Smog Risk Reduction for Lahore Metropolitan, Pakistan

Author

Amna Ali

Regn No

00000363932

Supervisor

Dr. Irfan Ahmed Rana

DEPARTMENT OF URBAN AND REGIONAL PLANNING, NIT SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

ISLAMABAD

APRIL, 2023

Smog Risk Reduction for Lahore Metropolitan, Pakistan

Author

AMNA ALI

Regn Number

00000363932

A thesis submitted in partial fulfillment of the requirements for the degree of

MS Urban and Regional Planning

Thesis Supervisor

Dr. Irfan Ahmed Rana

Thesis Supervisor's Signature: _____

DEPARTMENT OF URBAN AND REGIONAL PLANNING, NIT SCHOOL

OF CIVIL AND ENVIRONMENTAL ENGINEERING

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

ISLAMABAD

APRIL, 2023

THESIS ACCEPTANCE CERTIFICATE

Certified that copy of the thesis titled "Smog Risk Reduction for Lahore Metropolitan, Pakistan" written by Ms. Amna Ali (Registration No. 00000363932), of Urban & Regional Planning (NIT-SCEE) has been vetted by the undersigned, found complete in all respects as per NUST Statutes/Regulations, is free of plagiarism, errors and mistakes and is accepted as partial fulfilment for the award of MS degree. It is further certified that necessary amendments aspointed out by GEC members of the scholar have also been incorporated in the said thesis.

Signature: _____

Name of Supervisor: Dr. Irfan Ahmad Rana

Date: 11/4/2023

Signature HOD: _____

Date: 11/4/2023

Signature (Dean/Principal): _____

PROF DR. MUHAMMAD IRFAN
Principal & Dean
SCEE, NUST

Date: 14 JUN 2023

3

Declaration

I certify that this research work titled **"*Smog Risk Reduction for Lahore Metropolitan, Pakistan*"** is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.

Signature of Student

AMNA ALI

2021- NUST- MS- URP- 00000363932

Plagiarism Certificate (Turnitin Report)

This thesis has been checked for Plagiarism. Turnitin report endorsed by Supervisor is attached.

Signature of Student

AMNA ALI

Registration Number:00000363932

Signature of Supervisor

Acknowledgements

I am thankful to my Creator Allah Subhana-Watala to have guided me throughout this work at every step and for every new thought which you setup in my mind to improve it. Indeed, I could have done nothing without your priceless help and guidance. Whosoever helped me throughout the course of my thesis, whether my teacher, parents or any other individual was Your will, so indeed none be worthy of praise but You.

I am heartedly thankful to my supervisor, **Dr. Irfan Ahmad Rana** for his expertise and inspiring instructions. He gave me enough independence to decide things throughout my research. He helped me grow in both my proficiency and in self-confidence as a researcher.

This research is wholeheartedly dedicated to my beloved father, **Chaudhry Muhammad Ali**, who taught me how to write and learn. He has been my source of inspiration and gave me strength during my difficult times. I owe a deep debt of gratitude to him for being supportive from the beginning till the completion of research work.

This research was also not possible without the support of my husband, **Capt. Abdul Rehman**. He remained a source of motivation and helped me through especially data collection.

Last but not least, my cordial gratitude goes to **my siblings, parents-in-laws and my friends.** It is through their benevolent help and whole hearted prayers that enabled me to complete my studies.

Amna Ali

Dedicated to my exceptional ***parents, siblings and supportive parents-in-law*** *whose tremendous support and cooperation led me to this wonderful accomplishment. I also appreciate my husband,* ***Capt. Abdul Rehman****, for his efforts expended on me during my entire research. I would like to take this opportunity to say warm thanks to my beloved family.*

Abstract

Recently, Pakistan has experienced drastic effects of smog; smog is the mixture of fog and smoke, polluted air formed by human activities like burning of coal, excessive use of vehicles and many others. Lahore is one of the most crowded cities of Pakistan and facing the soil or road dust due to construction, industrial and vehicular release of gases. These all has increased the pollutants in the atmosphere, especially PM 2.5 that is recorded four times more in winter than in summer for the data recorded over the years from November, 2005 to December, 2007 (Lodhi, 2019). Lahore experienced the smog for the first time in the month of November, 2016. In earlier studies, very limited research work has been done related to smog, therefore, this research is aimed to study the pattern of smog in Lahore (Zartab Jahan, 2019). The study aimed to identify techniques through GIS and RS to evaluate the vulnerability assessment and to identify the institutional challenges which contributes in smog risk reduction through urban planning. Satellite images is used for this study to identify the most vulnerable areas so that it will help to locate that what type of communities or people are most likely to get effect by this risk. The study area is specific due to the nature of risk; to study smog risk reduction the area of application is Lahore. Lahore is the second largest metropolitan area in Pakistan, and the capital city of Punjab province. The population of Lahore district is 11,119,985 according to the 2017 census with the area of 1,772 km^2. As per justification, Lahore has been the victim of this risk from 2016 and many health issues has been reported due to smog. Moreover, the air quality index (AQI) of Lahore in December 2021 was 296 which consider hazardous air for breathing. Considering the health and environment issues of Lahore, the study area has been specific to Lahore District boundary.

Table of Contents

Contents

LIST OF TABLES

LIST OF GRAPHS

CHAPTER 1
INTRODUCTION

1. Introduction

Pakistan has been facing a growing smog problem in recent years, particularly in major cities such as Lahore and Karachi. The chances of increasing smog in the coming years in Pakistan remain high due to a variety of factors. One major factor is the country's rapidly growing population and economic activity, which is leading to increased demand for energy and transportation. Many industries in Pakistan rely on fossil fuels, which contribute to high levels of air pollution and smog. Additionally, transportation, particularly the use of diesel-powered vehicles, is a major contributor to air pollution in cities. Climate change is another factor that can exacerbate smog formation in Pakistan, as rising temperatures can increase the levels of volatile organic compounds and nitrogen oxides in the atmosphere.

Furthermore, the lack of effective environmental policies and enforcement in Pakistan has allowed many industries to operate without adequate pollution controls, leading to further degradation of air quality. While there have been some efforts to address the smog problem in Pakistan, such as implementing measures to reduce emissions from vehicles and industry, these efforts have been limited in scope and effectiveness. Overall, the chances of increasing smog in the coming years in Pakistan are high unless significant and sustained efforts are made to address the underlying causes of air pollution and promote cleaner and more sustainable forms of economic growth and transportation.

Lahore is a metropolitan city with rapid urbanization and large number of populations, both activities has contributed in pollution and smog formation. Lahore experienced the smog for the first time in the month of November, 2016 (Jahan et al., 2019). Smog in the atmosphere is caused by human activities and climatic conditions. Activities like the burning of coal in industries, vehicular smoke, crop burning, construction, firework and the smoke of brick kilns are the primary sources that add fundamental particles to the atmosphere for the smog (Barry, 2016). Smog is a public health hazard, of which many of the researchers has not conducted any research, as current research efforts have mainly concentrated on how to use technical methods to control smog

pollution, the chemical properties of smog, its causes, and its negative impacts on human health (Wang et al., 2019).

Pakistan is ranked number fourth in the most populous countries in Asia. In Pakistan, two-third of its population resides in the province of Punjab. In Punjab, one of the most populated city is Lahore. Besides over-population, another reason for this megacity is their abysmal air quality. According to recent data, the Air Quality Index (AQI) in certain areas of Lahore has frequently exceeded 400 μg/m3 in the month of November 2021 while the safe AQI value is considered below 50 μg/m3. The major reason for this deteriorated air quality in winter months is smog (Ashraf et al., 2022). Therefore, it is noted that the scale of the problem is massive and its consequences will be dire in the years to come. Prolonged or heavy exposure to hazardous air causes varied health complications, including asthma, lung damage, bronchial infections, strokes, heart problems, and shortened life expectancy. A report in *Dawn* from back in 2019 points out how a 2019 analysis by the Air Quality Life Index produced by the Energy Policy Institute of the University of Chicago showed that long-term exposure to particulate matter air pollution was reducing the average Pakistani's life by "more than two years." (Alam, 2019)

This study is intended to explore the risk perception, vulnerability assessment and preparedness for smog. Risk perception is a significant part if social weakness evaluation and local area strength. Risk insight might fluctuate spatially, contingent upon openness, financial circumstances, social and strict foundation. Both the "inclusive" and "resilient" viewpoint can be accomplished by understanding the gamble impression of designated local area by exhaust cloud dang (Rana et al., 2020).

As smog patterns has been seen in recent times which effects to environment, climate change and health of vulnerable community, that's why the study will carry out findings related to urban planning which contributes to reduce the effects of smog.

Pakistan's urban air pollution is among the world's worst, wreaking havoc on public health and the economy. Smog has been seen in Lahore from 2016 till now during the months of October, November and December. To reduce the risk of smog on health and environment, the study will contribute advantages such as covering Lahore District during the data collection will identify the most vulnerable communities with people who has been severely affected from smog risk. After

identifying the communities, it will be easy to prepare such peoples according to risk factor.

Moreover, in terms of urban planning, including planning techniques into the process of reducing risk from the community will contribute to the planned areas and will also prevent environment. Keeping in view all the steps, the last and most important advantage is to prepare and provide mitigation measures related to smog risk reduction in Lahore to reduce the effect of smog risk in future. These are the advantages this study will contribute for the environment and health of effected people which also include people with disabilities (PWD).

1.1. Objectives

1. To assess the smog hazard and risk for metropolitans.
2. To study the smog vulnerability and capacities of exposed community.
3. To assess risk perception and preparedness of exposed community.
4. To identify institutional challenges in reducing smog.
5. To suggest measures to mitigate smog risks and enhance community resilience.

1.2. Research Gap

In urban planning, no research has been done on this topic yet, meanwhile other fields of environment or transportation has done some limited work on this.

1.3. Addition to Research

Smog is one of the most concerning issues of Pakistan in terms of environment and health. It has severe effects on the vulnerable community. The study will help to identify gaps related to lack of environment and lack of preparedness. Moreover, the study will reflect the causes of smog during the time pattern as well as it will help to aware public regarding health issues, health precautions and enhance the planning of area according to mitigation measures.

CHAPTER 2
LITERATURE REVIEW

2. Literature Review

The word smog is an amalgamation of two words, ‘smoke’ and ‘fog’. Fog is reckoned as a visible low lying cloud, made up of small water droplets or ice crystals (Ali et al., 2019). At least two distinct types of smog are recognized: sulfurous smog and photochemical smog. Sulfurous smog, which is also called “London smog,” results from a high concentration of sulfur oxides in the air and is caused by the use of sulfur-bearing fossil fuels, particularly coal. This type of smog is aggravated by dampness and a high concentration of suspended particulate matter in the air. Smog like air pollution trapped higher in the atmosphere can persist as atmospheric brown clouds, which can cause climatic and health effects. Photochemical smog, which is also known as “Los Angeles smog,” occurs most prominently in urban areas that have large numbers of automobiles. It requires neither smoke nor fog. This type of smog has its origin in the nitrogen oxides and hydrocarbon vapors emitted by automobiles and other sources, which then undergo photochemical reactions in the lower atmosphere. The highly toxic gas ozone arises from the reaction of nitrogen oxides with hydrocarbon vapors in the presence of sunlight, and some nitrogen dioxide is produced from the reaction of nitrogen oxide with sunlight. The resulting smog causes a light brownish coloration of the atmosphere, reduced visibility, plant damage, irritation of the eyes, and respiratory distress. Surface-level ozone concentrations are considered unhealthy if they exceed 70 parts per billion for eight hours or longer; such conditions are fairly common in urban areas prone to photochemical smog. There are almost two main components of Smog, (i) ground-level ozone, and (ii) fine particulate matter. The paper focused on pm2.5 of air quality index of Lahore. Therefore, this research is based on second type of smog which is known as “Photochemical Smog”, as Lahore is a dense urban area where smog can be seen on the regular pattern from October to February every year sin 2016.

Risk perception is intensively studied in social sciences and psychology field. The terminology is widely used to measure psychological influence on decision making and consequent actions. Risk perception has emerged as a standard scientific method to assess public acceptance and their reactions/ adjustments regarding a potential hazard. Generally, it can be defined as “people’s judgements about events, situations or activities that could lead to negative consequences” (Ortwin

Renn, 2008). The empirical evidence shows that the studies on climate change risk perception, air pollution risk perception and environment degradation risk perception has already been done, on the other hand, research on smog risk perception is very limited globally. This research emphasis on smog risk perception in which community's behavior and fear has been analyzed. Contradictory, to study smog risk perception the study's literature review has done some study on climate change, air pollution, particulate matter. The literature shows that innovative and individual based approaches are needed to assess accumulations of human exposure, study different behavioral patterns and responses of people, and understand the pollutants' impacts for specific physiological conditions of the human body (Yang et al., 2017), whereas another study suggest that both smog concerns, such as perceived smog risk, and willingness to pay (WTP) were both directly and indirectly positively correlated with public acceptance. These findings imply that policymakers should increase policy fairness with environmental-oriented policy design and should express potential policy effectiveness of the smog controlling policy to citizens to increase their acceptance level (Zhou & Dai, 2017). While relating smog and air pollution effect to health, the study refers that air pollution has adverse effects on health, particularly CVS. It can precipitate AMI, heart failure, arrhythmia and even cardiac arrest. Air pollution with particulate matter (both fine and coarse) has been correlated to both CVS and total mortality (Society et al., 2017). Some examples of smog related studies have been conducted in Poland (Grzywa-celińska et al., 2020), California (Lin, 2010), China (Sajjad et al., 2020), Malaysia (Cheng et al., 2017), Canada (Mehiriz & Gosselin, 2019). Although some research has been done in on smog, it generally focused on smog knowledge (Riaz & Hamid, 2018), characteristics of smog (Jabeen et al., 2021), assessment of smog (Ashraf et al., 2022), and comparative study on smog (Jahan et al., 2019). In Pakistan, risk discernment and its determinants have been tended to just in a small bunch of studies, this study targets understanding the gamble discernment and calamity risk in metropolitan regions. Accordingly, it is basic to concentrate on the determinants of exhaust cloud risk insight, so it can assist creating brown haze with taking a chance with the executives' techniques. Albeit various elements impact exhaust cloud risk insight, yet the chose ones are applicable to evaluate the "financial" factors after a broad writing audit. Smog and climate change are both environmental issues that are closely related but also distinct from each other.

Smog is a type of air pollution that occurs when pollutants such as nitrogen oxides and volatile organic compounds react in the atmosphere with sunlight to form ground-level ozone and

particulate matter. Smog can cause respiratory problems, eye irritation, and other health issues, as well as harm plants and animals.

Climate change, on the other hand, refers to the long-term changes in global weather patterns and average temperatures that are primarily caused by the buildup of greenhouse gases, such as carbon dioxide and methane, in the atmosphere. Climate change can lead to a wide range of environmental and social impacts, including sea level rise, more frequent and severe heat waves, droughts, floods, and storms, and the extinction of many plant and animal species.

While smog and climate change have different causes and effects, they are related in that many of the sources of smog, such as transportation and industrial activities, are also major contributors to greenhouse gas emissions and climate change. Addressing both issues will require efforts to reduce emissions from fossil fuels and other sources, as well as promote cleaner and more sustainable forms of energy and transportation.

CHAPTER 3
METHODOLOGY

3. Methodology

3.1 Area Selection

Lahore is the second largest metropolitan area in Pakistan, and the capital city of Punjab province. The population of Lahore district is 11,119,985 according to the 2017 census with the area of 1,772 km². The study area is specific due to the nature of risk; to study smog risk reduction the area of application is Lahore, as Lahore is the primary city of Pakistan that experience smog in November 2016 for the first time. After that, Lahore has been the most vulnerable city due to smog. The city has been divided into three different divisions. The divisions are based on the no. of population and built-up criteria. The divisions are as fellows; (i) City Center, (ii) Private Housing Schemes, and (ii) Peri-Urban areas.

City center refers to the core internal areas of Lahore which includes; walled city, model town, johar town, allama Iqbal town, Mustafa town, samanabad and other. Private housing schemes is the area consisted at Thokar niaz baig to bahria town, the linear development which emphasize on multiple private housing schemes comes under this category. The last category of peri-urban areas consist the airport based residential area, cantonment and askari.

The reason behind this division is that the pattern of smog is different in such areas, peri-urban areas where open area has more percentage than the built-up area face more smog than the other areas. Whereas, built up area like city centers contribute in air pollution by heavy traffic and infrastructure which pushes smog (air quality index) AQI on the other level. Thus, this study covers Lahore metropolitan area under the division of three further categories.

3.2 Sampling and Data Collection

Cochran's method was used to identify the required number of samples (Mehiriz & Gosselin, 2019). According to the recent census Lahore district has population of 11,119,985. With the confidence level of 95% and a precision value of 0.05, the Cochran's sampling method gave a number of 200 samples from each divided category, which is total as 600 samples from Lahore

division. The survey was done in December 2022 to January 2023 when smog was at its peak. Thereafter, the survey was conducted successfully with complete questionnaires and zero missing value.

3.2.1. Sampling

Proportionate sampling method has been used in this research where 600 households for survey has been selected 200 each from area division. The divisions are as fellows; (i) City Center, (ii) Private Housing Schemes, and (ii) Peri-Urban areas.

3.3 Smog Risk Perception Index

Risk perception is by and large subjective in nature; in any case, files have ended up being helpful as one of the strategies to evaluate it. Records in catastrophe risk science and environmental change weakness are viewed as a vigorous strategy to sum up and evaluate confounded information into an easier structure (UNU-EHS Expert Working Group on Measuring Vulnerability, 2013). Construction of an index requires data standardization to aggregate the datasets. However, weights are also used to standardize the responses for the computation of composite index (Rana & Routray, 2016).

Indicators	**Reference**
Vulnerability	
Age Dependency (No. of Children's) (No. of Elders) (No. of disabled persons) Housing (Temporary dwelling unit) (Households that are renter occupied) Health (Do not have access to piped water) (Without access to borehole) (Without any toilet facility) (Households that (all members aged 5+ years) (Women with special condition e.g. pregnancy) Communication (Households that do not own a television (TV) (Households that do not own a mobile) (Population 18+ illiterate) Economy (18 years plus not working) (Households where no member possesses a bank account) Air quality (Households that do not properly dispose of solid waste) (Presence of Exhaust Fan) (Presence of Kitchen Indoor/Outdoor) (Households using polluting fuel for cooking)	(Clarke et al., 2022)
Climate Change Indicators	
Rise in temperature (Heat intensity, over evaporation) The shift in rainfall patterns (Irregularities in rivers and canals)	(Khan et al., 2020)
Perception and knowledge	
Perceived impacts of Smog	(Khan et al., 2020)
Knowledge about smog (SK) Information needs about Smog Information seeking about Smog Smog perception	(W. Zhu & Lu, 2021)
Exposure	
Household Size	Rana and Routray (2016), Rauf et al. (2017)
Travel time to workplace (in minutes)	Ghumman and Horney (2016)
Household work location	Krüger et al. (2017)
Occupational Environment	Habeeb et al. (2015)
Household members are daily exposed to the air	Nahlik et al. (2017), Pogaˇcar et al. (2019)
Working Hours (Day or Night Shift)	Kovats and Hajat (2008), Smith et al. (2014)
Sensitivity	

No. of people aged 13 or younger	(Q. Zhu et al., 2014)
No. of disabled individuals	
Road Width	(Paterson et al., 2014)
Household with a member with chronic illness (Respiratory, Diabetes, Hypertension, Allergy, Cardiac, Neural Disorders, Other non-respiratory diseases, Eye Irritation)	Yoon (2012)
Number of elderlies in the household	Kim et al. (2020)
Coping Capacity	
No. of Literate Persons	(Paterson et al., 2014)
Air quality notification system (Subscription to any app, Knowledge about app)	(Reid et al., 2009)
Government officials working on environmental regulations	(Lee et al., 2012)
No. of Trees Present (Total Concrete or Not)	
Household with access to the nearest medical facility within 1 km	(Paterson et al., 2014)
Household access to means of transportation car, public transport, motorcycle	Rana and Routray (2016)
Number of windows in the house	Tate (2012)
Adequate ventilation system in the house	
Presence of a veranda in the house	Tapsell et al. (2010)
Presence of nearest park in the neighborhood	Davis et al. (2005)
Household head education level	(Venter et al. (2020), Z¨olch et al. (2019))
Household having health/life insurance	Pandey and Jha (2012)
Household members having access to green spaces at work	Kousky (2019)
No. of Earning Members	(Venter et al. (2020), Z¨olch et al. (2019))
Preparedness	
Wear mask on smog days	(Pinheiro et al., 2021)
Avoid going out during smog	
Do you feel any issue while driving	
Any knowledge about smog timings	
Wearing eye glasses on smog days	

Table 1 Smog Risk Reduction Indicators

CHAPTER 4

SOCIO-ECONOMIC PROFILE

4. Socio-Economic Profile of Respondents

4.1. Introduction

Socioeconomic profile refers to a comprehensive analysis of the economic and social characteristics of a particular population or group. It typically includes information about income, education, occupation, housing, healthcare, and other indicators that help to understand the well-being and quality of life of a community or society.

