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Transportation Sector in Kathmandu Valley: Responsible for Significant Amount of Carbon Dioxide Emission & Correlation to Chronic Obstructive Pulmonary Disease (COPD)

by

Gaurav Thapa

A THESIS

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ABSTRACT

For both developing and developed countries, one of the most serious problems is air pollution and also the primary cause of death. Air pollution was the second leading cause of mortality in one of the Kathmandu Valley's main hospitals in 2011, and the third leading cause in the United States. One of the key factors was the use of fossil fuels for transportation. Vehicle registration in the 665-sq.km Kathmandu Valley climbed from 45,871 in 1990/1991 to 570,145 in 2010/2011, a 12-fold increase in 20 years. Various government divisions provided statistics on car registration and the number of COPD patients. A survey of Kathmandu Valley residents was also used to acquire data on average daily commute distance and fuel mileage. This article calculates the quantity of carbon dioxide (CO_2) emissions produced by the transportation industry., and a link between CO_2 emissions and COPD patients is established. The additional environmental pollutants like CO, NOx, SOx, and PM10 were also evaluated in this research. The CO_2 emission in Kathmandu is in increasing trend. The emission in 2020 was approximately 1800 KT, whereas the emission is projected to significantly increase in the next 10 years by 4900 KT, according to the findings. Also, there is a strong positive correlation between CO_2 emission and COPD patient in Kathmandu Valley. To reduce pollutant emissions, a more thorough inspection and maintenance program is required, which must include commercial vehicles. They are also the most essential vehicle category to address when it comes to reducing fuel usage and CO_2 emissions.

Keywords: *fuel consumption, carbon dioxide emission, health impact, Chronic Obstructive Pulmonary Disease*, *Kathmandu valley*

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LIST OF ABBREVIATIONS

CDC : Centre for Disease Control and Prevention

CO_2 : Carbon Dioxide

COPD : Chronic Obstructive Pulmonary Disease

CO_X : Carbon Oxides

DHS : Department of Health Sciences

DOTM : Department of Transport Management

GHGs : Green House Gases

ICIMOD : International Centre for Integrated Mountain Development

IPCC : Intergovernmental Panel on Climate Change

MLitres : Million Litres

NIEHS : National Institute of Environmental Health Sciences

NIH : National Institutes of Health

NO_X : Nitrogen Oxides

PM : Particulate Matter

SO_2 : Sulphur Dioxide

USDOT : United States Department of Transport

VOCs : Volatile Organic Compounds

WHO :World Health Organization

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CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Air pollution is one of the most serious environmental problems, affecting people, animals, agriculture, cities, forests, and aquatic ecosystem (CSE, 2013). Air pollution is increasing day by day in the world as the result of carbon dioxide (CO_2) emission from anthropogenic activities (The World Bank, 2003). We humans are solely responsible for this increment. According to National Institute of Environmental Health Sciences (NIEHS), air pollution is defined as mixture of fine particles created by the combustion of fossil fuels, which directly or indirectly causes harm to human health (NIEHS, 2017). Carbon Oxides (CO_X), Nitrogen Oxides (NO_X), Volatile Organic Compounds (VOC_S), Particulate Matter (PM), and Sulphur Dioxide (SO_2) are the five traditional air pollutants (Holgate, S.T, et al., 1999). Emission of CO_2 have local, regional and global effects. Local effects refer to the quality of ambient air within a few kilometers' radius. Regional effects refer to pollutants such as acid rain, photochemical reactions, and water quality degradation. Global effects refer to ozone layer depletion and global warming induced by greenhouse gas emissions (Rice, S.A., 2003).

In Nepal, air pollution was mainly caused due to a rise in the number of vehicles (14% yearly) and urbanization (4-5% annually) (Jha, P.K., et al., 2003). Vehicles that were not properly maintained were another source of pollution; 23% of vehicles emitted greenhouse gases that exceeded the standard established (Jha, P.K., et al., 2001). Additionally, the bowl-shaped geology of the Kathmandu Valley exacerbated the situation since it enabled the trapping of air pollutants within the surrounding mountains. Consequently, the pollutants were more likely to accumulate and hence cause more severe consequences (CEN, ENPHO, 2003).

The fine dust content in the greater Kathmandu area is well above the safety limit value set by the WHO (The World Bank, 2003). In the Kathmandu Valley, vehicles alone are responsible for 38% of total PM10 emissions of particulate matter (Joshi,S.K.,2003). About 63% of the total PM10 comes from vehicle and road dust, while airborne dust accounts for 25% of the PM10 emissions in the Kathmandu Valley (CDC, 2015). Based on the data available from previous years, it cannot be determined whether the pollution level in Kathmandu is improving or just fluctuating between different numbers with similar pollution. In 2017 the recorded PM2.5 value was 45.9 µg / m³. This was followed by a significant increase of 54.4 µg / m³ in 2018, which suggests that the pollution has worsened significantly from 2017 to 2018 (Shrestha, R.M., et al.,2010).

The NIH (National Institutes of Health) has defined COPD as “a progressive disease which causes difficulty in breathing” (NIH, 2012). COPD includes emphysema, chronic bronchitis, and asthma (CDC, 2015). In 2009/2010, a COPD data from Bir Hospital, which is one of the oldest hospitals, depicted that COPD was the second highest cause of morbidity in Nepal (DHS, 2011). The effects on the health of atmospheric pollution are still a concern for public health all over the world. Subjects with chronic respiratory diseases, such as chronic obstructive pulmonary disease (COPD) and asthma are particularly vulnerable to the harmful effects of atmospheric pollutants. Atmospheric pollution can induce the acute exacerbation of the COPD and the beginning of asthma, increasing respiratory morbidity and mortality.

Air pollution is a big worry for the residents of Kathmandu, threatening the lives of thousands of people every year. If immediate action is not taken in time, this situation will obviously worsen in the next few years. It is imperative to educate ordinary people about the harmful aspects of air pollution and the necessary preventive measures to prevent its fatal consequences.

The three proposed initiatives to tackle air pollution in the Kathmandu Valley: improving and promoting public mode of transportation, improving vehicle speed, and introducing & encouraging the usage of electric vehicles, which might help reduce the energy demand of public transportation by more than 60% (Dhakal, S., 2003).Previous emission inventories soon become obsolete as a result of this fast increase and the associated technical advancements.

1.2 Problem Statement

What is mainly worrying is between 1971 and 2004, the rate of growth of carbon dioxide emissions, including through the use of more fossil fuels, is estimated to increase at a rate of 10% per year of vehicles (Levine et al, 2007). With the increase in number of vehicles inside Kathmandu Valley, the potential of greenhouse gases emission also increases, yet the study of carbon emission from individual is unexplored.

The increase in vehicles inside Kathmandu Valley, increases the fuel usage eventually increases the emission of carbon dioxide. Also hand in hand there is emission of other environmental pollutants like Carbon Monoxide, Nitrogen Oxides, Sulphur Oxides and Particulate Matters which directly affects the health in people. So there is huge chance of having asthma, bronchitis and Chronic Obstructive Pulmonary Disease (COPD).

Transportation currently accounts for about 55% of total Nepal GHG emissions, and this is expected to rise in the future as population and economic growth, combined with GHG emission reductions in other sectors (such as, housing and industry), will focus attention on all modes of transportation (Transportation Research Board, 2010)

1.3 Research objective

The main objective of the study is to estimate the amount of carbon dioxide emission from transportation sector in Kathmandu Valley and to assess its correlation with COPD patient.

The specific objectives of the study are as follows:

- To calculate the fuel usage and assess the factors for emission of CO_2 gas
- To evaluate the correlation between CO_2 emissions and COPD patients
- To calculate the other emissions like CO, HC NOx and PM10

This study attempts to address the following research questions:

- How much fuel (petrol/diesel) is used inside Kathmandu Valley ?
- What would be the mitigating /adapting measures to control carbon emission from transportation sector?

The Research is guided by following breakdown of the study into several areas. To answer the above questions, the following assessment has been done.

- Vehicle Type and Fuel (Petrol/Diesel) Used in the Kathmandu District.
- Categorization of Heavy, Light and Two Wheelers.
- Study of standard emission rate from petrol engines and diesel engines.
- Study of distance travel and mileage daily with survey data.
- Study of COPD patients inside Kathmandu Valley from different hospitals.

1.4 Scope of the Study

The study made an attempt to find and understand the total fuel usage and carbon dioxide emission from the vehicles inside the Kathmandu Valley. Vehicles are classified into heavy, light, and two wheelers category. The Heavy vehicles use diesel where light vehicles and two wheelers uses petrol as fuel. This article explores the physical reach of air pollution and their potential contributions to health impact. Much of this potential lies in the ability of these technologies to address issues that are generally on the fringes of the air pollution agenda. Air pollution monitoring tends to focus primarily on human health and largely ignores other aspects of sustainable development. Many air pollution-related aspects of the sustainability of development in human systems are not being given their due attention. Opportunities exist for air pollution monitoring to attend more to these issues. Improvements to the resolution and scale of monitoring make these opportunities realizable

1.5 Limitation of Study

The limitations of this study can be summarized by the following categories;

- Failed to address the exact number of vehicles operating inside the Kathmandu Valley.
- Failed to limit the efficiency of older vehicles.

1.6 Area of Study

Study area covers the area of 665 km^2. Kathmandu Valley stands at an elevation of approximately 1400m above sea level. Due to this shape and hillside, Green House Gases have no dispersion & are trapped in the valley. The research area is mixed residential and commercial urban area with densely populated and dense traffic (Pant, et al, 2009). The valley of Kathmandu is formed like a bowl. Shivapuri Hills (at an elevation of 2,732 meters), Phulchowki (2,695 meters), Nagarjun (2,095 meters), and Chandragiri (2,095 meters) encircle the Kathmandu valley.

Figure 1.1 Map of Kathmandu Valley

CHAPTER TWO: LITERATURE REVIEW

2.1 Green House Gases

Greenhouse gases stair heat and make the planetary warmer. Human activities are responsible for almost all increase in greenhouse gases in the atmosphere in the last 150 years (Shrestha, et al., 1996). The largest source of greenhouse gas emissions from human activities in Kathmandu Valley is from burning fossil fuels for transport. In 2016, the Nepal Air Quality Environmental Performance Index (EPI) is ranked 177th from 180 countries and in Asia, Kathmandu is one of the most contaminated cities (Dhakal, S., 2003).

This chapter provides a review of technical expressions related to climate change and fuel usage & carbon dioxide emission from the transportation sector in Kathmandu Valley. Carbon dioxide emission comprises from two types of engines i.e., petrol engines and diesel engines. The standard emission rate from respective engines is studied with the reference from US emission standards . The research begins with the study of available literatures and references having different ideas of transportation category, cumulative vehicles from year 1989 to 2020, fuel usage and CO_2 emission.

This paper presents a review of carbon dioxide (CO_2) emissions from transportation in an attempt to establish a quick and suboptimal update of the methods used to calculate and analyze CO_2 emissions from transportation. Transportation is the largest contributor to air pollution through the release of high amounts of CO_2 gas into the atmosphere. The methods for calculating and analyzing the carbon footprint of transportation; which is of critical importance in the management of greenhouse gases that contribute to global warming; are still being developed.

Economic activities and development projects are essential in the pursuit of the modernization of a country and improvements of the standard of living of the population of a country. However, the environmental problems caused by the implementation of these economic activities and development projects are often ignored. Rapid expansion and development have caused numerous adverse environmental impacts. In consequence, this has an adverse impact on human health, the national economy and natural resources (Environment Quality Act, 2012). In this respect, air pollution has caused the greenhouse gas effect. Greenhouse gases trap heat in the atmosphere. There are four main greenhouse gases, namely carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and fluorinated gases. Table 2.1 presents the characteristics of these gases. Greenhouse gases are released by the combustion of fossil fuels, deforestation, industry, fermentation by enteric bacteria, among other factors.

