33	10.25
5 (40001 – 50000)	48	14.91
6 (Greater than 50000)	45	13.98
Total	**322**	**100.00**

Source: survey conducted by author

(Total Population of Lahore) X (percent of people in group 4) X (WTP in Rs.)

(6.4 million) X (0.1025) X (Rs. 237/-) = Rs. 155.47/- million per month

Willingness to pay per year = 155.47 X 12 = Rs. 1865.64/ million

7.2 Health Sector

After the willingness to pay for improvement of the traffic system was calculated; an estimate of willingness to pay was made with respect to the health system. Same procedure used to remove the heteroscedasticity problem has been applied as in the previous regression. The following regression has been estimated.

WTP_HEALTH_AMOUNT = β_1 + β_2*AWARENESS + β_3*PHD + β_4*MASTER + B_5*GRAD + β_6*METRIC + β_7*MIDDLE+ β_8*PRIMARY + β_9*MARITAL STATUS+ β_{10}*SEX + β_{11}*DOCTOR_FEE + β_{12}*INC_4 + β_{13}*TRAVEL_COST + β_{14}*CVD

Where

WTP_HEALTH_AMOUNT = Willingness to pay for betterment of health system of Lahore. (Rs)

AWARENESS = Awareness about relationship of climate change with health (yes = 1)

PHD = Doctor of Philosophy

MASTER	= Master's degree (16 years of education)
GRAD	= Graduation (14 years of education)
METRIC	= Metric (10 years of education)
MIDDLE	= Middle (8 years of education)
PRIMARY	= Primary (5 years of education)
MARITAL_STATUS	= If married then 1, other wise 0
SEX	= Sex (if male = 1, female =0)
DOCTOR_FEE	= Doctor fee
INC_4	= Income group (Rs. 30001 – 40000 per month)
TRAVEL_COST	= Travelling cost to hospital
CVD	= Have cardiovascular disease (if yes = 1, otherwise = 0)

By estimating the above regression, the residuals are obtained and then the auxiliary regression has been estimated which is suggested by White i.e. regressing the squared residuals on a constant, all explanatory variables, their squared and cross products. The heteroscedasticity problem was found in the test because the p value is less than 0.05. So to remove the problem, instead of simple OLS method, the weighted least squares (WLS) has been applied. By applying the WLS the problem of the heteroscedasticity was also removed. It was necessary to click on the heteroscedasticity consistent coefficient covariance and then choose White in order to resolve the problem posed by heteroscedasticity.

Table 7.7 show that the heteroscedasticity is removed, because the P value is greater than 0.05.

Table 7.7 White heteroscedasticity test:

F-statistic	1.740433	Probability	0.059871
Obs*R-squared	23.57212	Probability	0.072725

The results of WLS are as follows:-

Table 7.8 Estimated parameters of WTP for improvement of health system (CVM).

Dependent Variable: WTP_HEALTH_AMOUN			
Variable(s)	**Coefficient**	**Standard Error**	**t-Statistic [Prob]**
C	-687.8904	250.1930	-2.749439 [0.0074]
AWARENESS	250.3252	184.4585	1.357082 [0.1786]
PHD	563.7971	104.4798	5.396232 [0.0000]
MASTER	458.5887	91.56399	5.008396 [0.0000]
GRAD	700.0148	186.2917	3.757627 [0.0003]
METRIC	422.6713	97.84662	4.319733 [0.0000]
MIDDLE	146.2464	55.42792	2.638497 [0.0100]
PRIMARY	230.3419	111.7232	2.061718 [0.0425
MARITAL_STATUS	127.7981	113.0166	1.130790 [0.2615]
SEX	162.1401	113.6368	1.426827 [0.1575]
DOCTOR_FEE	0.013451	0.078350	0.171684 [0.8641]
INC_4	318.4855	162.4813	1.960137 [0.0535]
TRAVEL_COST	-0.041819	0.017553	-2.382485 [0.0196]
CVD	145.0832	86.46080	1.678023 [0.0972]
R-Squared 0.209661			
D-Watson 1.738634			

The willingness to pay equation (equation 18) in the theoretical model reflects marginal utility from one additional unit of health improvement: the higher willingness to pay shows higher marginal utility from improvement in the health system. In other words any factor affecting the marginal utility from one additional unit of health improvement positively will also affect the willingness to pay positively; increase in the value of such factors will also increase the marginal utility from one additional unit of health improvement and thus will also increase the willingness to pay and vice versa.

The results given above show that education is positively related to the willingness to pay for a better health system especially with respect to cardiovascular related disease. A PhD level person is willing to pay Rs. 564/- more than an illiterate person for a better health system especially for the cardiovascular related health problems. The Postgraduate (16^{th} year of education), graduate (14^{th} year of education), metric (10 years of education), middle (8^{th} years of education) and primary (5^{th} years of education) are willing to pay Rs. 459/-, 700/-, 422/-, 146/-and 230/- respectively more than an illiterate person respectively. The framework of the traffic system and the variable of education at every level ranging from primary to PhD is statistically different in the health system. The common factor in the traffic system and health system is that the graduates (14 years of education) are willing to pay more as compared to other categories.

For income, only category four is significant. It means that those people whose income lies between Rs. 30 – 40 thousands are willing to pay Rs. 319/- more than the people whose income is less than 10 thousand per month for improvement in health system. All other income categories, lower and upper, are insignificant.

The cost of travelling to a hospital/doctor is negatively related to the willingness to pay. People have to seek out medical help. Consequently, when their traveling expenditures increase they are less willing to pay for a better health system, conversely they want to bear the expenditure themselves. The last significant variable is CVD. People who have a cardiovascular related disease are willing to pay for better health system especially for a cardiovascular related health system. People who have CVD are willing to pay Rs. 145/- more than those who don't have this disease.

The calculation method of willingness to pay with respect to level of education was the same for the health system and transport system; the difference arose in the resulting sum due to difference in the value of willingness to pay for the transport system and the health system.

The details are given as follows:-

1. (Number of people who have completed Metric level education) X (Willingness to pay in Rs.)

   (40812) X (Rs. 423/) = Rs. 17.26/- million per month

   Willingness to pay per year = 17.26 X 12 = Rs. 207.12/- million

2. (Number of people who have completed graduation level education) X (Willingness to pay in Rs.)

   (31069) X (Rs. 700/-) = Rs. 21.75/- million per month

   Willingness to pay per year = 21.75 X 12 = Rs. 261/- million

Table 7.9 Total WTP for education.

WTP for Education	**Metric (10 years Completed)**	**Graduate (14 years Completed)**	**Net Effect of 4 Years of Education at Higher level.**
Willingness to pay for year 2010 (Lahore)	207.12 (Million Rs.)	261 (Million Rs.)	53.88 (Million Rs.)
Willingness to pay for year 2010 (Pakistan)	5451.62 (Million Rs.)	6749.46 (Million Rs.)	1297.84 (Million Rs.)

Source: Calculations based on survey conducted by author

Willingness to pay with respect to remaining education level can be calculated by applying the same methodology.

For income groups, the results show that only category 4 is willing to pay for better health system especially for cardiovascular related diseases in Lahore. The willingness to pay for this group is Rs. 319/- higher as compared to group one. Six income groups have been defined in Table 7.6.

(Total population of Lahore) X (Percent of people in group 4) X (WTP in Rs.)