Some of the key indicators that are often used to construct socioeconomic profiles include:

- Income: This includes information on the average household income, poverty rates, and income inequality.
- Education: This includes information on the level of education attained by the population, such as the percentage of individuals with high school diplomas or college degrees.
- Occupation: This includes information on the types of jobs held by individuals in the population, as well as the unemployment rate and labor force participation rate.
- Housing: This includes information on the quality and affordability of housing, as well as homeownership rates and rental costs.
- Healthcare: This includes information on access to healthcare services and the prevalence of health conditions within the population.
- Demographics: This includes information on the age, gender, race, and ethnicity of the population.

Socio-economic profile in social science research is the most important section, as it consists the details of respondents. Therefore, this chapter contains personal or household information of 600 individuals.

Socioeconomic Indicators	Classes	Frequencies	%
Age	<=25	383	66.30%
	26-45	154	22.30%
	46-65	58	10.60%
	65+	5	0.80%
Gender	Male	433	72
	Female	167	28
Household Income	<=40,000	117	19.5
	40,001-70,000	192	32
	70,001-110,000	121	21.1
	110,001+	170	27.4
Household Size	<=2	12	2
	3 to 6	331	55.3
	7 to 10	202	33.8
	11+	55	8.9
Type of Dwelling	Owned	496	82.7
	Rented	104	17.3

Table 2 Socio Economic Profile of Respondent

4.2. Age

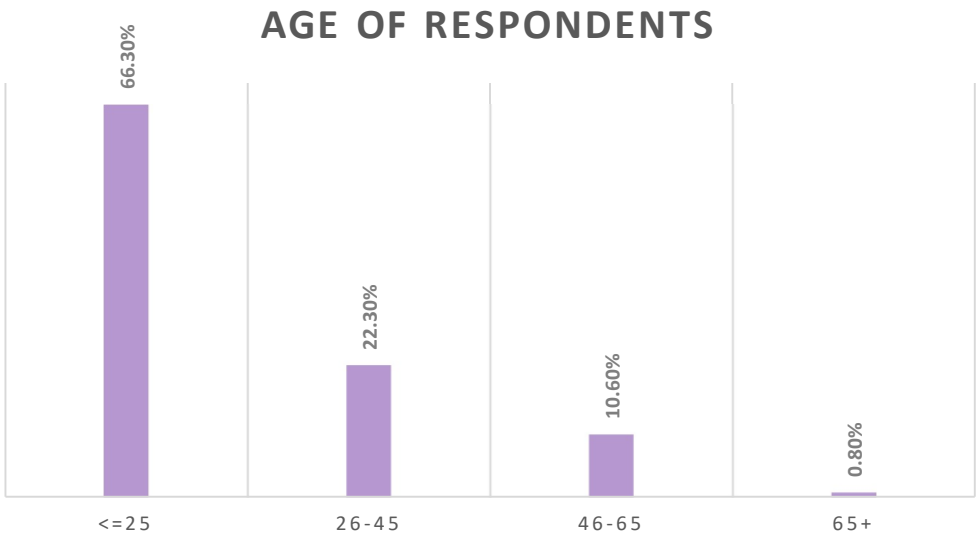
The age of the respondents plays a significant role in the reliability and validity of research data. The quality of research varies with the age of respondents and the results obtained from data responded by aged respondents somewhat provide less precision as compared to data obtained from young respondents (Andrews & Herzog, 1986).

The overall analysis of 600 respondents shows that majority of the respondents are from <=25 years which is 66.3% whereas, 26 years to 45 years age follows to 22.3% and in third 46 years to 65 years respondents have the percentage of 10.6%. As the study has targeted old age that's why conducting survey with 65+ years was necessary which has 0.80%.

Smog is negative environmental impact whose effects can be seen in every age group, <=25 years responds the most, because of the major impacts on their daily routines and health.

Socioeconomic Indicator	**Classes**	**Frequencies**	**%**
Age	<=25	383	66.30%
	26-45	154	22.30%
	46-65	58	10.60%
	65+	5	0.80%

Table 3 Age of Respondents



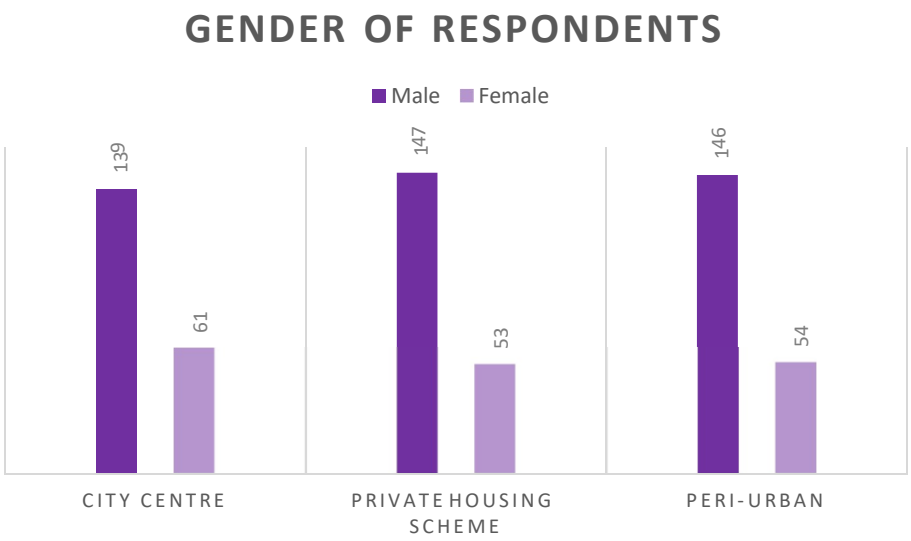
Graph 1 Age of Respondents

4.3. Gender

The data was collected on the basis of whoever available at the time of respond, which is why this study is independent of gender biasness. The data was collected from three different areas as mentioned in area selection section, 139 respondents were from males and 61 respondents are from females in city Centre, whereas Private Housing Scheme and Peri-Urban areas have the almost same frequencies of gender in responses.

Areas	**Gender**	
	Male Frequencies	Female Frequencies
City Centre	139	61
Private Housing Scheme	147	53
Peri-Urban	146	54

Table 4 Gender of Respondents



Graph 2 Gender of Respondents

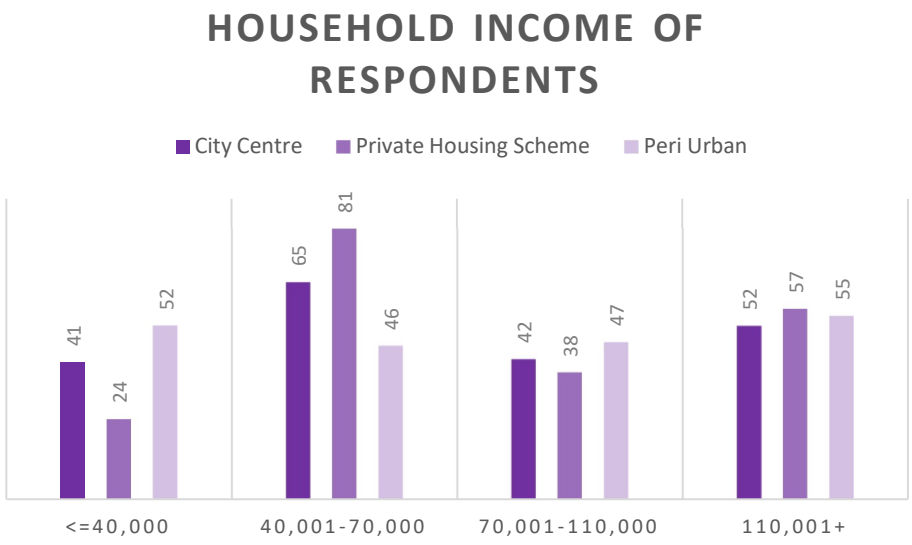
4.4. Income

The income of the respondents shows the financial stability and affordability. The data shows that in all areas majority of respondents have the income range from 40,0001 to 70,000. Whereas following this range, the majority of respondents have income ranges from 110,001+. The other two categories have almost equal respondents.

Household Income of Respondents

	<=40,000	40,001-70,000	70,001-110,000	110,001+	Total
City Centre	41	65	42	52	200
Private Housing Scheme	24	81	38	57	200
Peri Urban	52	46	47	55	200

Table 5 Household Income of Respondents



Graph 3 Household Income of Respondents

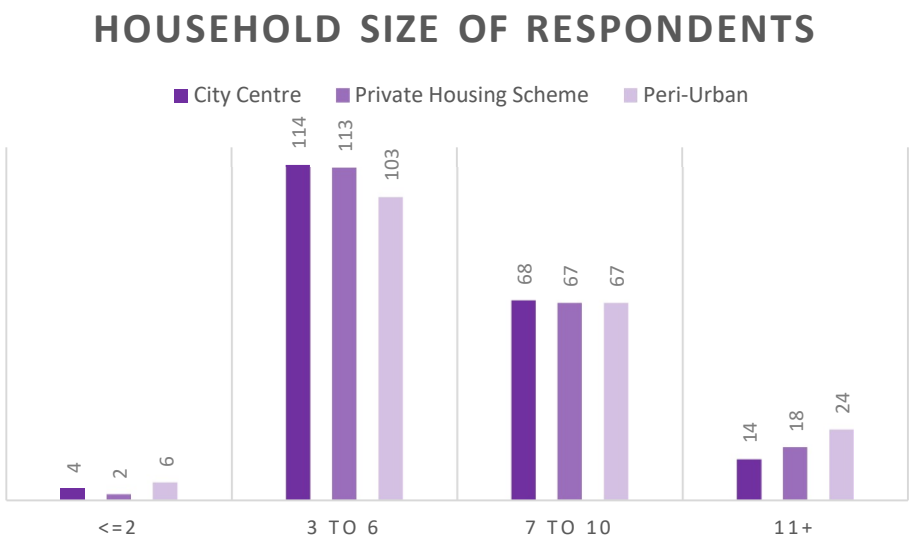
4.5. Household Size

Household size refers to the number of people who live together in a single dwelling and share living expenses such as rent, utilities, and food. The size of a household can vary depending on cultural, economic, and social factors. The collected data shows that majority of households in all areas are in between from 3 to 6 individuals. Then 7 to 10 have more frequencies, following to this is 11+ household size, while in the last <=2 household size frequencies lie.

Household Size of Respondents

	<=2	3 to 6	7 to 10	11+	Total
City Centre	4	114	68	14	200
Private Housing Scheme	2	113	67	18	200
Peri-Urban	6	103	67	24	200

Table 6 Household Size of Respondents



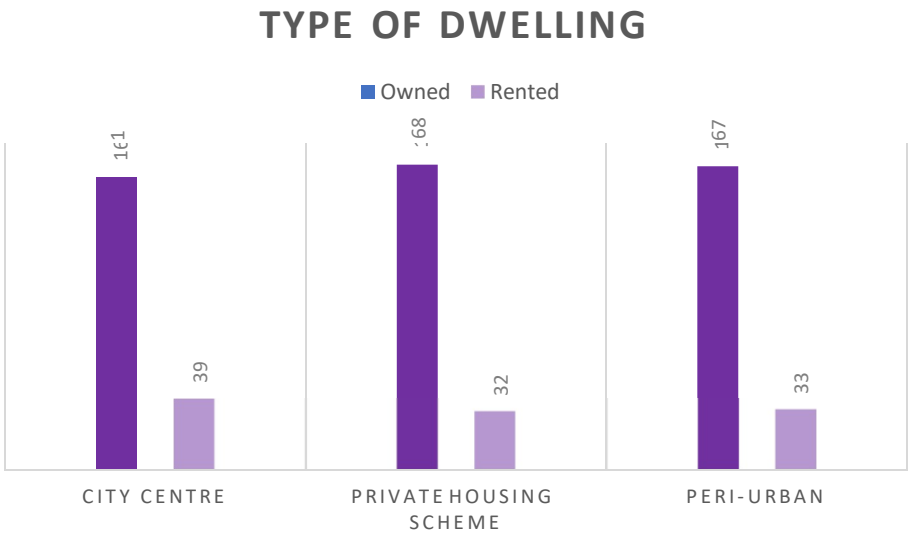
Graph 4 Household Size of Respondents

4.6. Dwelling Type

Dwelling type is an important consideration when analyzing social science research, accessibility, and sustainability. It can also impact social relationships and community development, as different types of dwellings can foster different types of social interactions and relationships between neighbors. Collected data represents that majority of respondents have owned houses. In private housing scheme, more frequencies of 168 responses have been shown while in second peri urban areas follows and in the last city center with the frequencies of 161.

Areas	**Type of dwelling**	
	Owned	Rented
City Centre	161	39
Private Housing Scheme	168	32
Peri-Urban	167	33

Table 7 Type of Dwelling



Graph 5 Type of Dwelling

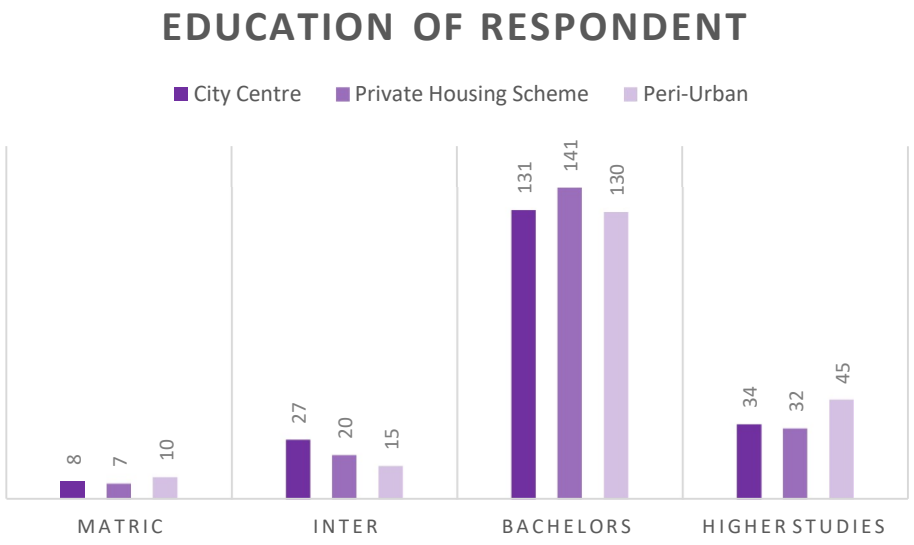
4.7. Education Level of Respondents

Respondents with higher levels of education may have different perspectives and opinions compared to those with lower levels of education. Majority of responses from all mentioned areas are from bachelors, in second, higher studies have more frequencies and least responses got from matric level of education.

Education of Respondents

	Matric	Inter	Bachelors	Higher Studies	Total
City Centre	8	27	131	34	200
Private Housing Scheme	7	20	141	32	200
Peri-Urban	10	15	130	45	200

Table 8 Education Level of Respondents



Graph 6 Education Level of Respondents

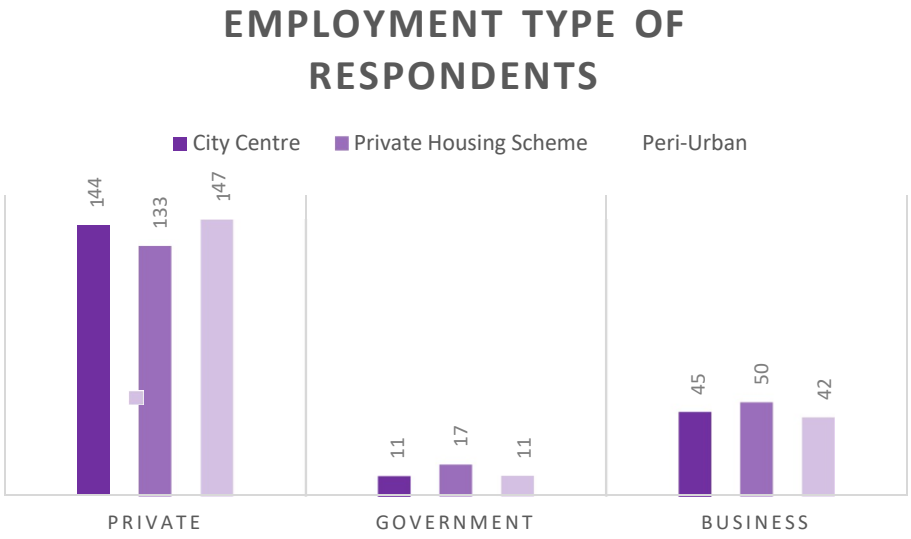
4.8. Employment Type

Employment type refers to the nature of the work and in social science research it's important to get data from the professionals. The collected data shows that from three specified areas, majority of the respondents were privately employed with the frequencies of 144, 133 and 147. Respectively, in second, the frequencies were shows in business employment type and in the last with very few frequencies come under the employment type of "Government".

Employment Type of Respondent

	Private	Government	Business	Total
City Centre	144	11	45	200
Private Housing Scheme	133	17	50	200
Peri-Urban	147	11	42	200

Table 9 Employment Type



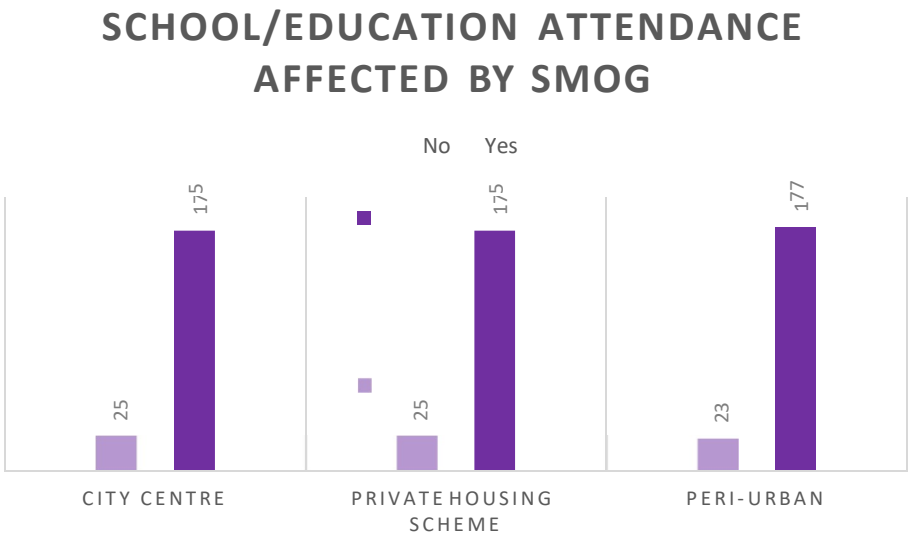
Graph 7 Employment Type

4.9. School/Education Affected by Smog

As the research is based on smog hazard, it's important to ask the question to the respondents that how much their education has been affected by smog, and the responses shows that almost 87.5% responses from all the three areas responded in "Yes", that smog has affected their school/education attendance, while remaining frequencies with very minimum number of respondents responded in "No" category, the reason of that these responses are majority of females that has to stay at home or any other reasons.

Area	School/Education attendance affected by smog	
	No	Yes
City Centre	25	175
Private Housing Scheme	25	175
Peri-Urban	23	177

Table 10 School/Education Affected by Smog



Graph 8 School/Education Affected by Smog

CHAPTER 5

RISK PERCEPTION ANALYSIS

5.Risk Perception Frequency Analysis

Risk perception alludes to a person's emotional assessment of the possible damage or peril presented by a specific circumstance or action. It is impacted by different elements, including individual experience, social and social variables, and the idea of the actual risk.