Table 2.1: Characteristics of Green House Gases

<table>
<tr><th>Types of Green House Gases</th><th>Source</th><th>Removal Source</th><th>Gas Reaction</th></tr>
<tr><td>Carbon Dioxide</td><td>• Burning of fossil fuel
• Deforestation</td><td>• Photosynthesis process
• Ocean</td><td rowspan="3">• Absorption of infrared radiation
• Indirectly affect the ozone concentration in the stratosphere</td></tr>
<tr><td>Nitrous Oxide</td><td>• Burning of biomass
• Combustion of fossil fuels
• Fertilizers</td><td>• Removal by soil
• Photolysis in the stratosphere</td></tr>
<tr><td>Sulphur Oxide</td><td>• Emitted through various industrial processes</td><td>• Photolysis and reaction with oxygen</td></tr>
<tr><td>Hydrocarbons</td><td>• Burning of biomass
• Rice paddies
• Fermentation by enteric bacteria</td><td>• Microorganism uptake
• Reaction associated with hydroxyl groups</td><td>• Absorption of infrared radiation
• Indirectly affect ozone concentration and water vapor in the stratosphere
• Production of CO_2</td></tr>
</table>

(United States Environmental Protection Agency, 2019)

This will result in the melting of polar ice sheets and mountain glaciers, higher global temperatures and rising sea levels (Mason-Delmotte, et al., 2018). There are many sources contributing to CO_2 emissions, such as the generation of electricity, commercial and residential buildings, agricultural activities, land use and forestry, industry and transportation (Olivier, et al., 2018). Of these sources, the major contributor of CO_2 emissions is urbanization and transportation because transportation is essential for carrying out daily activities, such as commuting to and from work and school or traveling. As the amount of these gases increases, they heat up and slow down the heat release process. The continuously increasing amount of CO_2 emitted by transportation has raised concerns. There is an urgent need to gain a clear understanding of the factors, types and quantities of fuel consumed and how the increasing amount of CO_2 emissions is contributing to global warming (Olajire, et al., 2018).

2.2 Sources of GHG Emissions

The transportation sector generates the largest share of greenhouse gas emissions. Greenhouse gas emissions from transportation primarily come from burning fossil fuel for our trucks, bus, excavators, cars, minibus, and two wheelers. There are many factors that contribute to air quality deterioration. Nepal is a rapidly urbanizing country. 2012 data shows that 4.6 million Nepalese live in urban areas (Khanal P, 1987) This trend is growing rapidly and the urban population is projected to reach 60 million by 2040 (Nepal Republica Media, 2012). The subsequent increase in the number of vehicles is one of the chief culprits of air pollution. The number of vehicles in the Kathmandu Valley has increased rapidly over the past 30 years.

2.3 Carbon Dioxide Emissions from Transportation

The increasing reliance on motor transport has led to the increased release of greenhouse gases, especially CO_2, which have an adverse impact on the environment and, in turn, contribute to global warming and climate change. The combustion of gasoline in an engine produces CO_2 and N_2O, which contributes to ozone depletion. In addition to burning fossil fuels, these vehicles release pollutants into the air that cause environmental damage. The quality of air is determined by the type of transportation system used. The use of motor vehicles is a major contributor to CO_2 emissions, and the amount of CO_2 emission is expected to rise if substantive steps are not taken to deal with this problem. The transport services sector has witnessed a rapid rise in the past four decades, with the continuous increase in carbon dioxide CO_2 emissions from this sector becoming an important worldwide issue. According to the International Transport Forum, CO_2 emissions from the road transport sector represent 30% of the overall carbon dioxide emissions from fossil fuel burning. The transport sector accounts for around 15% of total GHG emissions. Moreover, there was a 45% increase in global CO_2 emissions from 1990 to 2007. This continuing rise in CO_2 emissions from road transport is an immense challenge for road authorities and governments.

2.4 Burden of Air Pollution

According to the World Health Organization (WHO) report in 2008, 1.3 million deaths were estimated to be related to ambient air pollution globally. The figure became 3.7 million in 2012, which was nearly tripled. Two million deaths were attributable to the effects of household air pollution in 2008. This number also increased as nearly doubled (4.3 million) according to the latest report based on 2012 data by WHO recently. More than two million premature deaths each year were related to air pollution. Globally, seven million deaths were attributable to the joint effects of household and ambient air pollution in 2012.

Air pollution has impact on most of the organs and systems of human body. Air pollutants can induce and aggravate diseases like cardio cerebral vascular disease, ischemia heart disease. Air pollution even has adverse effects on nervous system, digestive system, and urinary system. Long-term ambient air pollution exposure was reported to increase all-cause mortality. Air pollution is the cause and aggravating factor of many respiratory diseases like chronic obstructive pulmonary disease (COPD), asthma, and lung cancer.

Struggle against air pollution seems to be a longtime task for both developed countries and developing countries, especially China. Apparently, as the air pollution remains a severe problem worldwide, to understand what constitute the air pollutants and what benefit measures could be taken is of help for people especially those with chronic respiratory diseases.

2.5. Impact of air pollution on human health

The health effects of air pollution remain a public health concern worldwide. Detrimental effects of air pollution were confirmed to be associated with growing morbidity and mortality. The adverse effects vary with the kinds of pollutants and locale. For instance, outdoor air pollutants like PM, NO_2, and SO_2 can increase mortality. Long-term exposure to fine PM can increase mortality, particularly from cardiovascular disease. It is reported that air pollutant such as O_3 can increase the risk of appendicitis. Higher levels of ambient O_3 exposure may even increase the risk of perforated appendicitis.

Inspiration of PM containing PAHs and diesel was correlated with an increased risk of bladder cancer. Populations in cities, where the air pollution is usually severe duo to local high concentrations of pollutants from industry and vehicle emission, are at higher health risks. SO_2 in the urban centers could increase children's hospital admissions. High concentrations of ambient particles can trigger the onset of acute myocardial infarction and increase hospitalization for cardiovascular disease.

COPD is characterized by an enhanced chronic inflammatory response in the airways and the lung to noxious particles or gases. Research demonstrated that women in developing countries had a high risk for chronic obstructive lung disease duo to exposure to household wood smoke from cooking. Air pollutants such as particular materials from fossil fuel combustion can cause inflammation in the lung and further impaired the reduced pulmonary function in COPD patients.

When exposed to particle pollution, patients with COPD usually have more emergency room visit, hospital admission, or even death in some cases. Infection is one of the inducing factors of exacerbations of COPD. As PM can bring many micro-organisms on the surface, inhalation of PM may contribute to more frequent exacerbation of COPD. Other mechanisms including the detriment of mucociliary clearance, increase of the adherence of virus to respiratory mucus cells, and impairment of the resistance ability of immune system are all involved in the adverse effects of pollutants.

2.6 Review of GHG Emissions Calculation Method

Usually there are mainly two methods for the calculation of environmental impacts (GHG emissions also included).Mainly process-based and economic input–output analysis based. Process-based method is a simple model in which different activities associated with a product or a service is analyze using process flow diagrams (Guggemos AA, Horvath A, 2005). For every activity, all materials and energy used in the process are identified in whole process. Thus, the environmental impacts and emissions can be measured accounting for vehicle usage and consumption of the energy. Investigated the energy consumption of vehicles and calculated the CO_2 emission due to combustion of petrol and diesel (City Council, 2009)

Economic input–output analysis-based method considers both the direct environmental impact of a product or a service, as well as all indirect impacts involved in the supply chain. USA and Japan researchers have adopted the input out method, probably because the Input/Output Table of USA and Japan contains more than 400 sectors, which is elaborate enough to assess the environmental impacts in the construction industry.(Baidya S, Borken-Keefeld, 2009). By using this method CO_2 emission from transportation sector is calculated.

2.7 Measures for reducing adverse effects of air pollution in general

The detrimental effects to health from air pollution are largely determined by the concentration of air pollutants and the amount of exposure time. People can take many measures to reduce the amount of pollutant inhalation. Some measures are appropriate for all people. Some others are of particular importance for those with chronic respiratory diseases. People should keep a good living habit and regulate their daily activity according to the local air quality report. For people with chronic respiratory disease like COPD, reduction of exposure to indoor and outdoor air pollution can reduce the risk for acute exacerbation of COPD. For asthma patients, less exposure can reduce the onset of asthma. Regular treatments under the guidance of physicians are recommended. Because air pollution usually maintains at different level for days or months, taking extra measures is of help for people especially those with chronic respiratory diseases.

2.8 Article Reviews

The reviews of the American Thoracic Society (ATS), up to May 2008, and a special report from the Health Effects Institute (HEI), up to October 2008, have both addressed the role of ambient air pollution in the development of COPD, *i.e.* the long-term effects. In the ATS review, which focused on the causes of COPD other than active smoking, the conclusion was that there is limited/suggestive evidence for a role of ambient air pollution. The incidence of COPD doubled after the great London fog of 1952 (as demonstrated by autopsy), suggesting that short-term exposure to ambient air pollution may adversely affect the health of people with COPD. Whether chronic exposure to air pollution will lead to COPD remains unknown, with different regions reporting varying results, and sufficient confirmatory evidence remains lacking.

Developed western countries have conducted large cohort studies to examine the relationship between chronic air pollution and COPD over the past decade, while only a few related studies have been conducted in China; several key studies have been summarized.

PM and NO_2 are the most studied pollutants, followed by O_3 and SO_2. The European Study of Cohorts for Air Pollution Effects (ESCAPE) is a large European cohort study evaluating the chronic health effects of air pollution and involves 13 countries with an average follow-up time of 14 years. Using data from ESCAPE and land regression models, Schikowski et al analyzed the correlation between the annual mean concentrations of PM and NOx and COPD prevalence during a 3-year follow-up period (2008–2011).

Research conducted by J. Sunyaron on the short-term effects of air pollution, case definition was based on doctor diagnosis in death certificates and clinical records, as well as in self-reported daily variations of symptoms and treatment in patients with a diagnosis of COPD based on clinical criteria. Mortality due to COPD was based on diagnosis labels in death certificates. Although acute exacerbations are considered to be the most common cause of hospital admission in COPD patients, there is no well-established definition, and the studies have used the diagnosis labelling stated in medical records.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

Research methodology simply refers to the practical "how to" of a particular research paper. More specifically, it is about how a researcher systematically designs a study to ensure valid and reliable results that match the research goals and objectives.

Every research project begins with the selection of a research topic and the determination of a final destination. It basically responds to the research design in a variety of ways in order to achieve the end goal. The research design and data calculation are critical to the success of any study.