(6.4 million) X (0.1025) X (Rs. 319/-) = Rs. 209.26/- million per month

Willingness to pay per year = 209.26 X 12 = Rs. 2511.12/- million

7.3 Summary of the Results:

From these results it can be concluded that the people of Lahore are more concerned and are willing to pay a much higher amount for the improvements in the health system especially for cardiovascular disease as compared to improvements in the Lahore's traffic system. The Table 7.10 shows a summary of the results of the regressions given below.

It has been concluded that people of Lahore are willing to pay more for improvement in health as compared to improvement in traffic system. Those people who got matriculation (10 years of education) are willing to pay around 341 percent more for health as compared to the improvement in traffic system. Those who graduated (14 years of education) are willing to pay around 302 percent more for health system as compared to improvement in traffic system. If we see the difference of four years of education (from matriculation to graduation) then it is concluded that willingness to pay for improvement in traffic system is higher by 38 percent and for health system higher by 26 percent. The income group four (income between Rs. 30001 – 40000 per month) is willingness to pay more around 35 percent for health as compared to improvement in the traffic system.

Table 7.10 Summary results of WTP

	Willingness To Pay (for Lahore - 2010)	
	Traffic System	**Health System (Cardiovascular Diseases)**
Metric (10 years of Education)	47 (Million Rs.)	207.12 (Million Rs.)
Graduation (14 years of Education)	64.87 (Million Rs.)	261 (Million Rs.)
Income Group 4 (Rs. 30001 – 40000 per month)	1865.64 (Million Rs.)	2511.12 (Million Rs.)
Outdoor workers	2640 (Million Rs.)	
Participation	16812 (Million Rs.)	

Source: Calculations based on survey conducted by author

Chapter 8: Conclusions and Policy Implications

8.1 Conclusions

The study has been divided into four main parts. In the first part the transport sector's contribution to Pakistan's share of GHG emissions has been ascertained; in second part the concentration of CO_2 and consequently its effect on climate change has been estimated. In the third part the relationship of temperature with the number of patients of cardiovascular disease, an indicator of health, in Lahore and Rawalpindi cities is examined. In the fourth part our objective is to find out the willingness to pay for improved health and better transport system.

Like other countries, Pakistan is heavily dependent on petroleum products. It has been observed that the demand for petroleum products is growing rapidly in Pakistan. From 1980-2009 the diesel consumption has increased by 326 percent and petrol consumption increased by 182 percent. Petrol consumption has shown a relatively smaller increment as compared to diesel consumption. This is due to the conversion of many petrol vehicles to CNG. In Pakistan till 2009, around 2 million vehicles had been converted to CNG, which is around 21 percent of the total vehicles (both diesel and petrol). Thus, the first conclusion is that we are less dependent on petrol as compared to diesel and our dependency on CNG is increasing.

The share of CO_2 emissions from road transport in total emissions of CO_2 is about 19 percent in Pakistan. In Pakistan, the carbon dioxide emissions from road transport have been increasing with an average annual growth of 9 percent from 1980 to 2009. Predicted values of carbon dioxide emissions from road transport show that in year 2030 it will be in the range of 36 to 42 million metric tons while currently it is around 25 million metric tons. In 2009 the estimated damages from the emissions of carbon dioxide in the road transport sector were US$ 473 million. The total damages of carbon dioxide emissions from the road transport sector of Pakistan are estimated to rise between US$ 720 to 840 million by 2030. From the point of view of policy making, it is imperative to take cautious measures to prevent further damages.

Our total emissions were 156 million metric tons in 2007 and the average growth of total emissions was 6.4 percent in the period between 1980 to 2007 and from road transport the emissions of CO_2 were 22 million metric tons in 2007 and annual growth of emissions from road transport was around 9 percent in the same period. Thus, it can be concluded that our growth in emissions from road transport is more (in terms of percentage) than the growth of total emissions. Therefore, it can be stated that our road transport is contributing relatively more in changing the climate.

The second conclusion of this study is that there is a strong relationship between emissions/concentration of CO_2 with the average temperature. If there are 12760 million metric tons of CO_2 emissions then it will be associated with 1°C increase in average temperature.

The third main conclusion is that in Lahore the relationship of cardiovascular disease is inversely related to the Lahore's average temperature. So this is contrary to the findings in developed world. The main difference is that the major studies have been conducted in Europe, Canada and America where cold weather prevails during most of the year[51]. People in these areas are used to live in a cold area so an increase in temperature would lead to cardiovascular complications. Lahore is mostly warm. People living in Lahore are used to warm weather. Consequently, when the weather

[51]In Pakistan, 12 locations are cooler, 22 are warmer. Globally, 2282 are cooler, 698 are warmer (World Climate 2010).

gets warmer, cardiovascular problems do not increase. For this purpose various doctors, belonging to different hospitals in Lahore, were interviewed; they concurred that in winter there are more cardiovascular patients than in summer.

When the same analysis was done in the Rawalpindi, which is colder than Lahore city, the results are opposite. In Rawalpindi, the relationship between cardiovascular disease and temperature is positive. Whenever temperature rises people suffer. In Lahore, this problem arises during winter and in Rawalpindi this problem occurs during summer. Similarly, in western countries this problem is observed during the summer whereas in Asia this problem occurs in winter.

In the fourth part of the study, contingent valuation method has been applied to assess willingness to pay. In Lahore, people are willing to pay a huge amount for improvement in the traffic system and health system especially for heart problems. According to our analysis, people who work outdoors, people who want to participate in the betterment of the traffic system and expenditure on conveyance all contribute to a positive willingness to pay for betterment of the traffic system. Similarly, income group4 (Rs.30001-40000 per month), pollution reducing technologies, pollution problem solutions and people who have their own conveyance exhibit a positive willingness to pay for improvement of the traffic system. However, age has a negative relationship with the willingness to pay.

In the health system, education, income group4 and people who are facing cardiovascular diseases display a positive relation with willingness to pay. However travel cost to hospital/doctor has a negative relationship with the health system especially cardio related health system.

The fourth conclusion is that educated people and middle income class people are willing to pay for improvement of both the systems. Education brings awareness to life. People want to live in a healthy and clean environment. Consequently, they are willing to pay for both the systems. The middle income class is the only class who is willing to pay for both systems.

Finally the lower bound of the willingness to pay has been calculated for some categories like education, participation, income and indoor/outdoor work. Comparative analysis has also been presented for willingness to pay with reference to both systems i.e. traffic system and health system especially cardio related health system. It has been concluded that people of Lahore are more concerned about their health system than the traffic system; thus their willingness to pay for improvement of health is higher than that for the traffic system (see Table 7.10).

8.2 Policy Implications:

As it has been concluded that the climate is changing i.e. emissions are increasing which result in an increase in temperature. The risks of serious impacts of this increase in temperature indicate that there is a dire need to quickly resolve the problem.

There is considerable disagreement within and between nations, concerning which policies should be implemented to mitigate climate change and its various impacts. Kyoto protocol is the first significant international effort to reduce GHG. It assigns emissions limits to participating developed countries in the period between 2008-2012 but offers flexibility by allowing these countries to alter their limits by buying and selling emissions allowances from other countries or by investing in projects that lead to emissions reductions in developing countries.

Environmental damages are not associated with private cost (household, firms etc.) therefore the role of public policy is necessary for the solution of the problem. Waiting for economic recovery rather than making a decision now will create more obstacles in future.