Risk perception is by and large subjective in nature; in any case, files have ended up being helpful as one of the strategies to evaluate it. Records in catastrophe risk science and environmental change weakness are viewed as a vigorous strategy to sum up and evaluate confounded information into an easier structure (UNU-EHS Expert Working Group on Measuring Vulnerability, 2013). Construction of an index requires data standardization to aggregate the datasets. However, weights are also used to standardize the responses for the computation of composite index (Rana & Routray, 2016).

Risk perception indicators were carefully chosen after rigorous literature review (Table 1). The indicators selected on the basis of “Fear and Threat” and “Behavior and Trust”. Each indicator was mapped on a Likert scale of 1 to 5. Each scale was given weight on how much it increases risk perception (1= Very high, 0.8= High, 0.6= Moderate, 0.4= Low and 0.2= Very low). These weights/scores were added to come up with a composite index (CI) value for each household (Eq. 1). Smog Risk perception index was thus formulated using Eq. 2. Thereafter, index values above average were categorized as High-Risk Perception (1), and below as Low Risk Perception (0).

Sr.	**Smog Risk Perception Indicators**	**Empirical Evidences by Studies**
1	Perceived impacts of Smog	(Khan et al., 2020)
	Question: How much do you think that smog can affect your regular routine work?	
2	Perceived threat to health	Ghumman and Horney (2016)
	Does smog affect your health?	
3	Fear of future	(Q. Zhu et al., 2014)
	What do you believe is the chance of increasing smog in the coming years?	
4	Perceived impacts of Smog	(Clarke et al., 2022)
	How harmful was last year's smog to you and your family?	
5	Perceived fear of smog	Habeeb et al. (2015)
	How much do you fear smog and its effects?	
6	Perceived ability to cope	
	What do you believe is your ability to cope with a future smog?	
7	Air quality notification system (Subscription to any app, Knowledge about app)	(Reid et al., 2009)
	What is the level of understanding of smog-related AQI levels?	
8	Knowledge of emergency protocols	Smith et al. (2014)
	What is the level of understanding of emergency protocols?	
9	Information need about Smog	(W. Zhu & Lu, 2021)
	How much do you understand daily readings of AQI?	
10	Government officials working on environmental regulations	(Lee et al., 2012)
	What is your trust level in Government officials working on environmental regulations?	

Table 11 Smog Risk Perception Indicators

5.1. Climate Change Indicators

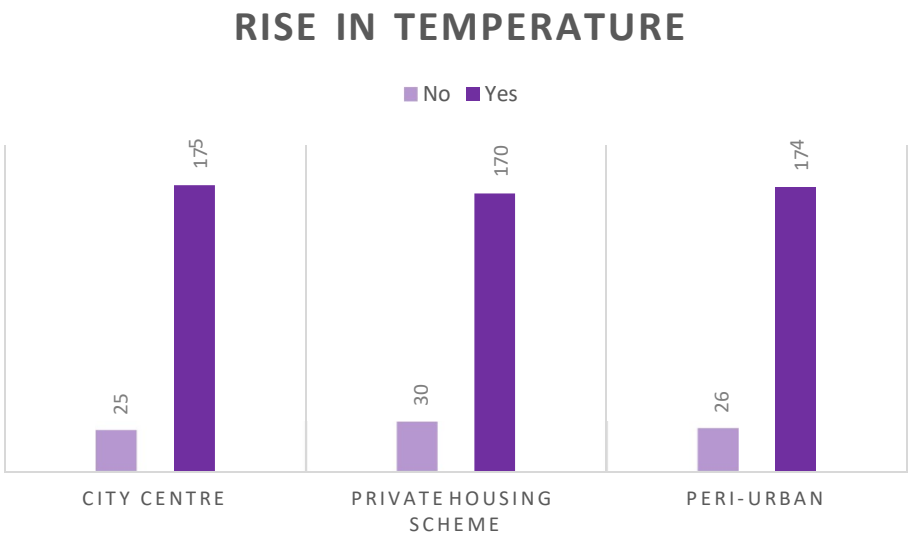
As smog is influenced by climate change, therefore, in risk perception analysis it is important to consider climate change. Climate change can exacerbate the formation of smog by creating conditions that are more conducive to its formation. Addressing smog and climate change requires a coordinated effort to reduce emissions of both smog-forming pollutants and greenhouse gases.

5.1.1. Rise in Temperature

The rapid changes in climate increasing temperature annually, which also contributing in smog risk. The respondents have been asked whether they felt rise in temperature so far or not. At which, mostly respondents respond from all three areas that they have felt rise in temperature with number of frequencies of 175, 170 and 174. While, minimum number of responses has been collected in "No" category.

Areas	**Do you feel rise in temperature**	
	No	Yes
City Centre	25	175
Private Housing Scheme	30	170
Peri-Urban	26	174

Table 12 Rise in Temperature



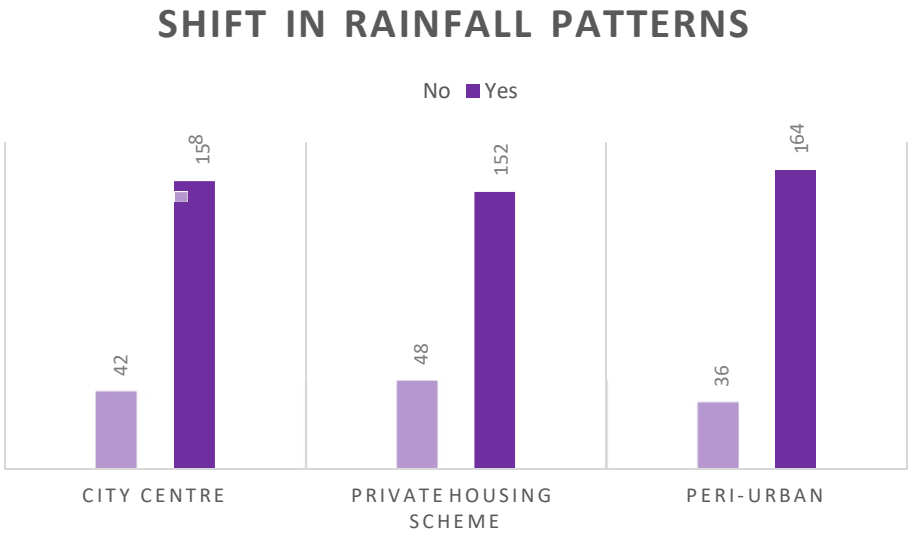
Graph 9 Rise in Temperature

5.1.2. Shift in Rainfall Patterns

Climate change is causing shifts in rainfall patterns around the world, as warmer temperatures alter the water cycle and atmospheric circulation patterns. Considering the issues, the question has been asked about the shifts in rainfall patterns. The large number of frequencies from all three areas has been under "Yes" category with the count of 158, 152 and 164.

Area	Is there shift in rainfall patterns	
	No	Yes
City Centre	42	158
Private Housing Scheme	48	152
Peri-Urban	36	164

Table 13 Shift in Rainfall Patterns



Graph 10 Shift in Rainfall Patterns

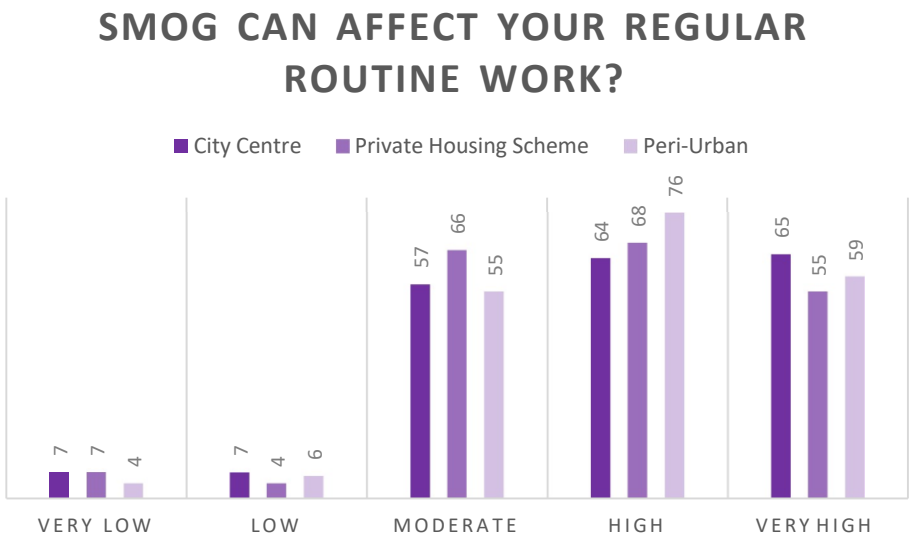
5.2. Risk Perception Indicators

5.2.1. Smog can Affect Regular Routine Work

The collected data has shown that in peri-urban areas 76 respondents responds that their work routine highly affected while in city center 65 number of respondents respond in very high category. Whereas in private housing schemes 66 number of frequencies shows that smog has affect their regular work routine moderately.

		How much do you think that smog can affect your regular routine work?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	7	7	57	64	65	200
	Private Housing Scheme	7	4	66	68	55	200
	Peri-Urban	4	6	55	76	59	200
	Total	18	17	178	208	179	600

Table 14 . Smog can Affect Regular Routine Work



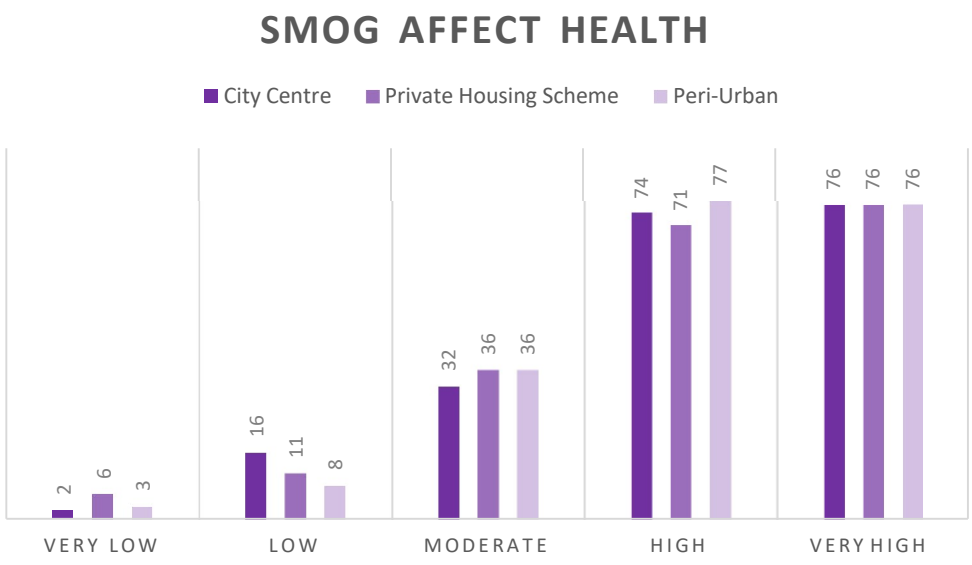
Graph 11 . Smog can Affect Regular Routine Work

5.2.2. Smog Affect Health

The collected data has shown that in peri-urban areas 77 respondents responds that smog has affected health highly affected while in city center 76 number of respondents respond in very high category. Whereas in private housing schemes 36 number of frequencies shows that smog has on health moderately.

		Does smog affect your health?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	2	16	32	74	76	200
	Private Housing Scheme	6	11	36	71	76	200
	Peri-Urban	3	8	36	77	76	200
	Total	11	35	104	222	228	600

Table 15 Smog Affect Health



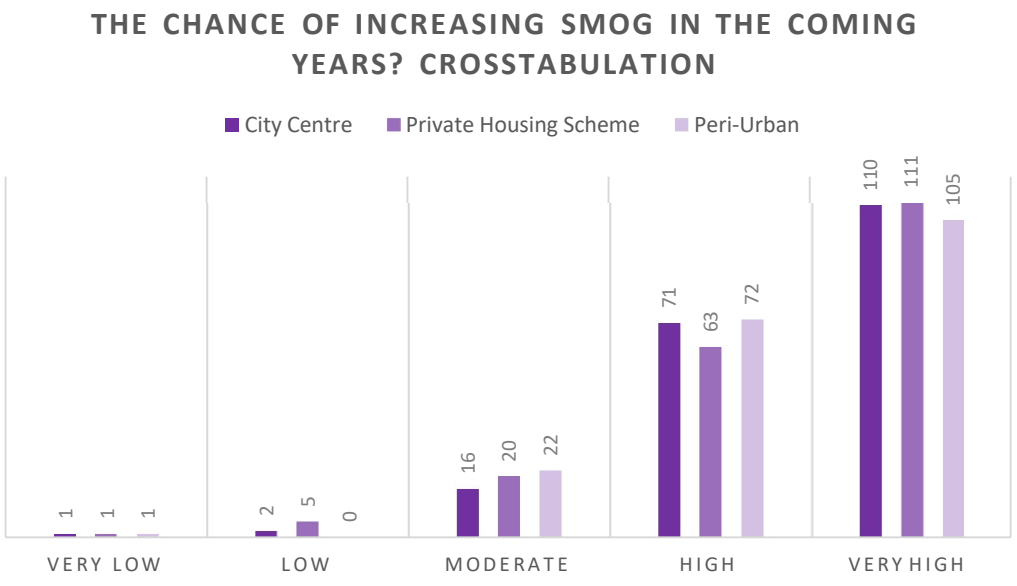
Graph 12 Smog Affect Health

5.2.3. Chance of Increasing Smog in Coming Years

The collected data has shown that in peri-urban areas 72 respondents responds that there are high chances of increasing smog in coming years while in city center 110 number of respondents respond in very high category. Whereas in private housing schemes 16 number of frequencies shows that smog moderate chance of increasing smog in coming years.

		What do you believe is the chance of increasing smog in the coming years?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	1	2	16	71	110	200
	Private Housing Scheme	1	5	20	63	111	200
	Peri-Urban	1	0	22	72	105	200
	Total	3	7	58	206	326	600

Table 16 Chance of Increasing Smog in Coming Years



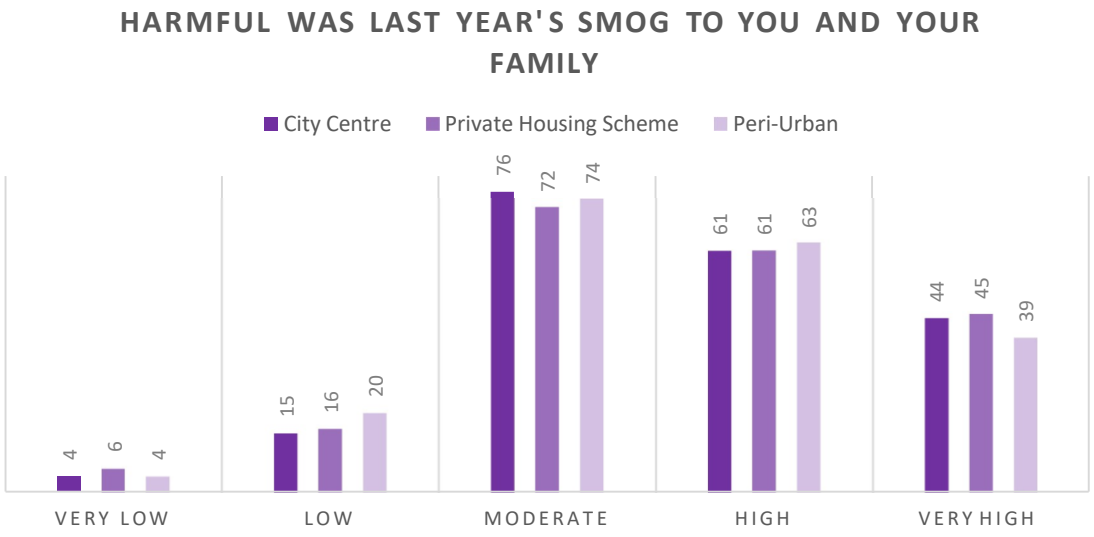
Graph 13 Chance of Increasing Smog in Coming Years

5.2.4. Last Year Smog Affect

The collected data has shown that in peri-urban areas 63 respondents responds that last year smog has highly affected them while in city center 44 number of respondents respond in very high category. Whereas in private housing schemes 72 number of frequencies shows that last year smog moderately affected their families.

		How harmful was last year's smog to you and your family?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	4	15	76	61	44	200
	Private Housing Scheme	6	16	72	61	45	200
	Peri-Urban	4	20	74	63	39	200
	Total	14	51	222	185	128	600

Table 17 Last Year Smog Affect



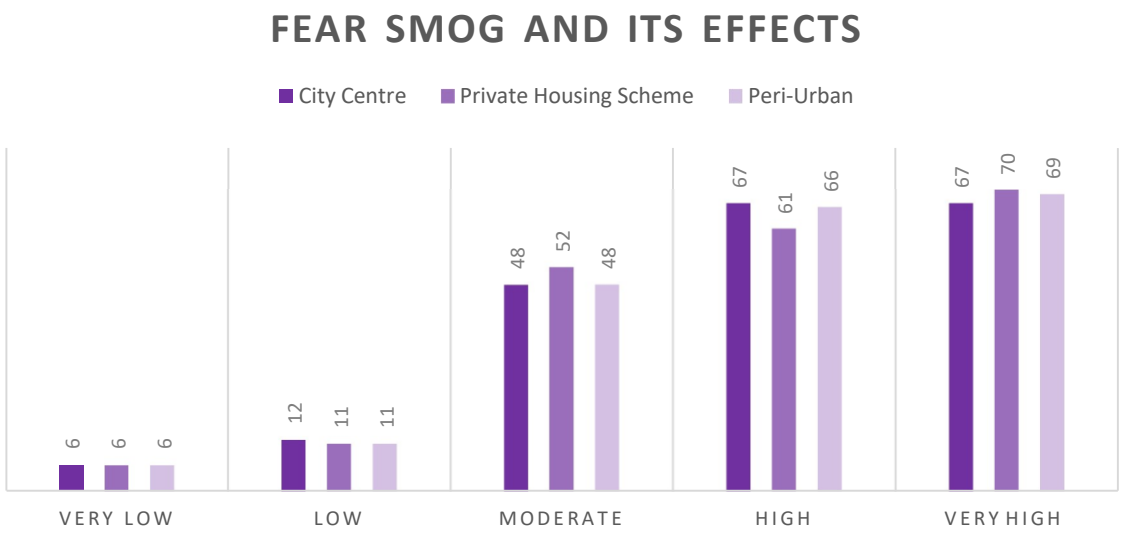
Graph 14 Last Year Smog Affect

5.2.5. Fear Smog and It's Effects

The collected data has shown that in peri-urban areas 66 respondents responds that they have high smog fear while in city center 44 number of respondents respond in very high category. Whereas in private housing schemes 72 number of frequencies shows that they don't have much fear related to smog and its effect, and responded moderately.

		How much do you fear smog and its effects?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	6	12	48	67	67	200
	Private Housing Scheme	6	11	52	61	70	200
	Peri-Urban	6	11	48	66	69	200
	Total	18	34	148	194	206	600

Table 18 Fear Smog and It's Effects



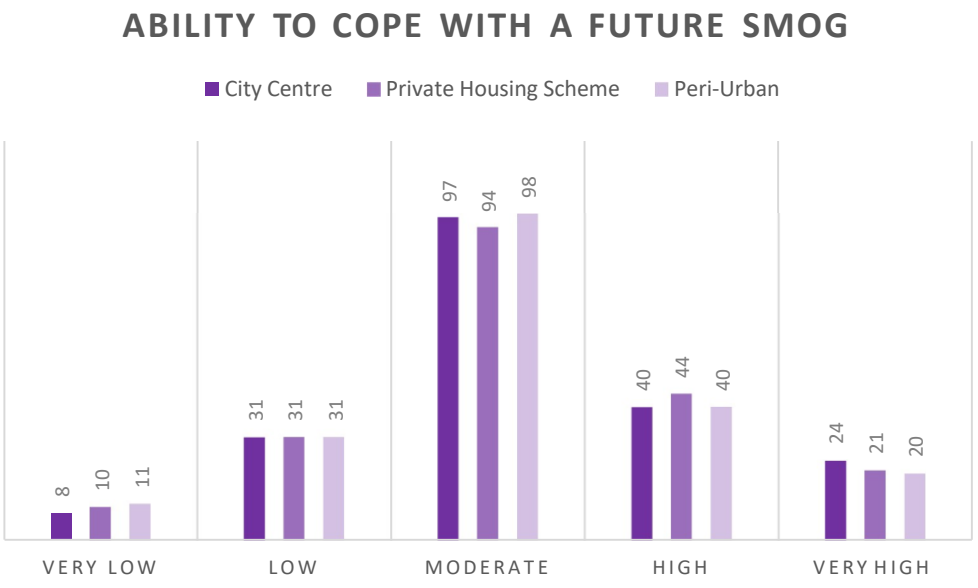
Graph 15 Fear Smog and It's Effects

5.2.6. Ability to cope with Future Smog

The data showed that in peri-urban areas 40 respondents responds that they have high ability to cope with future smog while in city center only 24 number of respondents respond in very high category. Whereas in private housing schemes 94 number of frequencies shows that they have moderate ability to cope with future smog.