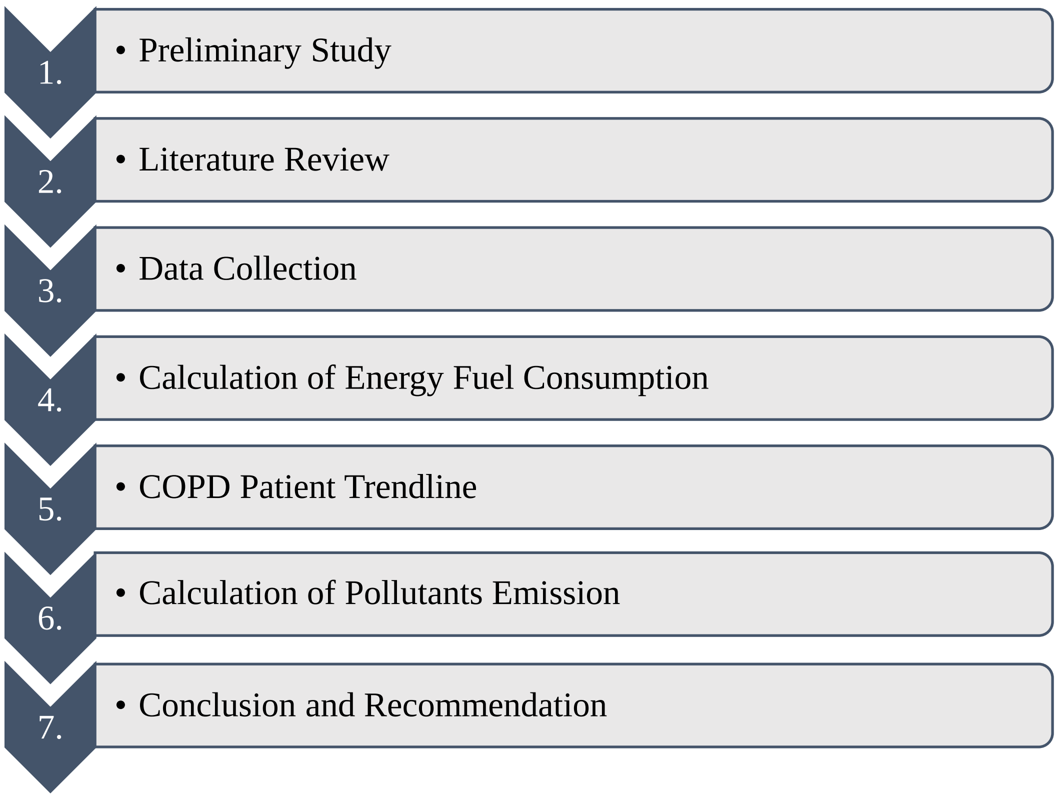

Figure 3.1: Flowchart of Research Design

The carbon dioxide emission is calculated by using the data from different vehicle and fuel type. The carbon dioxide emission from the vehicles is calculated on the daily basis and further calculated for yearly basis. Number of COPD patients have been admitted due to air pollution and data from hospitals are taken for the graphical representation and correlation is calculated on the basis of patients and quantity of emission of CO_2.

3.2 Data Collection & Analysis

Data collection is the process of collecting and measuring the data on targeted variables through a thoroughly established system to evaluate outcomes by answering relevant questions. In terms of data collecting, there are four options: in-person interviews, mail, phone, and internet. Mostly here, the internet archives is used for the research and physical survey is done in limited amount of time.

The DMV (Department of Motor Vehicles) in Kathmandu, Nepal, and the ICIMOD (International Centre for Integrated Mountain Development) in Kathmandu, Nepal, provided data on motor vehicles in the Kathmandu Valley. The vehicle data was collected between 1989 and 2020 and is shown in Table 3.2 (ICIMOD Homepage, 2017).

A survey of drivers was used to acquire data on vehicle trip mile per day and vehicle miles. Drivers were given two questions the amount of time they drove on average per day and the number of kilometers their vehicles travelled on a liter of fuel. Subsequently, the calculation of fuel consumption rate (diesel and gasoline) by the light vehicles (gasoline), heavy vehicles (diesel), and motorized two-wheelers were done separately.

The total calculated amount of CO_2 emission was shown in figure based on the fuel use. The CO_2 emissions were found to be growing exponentially. The total calculated amount of CO_2 emission was shown in Fig. 5 based on the fuel use. The CO_2 emissions were found to be growing exponentially.

CO_2 is a traditional air pollutant. COPD patient data was studied from 1997/1998 to 2011/2012 to see the effects of CO_2 emissions. The COPD data was gathered from the DHS's annual reports (Department of Health Services) The trend of COPD patients admitted is shown in result section which is also increasing exponentially.

Also, the other environmental pollutants are collected from the five data references and these are tabulated as follows:

Table 3.1: Equivalent gram of pollutant per kg of CO_2

	gram of pollutant per Kg of CO_2			
CO_2	CO	HC	NO_X	PM10
1 kg	33.5	11.1	13.5	1.9

ADB, 2006. Energy Efficiency and Climate Change Considerations

The following steps were taken for the research:

- The data of vehicle registration was taken from The Department of Transport Management in Kathmandu. This data was divided into three main categories: light vehicles, heavy vehicles, and motorized two-wheelers.
- A survey of valley inhabitants was done to ascertain mileage of the vehicles and the travel mile per day for the three categories of vehicles.
- Every year, older vehicles become less efficient due to wear and tear, and hence, eventually they consume more fuel. As a result, the USDOT Bureau of Transportation Statistics data were utilized to determine the fuel consumption of older automobiles.

The pollution requirements in the Kathmandu Valley are not the same as those in the United States. Due to a shortage of data, CO_2 emission data from the USEPA (Environmental Protection Agency) from 2012 was utilized instead. Here diesel emits 2.66 kg/L (22.2 lbs/gallon) and gasoline emits 2.33 kg/L (19.4 lbs/gallon) of CO_2 (EPA, 2005).

Finally a hypothesis is created that Carbon Dioxide is correlated to Chronic Obstructive Pulmonary Disease. So, we plot the correlation between the carbon emission from transportation sector and the data of COPD.

Table 3.2: Cumulative vehicle from 1989 to 2020 and % increase

Year	Heavy	Light	2- Wheelers	Sub Total	% increase
1989/90	3386	12626	18594	34606	
1990/91	3883	13893	22357	40133	16.0%
1991/92	4349	15599	28240	48188	20.1%
1992/93	4839	17657	33103	55599	15.4%
1993/94	6474	20720	40006	67200	20.9%
1994/95	7026	23253	47964	78243	16.4%
1995/96	7664	25646	57796	91106	16.4%
1996/97	9254	28445	67663	105362	15.6%
1997/98	9993	31555	74481	116029	10.1%
1998/99	10715	33734	84003	128452	10.7%
1999/00	11594	37403	94081	143078	11.4%
2000/01	12716	41556	112809	167081	16.8%
2001/02	14140	44810	135344	194294	16.3%
2002/03	15401	47868	154666	217935	12.2%
2003/04	16353	53180	172955	242488	11.3%
2004/05	17494	56532	191941	265967	9.7%
2005/06	19584	60742	212942	293268	10.3%
2006/07	20974	65419	245445	331838	13.2%
2007/08	23148	69579	281839	374566	12.9%
2008/09	25925	75170	323893	424988	13.5%
2009/10	28926	84318	394420	507664	19.5%
2010/11	30857	91223	449512	571592	12.6%
2011/12	32045	99494	494406	625945	9.5%
2012/13	33766	108992	548457	691215	10.4%
2013/14	36052	120630	601951	758633	9.8%
2014/15	39656	132811	657795	830262	9.4%
2015/16	45578	157749	722722	926049	11.5%
2016/17	52956	175907	817473	1046336	13.0%
2017/18	60427	197458	906108	1163993	11.2%
2018/19	68402	220890	998112	1287404	10.6%
2019/20	76198	243542	1095588	1415328	9.9%

Table 3.3: Avg Vehicle distance travel and fuel consumption of Vehicle

Description	Fuel Used	Avg Vehicle Distance Travel	Avg Vehicle Mileage (L/ KM)
Heavy Vehicles	Diesel	70	4.5
Light Vehicles	Petrol	45	10.5
2 Wheelers	Petrol	22	32

3.3Calculation of energy consumption

To calculate the use of diesel and petrol, we take the survey data.

Fuel consumed per day = N * VC* FD

Where N = number of vehicles

VC = vehicle coefficient (0.8)

FD = fuel consumed per vehicle

Therefore, we calculate the fuel consumed in a year by multiplying by 365. We keep the units in million liters.

For the emission of CO_2, we use the standard rate given above for the respective fuel.

3.4 COPD Patient

In both developed and developing nations, COPD is one of the main causes of illness and death (ATS, 2017). COPD is presently causing more fatalities in Asia than it is in affluent Western nations, both in terms of overall number of deaths and disease burden (Brunekreef, B., Holgate, S.T., 2002). The crude prevalence of COPD in a rural population in Nepal was 18 percent in symptom-based research. Another research conducted in Nepal Medical College Teaching Hospital (NMCTH) found that 17.3 percent of the population had COPD.

Figure 4.4 depicts the COPD patient data. According to Figure , the number of COPD patients admitted grew rapidly from 4,136 in 1997/98 to 19,401 in 2012/13 (DHS, 2011). COPD patients are on the rise in the Kathmandu Valley for a variety of factors, including air pollution, cigarette smoking, chemical exposure, and genetics. Additionally, as a city's population grows, so does the number of COPD patients. A graph was drawn between CO_2 emissions and COPD patient per 1,000 population to evaluate the link between CO_2 emissions and COPD patient admission in hospitals, as shown in Figure 4.5

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Results

This research has a substantial influence on the computation of CO_2 emissions produced by the transportation industry, as well as the impact on the health of Kathmandu Valley inhabitants. The overall number of cars rose by 12 times between 1990/1991 and 2010/2011, according to vehicle registration statistics.

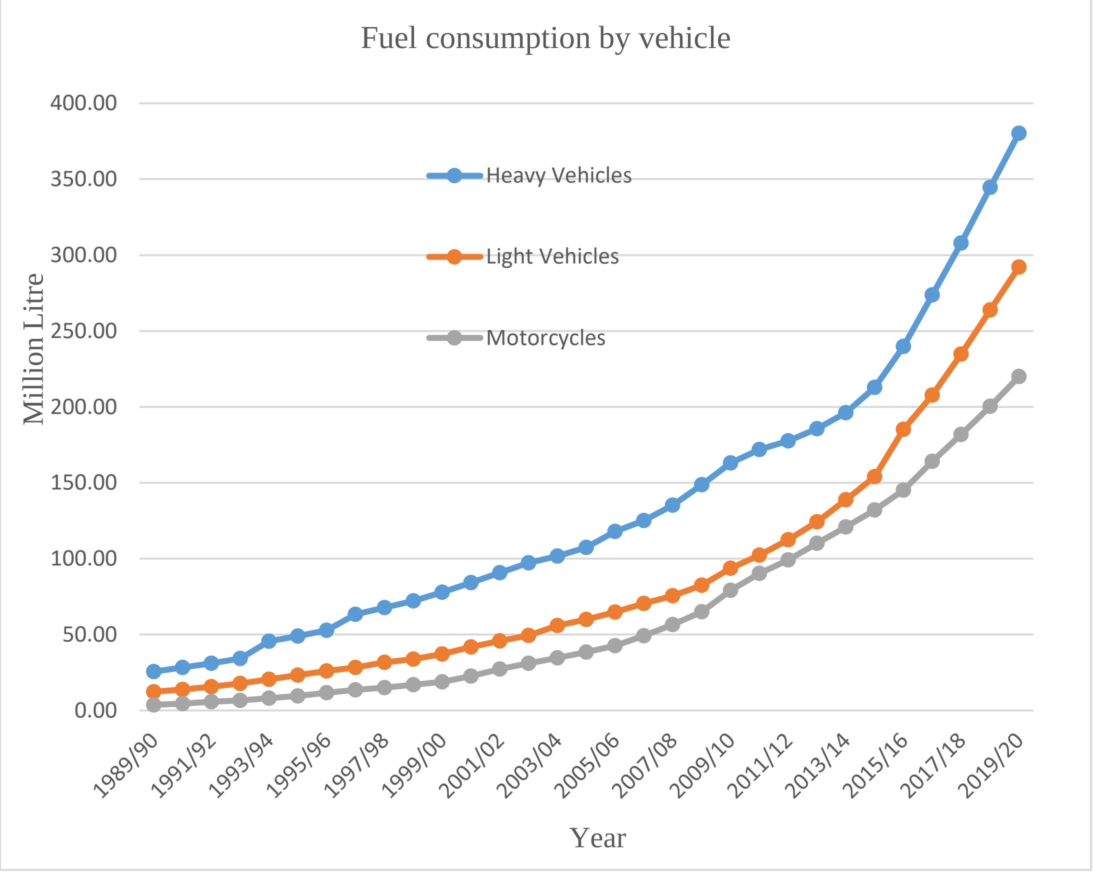

Figure 4.1: Fuel Consumption by different types of vehicles

Figure 4.1 represents trend lines of fuel consumptions by different vehicles in three main categories. The Categories are Heavy vehicles, Light vehicles and motorcycles. In the graph, the x axis represents the timeline (in years) from 1989 to 2020. Similarly, the y-axis shows the fuel consumption in liters in millions. In the figure, we can see that the fuel consumption has increased over the years. The trendline is in increasing trend, therefore, the fuel consumption is likely to increase in the future years as well.