Therefore two types of policies are suggested.

1. External policy
2. Internal policy

8.2.1 External Policy:

External policy is a policy which is linked to international conflict. This can be proposed in the discussions at international forums. Following points have been proposed for external policy.

- There must be fair and strong good global governance or international body such as United Nations or IPCC which can strongly enforce the international agreements. Every region must participate in them[52]. Each country must be bound to the decisions made by this body.
- Clean Development Mechanism (CDM) was agreed in the Kyoto Protocol (IPCC 2007) and defined in the Article 12 of the protocol. It is defined as, the industrialized countries (Annex I countries) should assist developing countries to achieve sustainable development and contribute to prevention of dangerous impacts caused by climate change. Industrialized countries should abide by the agreement and should invest in developing countries to prevent and combat climate change.
- As mentioned earlier that developed countries are more responsible for climate change and developing countries are more at risk. Developing countries lack the capacity to pay for emissions reduction so it is the responsibility of the developed world to invest in developing countries.
- Developed countries should reduce emissions and developing countries should stop further

[52] Pakistan is already actively participating in the meetings of IPCC and UNFCC an mentioned in the first chapter of the thesis.

increase in emissions. They do not have the capacity to reduce emissions but they can initiate the measures to control the emissions by introduction of the green technology.

- We should work on carbon trading[53]. Carbon markets do not work like other commodities.

  This is a market where changes occur with reference to the right to emit a certain volume of CO_2. Thus, if a developed country would like to have more emissions they can pay developing countries, which have fewer emissions, for this right. By selling these rights to emission, developing countries can earn the foreign reserves which can be used to import the green industrial technology so that the industry can be developed in a developing country on one the hand and emissions can be controlled on the other hand.

- The International community has an obligation to support developing countries, which are not responsible for climate change, in adapting and mitigating the impact of climate change

8.3 Climate Change Policy

- We must adopt some sort of double dividend policy (win-win situation) in shaping the tax system. It means that we must levy tax on those who are responsible for emissions and should give rebate to those who are using green technology. In this way we will get a double dividend i.e. reducing emissions or getting the revenue and giving incentives to those who are using green transport.
- There must be some rebate or zero tax for importers of green transport.
- We must add a tax to those items that are creating the problem of climate change. For example instead of levying tax on petrol we must tax those vehicles that are emitting a large amount of GHG and not using green technology or controlling devices for emissions. By levying the tax on petroleum, we are taxing the whole country. We must not tax those who are not responsible for the problem.

[53] Pakistan has good opportunity in this policy. For example see section 3.4 and table 2.1A to see details.

- We must reduce subsidies on those items that create the emissions.

- For implementation of this policy we need technology and finance (essential for mitigation and adaptation). For technology we should announce tax free imports and provide loans to the private sector and to those who are importing the green transport. Moreover we should start some sort of the project based on private-public partnership that is related to green technology and must give easy access to loans for importing green technology. For example public transport which is using the CNG.

- For finance we should start carbon trading and tax those who are responsible for emissions. Moreover people of Lahore are willing to pay a huge amount for betterment of the traffic system. We should also avail this opportunity.

8.4: Health Policy:

- The results of the survey indicate that people are willing to pay a huge amount for the health system especially for cardio related disease[54]. The Government should use this opportunity and provide better health services and state of the art technology to the people.

[54] See table 7.10

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Appendix

List of Patient's Cities at PIC

1	Abbott bad	26	Fatah jag	51	Ayah	76	Raba
2	Arifwala	27	Gojra	52	Manawala	77	Rahim Yar Khan
3	Attock	28	Gotki	53	MandiFaizabad	78	Raiwind
4	Bahawal Nagar	29	Gujranwala	54	Manga mandi	79	RajanPur
5	Bahawalpur	30	Gujrat	55	Mansehra	80	Sahiwal
6	Bannu	31	Hafizabad	56	Mianchanu	81	Sargodha
7	Baowala	32	Hujra Shah Mukeem	57	Mianwali	82	Sawabi
8	BastiSadau Shah	33	Hyderabad	58	Mir Pur	83	ShakarGhar
9	Bhakkar	34	Islamabad	59	Multan	84	Sharakpur
10	Bhimbher	35	Jandyala	60	Muridkay	85	Sheikhupura
11	Burewala	36	Jhang	61	Murree	86	Sialkot
12	Chakwal	37	jhawalabehari	62	MuzaffarGarh	87	swat
13	Changa Manga	38	Jhehlum	63	Muzaffarbad	88	Taank
14	Chaniot	39	Kahna No	64	Nankana Sahib	89	Toba Take Singh
15	ChechaWatni	40	Kamoki	65	NarangMandi	90	Vehari
16	ChoaSadhan Shah	41	Kana Kacha	66	Narowal	91	WahCantt
17	Choong	42	Karachi	67	Nawab shah	92	Wazirabad
18	Chunian	43	kasoor	68	Noshehra	93	Zafarwala
19	D. G. Khan	44	khanewal	69	Okara		
20	D. I. Khan	45	Khushab	70	Pakpattan		
21	Daska	46	Kohat	71	Pasroor		
22	Depalpur	47	KotRadhaKishan	72	Pattoki		
23	Dholanwal	48	Kotli	73	Peshawar		
24	Faisalabad	49	Lodhran	74	PindDandan khan		
25	Farooqabad	50	Lahore	75	Quetta		

Source: Hospital Sources

List of Patient's Cities at Sir Ganga Ram Hospital

1	Bahawal Nagar	16	Khaniwal	31	Sargodha
2	Bahawalpur	17	Khushab	32	Sharakpur
3	BhaiPhero	18	Lahore	33	Sheikhupura
4	Bhakhar	19	MandiBahauddin	34	Sialkot
5	Buraywala	20	Muridkay	35	Vehari
6	Faisalabad	21	Muzaffarabad		
7	Gujranwala	22	Nankana Sahib		
8	Gujrat	23	Narowal		
9	Hafizabad	24	Noshehra		
10	HawaliLakha	25	Okara		
11	Jaranwala	26	Pasroor		
12	Jehlum	27	Patoki		
13	Kamalia	28	Rahim Yar Khan		
14	Kasoor	29	Rawalpindi		
15	Khan Pur	30	Sahiwal		

Source: Hospital Sources

Appendix for Chapter 1

Top 10 Warmest Years (NOAA) (1880-2014)

Rank	Year	Anomaly °C
1	2014	0.69
2 (tie)	2010	0.65
2 (tie)	2005	0.65
4	1998	0.63
5 (tie)	2013	0.62
5 (tie)	2003	0.62
7	2002	0.61
8	2006	0.6
9 (tie)	2009	0.59
9 (tie)	2007	0.59

Appendix for Chapter 2

Table 2.1A CO_2e emissions of Pakistan at selected years: (Million Metric Tons)