		What do you believe is your ability to cope with a future smog?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	8	31	97	40	24	200
	Private Housing Scheme	10	31	94	44	21	200
	Peri-Urban	11	31	98	40	20	200
	Total	29	93	289	124	65	600

Table 19 Ability to cope with Future Smog



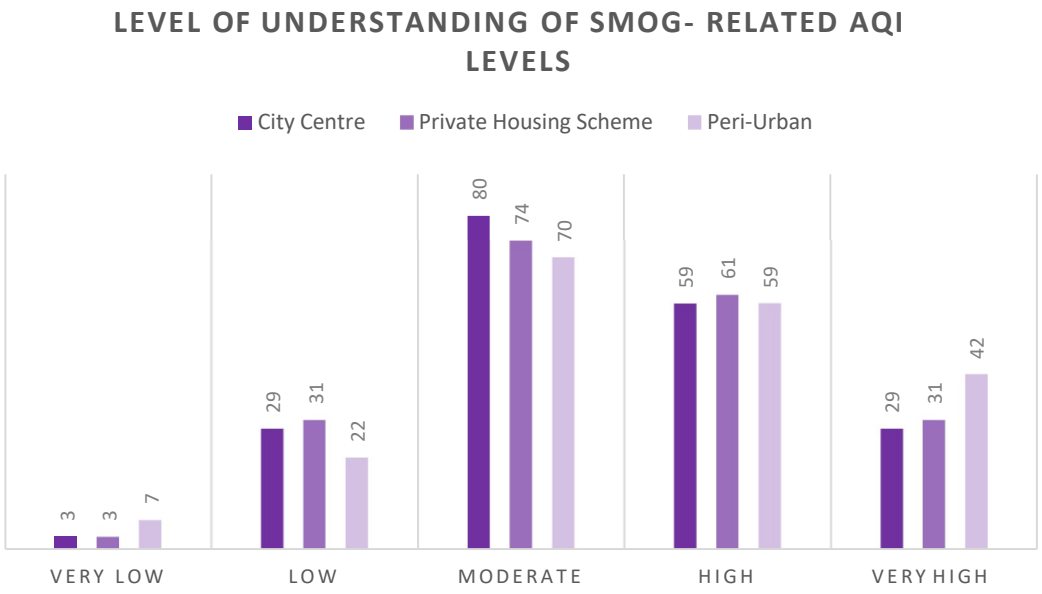
Graph 16 Ability to cope with Future Smog

5.2.7. Understanding of AQI Levels

The data showed that in peri-urban areas 59 respondents responds that they have high level of understanding of smog related AQI levels while in city center only 29 number of respondents respond in very high category. Whereas in private housing schemes 74 number of frequencies shows that they have moderate level of understanding of smog related AQI levels.

		What is the level of understanding of smog-related AQI levels?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	3	29	80	59	29	200
	Private Housing Scheme	3	31	74	61	31	200
	Peri-Urban	7	22	70	59	42	200
	Total	13	82	224	179	102	600

Table 20 Understanding of AQI Levels



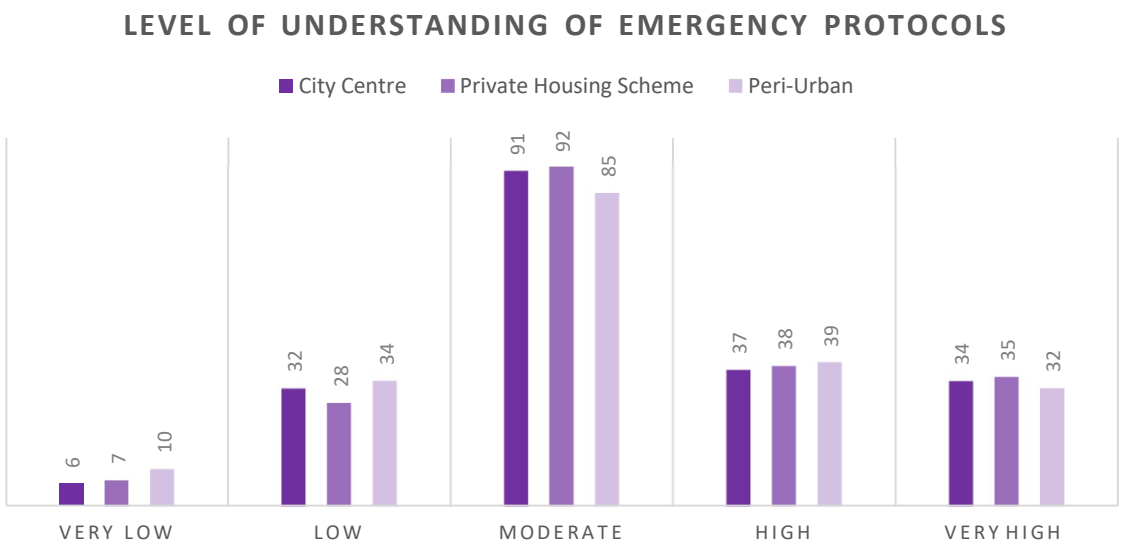
Graph 17 Understanding of AQI Levels

5.2.8. Understanding of Emergency Protocols

The data showed that in peri-urban areas 39 respondents responds that they have high level of understanding of emergency protocols while in city center 34 number of respondents respond in very high category. Whereas in private housing schemes 92 number of frequencies shows that they have moderate level of understanding of emergency protocols.

		What is the level of understanding of emergency protocols?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	6	32	91	37	34	200
	Private Housing Scheme	7	28	92	38	35	200
	Peri-Urban	10	34	85	39	32	200
	Total	23	94	268	114	101	600

Table 21 Understanding of Emergency Protocols



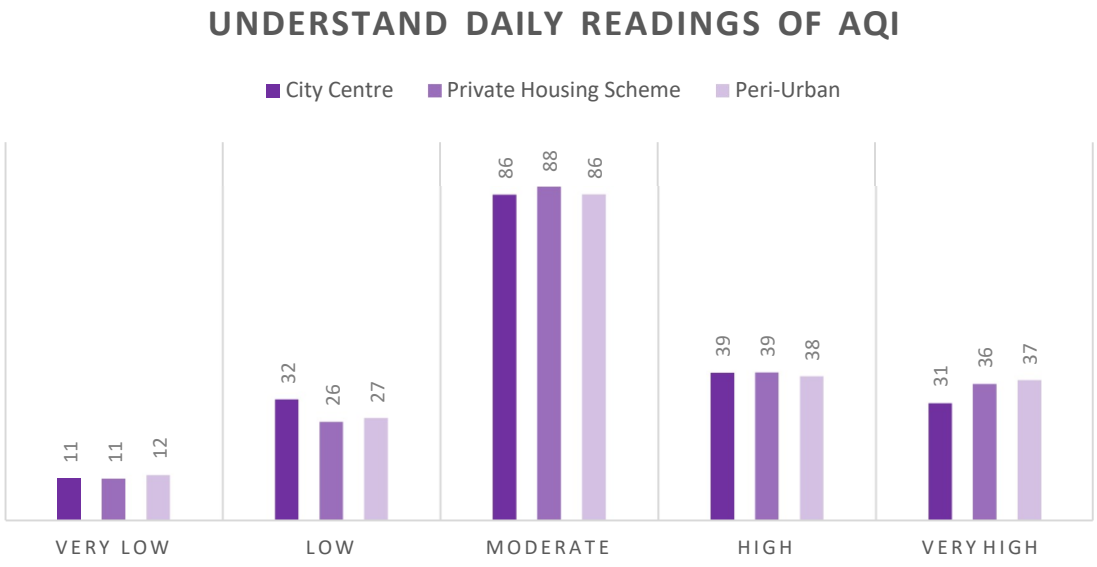
Graph 18 Understanding of Emergency Protocols

5.2.9. Understanding Daily Readings of AQI

The data showed that in peri-urban areas 38 respondents responds that they have high level of understanding daily readings of AQI while in city center 31 number of respondents respond in very high category. Whereas in private housing schemes 88 number of frequencies shows that they have moderate level of understanding daily readings of AQI.

		How much do you understand daily readings of AQI?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	11	32	86	39	31	200
	Private Housing Scheme	11	26	88	39	36	200
	Peri-Urban	12	27	86	38	37	200
	Total	34	85	260	116	104	600

Table 22 Understanding Daily Readings of AQI



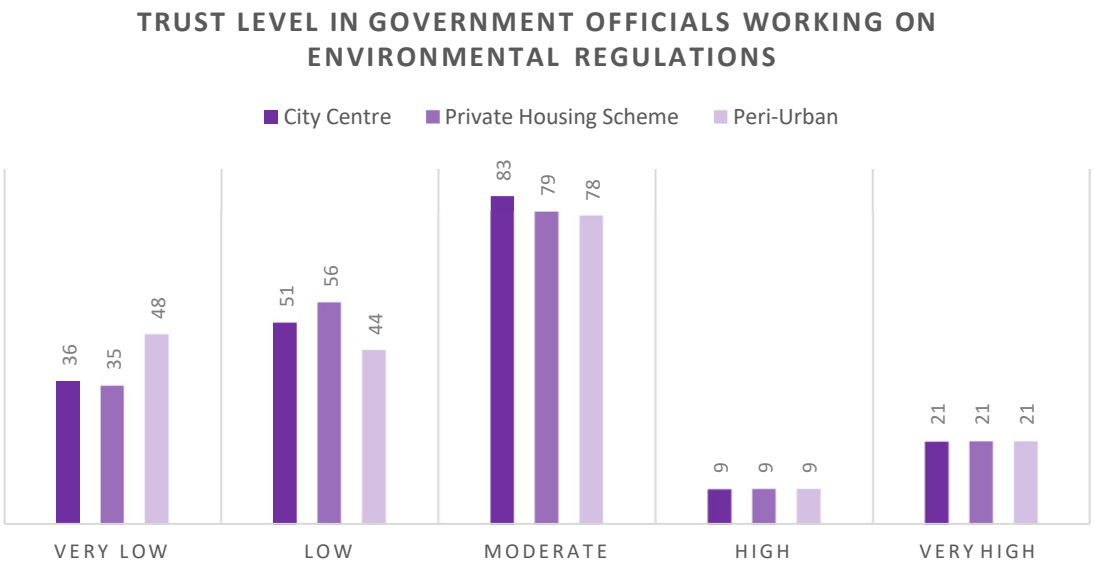
Graph 19 Understanding Daily Readings of AQI

5.2.10. Trust Level in Government Officials

Collected data shows that 48 number of respondents from peri urban area have very low trust level in Government officials working on environment regulations whereas respondents from private housing scheme have frequency of 56 people who responded in low category, while 83 respondents from city center shows that they have moderate trust level in Government officials who are working on environmental regulations.

		What is your trust level in Government officials working on environmental regulations?					Total
		Very Low	Low	Moderate	High	Very High	
Area name	City Centre	36	51	83	9	21	200
	Private Housing Scheme	35	56	79	9	21	200
	Peri-Urban	48	44	78	9	21	200
	Total	119	151	240	27	63	600

Table 23 Trust Level in Government Officials



Graph 20 Trust Level in Government Officials

CHAPTER 6
VULNERABILITY ASSESSMENT

6. Vulnerability Assessment

Smog vulnerability is often regarded as a product of the effects of sensitivity, exposure, and adaptive capacity. It is often linked to buildings, urban structures, and characteristics of individuals. Some of the factors that influence smog vulnerability include the built environment, climate change, human activities, crop burning, self-perception of risk, polluted environment, and heavy traffic and industrialization. These factors impact an individual's sensitivity and exposure to smog vulnerability as well as also impact their capacities to respond, anticipate, and adapt to conditions of smog (Luis Inostroza, 2016).

A vulnerability assessment for smog involves identifying the factors that make a population or area more susceptible to the harmful effects of smog. This can help policymakers and public health officials to develop targeted strategies to reduce exposure and improve health outcomes.

Some of the factors that can increase vulnerability to smog include:

1. Age: Children and elderly individuals are more vulnerable to the health effects of smog due to their underdeveloped or weakened respiratory and immune systems.
2. Pre-existing health conditions: People with pre-existing health conditions such as asthma, chronic obstructive pulmonary disease (COPD), and heart disease are more vulnerable to the effects of smog and may experience more severe symptoms.
3. Socioeconomic status: Individuals from lower socioeconomic backgrounds may be more vulnerable to the effects of smog due to factors such as living in areas with higher levels of pollution, having limited access to healthcare, and being unable to afford air purifiers or other measures to reduce exposure.
4. Location: Individuals living in urban areas or near major sources of pollution such as highways or industrial sites may be more vulnerable to the effects of smog.
5. Exposure duration and intensity: Individuals who are exposed to high levels of smog for prolonged periods of time are more vulnerable to the health effects of smog.

By identifying the factors that make populations or areas more vulnerable to the effects of smog, policymakers and public health officials can develop targeted strategies to reduce exposure and

improve health outcomes. These strategies may include measures such as improving public transportation, promoting cleaner energy sources, implementing regulations on industrial emissions, and providing resources for vulnerable populations to reduce exposure.

6.1. Sensitivity

Sensitivity analysis is an important aspect of vulnerability analysis for smog because it helps to identify which factors have the greatest impact on vulnerability and which factors may have a smaller impact. This information can be used to prioritize interventions and target resources effectively.

Some of the factors that may be considered in a sensitivity analysis for vulnerability to smog include:

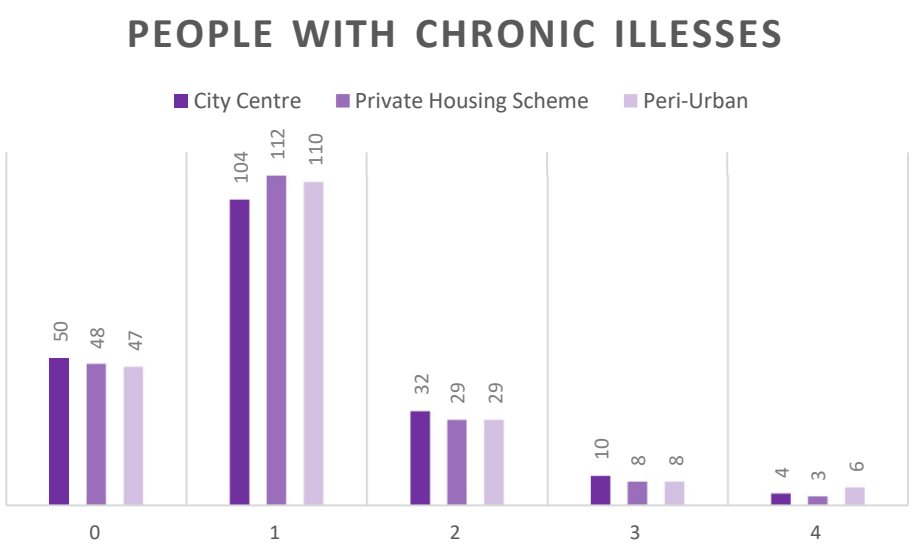
1. Exposure duration and intensity: The length and intensity of exposure to smog can have a significant impact on vulnerability. Individuals who are exposed to high levels of smog for prolonged periods of time are at greater risk of experiencing negative health effects.
2. Population density: The density of the population in a particular area can affect vulnerability to smog. Areas with high population densities may experience greater levels of pollution due to the concentration of emissions from vehicles and other sources.
3. Age and health status: The vulnerability of certain populations, such as children and the elderly, can be impacted by age and pre-existing health conditions.
4. Socioeconomic status: Vulnerability can be influenced by socioeconomic factors, such as poverty, access to healthcare, and access to resources that can reduce exposure to smog.
5. Climate and weather patterns: Changes in climate and weather patterns can affect the formation and dispersion of smog, which can impact vulnerability.

6.1.1. Members with chronic Illness

Chronic illness means long term illness one could have. Chronic illness can be triggered by smog. The data shows that majority of respondents have only one member with chronic illness with frequencies of 104, 112 and 110. Whereas, with frequencies of 50, 48 and 47 shows that there are zero members with chronic illness.

		How many members with chronic illnesses?					Total
		0	1	2	3	4	
Area name	City Centre	50	104	32	10	4	200
	Private Housing Scheme	48	112	29	8	3	200
	Peri-Urban	47	110	29	8	6	200
	Total	145	326	90	26	13	600

Table 24 Members with chronic Illness



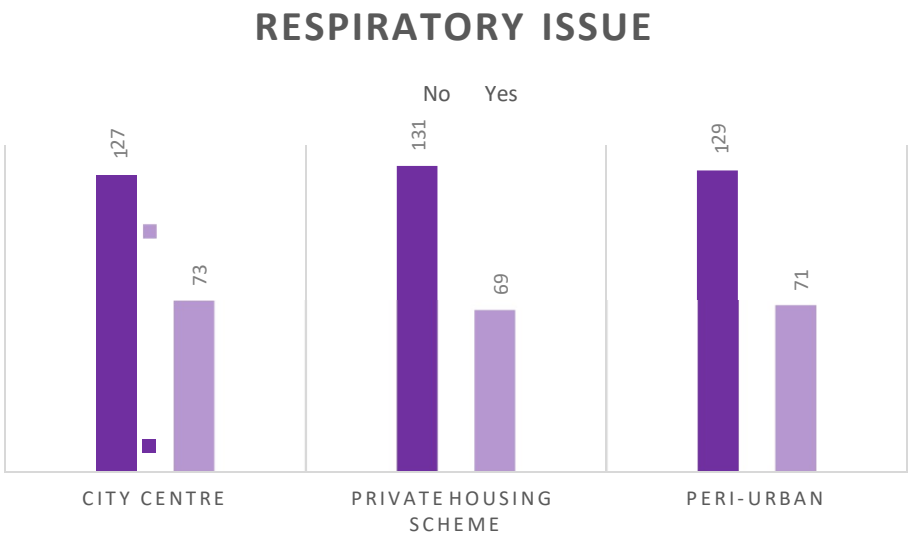
Graph 21 Members with chronic Illness

6.1.2. Respiratory Issue

The data showed that large number of frequencies shows that major respondents don't have respiratory issues with numbers of 127, 131 and 129.

		Respiratory		Total
		No	Yes	
Area name	City Centre	127	73	200
	Private Housing Scheme	131	69	200
	Peri-Urban	129	71	200
	Total	387	213	600

Table 25 Respiratory Issue



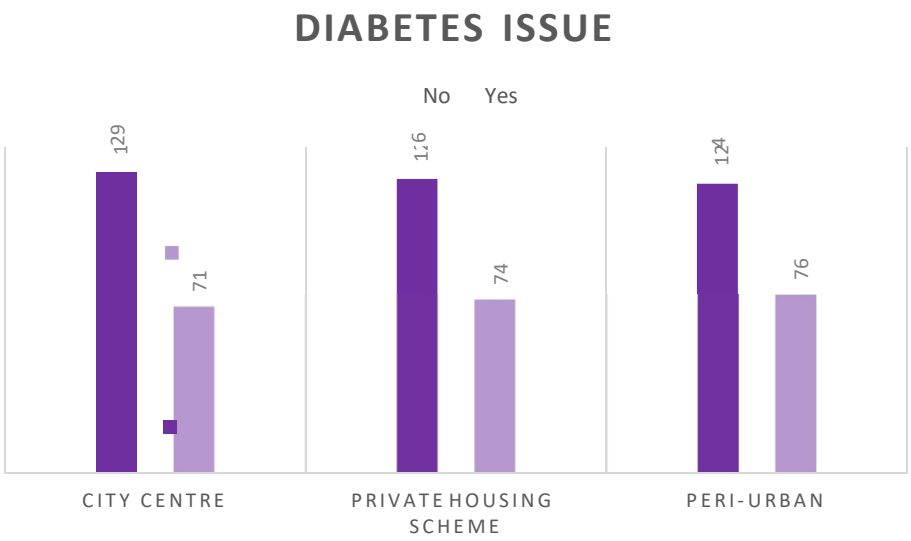
Graph 22 Respiratory Issue

6.1.3. Diabetes

Collected data represents that with frequencies of 129, 126 and 124 respondents from respective areas responded “No” to diabetes while in peri urban areas 76 number of respondents respond to “yes”.