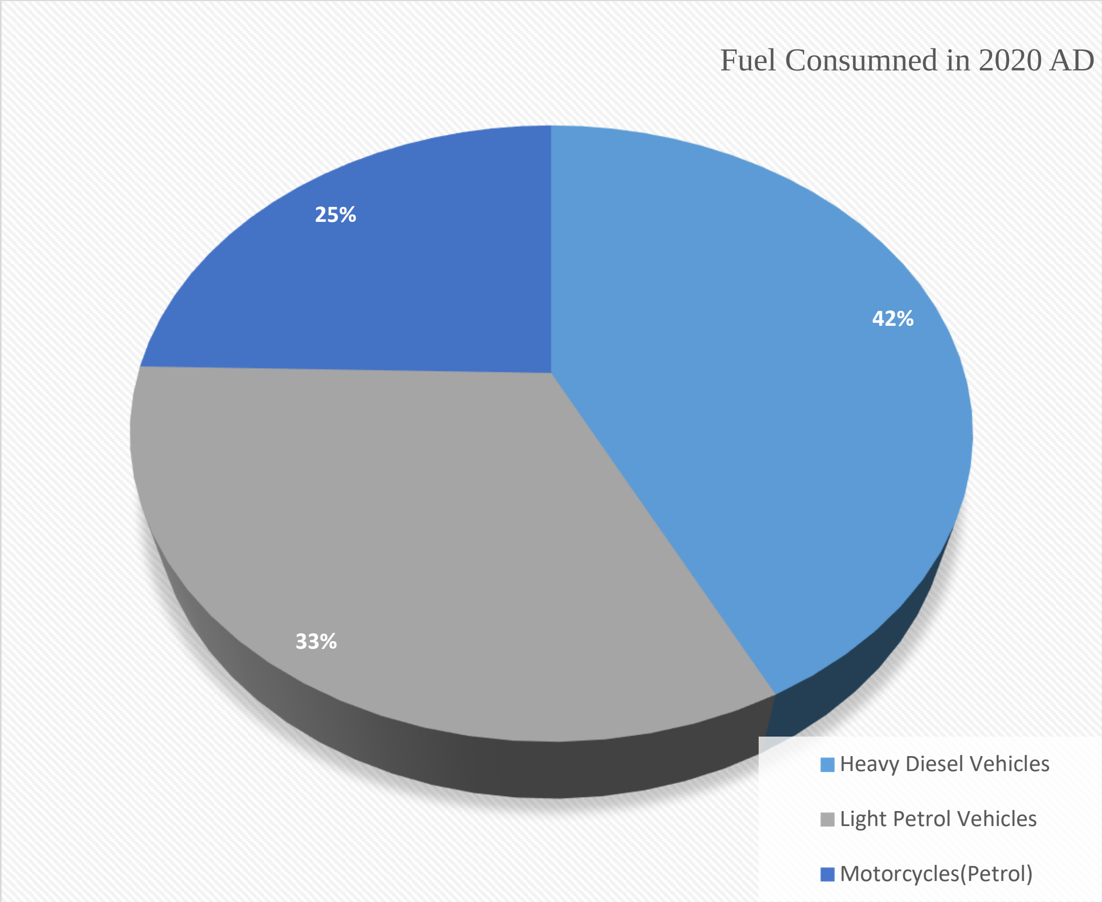

Figure 4.2: Recent use of fuel by different vehicles

Figure 4.2 represents pie chart of different types of fuel consumed by different vehicles in three main categories. The Categories are Heavy diesel vehicles, Light petrol vehicles and motorcycles (petrol). In the chart, we can see that diesel in heavy vehicles is 42% of the overall fuel consumed and is the most consumed fuel. This is followed by light petrol vehicles at 33%. The least consumed is petrol by motorcycles which is 25%. The statistics show that there are huge numbers of motorcycles in the valley, since they consume 25% of the petrol even though they have significantly higher mileage than light petrol vehicles.

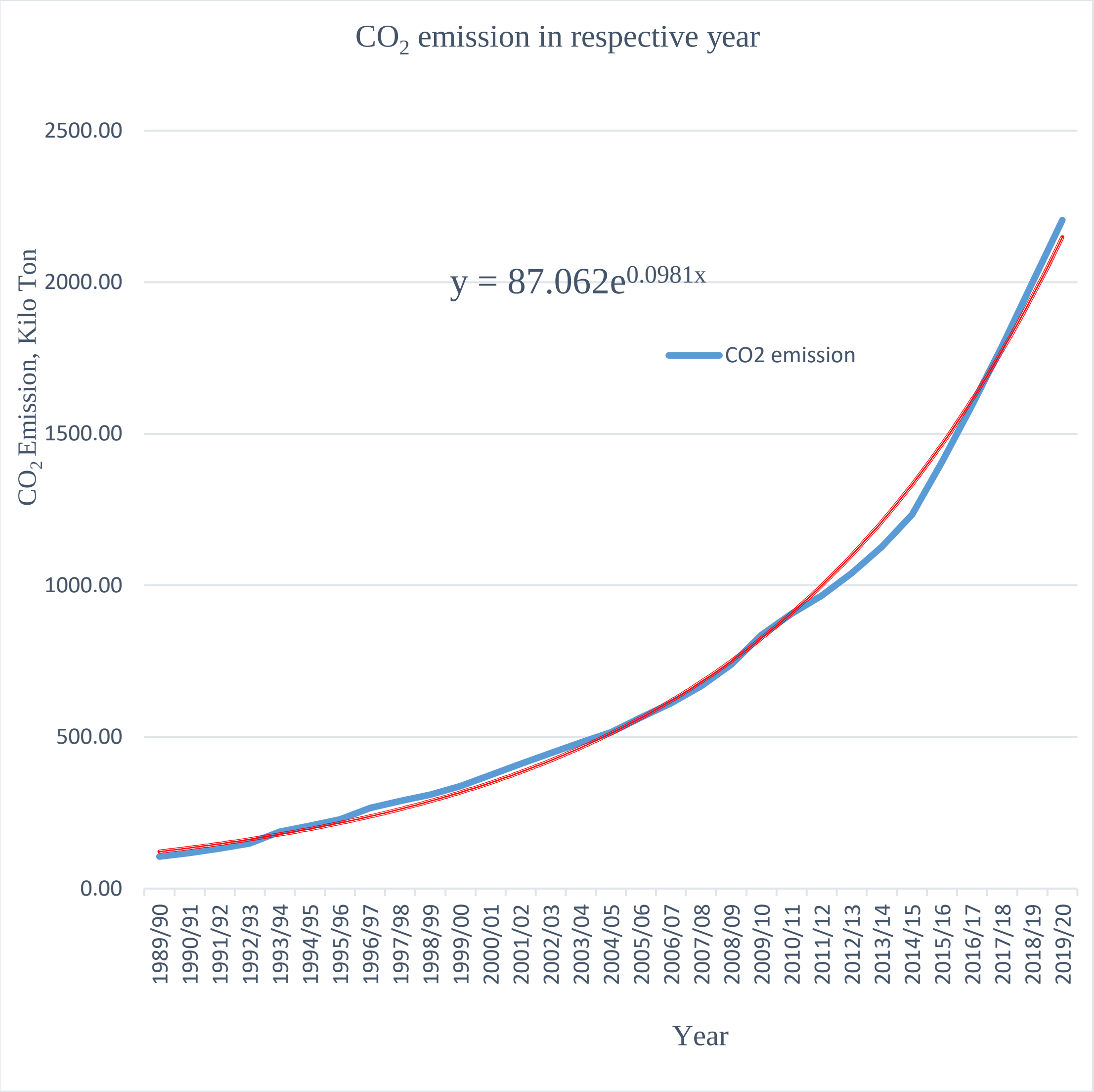

Figure 4.3: Graph showing the CO_2 emission per year

Figure 4.3 shows the graph of CO_2 emission per year, from the year 1989 to 2020. The blue line shows the emission in kilo ton. The x – axis shows the years 1989 to 2020, whereas the y-axis represents CO_2 emission in Kilo ton. The orange line shows the rate of increment in the emission, which is represented by the formula **y = 87.062*e^0.0981*x**. y can be used to make projections for the future years as well. In the formulae, we can make projection of future emissions by replacing the value of x with the year we want to project for. In the graph, we can see that the emission has increased significantly over the years. There is a huge increase in emission from the year to 1989 to 2020 which projects an alarming trend.