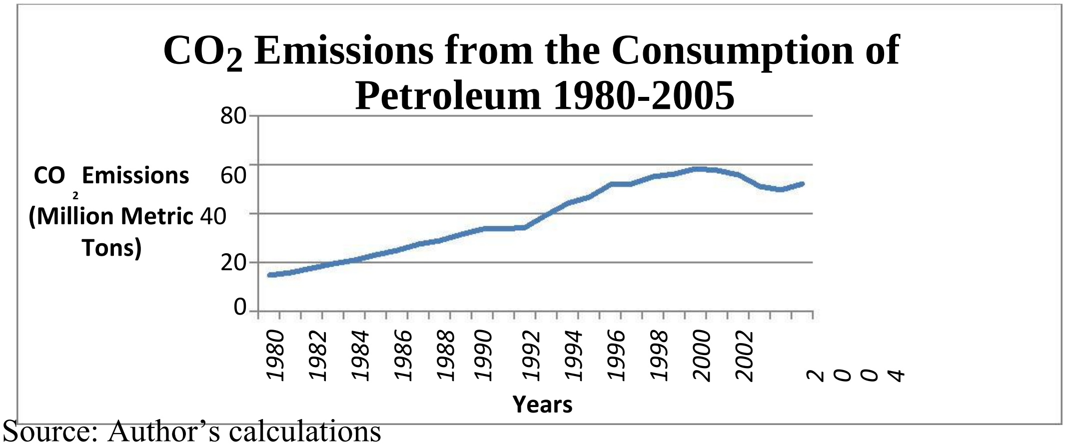
Years	Total Emissions	Percent of World Emissions	Per Capita Emissions
1988	55.6 (48)	0.27 percent	0.5 (125)
1998	93.8 (36)	0.41 percent	0.7 (130)
2006	136.9 (32)	0.48 percent	0.9 (133)
2007	148.9 (32)	0.50 percent	0.9 (132)

NOTE: figures in parenthesis are world ranking.

Table 2.2A Average and Growth of Emissions in Pakistan

CO_2e emissions in Million Metric Tons (1980)	CO_2e emissions in Million Metric Tons (2007)	Total Change (1980 – 2007)	Average Annual Growth CO_2e	Total Growth of CO_2e
28	148.9	120.9	6.4 percent	431.3 percent

Figure 2.2A CO_2 Emissions from the consumption of petroleum



Source: Author's calculations

Figure 2.5A Mean of Maximum Temperature of Pakistan

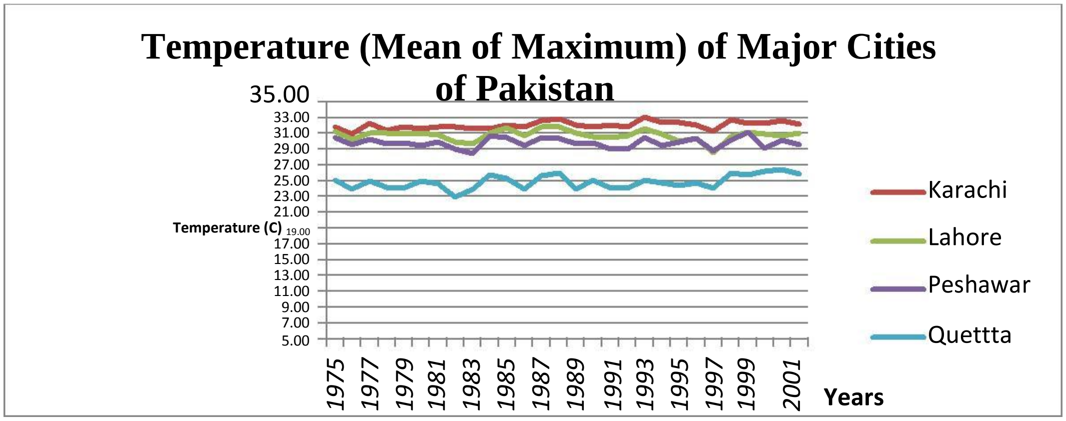
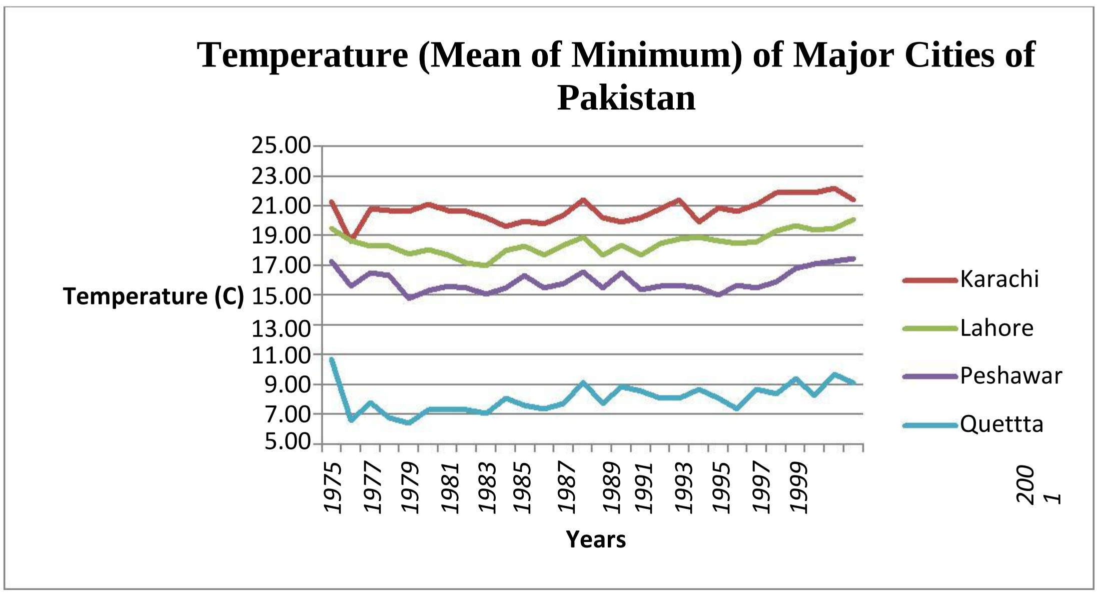
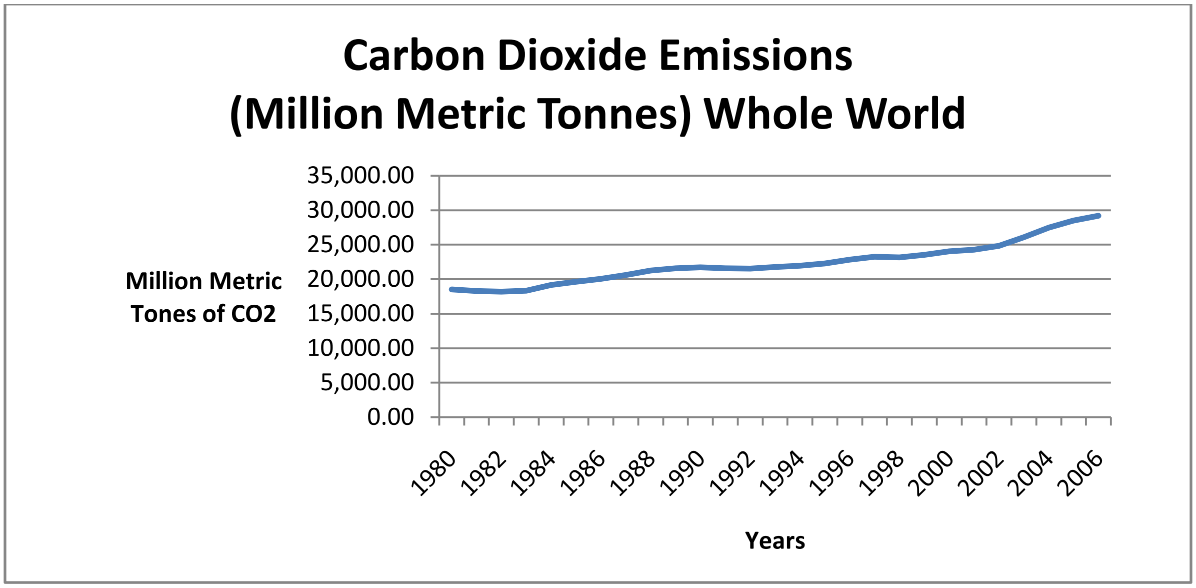