		Diabetes		Total
		No	Yes	
Area name	City Centre	129	71	200
	Private Housing Scheme	126	74	200
	Peri-Urban	124	76	200
	Total	379	221	600

Table 26 Diabetes



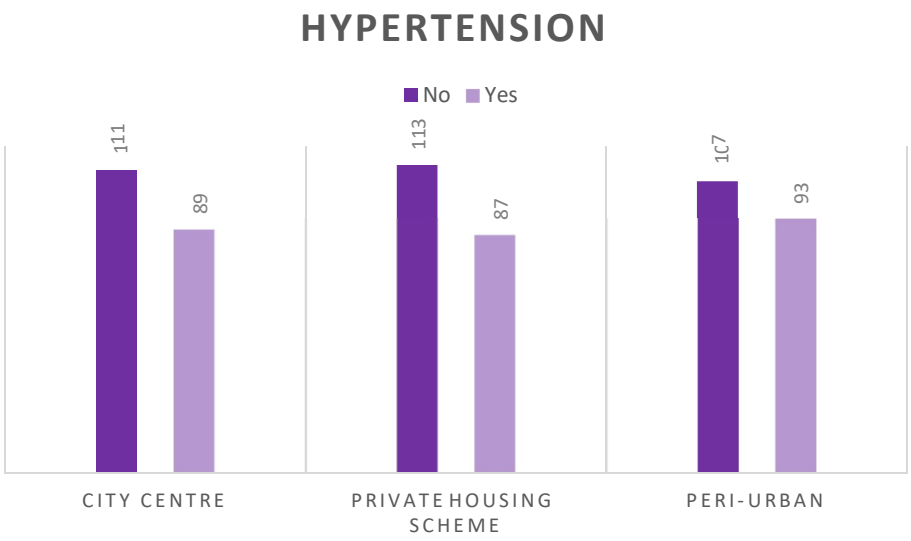
Graph 23 Diabetes

6.1.4. Hypertension

Collected data represents that with frequencies of 111, 113 and 107 respondents from respective areas responded “No” to hypertension while in peri urban areas 93 number of respondents respond to “yes”.

		Hypertension		Total
		No	Yes	
Area name	City Centre	111	89	200
	Private Housing Scheme	113	87	200
	Peri-Urban	107	93	200
	Total	331	269	600

Table 27 Hypertension



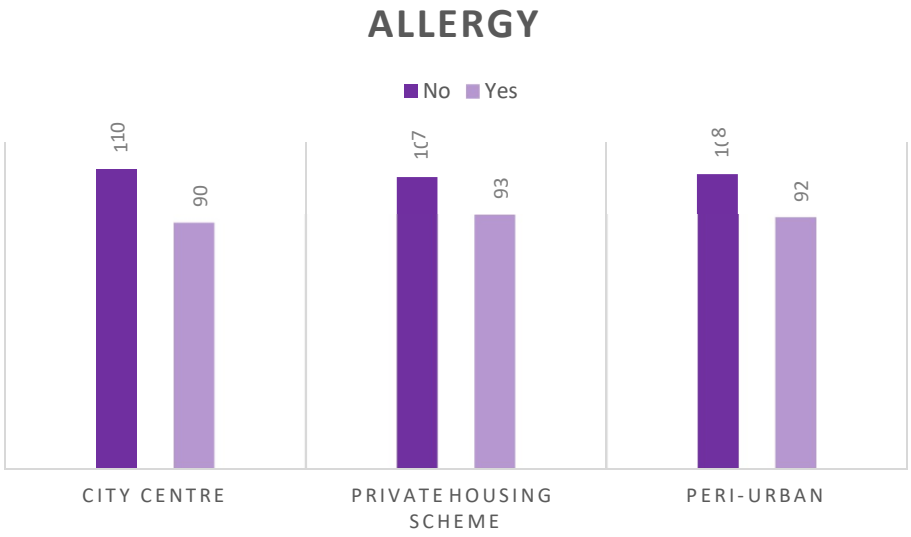
Graph 24 Hypertension

6.1.5. Allergy

Collected data represents that with frequencies of 110, 107 and 108 respondents from respective areas responded “No” to any type of allergies while in private housing schemes area 93 number of respondents respond to “yes”.

		Allergy		Total
		No	Yes	
Area name	City Centre	110	90	200
	Private Housing Scheme	107	93	200
	Peri-Urban	108	92	200
	Total	325	275	600

Table 28 Allergy



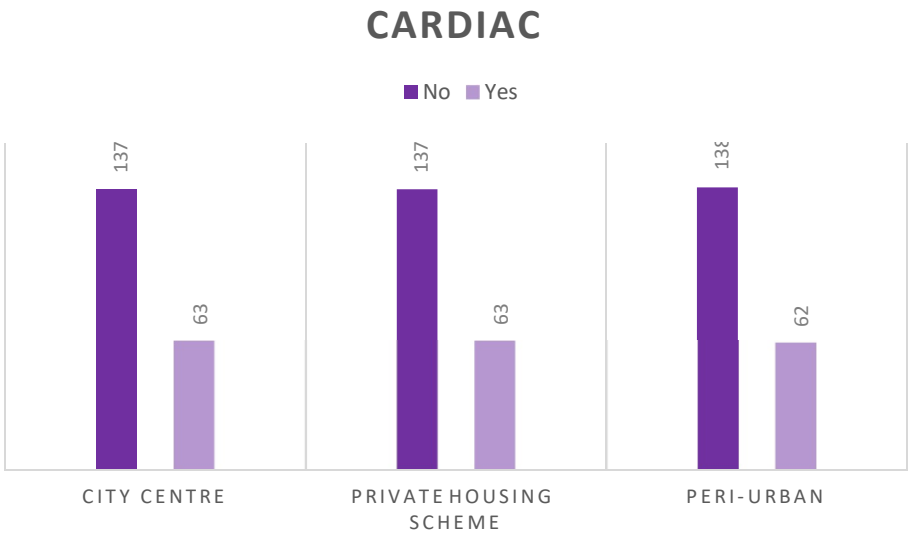
Graph 25 Allergy

6.1.6. Cardiac

Collected data represents that with frequencies of 137, 137 and 138 respondents from respective areas responded “No” to cardiac issues while in private housing schemes and peri urban areas 93 number of respondents respond to “yes”.

		Cardiac		Total
		No	Yes	
Area name	City Centre	137	63	200
	Private Housing Scheme	137	63	200
	Peri-Urban	138	62	200
	Total	412	188	600

Table 29 Cardiac



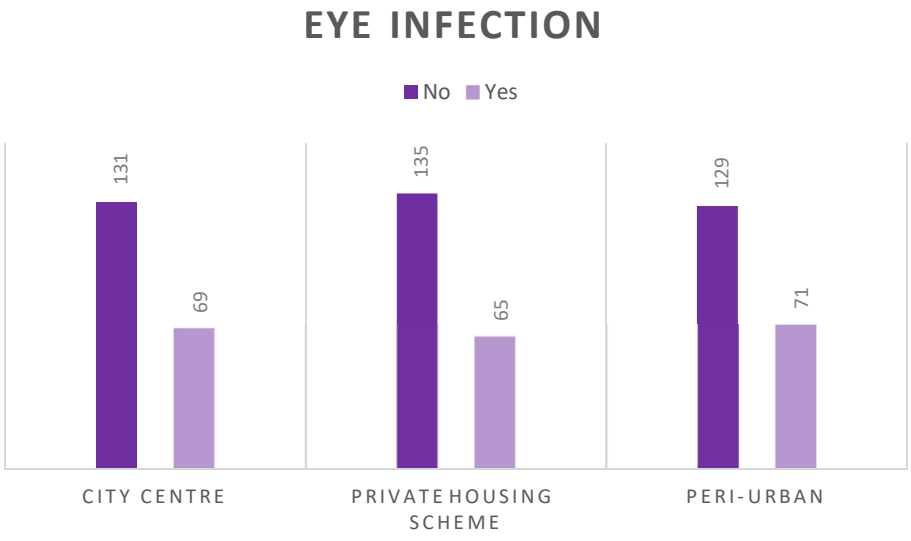
Graph 26 Cardiac

6.1.7. Eye Infection

Collected data represents that with frequencies of 131, 135 and 129 respondents from respective areas responded “No” to eye infection while in peri urban areas 71 number of respondents respond to “yes”.

		Eye Infection		Total
		No	Yes	
Area name	City Centre	131	69	200
	Private Housing Scheme	135	65	200
	Peri-Urban	129	71	200
	Total	395	205	600

Table 30 Eye Infection



Graph 27 Eye Infection

6.2. Exposure

The other predominant element of vulnerability is exposure which means “the degree, extent, and duration in which the system is in contact with or subject to perturbation” (Adger W. , 2006).

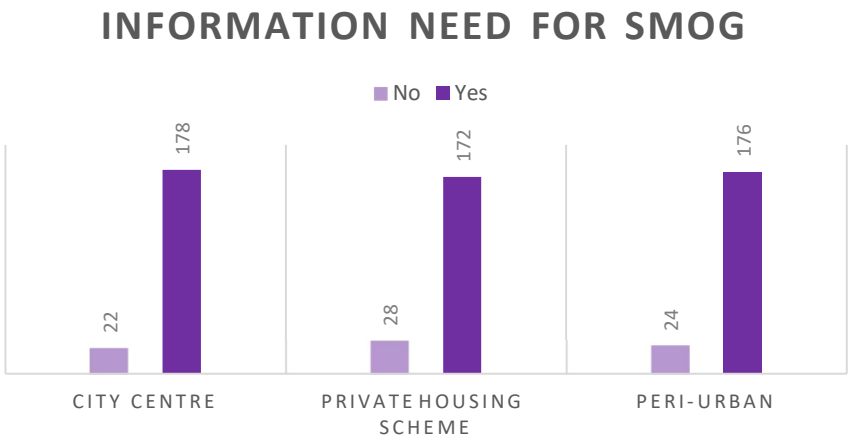
Whereas, (IPCC, 2014) defines exposure as ‘‘The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.’’

6.2.1. Information need for smog

As smog is a very vulnerable environmental condition for Pakistan, every individual has been affected from the bad impacts of smog. Information regarding smog is one of the most curious and important knowledge one should have. The data shows that 178,172 and 176 number of respondents from respective areas are willing to get information regarding smog. Whereas, a small number of respondents responds in denial.

		Information need about smog		Total
		No	Yes	
Area name	City Centre	22	178	200
	Private Housing Scheme	28	172	200
	Peri-Urban	24	176	200
	Total	74	526	600

Table 31 Information need for smog



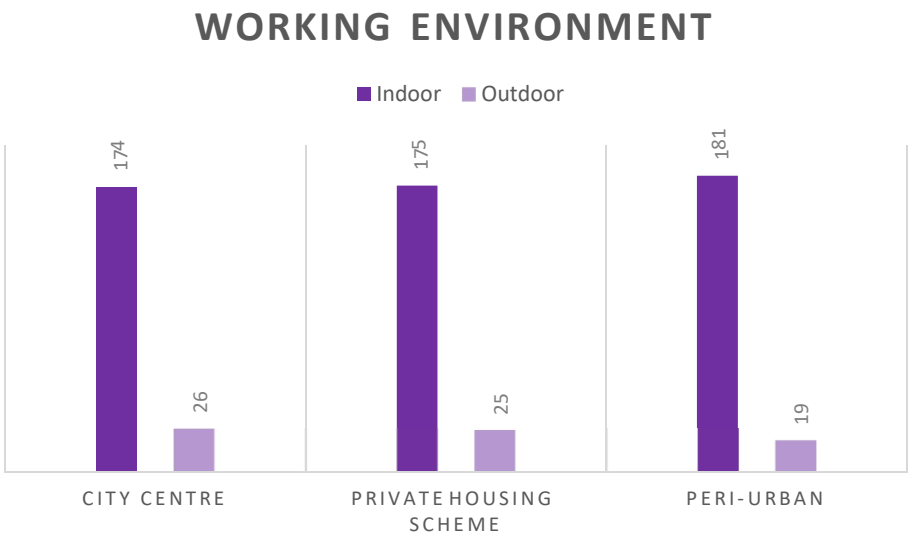
Graph 28 Information need for smog

6.2.2. Working Environment

Working environment during smog has serious impact on individual. Respondents who has practical or field jobs has been responded to “Outdoor” working environment with number of 26, 25 and 19 from respective areas. Whereas majority of respondents have “Indoor” working environment with the number of 174, 175 and 181 from the respective areas.

		Working Environment		Total
		Indoor	Outdoor	
Area name	City Centre	174	26	200
	Private Housing Scheme	175	25	200
	Peri-Urban	181	19	200
	Total	530	70	600

Table 32 Working Environment



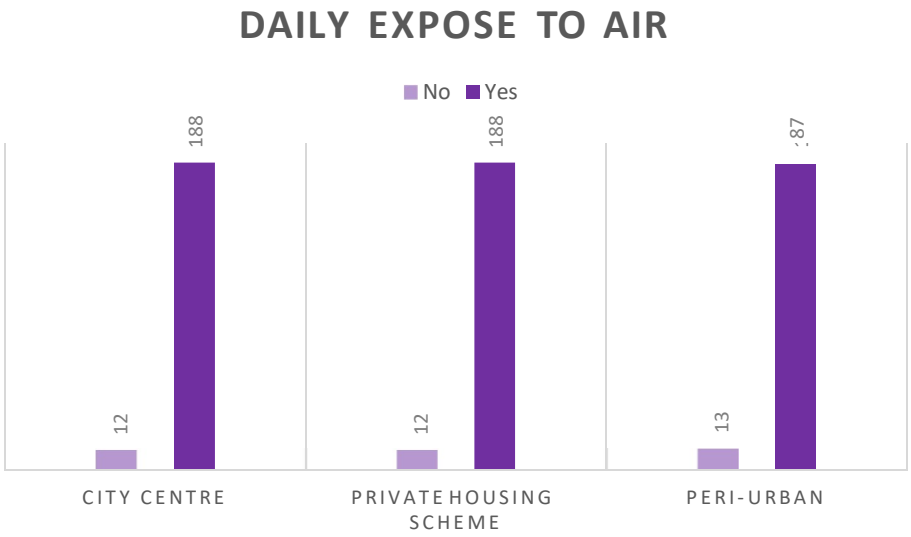
Graph 29 Working Environment

6.2.3. Daily expose to air

During smog, the number of times a person expose itself to air becomes more vulnerable every time, but due to the daily routines everyone has to expose themselves to air at least one time a day, the responses shows that 188,188 and 187 respondents expose themselves to air on daily basis from the respective areas.

		Do you expose yourself daily to the air?		Total
		No	Yes	
Area name	City Centre	12	188	200
	Private Housing Scheme	12	188	200
	Peri-Urban	13	187	200
	Total	37	563	600

Table 33 Daily expose to air



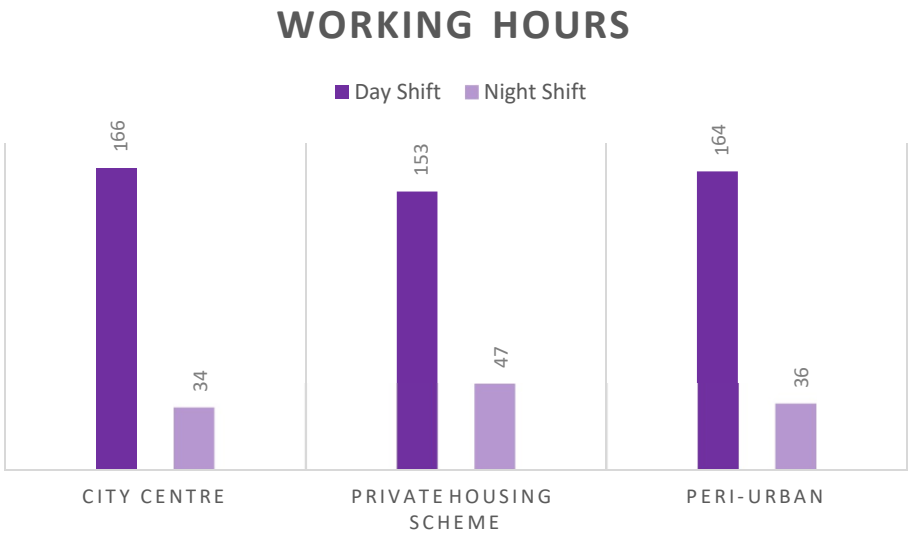
Graph 30 Daily expose to air

6.2.4. Working Hours

Working hours usually differ from job to job. Day shifts are more exposed to smog then the night shifts. The frequency data shows that 166, 153 and 164 respondents responded to “Day Shift” from all three areas whereas 34, 47 and 36 respondents respond to “Night Shift”.

		Working Hours		Total
		Day Shift	Night Shift	
Area name	City Centre	166	34	200
	Private Housing Scheme	153	47	200
	Peri-Urban	164	36	200
	Total	483	117	600

Table 34 Working Hours



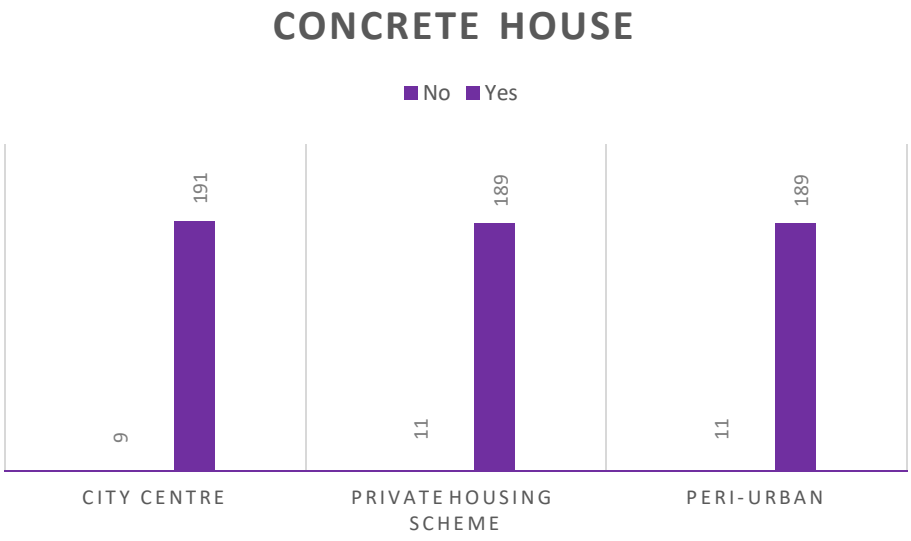
Graph 31 Working Hours

6.2.5. Concrete House

The analysis shows that concrete material has contributed to environmental pollution. Although, mostly house structure is based on concrete which is why 191, 189 and 189 respondents respond to “Yes” that their house structure is concrete based.

		House structure is concrete		Total
		No	Yes	
Area name	City Centre	9	191	200
	Private Housing Scheme	11	189	200
	Peri-Urban	11	189	200
	Total	31	569	600

Table 35 Concrete House



Graph 32 Concrete House

6.3. Coping Capacity

Coping capacity refers to a community's ability to prepare for and respond to the negative impacts of smog. Some factors that can influence coping capacity include access to resources, infrastructure, and institutional capacity.

Here are some ways in which communities can build their coping capacity for smog:

1. Education and Awareness: Education and awareness programs can help individuals and communities understand the causes and effects of smog and how to protect themselves from exposure.
2. Monitoring and Early Warning Systems: Implementing air quality monitoring and early warning systems can help communities prepare for periods of high smog levels and take preventive measures to reduce exposure.
3. Urban Planning and Design: Urban planning and design can play a critical role in reducing smog exposure by promoting pedestrian and cycling infrastructure, reducing traffic congestion, and locating sensitive land uses, such as schools and hospitals, away from major sources of pollution.
4. Green Spaces: The creation of green spaces can help to mitigate the negative effects of smog by absorbing pollutants and improving air quality.
5. Building Codes and Standards: Building codes and standards can be used to ensure that new buildings are designed to reduce energy consumption and emissions, thus reducing the overall impact of smog.
6. Emergency Response Plans: Developing emergency response plans can help communities respond to periods of high smog levels and provide resources and support to vulnerable populations.
7. Partnerships and Collaboration: Collaboration between community organizations, local governments, and other stakeholders can help to build collective action and increase the effectiveness of coping strategies.