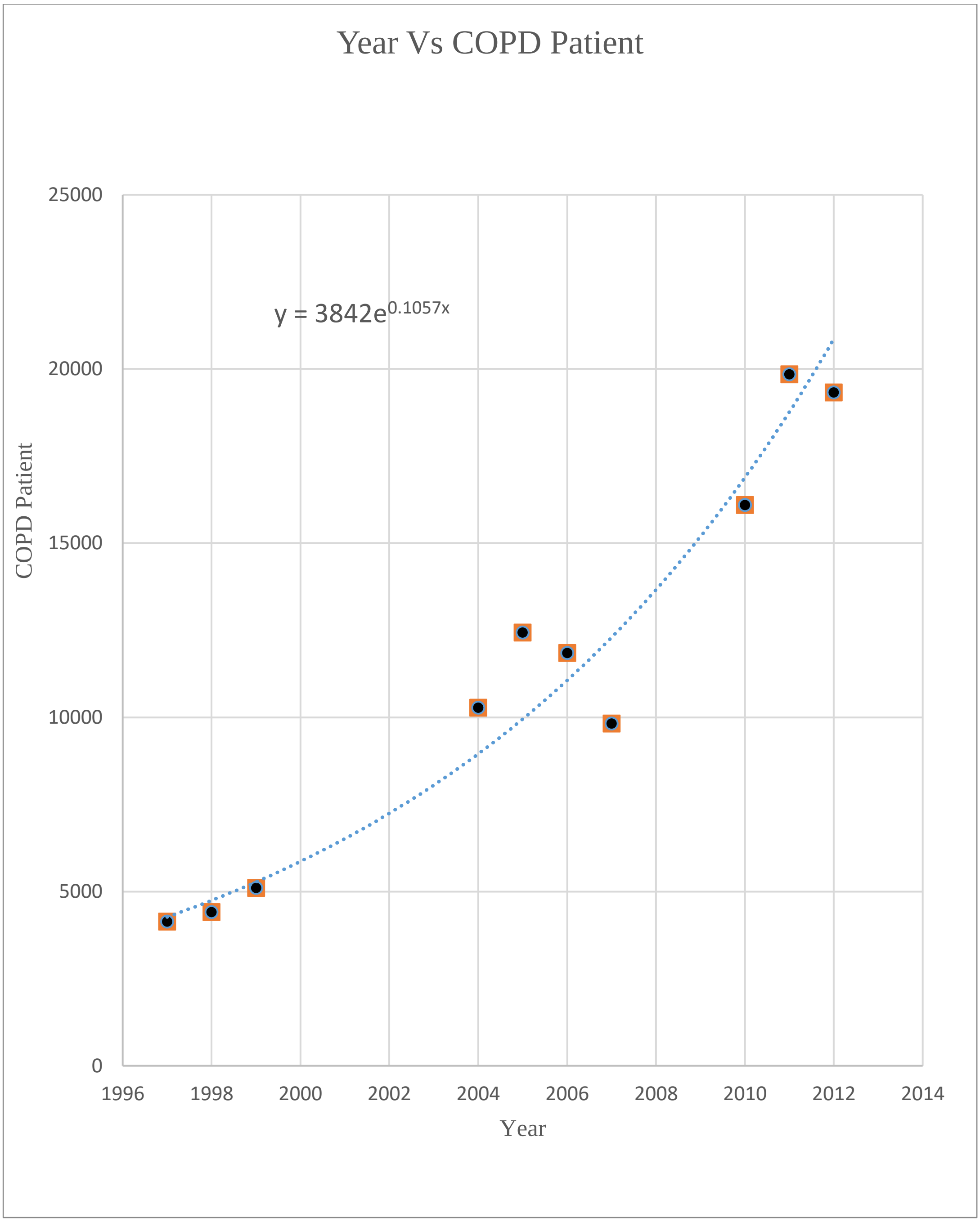

Figure 4.4: Trend of COPD Patient in Kathmandu Valley

Figure 4.4 shows the graph of COPD patients in Kathmandu per year, from the year 1997. The x – axis represents the year starting from 1997, whereas the y-axis shows the number of COPD patients. In the graph, we can see that the number of patients has increased over the years. The number has significantly increased over the years.

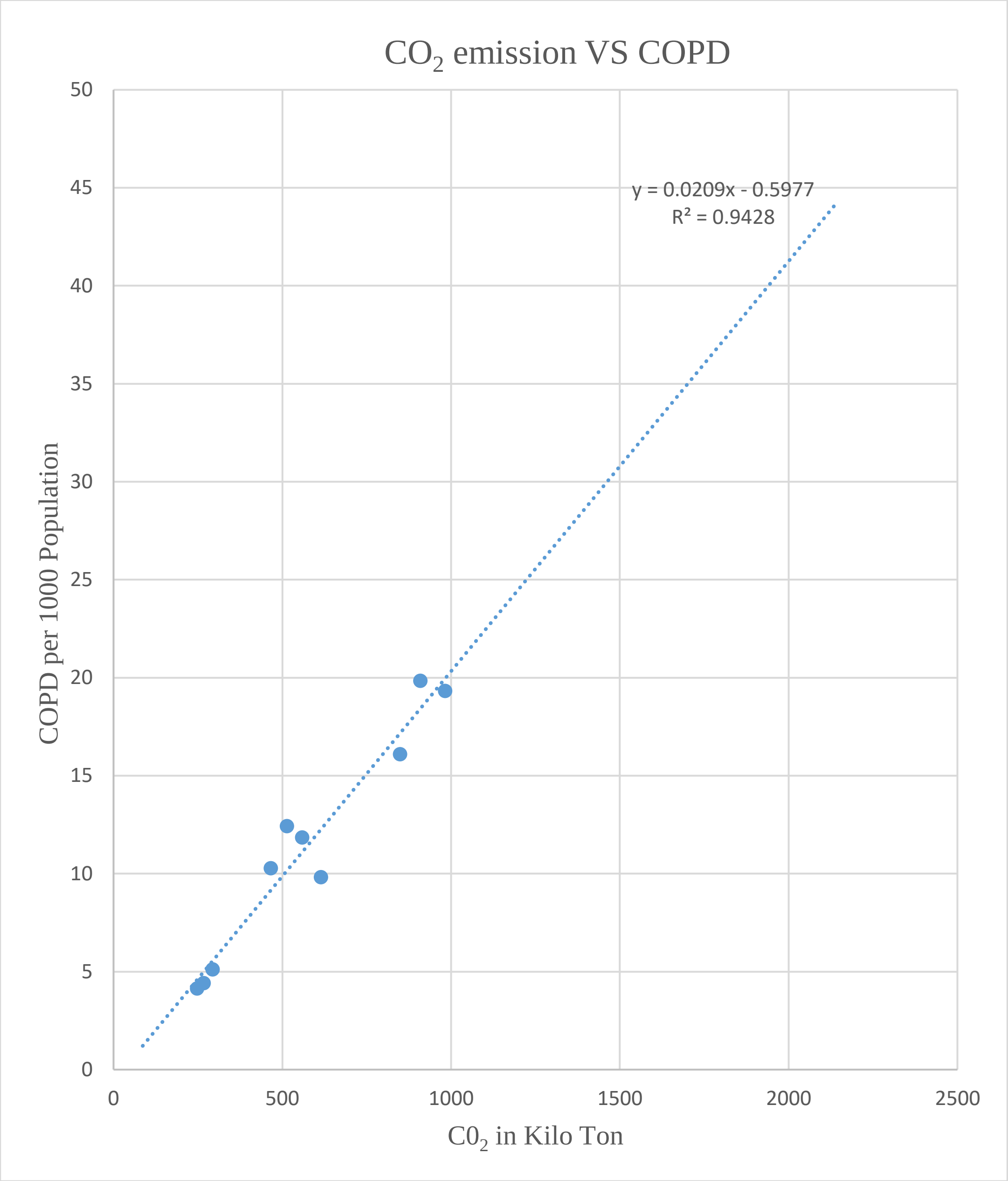

Figure 4.5: A correlation between COPD patient and CO_2 emission

There is strong positive correlation between CO_2 emission and COPD patient in Kathmandu Valley. Due to excessive air pollution inside Kathmandu valley, we can find the number of COPD patient increased in the hospitals. Figure 4.5 shows the graph of correlation between OPD patients and CO2 emissions. The x – axis represents the CO_2 emission in kilo ton, whereas y axis represents COPD per 1000 . The line shown in the graph **(y= 0.0209x -0.5977)**, shows a positive correlation between the two variables. However, the line shown in a uni-variate line.

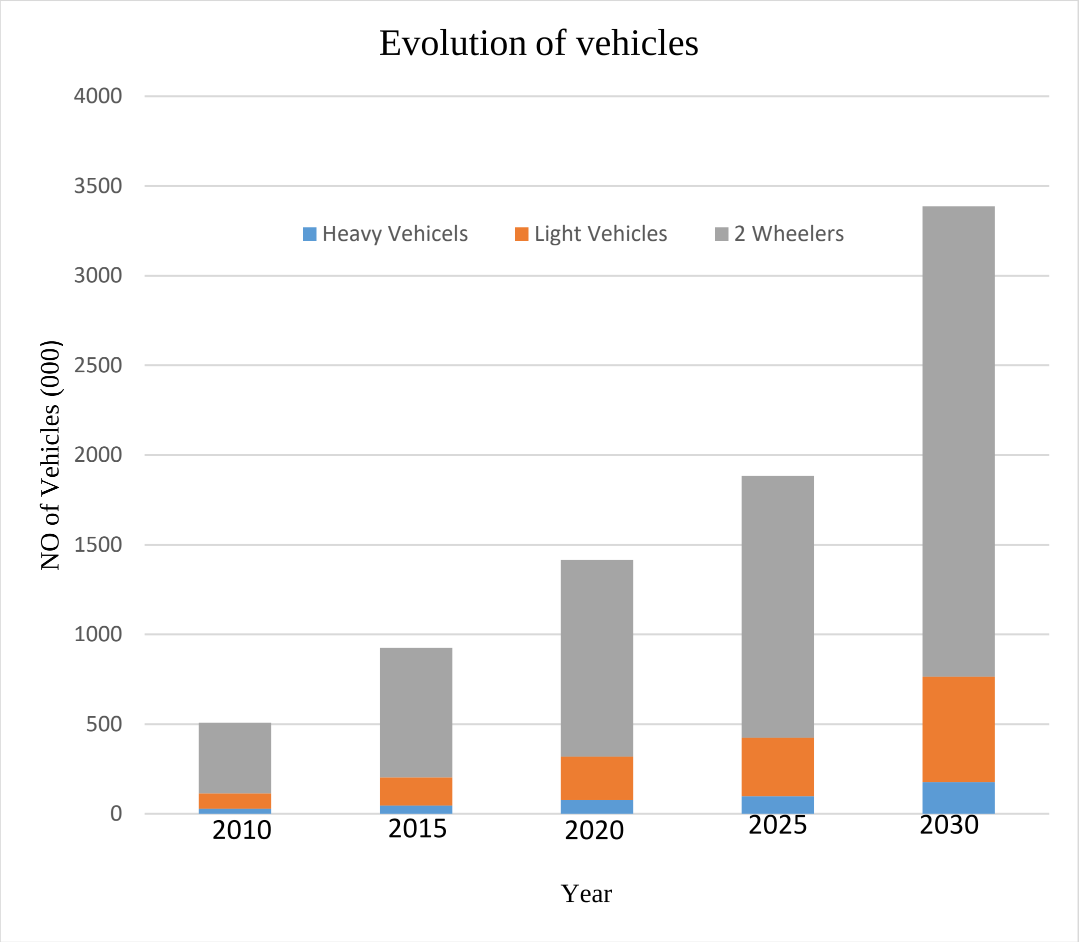

Figure 4.6: Vehicle fleet (‘000) in Kathmandu Valley

Figure 4.6 shows the bar graph of Evolution of vehicles in Kathmandu city from the year 2010 through 2030. The x – axis represents the year starting from 2010 to 2030, whereas the y-axis shows the number of vehicles. In the bars, the blue color represents heavy vehicles, orange represents light vehicles and grey represents two wheelers.

From the bar graph, we can see that the total number of vehicles have increased over the years. In a span of 2 decades, the total number of vehicles increased from 500,000 in 2010 to approximately 3,400,000 in 2030, which is a massive increment. However, the rate of increment in 2 wheelers is the highest, followed by light vehicles and finally heavy vehicles.