Figure 2.6A Mean of Minimum Temperature Pakistan

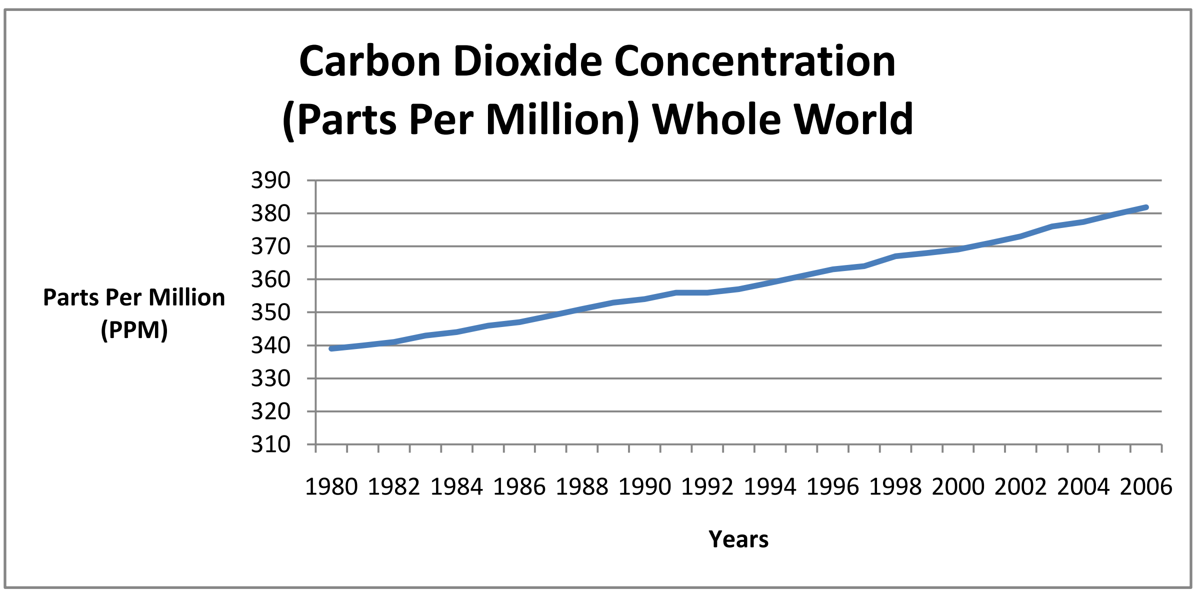


Appendix for Chapter 5

Figure 5.1A Global Emissions and concentration of CO_2



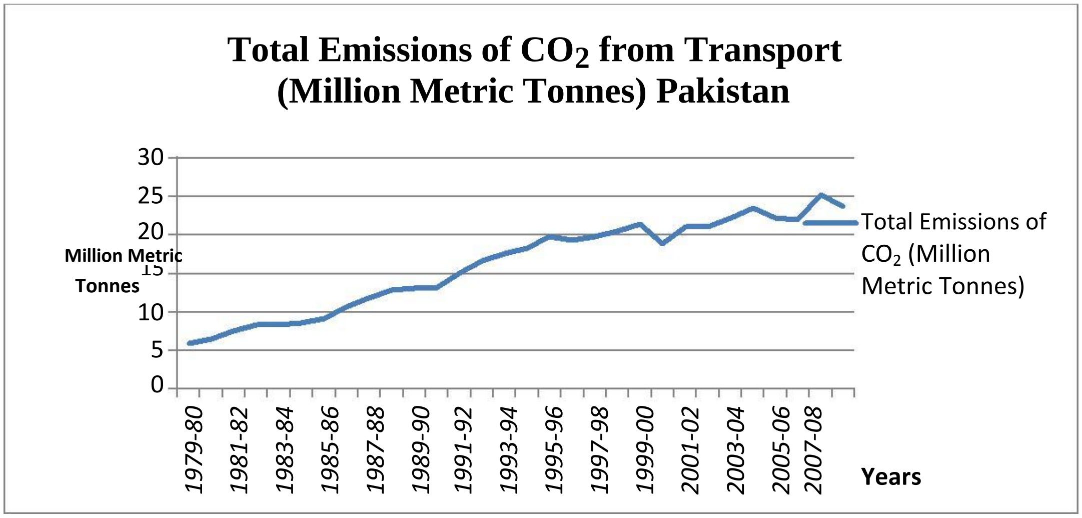
figure



Source: Author's calculations

Figure 5.2(a) shows the total emissions of CO_2 from transport sector and figure 5.2 (b) shows the concentration of CO_2 in each year while figure 5.2 (c) shows the cumulative Concentration of CO_2.

Figure 5.2 (a) Emissions of $CO_2$from transport sector in Pakistan



Source: Author's calculations

Figure 5.2 (b) Concentration of $CO_2$from transport sector in Pakistan in each year.

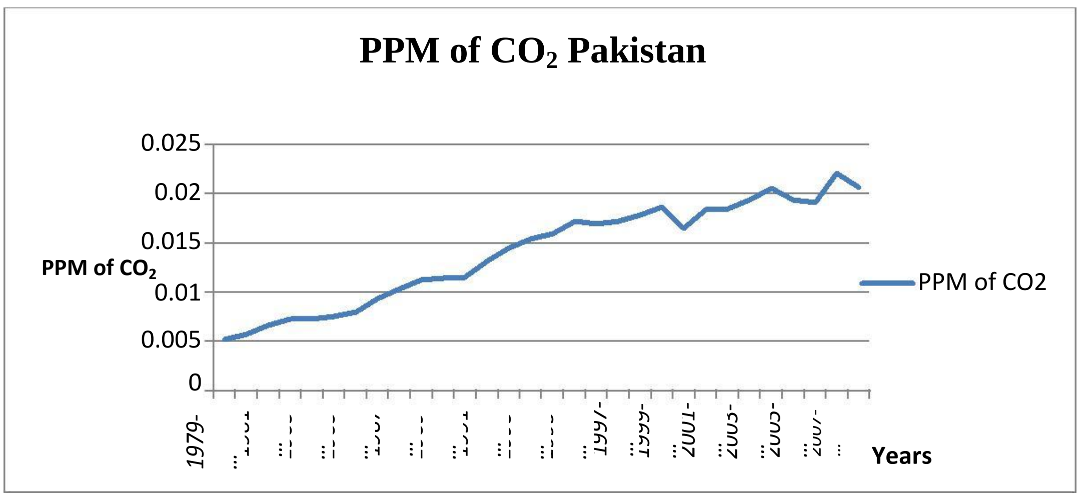
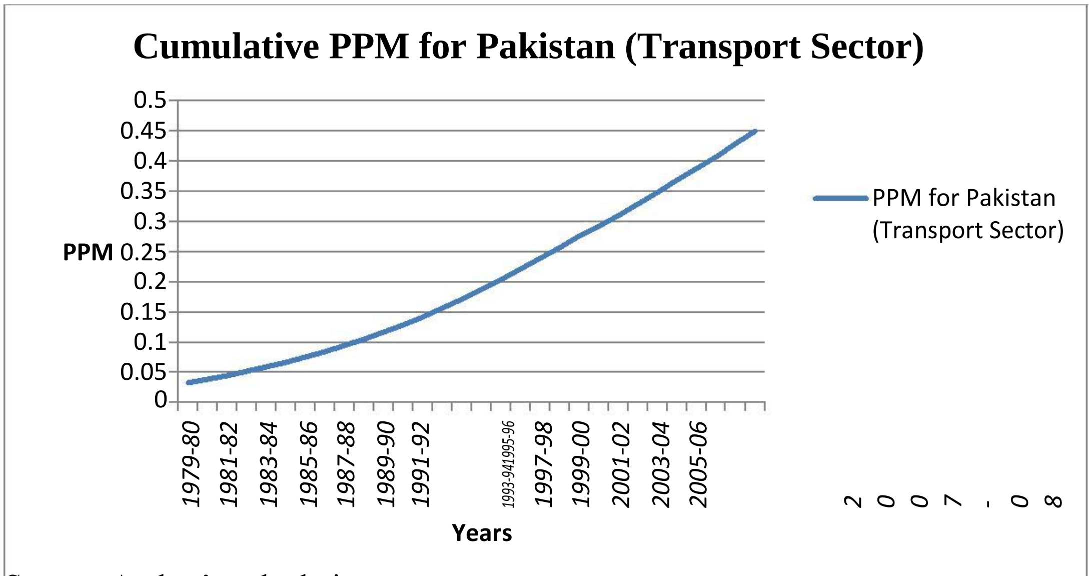