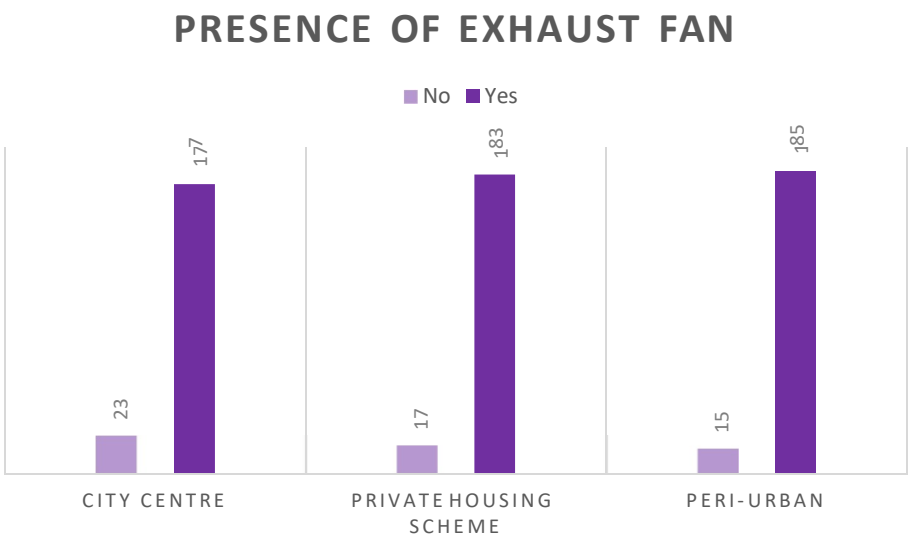
By building their coping capacity for smog, communities can better prepare for and respond to the negative impacts of smog, ultimately reducing their vulnerability and improving health outcomes.

6.3.1. Presence of Exhaust Fans

Exhaust fans helps to eliminate smoke from the area, having exhaust fans in rooms, offices, classrooms or houses can help to eliminate smog from the area as smog is also a mixture of fog and smoke. The frequency-based data shows that 177, 183 and 185 respondents respond in "Yes" that there is presence of exhaust fans while a small number of frequencies respond in "No".

		Presence of exhaust fans		Total
		No	Yes	
Area name	City Centre	23	177	200
	Private Housing Scheme	17	183	200
	Peri-Urban	15	185	200
	Total	55	545	600

Table 36 Presence of Exhaust Fans



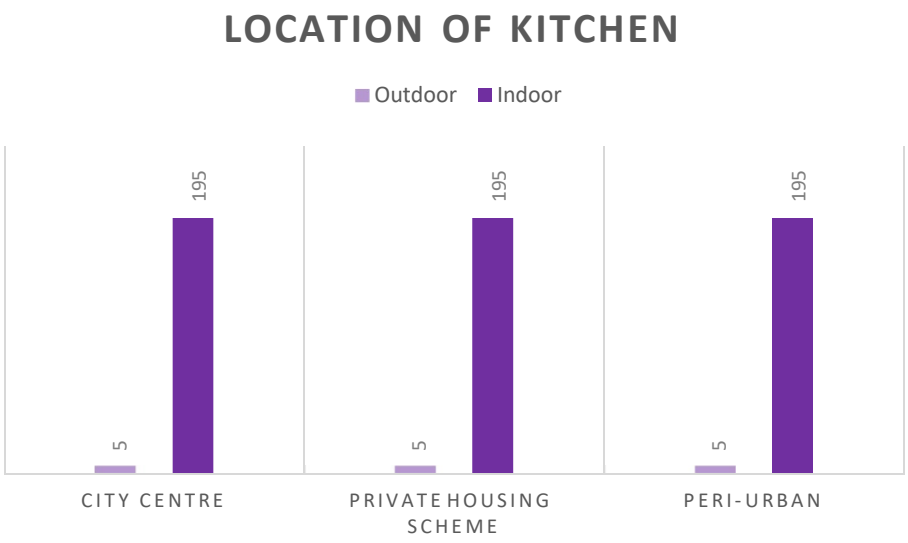
Graph 33 Presence of Exhaust Fans

6.3.2. Location of Kitchen

The data shows that 195, 195 and 195 number of respondents responds on the category of "Indoor" kitchen from the respective areas, while minimum number of respondents respond under the category of "Outdoor" kitchen.

		Location of Kitchen			Total
		Outdoor	Indoor		
Area name	City Centre	5	195		200
	Private Housing Scheme	5	195		200
	Peri-Urban	5	195		200
	Total	15	585		600

Table 37 Location of Kitchen



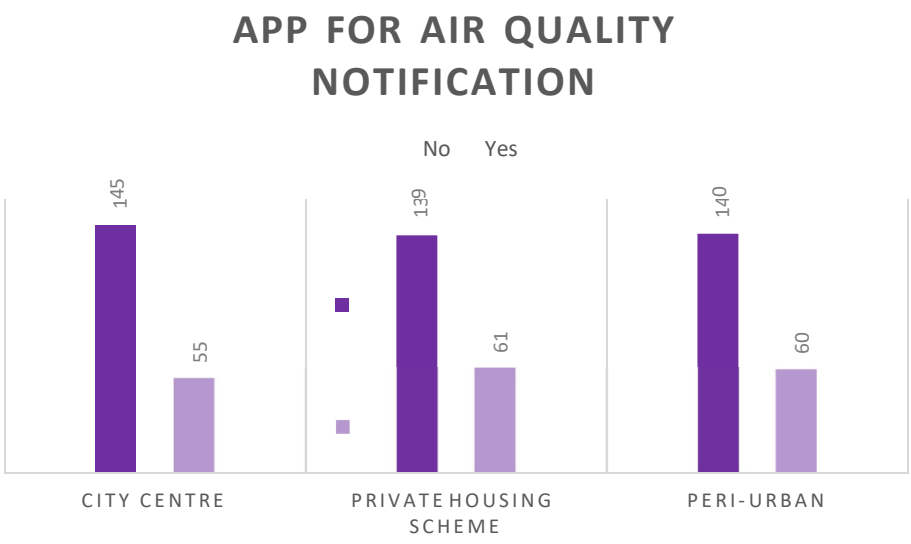
Graph 34 Location of Kitchen

6.3.3. App for air quality notification

Knowing any app for air quality notification helps to look around the AQI levels on daily basis, but majority of the responses are in denial category with the frequencies of 145, 139 and 140 from the respective areas. Whereas, a small number of responses responded that they know about the app related to air quality notification.

		Do you know about any app for air quality notification		Total
		No	Yes	
Area name	City Centre	145	55	200
	Private Housing Scheme	139	61	200
	Peri-Urban	140	60	200
	Total	424	176	600

Table 38 App for air quality notification



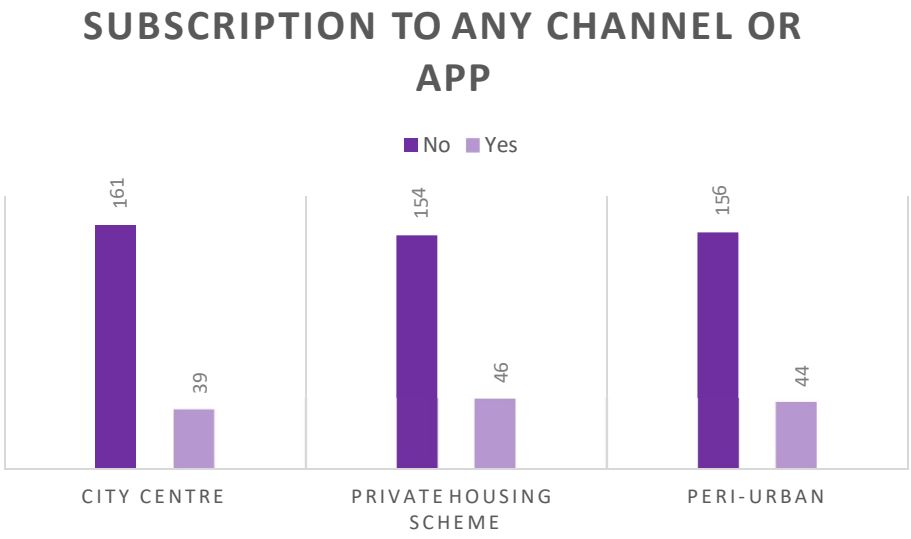
Graph 35 App for air quality notification

6.3.4. Subscription to any app or channel

Subscription to any app will help to inform about the increase or decrease of AQI levels. The frequency-based data shows that 161, 154 and 156 number of respondents responds in denial as they didn't subscribe to any channel or app for AQI level updates where as a small number of 39, 46 and 44 respondents from the respective areas responds in "yes".

		Have you ever subscribed to any channel or app for AQI Levels		Total
		No	Yes	
Area name	City Centre	161	39	200
	Private Housing Scheme	154	46	200
	Peri-Urban	156	44	200
	Total	471	129	600

Table 39 Subscription to any app or channel



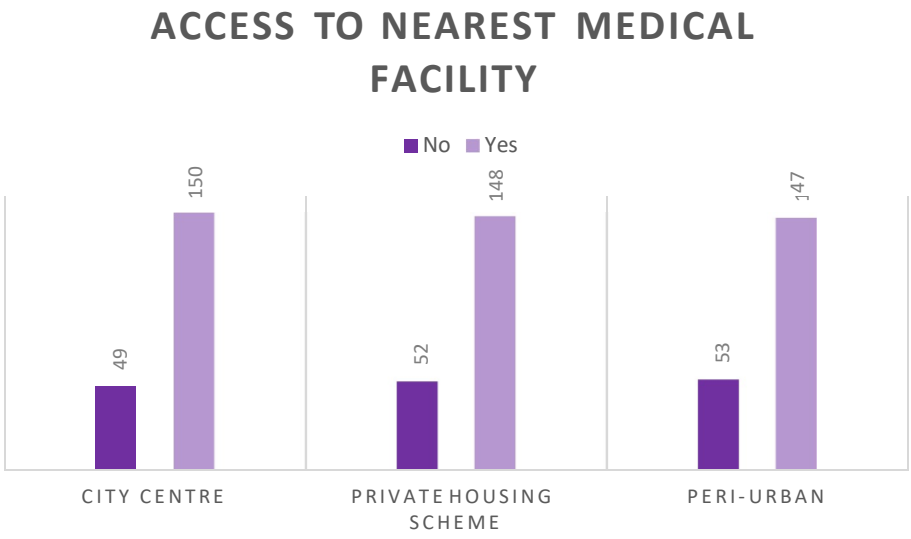
Graph 36 Subscription to any app or channel

6.3.5. Household with access to Medical Facility

Access to near medical facilities gives an ability to cope with any health issue. Collected data shows that 150, 148 and 147 frequencies of respondents have access to the nearest medical facility within 1 km whereas small number of respondents does not have access to medical facility within 1 km.

		Household with access to the nearest medical facility within 1 km		Total
		No	Yes	
Area name	City Centre	49	150	200
	Private Housing Scheme	52	148	200
	Peri-Urban	53	147	200
	Total	155	445	600

Table 40 Household with access to Medical Facility



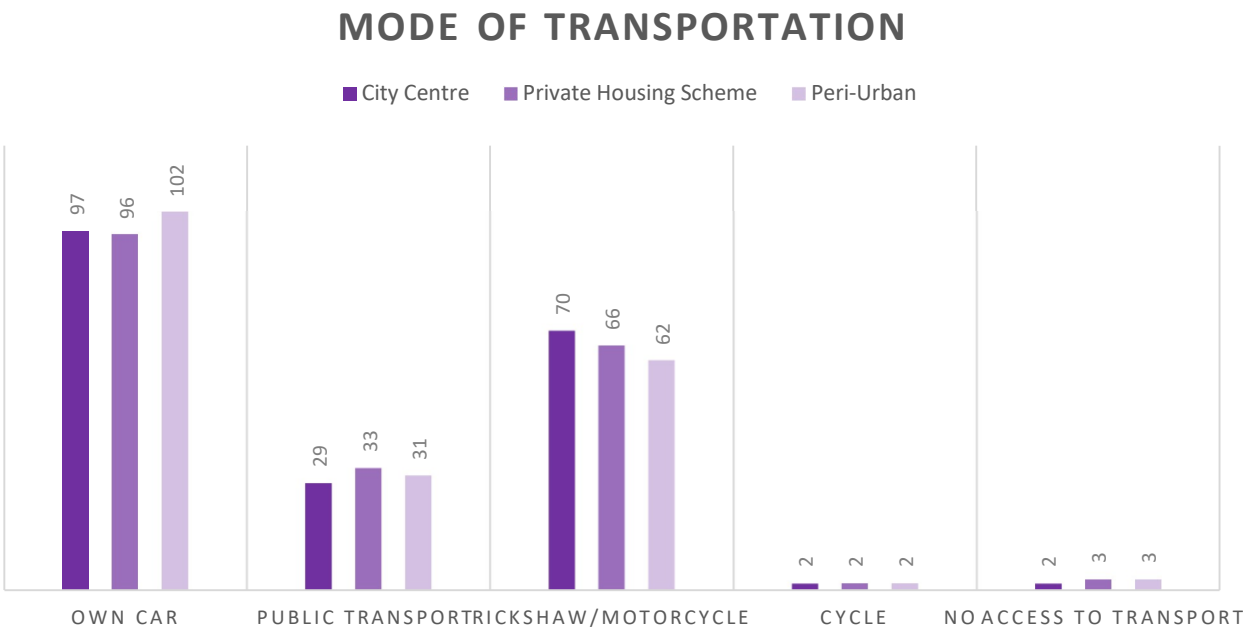
Graph 37 Household with access to Medical Facility

6.3.6. Access to Transportation Mode

The collected data shows that majority of respondents have access to own car with the frequencies of 97, 96 and 102 from all three areas, whereas, after own car; most of the respondents have access to rickshaw/motorcycle with the frequencies of 70, 66 and 62. Thirdly, public transport has access to 29, 33 and 31 number of respondents to their respective areas.

		Mode of transportation for travelling (multiple modes can be chosen)					Total
		Own Car	Public Transport	Rickshaw/Motorcycle	Cycle	No Access to Transport	
Area name	City Centre	97	29	70	2	2	200
	Private Housing Scheme	96	33	66	2	3	200
	Peri-Urban	102	31	62	2	3	200
	Total	295	93	198	6	8	600

Table 41 Access to Transportation Mode



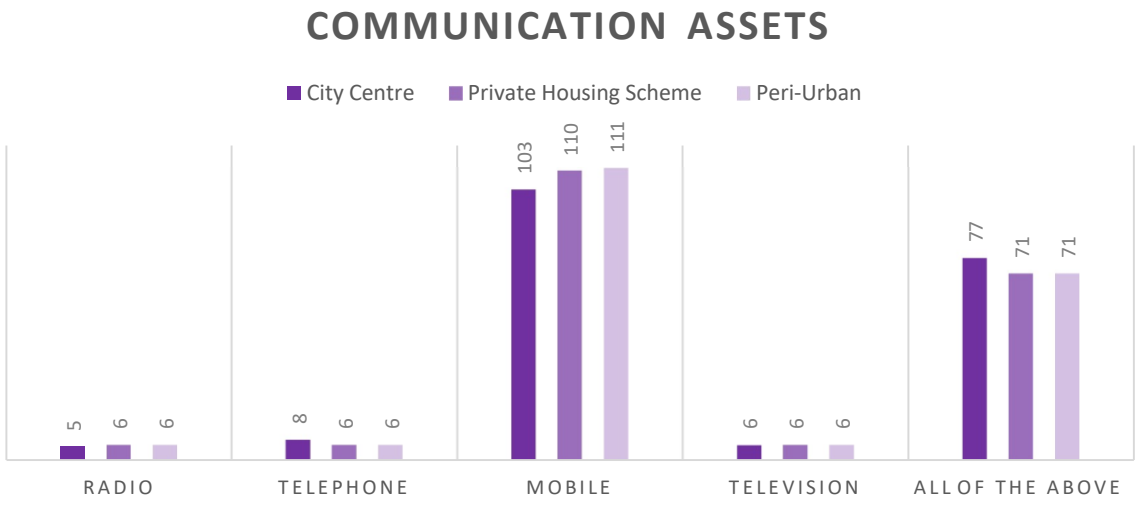
Graph 38 Access to Transportation Mode

6.3.7. Communication Assets Owned

The collected data shows that majority of the respondents own a mobile with the frequencies of 103, 110, and 111. Whereas 77, 71 ana 71 number of frequencies shows that they owned all types of communication assets in their respective areas.

		Communication assets owned (multiple assets can be chosen)					Total
		Radio	Telephone	Mobile	Television	All of the above	
Area name	City Centre	5	8	103	6	77	200
	Private Housing Scheme	6	6	110	6	71	200
	Peri-Urban	6	6	111	6	71	200
	Total	17	20	324	18	219	600

Table 42 Communication Assets Owned



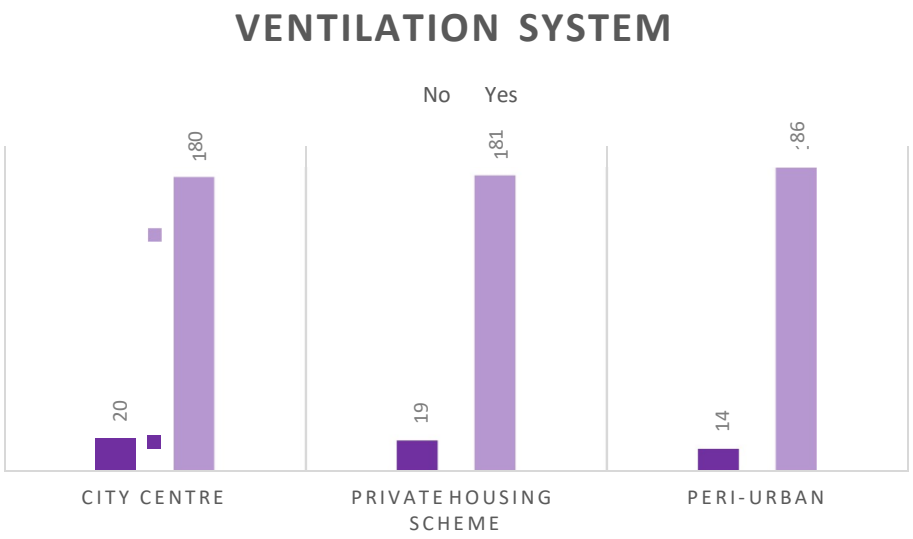
Graph 39 Communication Assets Owned

6.3.7. Adequate Ventilation System

Collected data shows that majority of respondents have adequate ventilation system in the house with the frequencies of 180, 181 and 186. Whereas a small number of respondents responded in denial with the frequencies of 20, 19 and 14 from their respective areas.