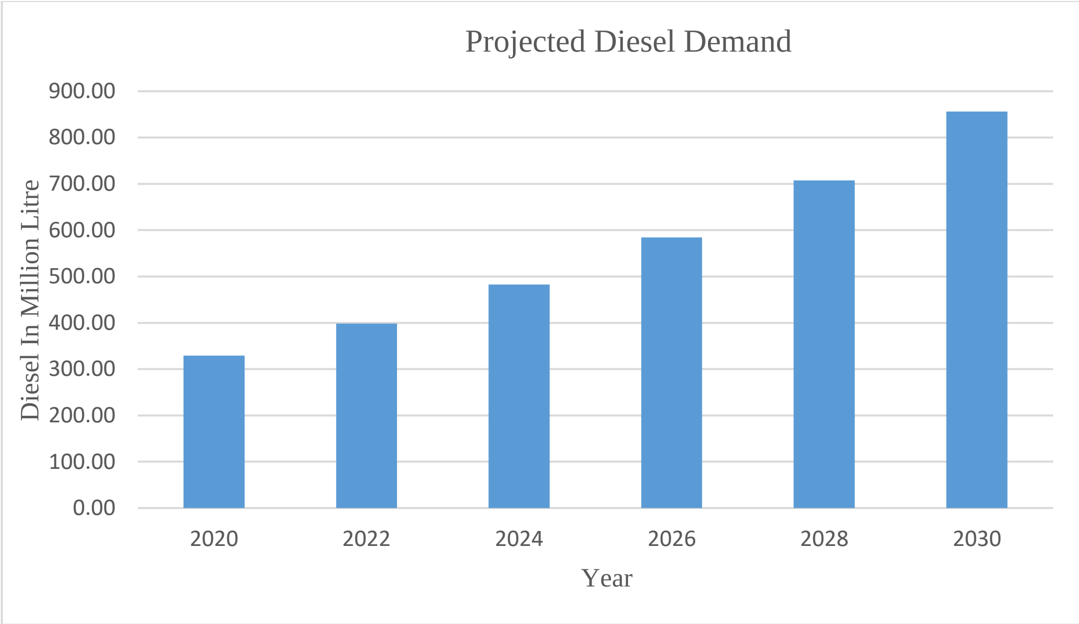

Figure 2.7: Total Projected Diesel Demand in Kathmandu Valley

Figure 4.7 shows the bar graph of projected diesel demand in Kathmandu city from the year 2020 through 2030. The x – axis represents the year starting from 2020 to 2030, whereas the y-axis shows diesel demand in million liters. While the demand in 2020 was approximately 310 million liters, the demand is projected to significantly increase in the next 10 years. The demand has been projected to increase to up to 850 million liters by 2030.

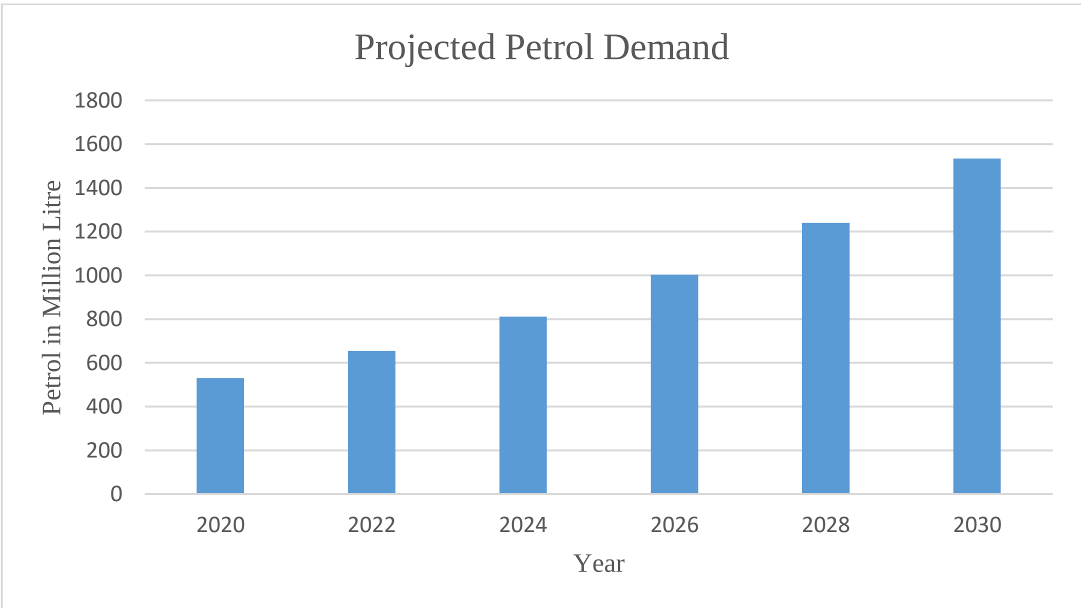

Figure 4.8: Total Projected Petrol Demand in Kathmandu Valley

Figure 4.8 shows the bar graph of projected petrol demand in Kathmandu city from the year 2020 through 2030. The x – axis represents the year starting from 2020 to 2030, whereas the y-axis shows petrol demand in million liters. While the demand in 2020 was approximately 550 million liters, the demand is projected to significantly increase in the next 10 years to increase to up to 1550 million liters by 2030.

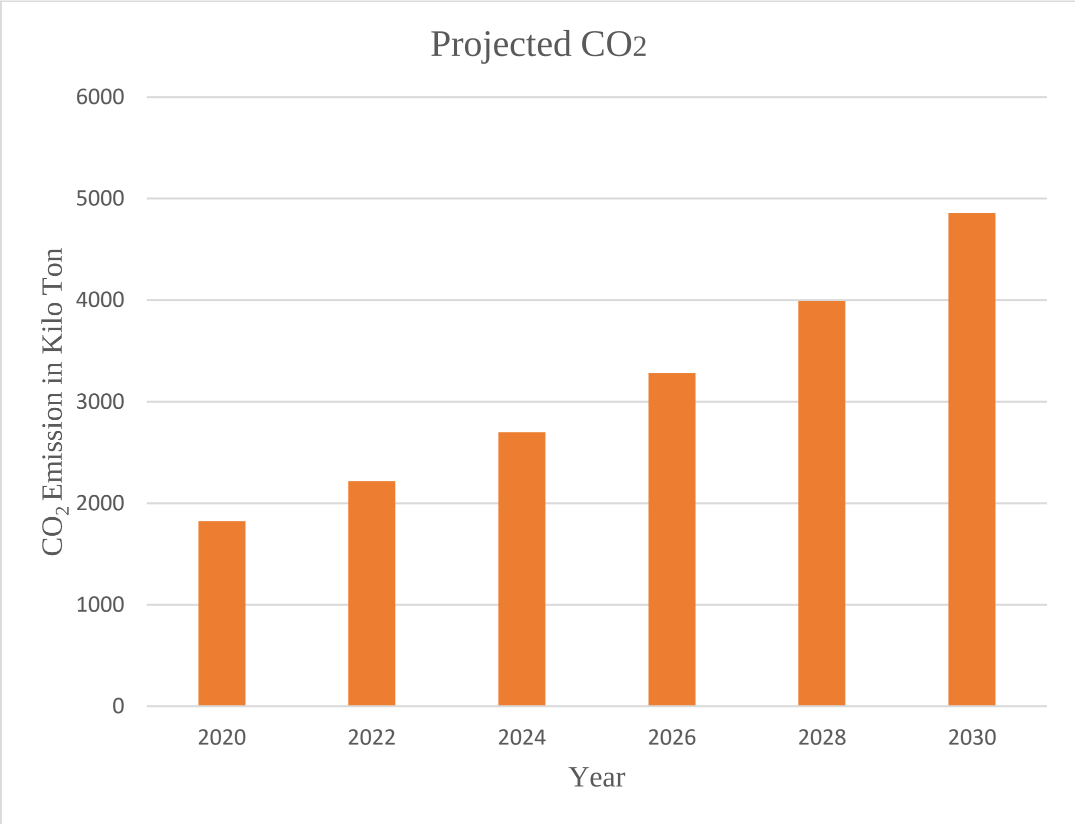

Figure 4.9: Projected CO_2 in Kathmandu Valley till 2030

Figure 4.9 shows the bar graph of projected CO_2 emission in Kathmandu valley from the year 2020 through 2030. The x – axis represents the year starting from 2020 to 2030, whereas the y-axis shows CO_2 emission in kilo ton. The CO_2 emission in Kathmandu is in increasing trend. The emission in 2020 was approximately 1800kilo ton, whereas the emission is projected to significantly increase in the next 10 years. The emission has been projected to increase to up to 4900 kilo ton by 2030.

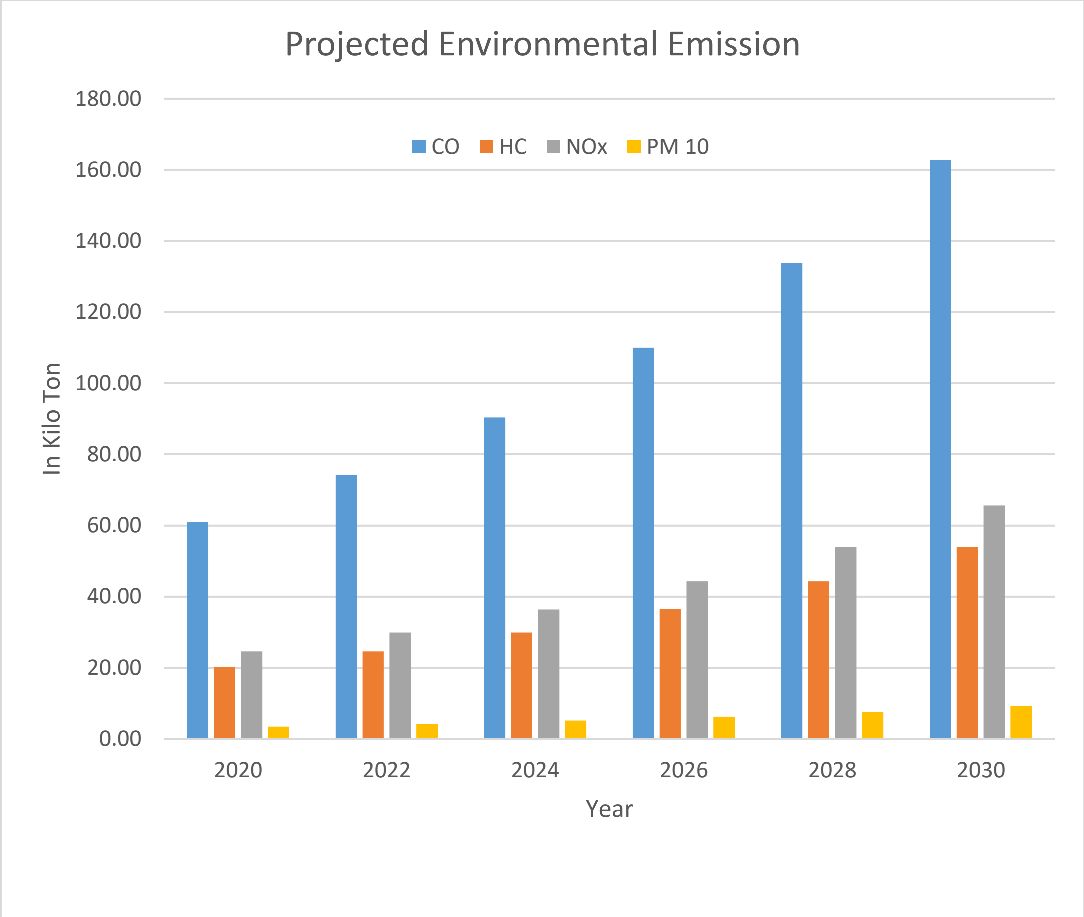

Figure 4.10: Projected Environmental Emission from fuel in Transportation Sector

Figure 4.10 shows the bar graph of projected Environmental emission in Kathmandu valley from the year 2020 through 2030. The x – axis represents the year starting from 2020 to 2030, whereas the y-axis shows CO emission in kilo ton. The bars show the different gases like CO, HC, NOx and PM10 represented by the colors blue, orange, grey and yellow respectively.

As we can see, the emission of most of the gases is in increasing trend. Comparatively, CO is projected to have the highest increment from 60 kilo ton in 2020 to 161 kilo ton in 2030. Similarly, NOx has the second highest projected increment, from 21 kilo ton in 2020 to 61 kilo ton in 2030. HC is projected to increase from 20 kilo ton in 2020 to approximately 51 kilo ton. The lowest increment is for PM10 which is projected not to increase much in the next 10 years. It has been projected to increase from approximately 3 kilo ton to approximately 9 kilo ton.