Figure 5.2 (c) Cumulative Concentration of $CO_2$from transport sector in Pakistan.



Source: Author's calculations

Appendix for Chapter 6

Figure 6.2 A: Total patients of Cardiovascular Disease and Daily Temperature of Lahore.

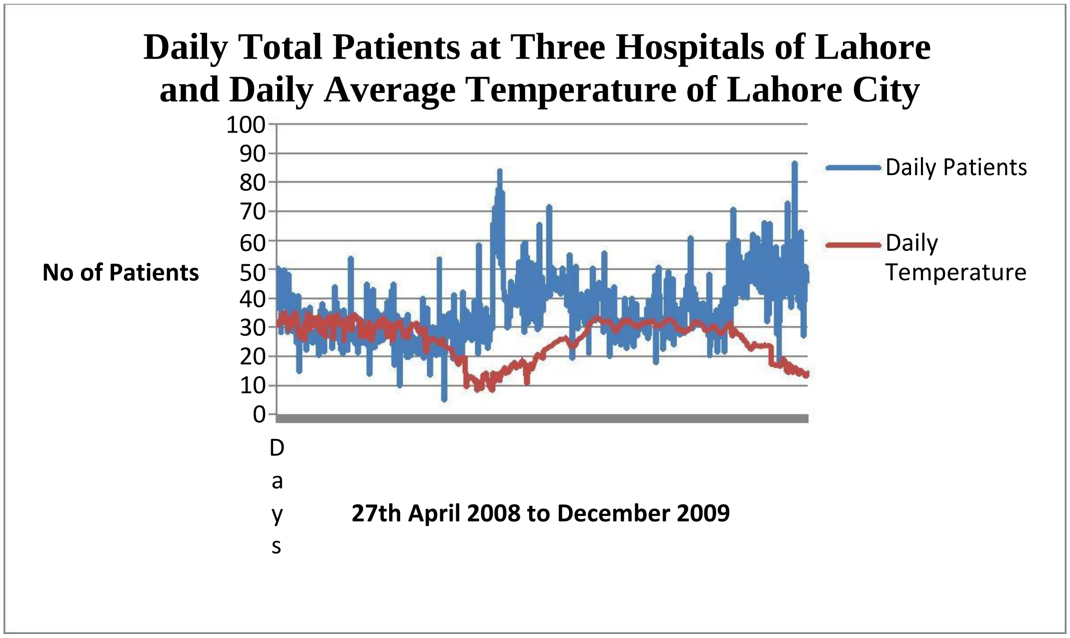


Figure 6.3 A: Patients of Cardiovascular Disease at PIC and Daily Temperature of Lahore.

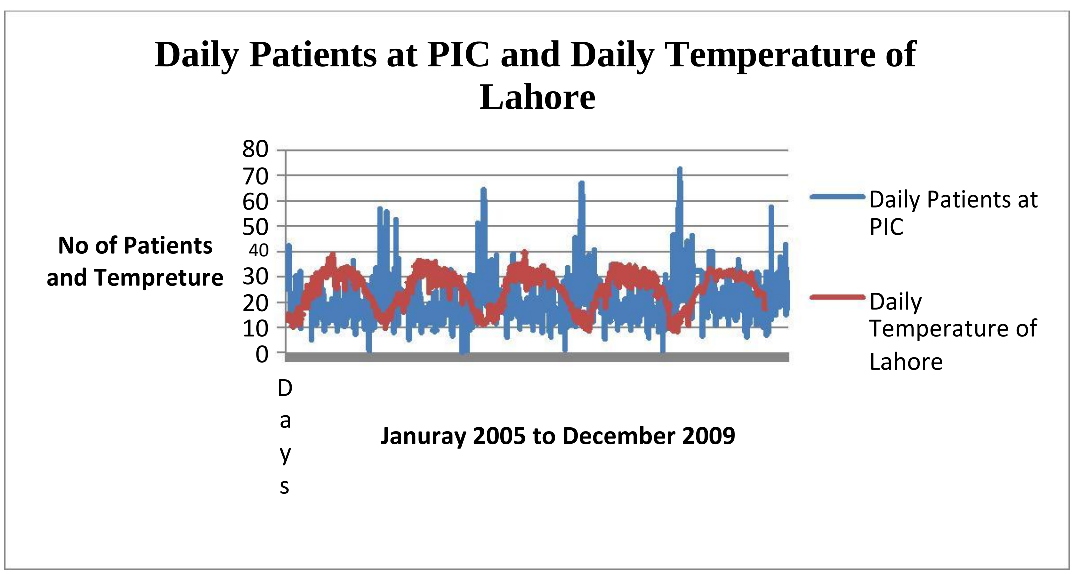


Figure 6.4 A: Patients of Cardiovascular Disease at Sir Ganga Ram Hosptial and Daily Temperature of Lahore.