		Adequate ventilation system in the house		Total
		No	Yes	
Area name	City Centre	20	180	200
	Private Housing Scheme	19	181	200
	Peri-Urban	14	186	200
	Total	53	547	600

Table 43 Adequate Ventilation System



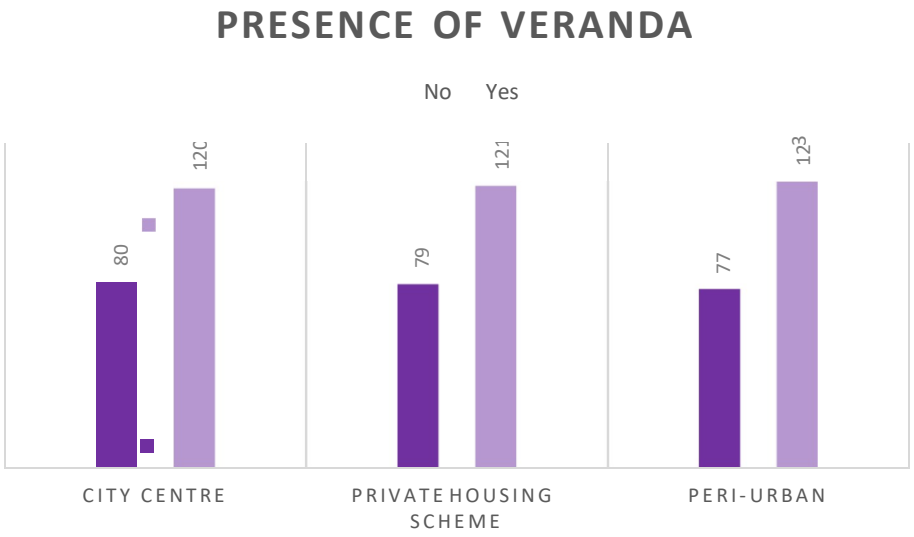
Graph 40 Adequate Ventilation System

6.3.8. Presence of Verandah

Collected data shows that majority of respondents have veranda in their homes with the frequencies of 120, 121 and 123 respectively in their areas. Whereas, the number of frequencies 80, 79 and 77 does not have any veranda in their homes.

		Presence of a veranda in the house		Total
		No	Yes	
Area name	City Centre	80	120	200
	Private Housing Scheme	79	121	200
	Peri-Urban	77	123	200
	Total	236	364	600

Table 44 Presence of Verandah



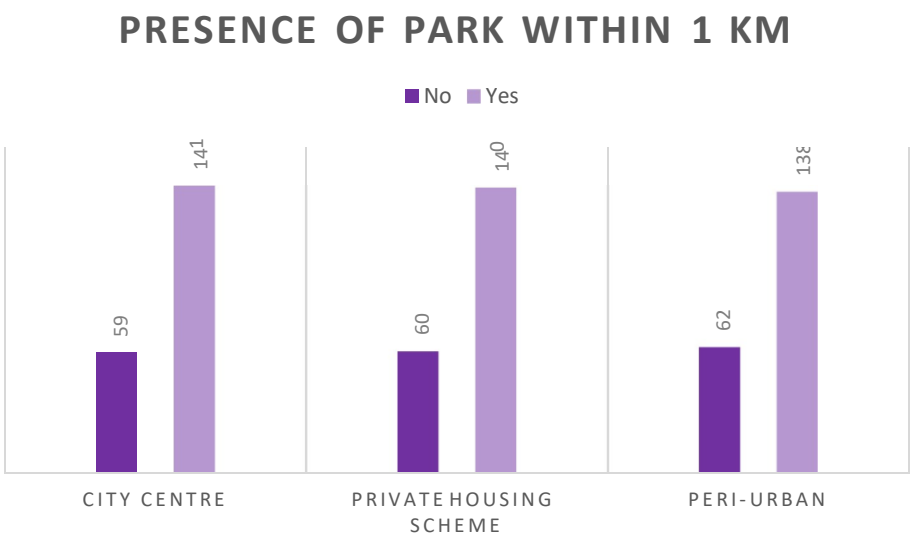
Graph 41 Presence of Verandah

6.3.9. Presence of Park

Collected data shows that majority of respondents have access to park within 1km of the house with the frequencies of 141, 140 and 138 from their respective areas. A small number of respondents shows denial in this perspective with the frequencies of 59, 60 and 62 from their respective areas.

		Presence of a park within 1km of the house		Total
		No	Yes	
Area name	City Centre	59	141	200
	Private Housing Scheme	60	140	200
	Peri-Urban	62	138	200
	Total	181	419	600

Table 45 Presence of Park



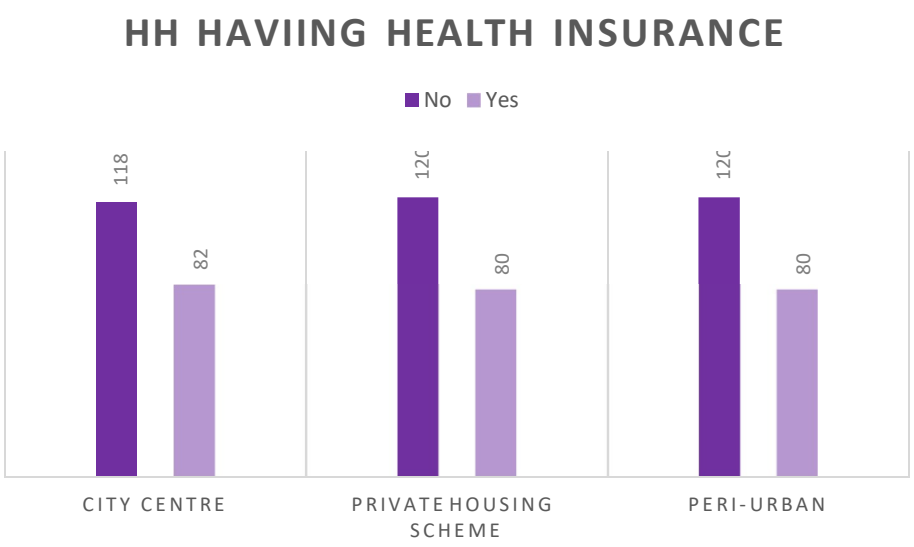
Graph 42 Presence of Park

6.2.10. Health/Life Insurance

The collected data shows that majority of respondents does not have health/life insurance with the frequencies of 118, 120 and 120 from their respective areas where as a small number of respondents responded that they do have health/life insurance with the frequencies of 82, 80 and 80 from their respective areas.

		Household having health/life insurance		Total
		No	Yes	
Area name	City Centre	118	82	200
	Private Housing Scheme	120	80	200
	Peri-Urban	120	80	200
	Total	358	242	600

Table 46 Health/Life Insurance



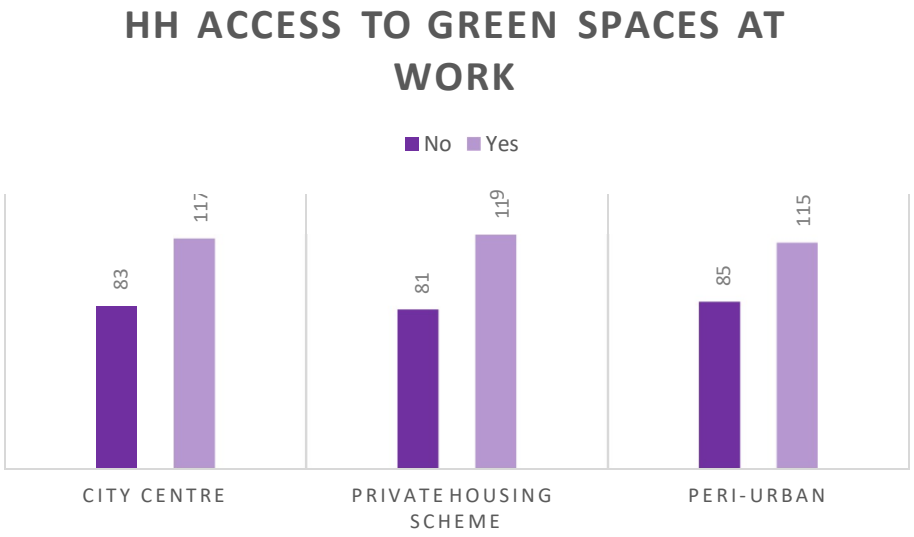
Graph 43 Health/Life Insurance

6.3.11. Access to green space at work

Collected data shows that majority of the respondents have access to green space at work with the frequency of 117, 119 and 115 from their respective areas where as frequencies of 83, 81 and 85 respondents shows that they didn't have green spaces at their work from the respective areas.

		Household members having access to green spaces at work		Total
		No	Yes	
Area name	City Centre	83	117	200
	Private Housing Scheme	81	119	200
	Peri-Urban	85	115	200
	Total	249	351	600

Table 47 Access to green space at work



Graph 44 Access to green space at work

CHAPTER 7

PREPAREDNESS

7. Preparedness

Preparedness for smog involves taking measures to minimize the negative impacts of smog on human health and the environment. Here are some strategies for preparedness for smog:

1. Monitor air quality: Use air quality monitoring systems to track smog levels and be aware of when they are high. This can help individuals and communities to take preventive measures to reduce exposure.
2. Stay informed: Stay up to date with the latest information about smog levels in your area and follow advice from health authorities and environmental agencies.
3. Reduce exposure: Take steps to reduce exposure to smog by staying indoors during periods of high smog levels, using air conditioning with high-efficiency filters, avoiding strenuous outdoor activity, and wearing a mask if necessary.
4. Promote cleaner energy sources: Promote the use of cleaner energy sources, such as renewable energy, to reduce emissions and improve air quality.
5. Implement regulations: Implement regulations on industrial emissions and vehicle emissions to reduce pollution levels and improve air quality.
6. Develop emergency response plans: Develop emergency response plans to prepare for periods of high smog levels and provide resources and support to vulnerable populations.
7. Build green spaces: Increase the number of green spaces in urban areas to absorb pollutants and improve air quality.
8. Support research: Support research to better understand the causes and impacts of smog and to develop new strategies for reducing emissions and improving air quality.

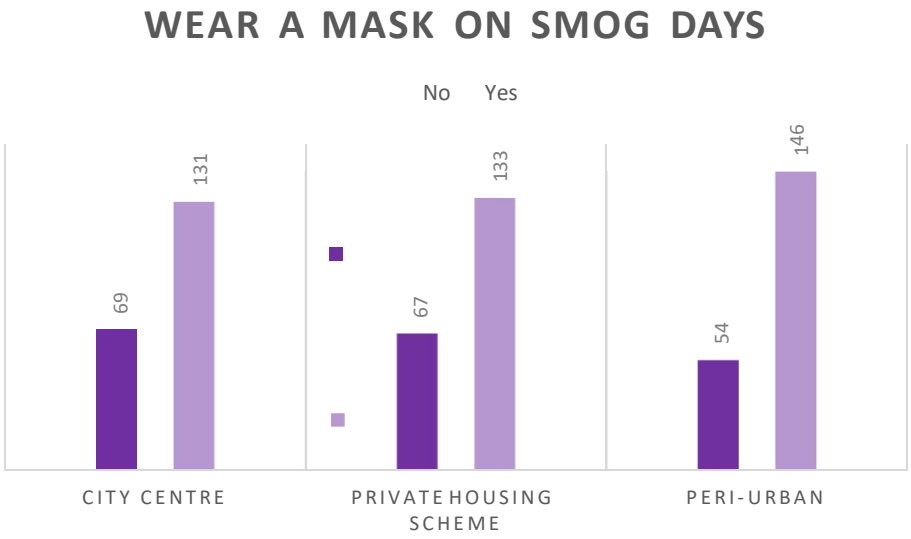
By taking these measures, individuals and communities can improve their preparedness for smog and reduce the negative impacts of smog on human health and the environment

7.1. Wear Mask During Smog Days

As smog is a hazardous mixture of smoke and fog which effects one's health to the extreme that he/she could have severe breathing and coughing issues. For this reason, it is important to wear mask during smog when going out. The collected data represents that majority of the responses does wear mask while going out with the frequencies of 131, 133 and 146 from the respective areas where as small number of frequencies 69, 67 and 54 shows that they do not wear mask.

		Do you wear a mask on smog days		Total
		No	Yes	
Area name	City Centre	69	131	200
	Private Housing Scheme	67	133	200
	Peri-Urban	54	146	200
	Total	190	410	600

Table 48 Wear Mask During Smog Days



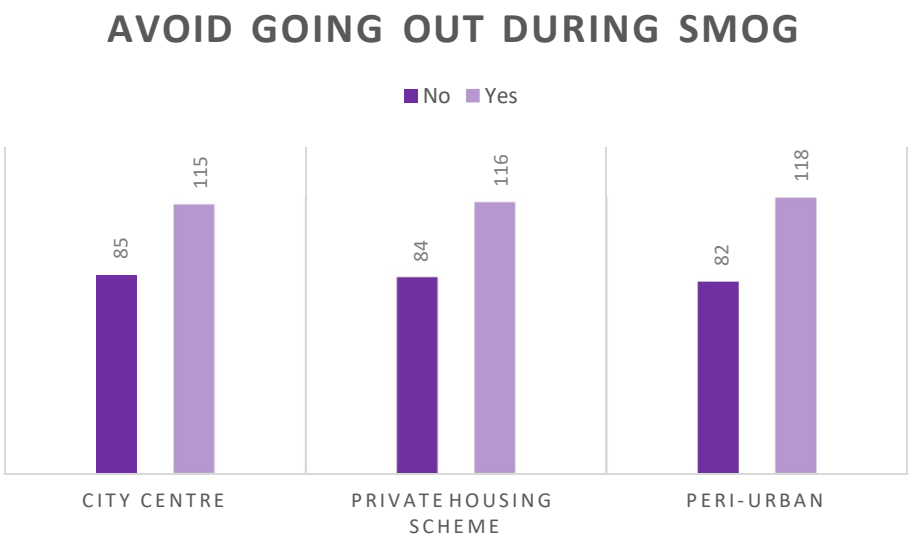
Graph 45 Wear Mask During Smog Days

7.2. Avoid going out

During smog, a person should prepare enough to avoid going out unnecessary which can protect he/she to get affected by smog. The collected represents that majority of people are well aware related to this as the frequency shows that 115, 116 and 118 number of individuals from respective areas avoid going out whereas frequencies with 85, 84 and 82 responded with denial.

		Avoid going out during smog		Total
		No	Yes	
Area name	City Centre	85	115	200
	Private Housing Scheme	84	116	200
	Peri-Urban	82	118	200
	Total	251	349	600

Table 49 Avoid going out



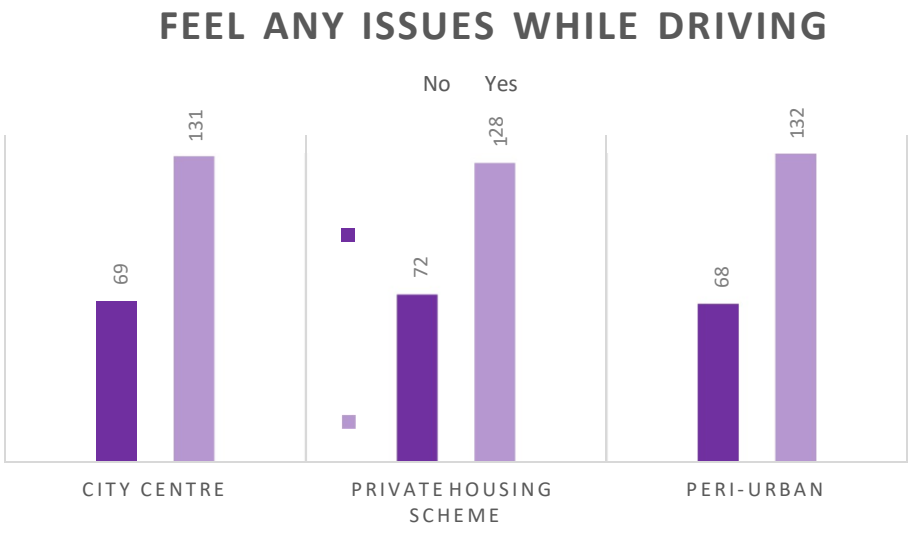
Graph 46 Avoid going out

7.3. Issue while driving

As already mentioned, that smog is a mixture of smoke and fog, it can affect one's visibility to see while driving. According to preparedness indicator, it is safe to avoid driving during smog and use public transport. In accordance to this, the majority of the respondents agree that they feel visibility issues while driving with the frequencies of 131, 128 and 132 from respective areas where as frequencies of 69, 72 and 68 shows that they do not feel any issue while driving during smog.

		Do you feel any issues while driving?		Total
		No	Yes	
Area name	City Centre	69	131	200
	Private Housing Scheme	72	128	200
	Peri-Urban	68	132	200
	Total	209	391	600

Table 50 Issue while driving



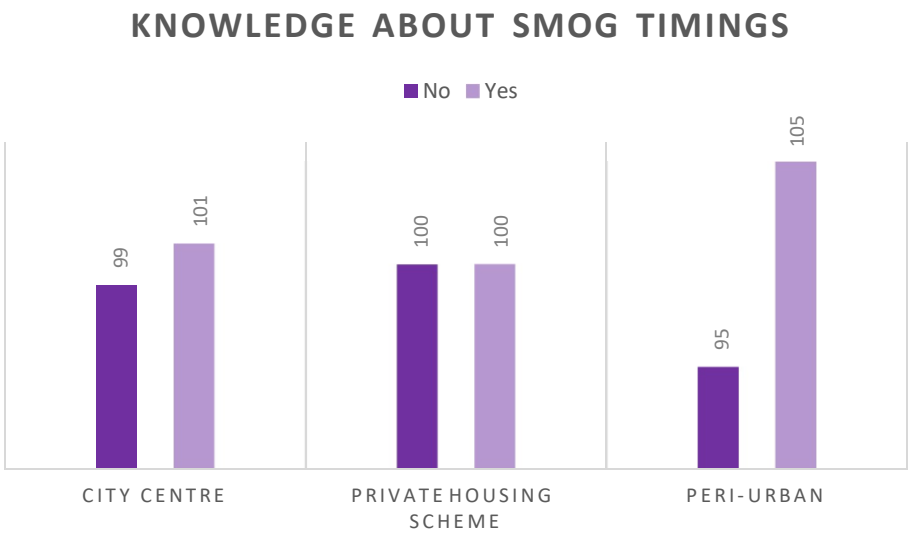
Graph 47 Issue while driving

7.4. Knowledge about smog timings

Smog usually appears at the morning or in the evening, knowing the times could help a person to be prepare while going out or avoid going out in these days. Collected data shows very slight difference about the knowledge of smog timings, it's almost equal that half of the respondents do know about smog timings and half of the respondents do not know about smog timings with the frequencies of 99, 100 and 95 from their respective areas.

		Any knowledge about smog timings		Total
		No	Yes	
Area name	City Centre	99	101	200
	Private Housing Scheme	100	100	200
	Peri-Urban	95	105	200
	Total	294	306	600

Table 51 Knowledge about smog timings



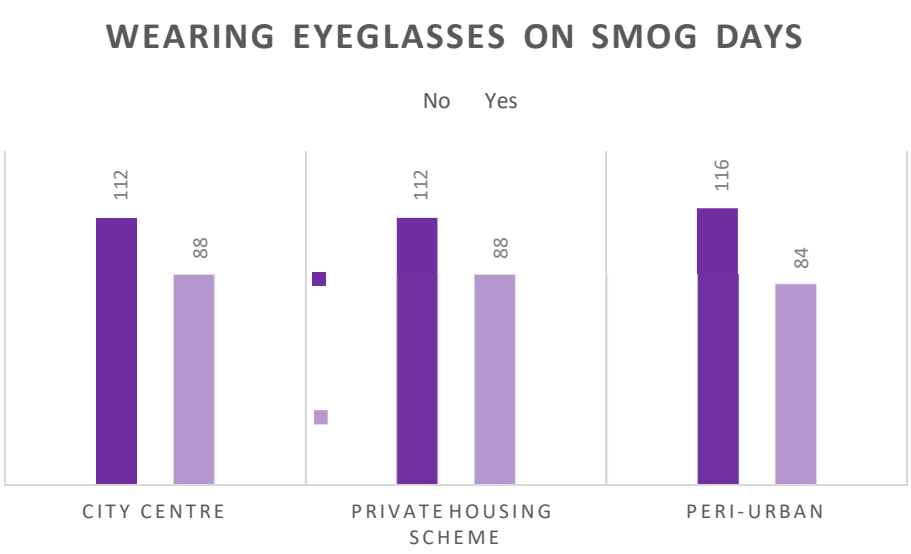
Graph 48 Knowledge about smog timings

7.5. Wearing Eye Glasses

The way smog is affecting one's internal health, the same way this hazardous mixture irritates a person's eyes. To be protected from this, it is important to wear eye glasses during smog. While the respondents are not well aware regarding this, as the data shows that majority of respondents responded in denial with the frequencies of 112, 112 and 116 from the respective areas whereas respondents with frequencies of 88, 88 and 84 shows positive response that they do wear eyeglasses during smog.