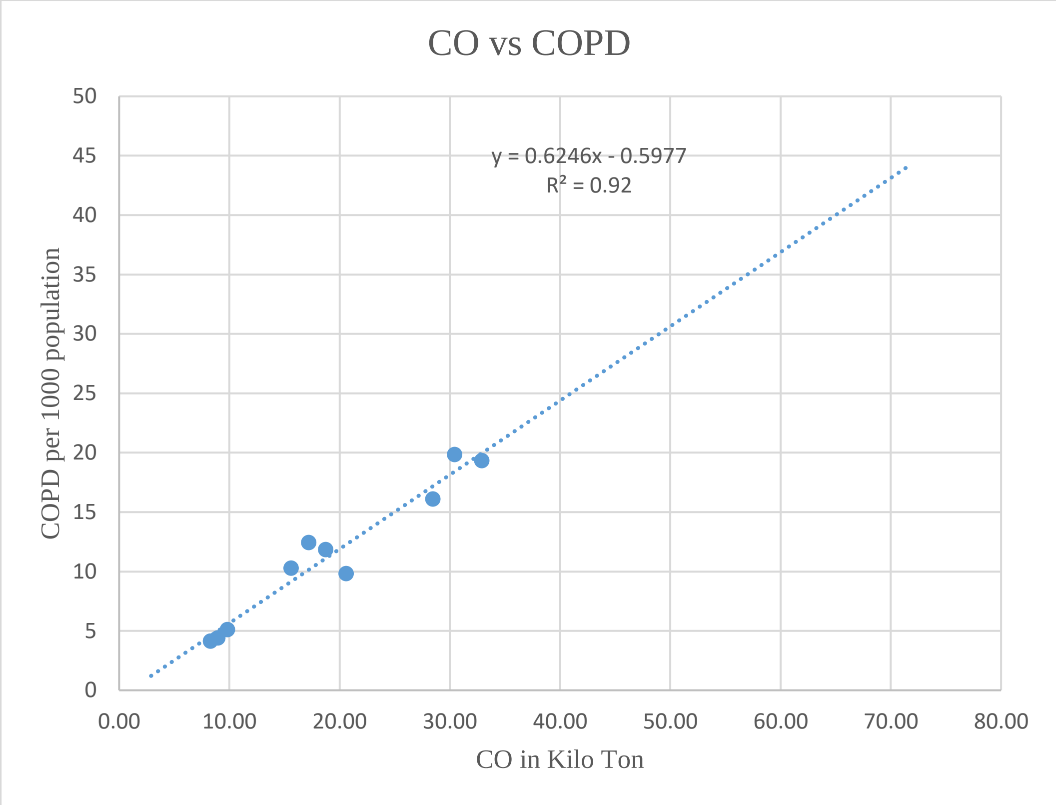

Figure 4.11: Correlation between CO and COPD

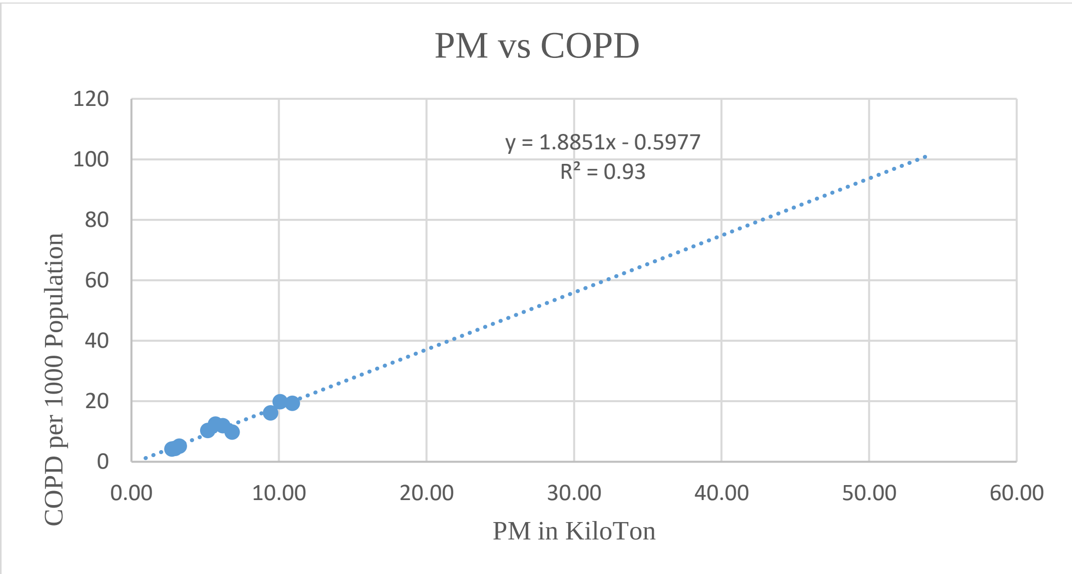

Figure 4.12: Correlation between Particulate Matter and COPD

4.2 Discussion

This research has a substantial influence on the computation of CO_2 emissions produced by the transportation industry, as well as the impact on the health of Kathmandu Valley inhabitants. Between 1991 and 2011, the population density of the Kathmandu valley grew from 1,230 to 2,800 people per square kilometer (MHP, 2011). The CO_2 emissions calculated for the Kathmandu Valley in 2019/2020 were 2200 kilotons, approximately 23 times more than in 1990/1991 (Mohanty, 2011).

When comparing the population density of cities, the Kathmandu Valley had a population density of 4,386/km^2 in 2009, which was half that of New York City, which had a population density of 10,434.62/km^2 (Planyc, 2010). Although New York's car emissions were significantly greater than those in the Kathmandu Valley, the rate of CO_2 emissions in New York was in a decreasing trend every year, whereas the trend is growing exponentially for Kathmandu Valley (Fact Monster, 2017).

According to the findings, there was a clear link between rising CO_2 emissions and an increase in the number of COPD patients in hospitals.

Since 1990, the Nepalese government has been formulating laws to reduce pollution, however the legislation's execution has been ineffective. Sufficient research on the quality of the air in urban and suburban areas was not conducted, and the results were categorically reported based on the amount of pollution. Poor air quality is widely believed to have a detrimental impact on people's health; however, research is limited, and there aren't enough studies to learn about short- and long-term impacts, seasonal models, regional variations, and other air quality issues that affect human health.

According to this analysis, if the sales of these motor vehicles are reduced by 75 percent by an equivalent number of public buses by 2030, a substantial amount of fuel consumption and significant amounts of environmental pollutants can be avoided. As a result, bus utilization for public transit should be encouraged.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

Every year, many individuals die as a result of air pollution. Air pollution has risen to the top five major causes of death in various countries and towns, including the Kathmandu Valley. From 1990/1991 to 2019/2020, the number of automobiles registered in the Kathmandu Valley increased by more than 19 -fold. In next decade, the total vehicles will double up, which is a massive increment.

As the number of automobiles increased, so did the rate of consumption of fossil fuels. This resulted in the amount of CO_2 emitted. The results in this report show that CO_2 emissions from transportation in the Kathmandu Valley have been increasing exponentially. A proportionate amount of fossil fuels consumed i.e. 330 million liters of diesel & 520 million liters of petrol. The statistics show that there are huge numbers of two-wheelers in the valley, since they consume 25% of the petrol even though they have significantly higher mileage than light petrol vehicles.

In first decade, CO_2 increased from 100 KT to 300 KT, followed by 900 KT and 2200 KT in next decades. For the Kathmandu Valley, the carbon dioxide emission calculated in 2019/2020, were nearly 23 times that of 1990/1991. The CO_2 emission in Kathmandu is in increasing trend. The emission in 2020 was approximately 2200 KT, whereas the emission is projected to significantly increase in the next 10 years by 4900 KT. This research also projects the possible amount of other environmental pollutants like CO, NOx, Sox and Particulate Matter.

Due to excessive air pollution we can see that the number of COPD patients have increased over the years which is shown in the graph. Starting from 1997, the registered patient were about 4000 and in 2013 the patients were 20000 which is five times in 15 years concluding to be exponentially increasing. From the findings, we can see that from 1997/1998 to 2019/2020, there was a positive correlation of the rate of COPD patients and CO_2 emissions in the Kathmandu Valley with R^2=0.94. Also side by side, the other pollutants (CO, NOx, PM) are also in positive correlation with rate of COPD.

Following are some recommendations to reduce CO_2 emissions in the Kathmandu Valley:

(1) The policies/standards so implemented should be complied with and enforced efficiently.

(2) the government should prioritize the import of fuels with lower carbon content;

(3) Introducing and building Bus rapid transit or metro railway on possible routes should be considered by the government

(4) Introducing the other sustainable public transportation modes, such as double decker large buses, street cable cars.

(5) The existing road networks should be efficiently expanded and improvised.

The usage of electric motorbikes instead of conventional gasoline motorbikes is another way to reduce future energy consumption and environmental emissions in the Kathmandu valley.

A number of promotional activities and best practices to support the Kathmandu Valley in reducing the need for motorized travel and improving air quality are: Switching to low-carbon public transportation is an important way to improve air quality, enforcement of emission standards that deal with the sulfur content of gasoline and diesel can reduce particulate emissions, reducing population growth and increasing urban density will help reduce urban expansion and the need for motorized travel.

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ANNEX

APPENDIX A: QUESTIONAIRE FOR SURVEY

1. What type of vehicle you use: Heavy, Light, 2-wheelers?
2. How long you drive in one day?
3. How many kilometers their vehicle can travel on a liter of fuel?

Table: Vehicle Registration from 1989 to 2020

	Heavy					Light Vehicles								Motorcycle
Year	Bus	Mini Bus	Truck	Excavators	**Total**	Car	Pickup	Microbus	Tempo	tractor	Ambulance	UN	**Total**	**Total**
1989/90	797	1028	1556	5	**3386**	9868	0	0	507	610	37	1604	**12626**	**18594**
1990/91	86	102	309	0	**497**	1142	0	0	18	69	3	35	**1267**	**3763**
1991/92	82	96	287	1	**466**	1460	0	0	103	87	9	47	**1706**	**5883**
1992/93	87	80	323	0	**490**	1800	0	0	41	93	3	121	**2058**	**4863**
1993/94	235	39	988	373	**1635**	2131	0	0	78	689	18	147	**3063**	**6903**
1994/95	102	41	409	0	**552**	2173	0	0	153	93	11	103	**2533**	**7958**
1995/96	117	37	482	2	**638**	2127	0	0	91	79	4	92	**2393**	**9832**
1996/97	133	146	899	412	**1590**	1953	0	0	123	637	9	77	**2799**	**9867**
1997/98	164	161	413	1	**739**	2627	0	0	237	107	7	132	**3110**	**6818**
1998/99	145	210	367	0	**722**	1659	0	0	259	103	3	155	**2179**	**9522**
1999/00	178	279	419	3	**879**	2757	0	0	523	121	5	263	**3669**	**10078**
2000/01	197	416	509	0	**1122**	3754	0	0	143	132	7	117	**4153**	**18728**
2001/02	170	472	751	31	**1424**	2568	351	173	137	0	25	0	**3254**	**22535**
2002/03	236	232	744	49	**1261**	1847	347	675	9	0	26	154	**3058**	**19322**
2003/04	285	116	540	11	**952**	4961	0	331	8	4	8	0	**5312**	**18289**
2004/05	198	445	440	58	**1141**	3156	17	34	24	0	7	114	**3352**	**18986**
2005/06	806	242	1007	35	**2090**	3369	492	79	36	0	0	234	**4210**	**21001**
2006/07	420	380	509	81	**1390**	3624	865	17	4	48	39	80	**4677**	**32503**
2007/08	531	504	948	191	**2174**	3359	672	53	11	0	65	0	**4160**	**36394**
2008/09	674	490	1230	383	**2777**	4362	979	78	9	0	50	113	**5591**	**42054**
2009/10	497	268	1488	748	**3001**	7435	1529	0	1	4	53	126	**9148**	**70527**
2010/11	392	283	813	443	**1931**	5423	1387	60	3	1	31	0	**6905**	**55092**
2011/12	392	268	355	173	**1188**	5561	2561	105	0	11	33	0	**8271**	**44894**
2012/13	611	374	319	417	**1721**	6334	3003	115	0	4	28	14	**9498**	**54051**
2013/14	763	214	647	662	**2286**	8397	2920	267	0	6	26	22	**11638**	**53494**
2014/15	897	917	992	798	**3604**	9945	2047	136	10	4	23	16	**12181**	**55844**
2015/16	1184	1895	1185	1658	**5922**	21647	3027	222	0	6	17	19	**24938**	**64927**
2016/17	1405	2132	1850	1991	**7378**	14542	3256	298	0	0	26	36	**18158**	**94751**
2017/18	1550	1906	1992	2023	**7471**	17756	3391	334	0	0	32	38	**21551**	**88635**
2018/19	1628	2046	2123	2178	**7975**	19806	3232	312	0	0	33	49	**23432**	**92004**
2019/20	1440	2113	2198	2045	**7796**	18990	3256	321	0	0	23	62	**22652**	**97476**