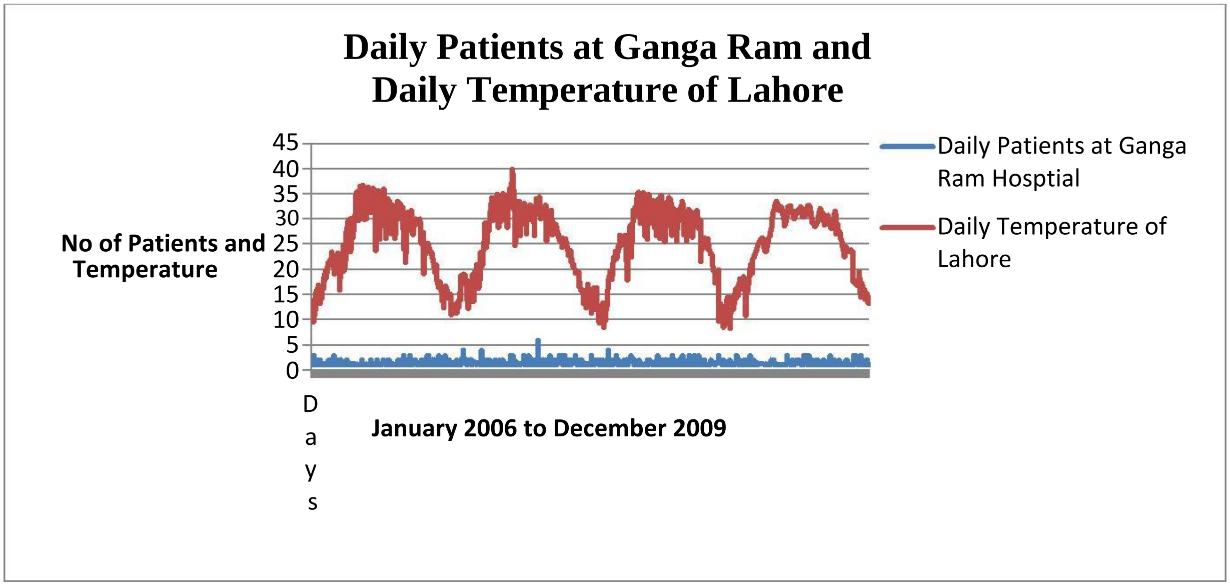


Figure 6.5 A: Patients of Cardiovascular Disease at Jinnah Hospital and Daily Temperature of Lahore.

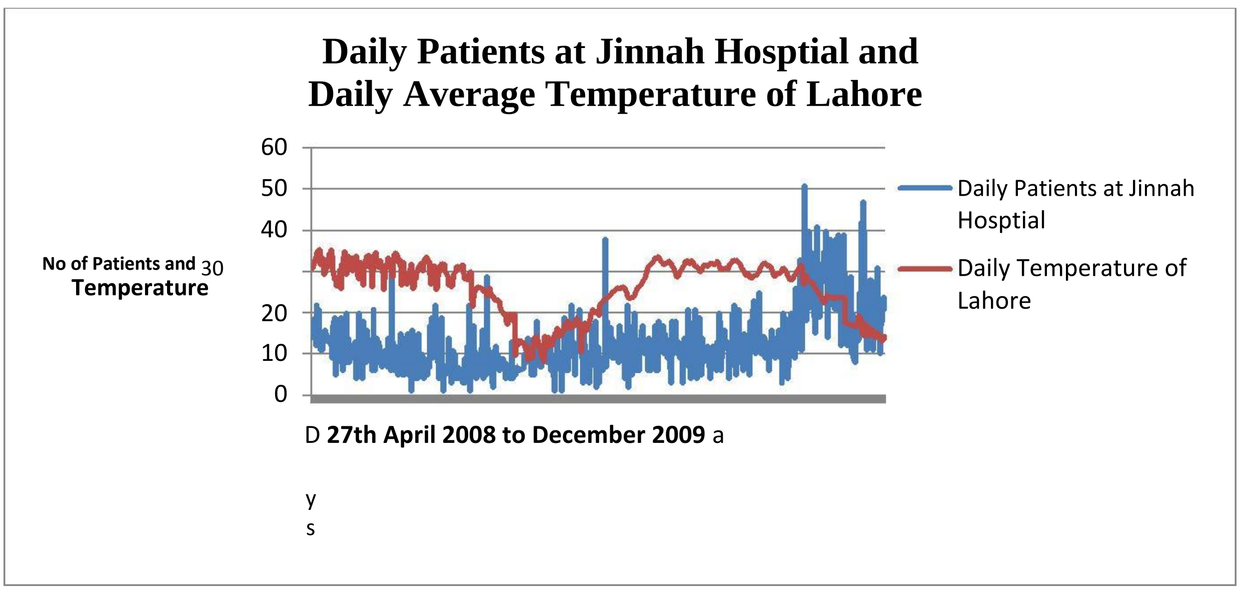


Table 6.3 A Number of Cardiovascular patients at PIC

Year	# of Cardiovascular Patients	Total # of Heart Patients	Percentage of Cardiovascular patients
2005	5632	71337	7.9
2006	5721	71135	8.0
2007	6260	70806	8.8
2008	6102	76737	8.0
2009	6859	86054	8.0

Source: Hospital Sources

Table 6.4 A: Total number of Cardiovascular patients at Sir Ganaga Ram Hospital

Year	# of Cardiovascular Patients	Total # of Heart Patients	Percentage of Cardiovascular patients
2005	N/A	N/A	N/A
2006	476	501	95
2007	511	553	92
2008	513	556	92
2009	480	515	93

Source: Hospital Sources
N/A = Not Available

Table 6.5A: Total number of Cardiovascular patients at Jinnah Hospital

Year	# of Cardiovascular Patients
2005	2687
2006	N/A
2007	N/A
2008	2463
2009	5395

Source: Hospital Sources

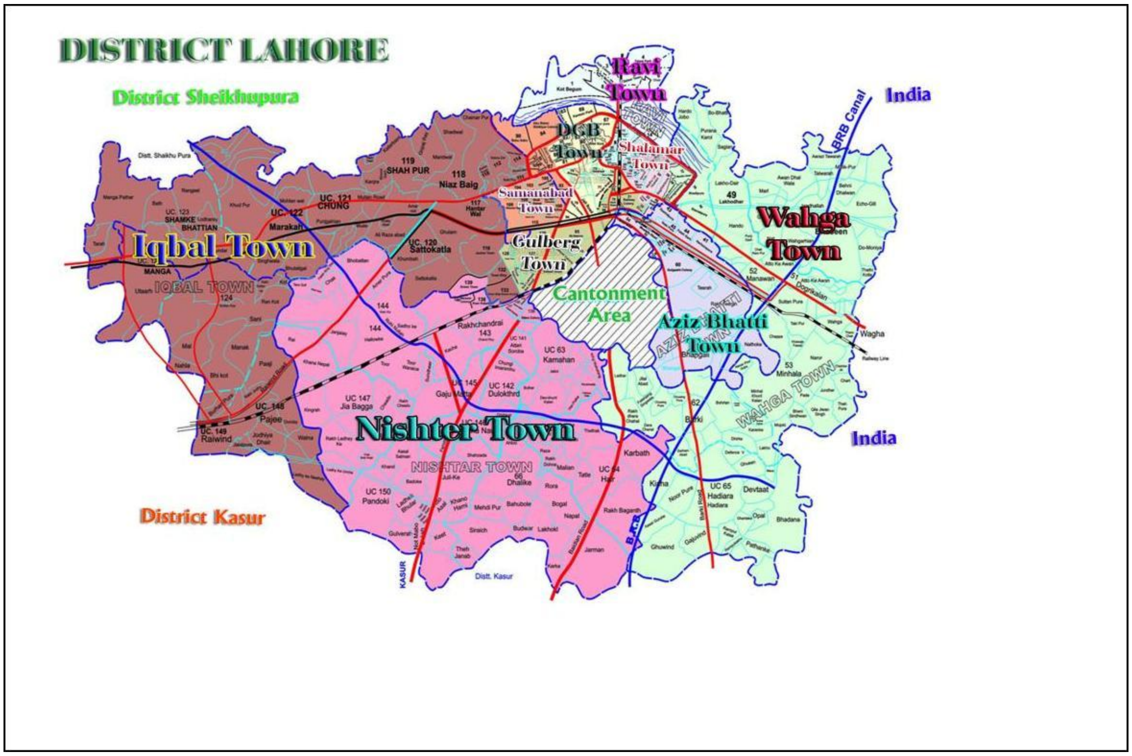
Figure 1.

NOTE: ***(Following Two Photographs are Taken from Environmental Protection Department, TownHall, Lahore)***

VIEW OF HAPHAZARD TRAFFIC AT LAHORE

Figure 2.

Lahore Map.



NOTE: ***<u>(The map of Lahore is taken from Environmental Protection Department, Town Hall, Lahore)</u>***

Survey Questionnaire:

I am conducting a survey for the improvement in health of Lahore citizens. This questionnaire deals with health of the people of Lahore especially for those who are affected with the high temperature. Please take a few minutes to express your opinions to improve quality of health in your community. Your answers are important to the success of this study.

Serial No.______________

Enumerator's Name: __________________________________

A. Demographic Section:

A1. Name of the respondent:__________________________A2. Area ______________________

A3. How many years have you been living in this area____________________________________

A4. Name of the person who is filling the questionnaire__________________________________

A5. Union Council: _____________________

A6. Contact Number:

Home _______________ Office__________________ Mobile_______________________

A7. Please describe your highest level of education (in years): ___________________________

A8 . What is your occupation? ____

A9. Age of the person who is filling the questionnaire____________________________________

A10. Relationship with the head of the family____

A11. Marital status of the person who is filling the questionnaire:

1. Married 2. Never married
3. Widow(er) 4. Divorced/separated

A12. Number of persons in your household:

			Age Group							
Sr. #	Name of the Person	Sex Male/Female	1 to 5 years	5 to 15 years	16-40 years	41-60 years	61 and above	Highest formal education	Profession	Work Place: Indoor /Outdoor

A13. Do you have your own conveyance? Yes No

A14. What type of conveyance you have?

1. A/C car
2. Non-A/C car
3. Two wheeler
4. Other ____

A15. What is the average expenditure on the conveyance? ______________________________

B. <u>Transport Section:</u>

B1. How much you use the following type of transport?

	Code
Private	
Public	

B2. Are you satisfied with the current transport system of Lahore? Yes No

B2(a). If No, do you think that there is a need to change the traffic system in Lahore?

	Code
Congestion	
Pollution	
Time Consuming	
Noise pollution	
Others (specify)	

B3. Would you like to participate to improve the traffic system? Yes No

B3(a) If yes, how would you rank among the following solutions?

Solutions	Rankings Codes
Overhead Brides	
Pedestrians Path	
Pollution Reducing Technology	
New Police Force	

B4. If the above mentioned solutions are implemented and current traffic system is replaced with the new improved system, would you like to contribute this new improved traffic system?

Yes No

B4(a) if yes how much you are willing to pay for improvement in the traffic system? ________

C. <u>Health Section:</u>

C1. Your Health status at present:

[1] Not Good [2] Average [3] Good [4] Very Good

C2. In last month which type of illness you/your family face?

1. Never face.
2. Mild physical health (Minor illness)
3. Moderate physical health (have one or more diseases which have great pain)
4. Severely physical health (have one or more diseases which are threaten to life)

C3. In what intensity you/your family have the following problems?

			Which of the following best describes your capacity to perform routine works?			
Name of the family member	Code for Disease Type	Codes for intensity	Without any assistance	Without much assistance	Need assistance but not for whole day	Need complete assistance

C4. Do you know that high atmospheric temperature affects your health? Yes No

C4(a). If yes, Please mark the disease which you think are related to the high temperature.

	Code
Cardiovascular disease	
Respiratory disease	
Pulmonary disease	
Skin infection	
Ear/nose/throat irritation	
Fever	
Asthma	
Bronchitis	

Cancer	
Headache	

C5. Do you have medical insurance? Yes No C5(a). If yes, amount/annum ___________

C5(b). If yes then what type of insurance you have:

a. Private b. Employer sponsored

c. Government sponsored d. Other

C6. What is the main reason to have insurance?

1. For general health 2. For specific disease

C7. How many times you/ your family members have visited the Doctors/Hospitals last month:

			which type of treatment you prefer				
Name of the Family member	Code for the disease	# of visits	Private Clinic	Private Hospital	Government Hospital	Others	Average Medical Bill

C8. The above mentioned diseases are due to high atmospheric temperature. If I take some actions to introduce a new system that reduce the temperature and save some people from the diseases, would you like to contribute in the new system? Yes No

C8(a) if yes, How much you are willing to pay for the new system? ______________

D. **Mitigating Activities:**

Name of the family member	Code for disease	# of sick days	Travel cost to hospital / Doctor/ month	Total time : (travel and waiting)	Doctor's fees	Cost of medicine/month	Number of days for medication	Accompanying person: Yes No	#of days of absence from work	Wages/ income lost during sick days

E. **Averting Behavior:**

	Yes	No	If yes, what is the average cost you bear
Use of A/C in summer			
Use of chimney/exhaust fan			
A/C car			

F. What is the total income of the household (in Rupees per month)? ________________

1. 10000 or less
2. Between 10001 and 20000
3. Between 20000 and 30000
4. Between 30000 and 40000
5. Between 40000 and 50000
6. Above 50000

Thank you for your cooperation:____

Survey Questionnaire: (For Doctors/Hospitals)

We are conducting a survey for the improvement in health of Lahore and Rawalpindi/Islamabad citizens. This questionnaire deals with health of the people of Lahore and Rawalpindi/Islamabad especially for those who are affected with CARDIOVASCULAR DISEASES (HTN, IHD, MI). Please take a few minutes to express your opinions to calculate the cost of illness and to improve the health policy for Lahore and Rawalpindi/Islamabad cities. Your answers are important to the success of this study.

Serial No.______________

Enumerator's Name: ________________________________

A. Demographic Section:

A1. Name of the Doctor ____

A2. Hospital Name______________________ A3. Designation ___________________________

A4. Contact Number: Home ___________________ Office__________________________

Mobile___________________ E-mail __________________________

B. Cost Section (in Case of EMERGENCY):

B1. Overall Cost of Cardiovascular Patients (Rs/ day):

Minimum______________ Maximum__________ Average__________________

Break-up Cost:

B2. Cost of Medicine (Rs/ day):

Minimum______________ Maximum__________ Average__________________

B3. Hospital Charges (Rs/ day):

Minimum______________ Maximum__________ Average__________________

B4. Doctor's Fee

Minimum______________ Maximum__________ Average__________________

C. Cost Section (in Case of REGULAR TREATMENT IN WARDS):

C1. Overall Cost of Cardiovascular Patients (Rs/ day):

Minimum_____________ Maximum__________ Average_________________

Break-up Cost:

C2. Cost of Medicine (Rs/ day):

Minimum_____________ Maximum__________ Average_________________

C3. Hospital Charges (Rs/ day):

Minimum_____________ Maximum__________ Average_________________

C4. Doctor's Fee

Minimum_____________ Maximum__________ Average_________________

Comments (if any)

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Thank you for your cooperation:____