Table: Fuel Consumption by Heavy Vehicles(MLitres)

Year	**No of vehicles**	**Fuel Consumption per day per vehicle**	**Vehicle Coefficient**	**Total Fuel Consumption per day**	**Total Fuel Consumption per year**	**Total Fuel Consumption per year(in millions)**
1989/90	3386	16.15	0.8	43736	15963579	15.96
1990/91	3883	16.15	0.8	50155	18306727	18.3
1991/92	4349	16.15	0.8	56175	20503723	20.5
1992/93	4839	16.15	0.8	62504	22813869	22.81
1993/94	6474	16.15	0.8	83623	30522213	30.52
1994/95	7026	16.15	0.8	90753	33124663	33.12
1995/96	7664	16.15	0.8	98993	36132567	36.13
1996/97	9254	16.15	0.8	119531	43628754	43.62
1997/98	9993	16.15	0.8	129076	47112831	47.11
1998/99	10715	16.15	0.8	138402	50516760	50.51
1999/00	11594	16.15	0.8	149756	54660879	54.66
2000/01	12716	16.15	0.8	164248	59950642	59.95
2001/02	14140	16.15	0.8	182642	66664208	66.66
2002/03	15401	16.15	0.8	198930	72609298	72.6
2003/04	16353	16.15	0.8	211226	77097581	77.09
2004/05	17494	16.15	0.8	225964	82476921	82.47
2005/06	19584	16.15	0.8	252960	92330400	92.33
2006/07	20974	16.15	0.8	270914	98883671	98.88
2007/08	23148	16.15	0.8	298995	109133175	109.13
2008/09	25925	16.15	0.8	334865	122225573	122.22
2009/10	28926	16.15	0.8	373628	136374038	136.37
2010/11	30857	16.15	0.8	398570	145477898	145.47
2011/12	32045	16.15	0.8	413915	151078823	151.07
2012/13	33766	16.15	0.8	436144	159192621	159.19
2013/14	36052	16.15	0.8	465672	169970158	169.97
2014/15	39656	16.15	0.8	512223	186961517	186.96
2015/16	45578	16.15	0.8	588716	214881279	214.88
2016/17	52956	16.15	0.8	684015	249665475	249.66
2017/18	60427	16.15	0.8	780515	284888127	284.88
2018/19	68402	16.15	0.8	883526	322486929	322.48
2019/20	76198	16.15	0.8	984224	359241821	359.24

Table: Fuel Consumption by Light Vehicles (MLitres)

Light Vehicles

No of vehicles	Fuel Consumption per day per vehicle	Vehicle Coefficient	Total Fuel Consumption per day	Total Fuel Consumption per year	Total Fuel Consumption per year(in millions)
12626	4.20	0.8	42440	15490722.69	15.49
13893	4.20	0.8	46699	17045193.28	17.05
15599	4.20	0.8	52434	19138268.91	19.14
17657	4.20	0.8	59351	21663210.08	21.66
20720	4.20	0.8	69647	25421176.47	25.42
23253	4.20	0.8	78161	28528890.76	28.53
25646	4.20	0.8	86205	31464840.34	31.46
28445	4.20	0.8	95613	34898907.56	34.90
31555	4.20	0.8	106067	38714537.82	38.71
33734	4.20	0.8	113392	41387932.77	41.39
37403	4.20	0.8	125724	45889394.96	45.89
41556	4.20	0.8	139684	50984672.27	50.98
44810	4.20	0.8	150622	54976974.79	54.98
47868	4.20	0.8	160901	58728806.72	58.73
53180	4.20	0.8	178756	65246050.42	65.25
56532	4.20	0.8	190024	69358588.24	69.36
60742	4.20	0.8	204175	74523798.32	74.52
65419	4.20	0.8	219896	80261966.39	80.26
69579	4.20	0.8	233879	85365831.93	85.37
75170	4.20	0.8	252672	92225378.15	92.23
84318	4.20	0.8	283422	103448974.8	103.45
91223	4.20	0.8	306632	111920655.5	111.92
99494	4.20	0.8	334434	122068268.9	122.07
108992	4.20	0.8	366360	133721277.3	133.72
120630	4.20	0.8	405479	147999831.9	148.00
132811	4.20	0.8	446424	162944588.2	162.94
157749	4.20	0.8	530249	193540789.9	193.54
175907	4.20	0.8	591284	215818672.3	215.82
197458	4.20	0.8	663724	242259395	242.26
220890	4.20	0.8	742487	271007899.2	271.01
243542	4.20	0.8	818629	298799428.6	298.80

Table: Fuel Consumption by Two Wheelers (MLitres)

Motorcycles

No of vehicles	Fuel Consumption per day per vehicle	Vehicle Coefficient	Total Fuel Consumption per day	Total Fuel Consumption per year	Total Fuel Consumption per year(in millions)
18594	0.33	0.8	4843	1767727	1.8
22357	0.33	0.8	5823	2125475	2.1
28240	0.33	0.8	7356	2684770	2.7
33103	0.33	0.8	8622	3147095	3.1
40006	0.33	0.8	10420	3803361	3.8
47964	0.33	0.8	12493	4559926	4.6
57796	0.33	0.8	15054	5494652	5.5
67663	0.33	0.8	17624	6432706	6.4
74481	0.33	0.8	19400	7080891	7.1
84003	0.33	0.8	21880	7986146	8.0
94081	0.33	0.8	24505	8944259	8.9
112809	0.33	0.8	29383	10724725	10.7
135344	0.33	0.8	35252	12867123	12.9
154666	0.33	0.8	40285	14704061	14.7
172955	0.33	0.8	45049	16442792	16.4
191941	0.33	0.8	49994	18247786	18.2
212942	0.33	0.8	55464	20244346	20.2
245445	0.33	0.8	63930	23334399	23.3
281839	0.33	0.8	73409	26794368	26.8
323893	0.33	0.8	84363	30792432	30.8
394420	0.33	0.8	102733	37497418	37.5
449512	0.33	0.8	117082	42735001	42.7
494406	0.33	0.8	128776	47003063	47.0
548457	0.33	0.8	142854	52141679	52.1
601951	0.33	0.8	156787	57227342	57.2
657795	0.33	0.8	171333	62536418	62.5
722722	0.33	0.8	188244	68709012	68.7
817473	0.33	0.8	212923	77716968	77.7
906108	0.33	0.8	236010	86143477	86.1
998112	0.33	0.8	259973	94890276	94.9
1095588	0.33	0.8	285362	104157296	104.2

Table: Carbon Dioxide Emission in Metric ton

Year	Total diseal usage (litre)	rate of emission (kg/litre)	Light Vehicle Usage	2 Wheelers Usage	Total petrol usage (litre)	rate of emission (kg/litre)	CO2 emission from diseal	CO2 emission from petrol	Total Emission
1989/90	15.96	2.66	15.49	1.77	17.26	2.33	42.45	40.21	82.67
1990/91	18.3	2.66	17.05	2.13	19.17	2.33	48.68	44.67	93.35
1991/92	20.5	2.66	19.14	2.68	21.82	2.33	54.53	50.85	105.38
1992/93	22.81	2.66	21.66	3.15	24.81	2.33	60.67	57.81	118.48
1993/94	30.52	2.66	25.42	3.80	29.22	2.33	81.18	68.09	149.28
1994/95	33.12	2.66	28.53	4.56	33.09	2.33	88.10	77.10	165.20
1995/96	36.13	2.66	31.46	5.49	36.96	2.33	96.11	86.12	182.22
1996/97	43.62	2.66	34.90	6.43	41.33	2.33	116.03	96.30	212.33
1997/98	47.11	2.66	38.71	7.08	45.80	2.33	125.31	106.70	232.02
1998/99	50.51	2.66	41.39	7.99	49.37	2.33	134.36	115.04	249.40
1999/00	54.66	2.66	45.89	8.94	54.83	2.33	145.40	127.76	273.16
2000/01	59.95	2.66	50.98	10.72	61.71	2.33	159.47	143.78	303.25
2001/02	66.66	2.66	54.98	12.87	67.84	2.33	177.32	158.08	335.39
2002/03	72.6	2.66	58.73	14.70	73.43	2.33	193.12	171.10	364.21
2003/04	77.09	2.66	65.25	16.44	81.69	2.33	205.06	190.34	395.39
2004/05	82.47	2.66	69.36	18.25	87.61	2.33	219.37	204.12	423.49
2005/06	92.33	2.66	74.52	20.24	94.77	2.33	245.60	220.81	466.41
2006/07	98.88	2.66	80.26	23.33	103.60	2.33	263.02	241.38	504.40
2007/08	109.13	2.66	85.37	26.79	112.16	2.33	290.29	261.33	551.62
2008/09	122.22	2.66	92.23	30.79	123.02	2.33	325.11	286.63	611.74
2009/10	136.37	2.66	103.45	37.50	140.95	2.33	362.74	328.41	691.15
2010/11	145.47	2.66	111.92	42.74	154.66	2.33	386.95	360.35	747.30
2011/12	151.07	2.66	122.07	47.00	169.07	2.33	401.85	393.94	795.78
2012/13	159.19	2.66	133.72	52.14	185.86	2.33	423.45	433.06	856.51
2013/14	169.97	2.66	148.00	57.23	205.23	2.33	452.12	478.18	930.30
2014/15	186.96	2.66	162.94	62.54	225.48	2.33	497.31	525.37	1022.68
2015/16	214.88	2.66	193.54	68.71	262.25	2.33	571.58	611.04	1182.62
2016/17	249.66	2.66	215.82	77.72	293.54	2.33	664.10	683.94	1348.03
2017/18	284.88	2.66	242.26	86.14	328.40	2.33	757.78	765.18	1522.96
2018/19	322.48	2.66	271.01	94.89	365.90	2.33	857.80	852.54	1710.34
2019/20	359.24	2.66	298.80	104.16	402.96	2.33	955.58	938.89	1894.47