		Wearing eyeglasses on smog days		Total
		No	Yes	
Area name	City Centre	112	88	200
	Private Housing Scheme	112	88	200
	Peri-Urban	116	84	200
	Total	340	260	600

Table 52 Wearing Eye Glasses



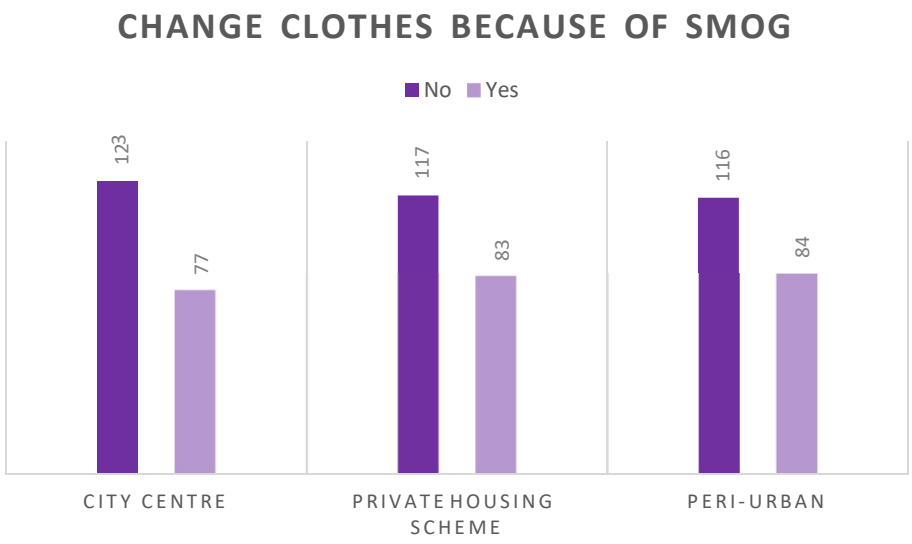
Graph 49 Wearing Eye Glasses

7.6. Change Clothes during Smog

The collected data shows that majority of respondents do not change their clothes after coming back from outside, the frequencies represent 123, 117 and 116 number of responses in denial while frequencies with 77, 83 and 84 from the respective areas shows that they do change their clothes during smog.

		Do you change clothes because of smog		Total
		No	Yes	
Area name	City Centre	123	77	200
	Private Housing Scheme	117	83	200
	Peri-Urban	116	84	200
	Total	356	244	600

Table 53 Change Clothes during Smog



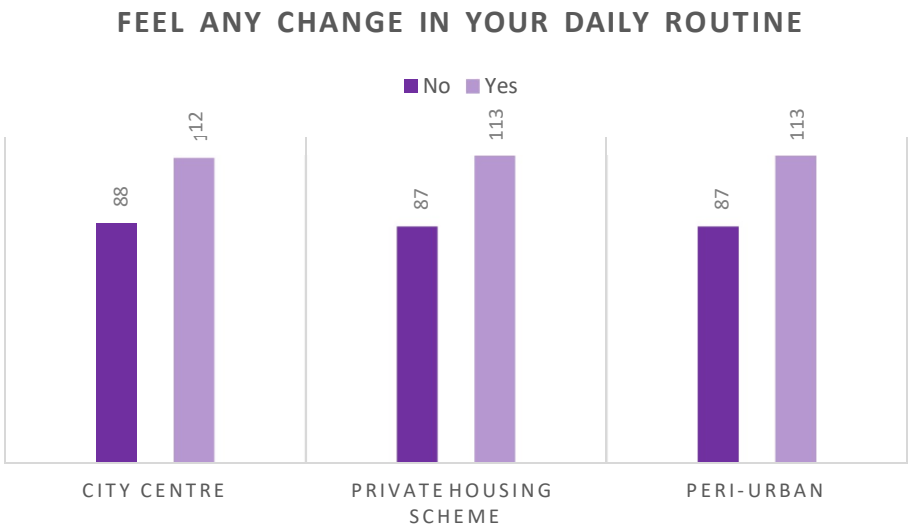
Graph 50 Change Clothes during Smog

7.7. Change in Daily Routine

The collected data shows that majority of respondents do feel change in their daily routine with frequencies of 112, 113 and 113 from respective areas while number of frequencies with 88, 87 and 87 do not feel any changes in their daily routines.

		Do you feel any change in your daily routine?		Total
		No	Yes	
Area name	City Centre	88	112	200
	Private Housing Scheme	87	113	200
	Peri-Urban	87	113	200
	Total	262	338	600

Table 54 Change in Daily Routine



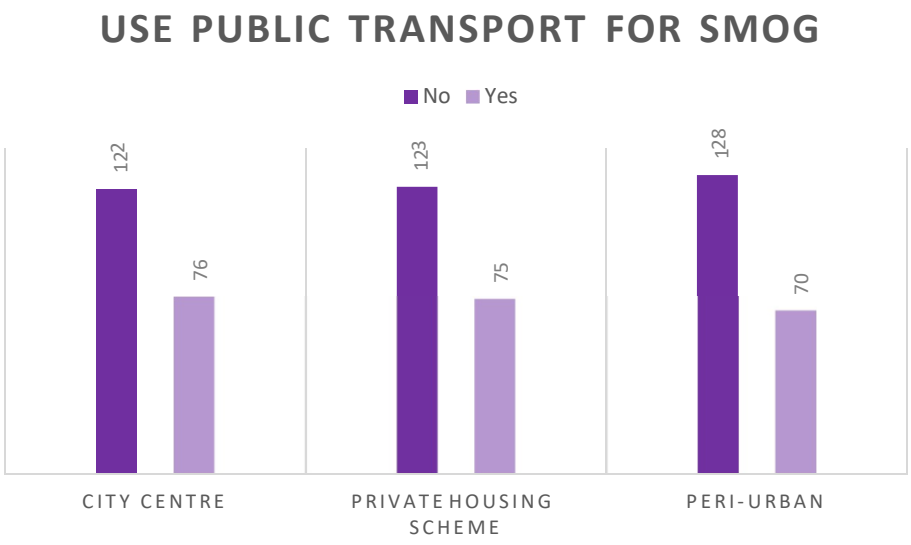
Graph 51 Change in Daily Routine

7.8. Use of Public Transport

The collected data shows that majority of respondents do not use public transport during smog, the frequencies represent 122, 123 and 128 number of responses in denial while frequencies with 76, 75 and 70 from the respective areas shows that they do use public transport during smog.

		Do you use public transport for smog?	
		No	Yes
Area name	City Centre	122	76
	Private Housing Scheme	123	75
	Peri-Urban	128	70
	Total	373	221

Table 55 Use of Public Transport



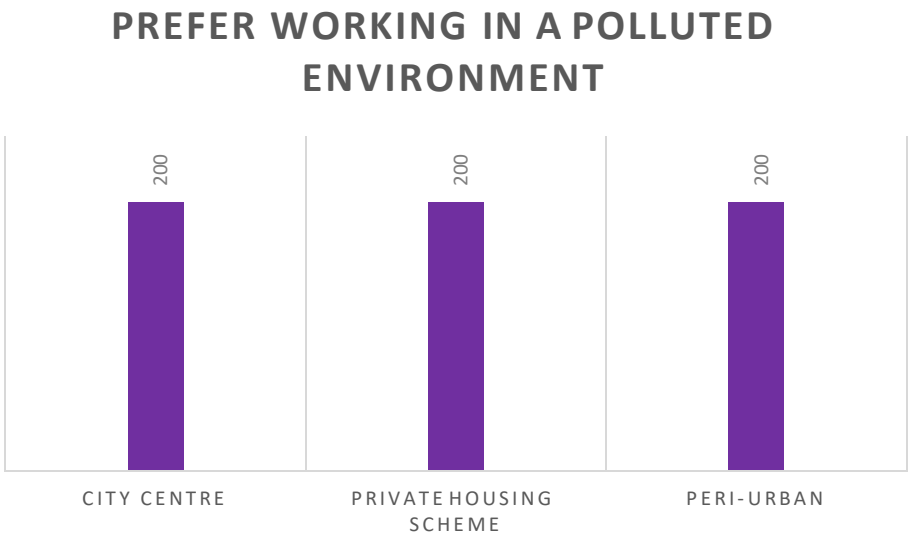
Graph 52 Use of Public Transport

7.9. Prefer working in polluted environment

The respondents show immense denial that they do not want to work in polluted environment with 100% responds from all the individuals in their respective areas.

		Do you prefer working in a polluted environment?	Total
		No	
Area name	City Centre	200	200
	Private Housing Scheme	200	200
	Peri-Urban	200	199
	Total	600	600

Table 56 Prefer working in polluted environment



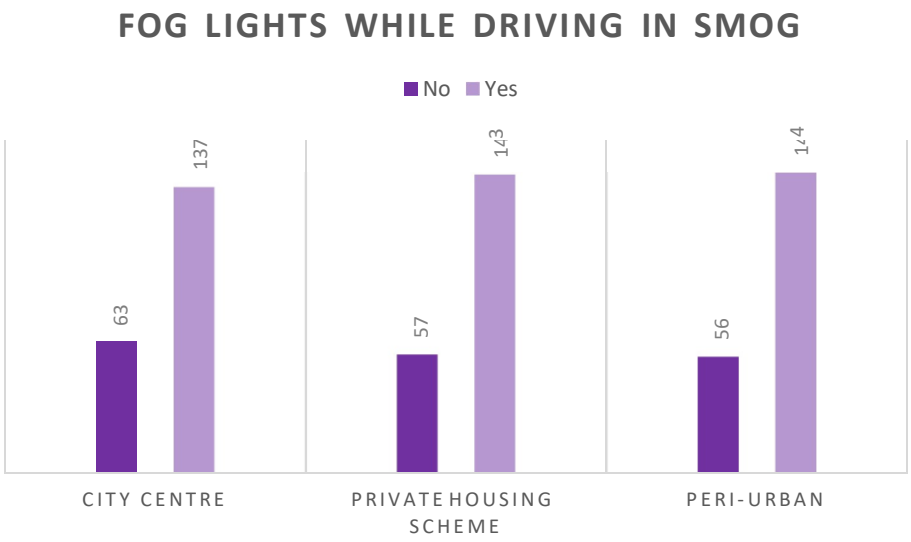
Graph 53 Prefer working in polluted environment

7.10. Use Fog Lights while Driving

The collected data shows that majority of respondents do use fog lights while driving during smog with the number of frequencies 137, 143 and 144 from their respective areas where as number of frequencies 63, 57 and 56 from their respective areas represent that they do not use fog lights during smog.

		Do you use fog lights while driving in smog?		Total
		No	Yes	
Area name	City Centre	63	137	200
	Private Housing Scheme	57	143	200
	Peri-Urban	56	144	200
	Total	176	424	600

Table 57 Use Fog Lights while Driving



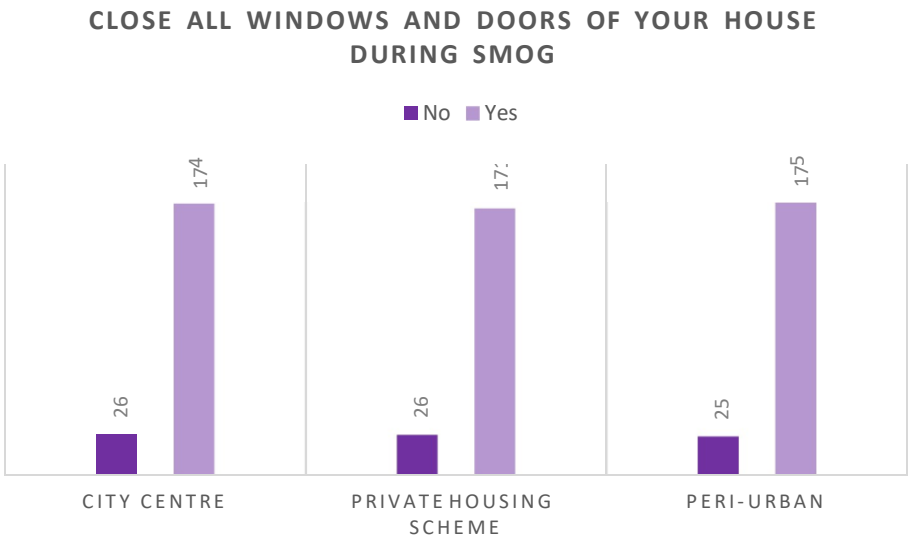
Graph 54 Use Fog Lights while Driving

7.11. Close Windows/Doors during Smog

The collected data shows that majority of respondents do close all windows and doors during smog with the number of frequencies 174, 171 and 175 from their respective areas where as number of frequencies 26, 26 and 25 from their respective areas represent that they do not close windows or doors of their houses during smog.

		Do you close all windows and doors of your house during smog?		Total
		No	Yes	
Area name	City Centre	26	174	200
	Private Housing Scheme	26	171	200
	Peri-Urban	25	175	200
	Total	77	523	600

Table 58 Close Windows/Doors during Smog



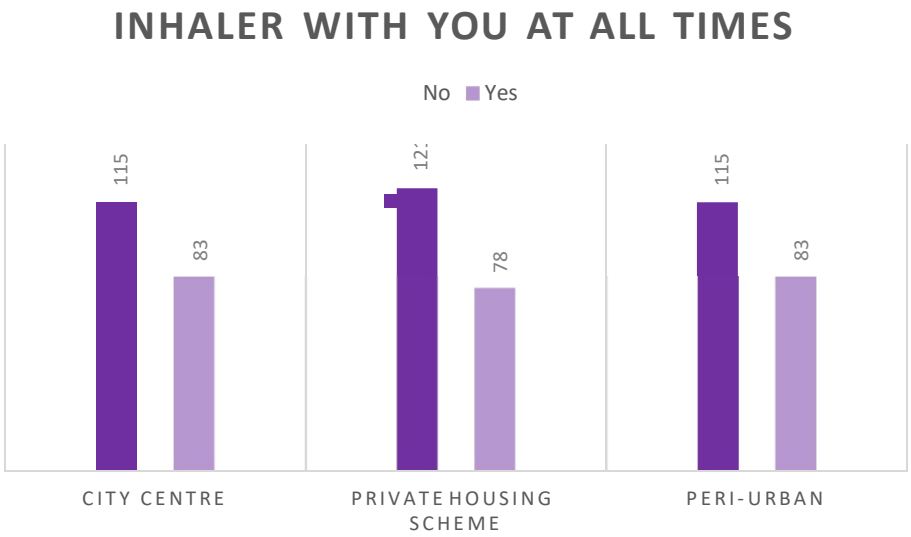
Graph 55 Close Windows/Doors during Smog

7.12. Having Inhaler during Smog

The collected data shows that majority of respondents do not take inhaler with them as they are not prescribed to it, the frequencies represent 115, 121 and 115 number of responses in denial while frequencies with 83, 78 and 83 from the respective areas shows that they do take inhaler with them during smog due to their health problems.

		For people with asthma & / or chronic obstructive pulmonary disease, have your inhaler with you at all times.		Total
		No	Yes	
Area name	City Centre	115	83	198
	Private Housing Scheme	121	78	199
	Peri-Urban	115	83	198
	Total	351	244	595

Table 59 Having Inhaler during Smog



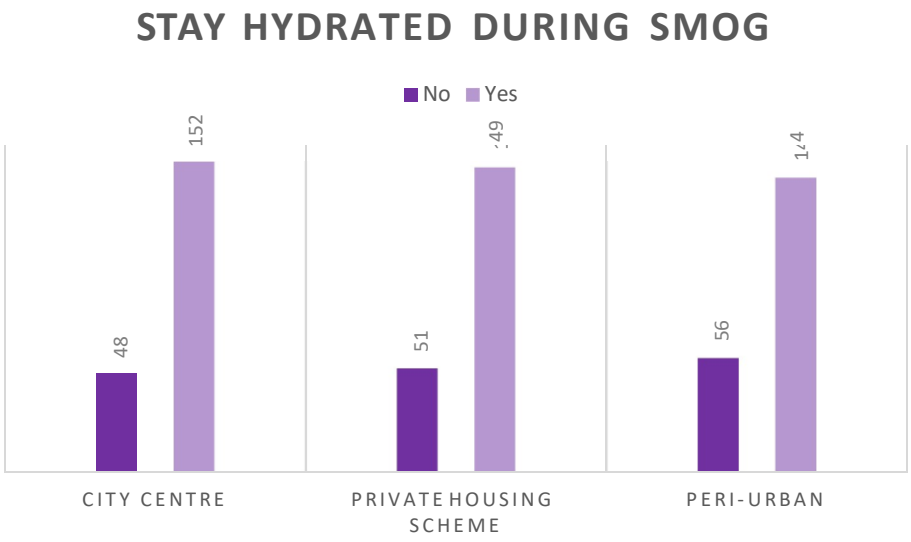
Graph 56 Having Inhaler during Smog

7.13. Stay Hydrated during Smog

The collected data shows that majority of respondents stays hydrated during smog with the number of frequencies 152, 149 and 144 from their respective areas where as number of frequencies 48, 51 and 56 from their respective areas represent that they do not stay hydrated during smog.

		Do you stay hydrated during smog		Total
		No	Yes	
Area name	City Centre	48	152	200
	Private Housing Scheme	51	149	200
	Peri-Urban	56	144	200
	Total	155	445	600

Table 60 Stay Hydrated during Smog



Graph 57 Stay Hydrated during Smog

CHAPTER 8

AIR QUALITY INDEX

8. Air Quality Index

The air quality index (AQI) is a numerical scale used to report air quality and inform the public about the potential health impacts of air pollution. The AQI is based on measurements of the concentrations of several pollutants, including ground-level ozone, particulate matter, sulfur dioxide, nitrogen dioxide, and carbon monoxide.

The AQI scale ranges from 0 to 500, with higher values indicating higher levels of air pollution and greater potential health impacts. The AQI is divided into six categories, each with a different color code to indicate the severity of air pollution and the associated health risks:

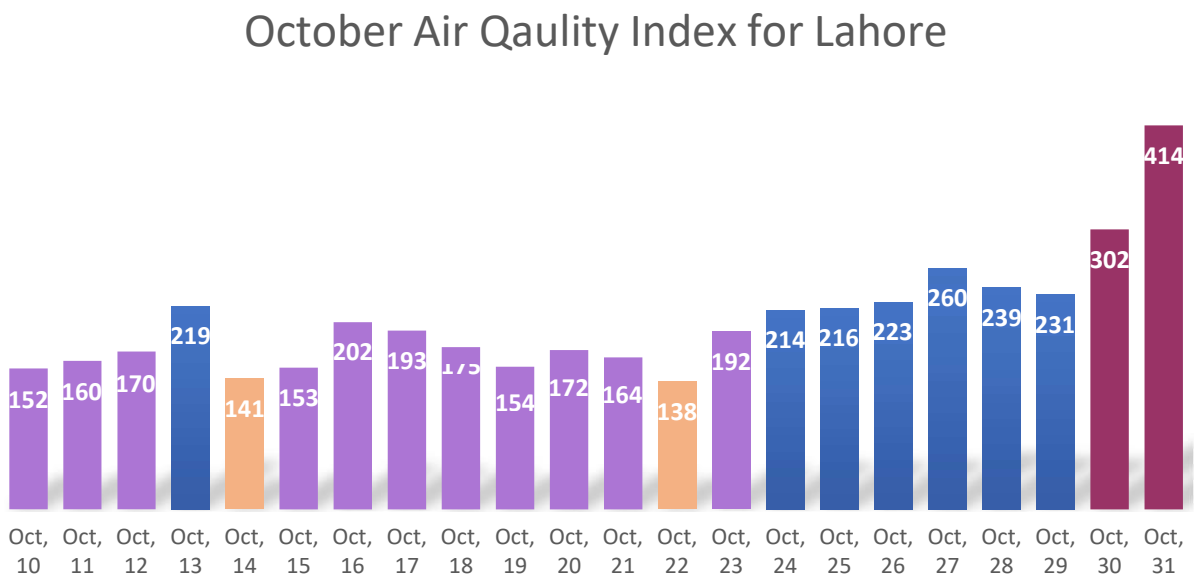
- (0-50): Good air quality
- (51-100): Moderate air quality
- (101-150): Unhealthy for sensitive groups
- (151-200): Unhealthy for everyone
- (201-300): Very unhealthy
- (301-500): Hazardous

The AQI can vary depending on the time of day, season, and weather conditions, as well as local sources of pollution such as traffic, industry, and wildfires. It is important to note that even low levels of air pollution can have negative health impacts, and sensitive populations such as children, the elderly, and individuals with respiratory or cardiovascular conditions may be more susceptible to these effects.

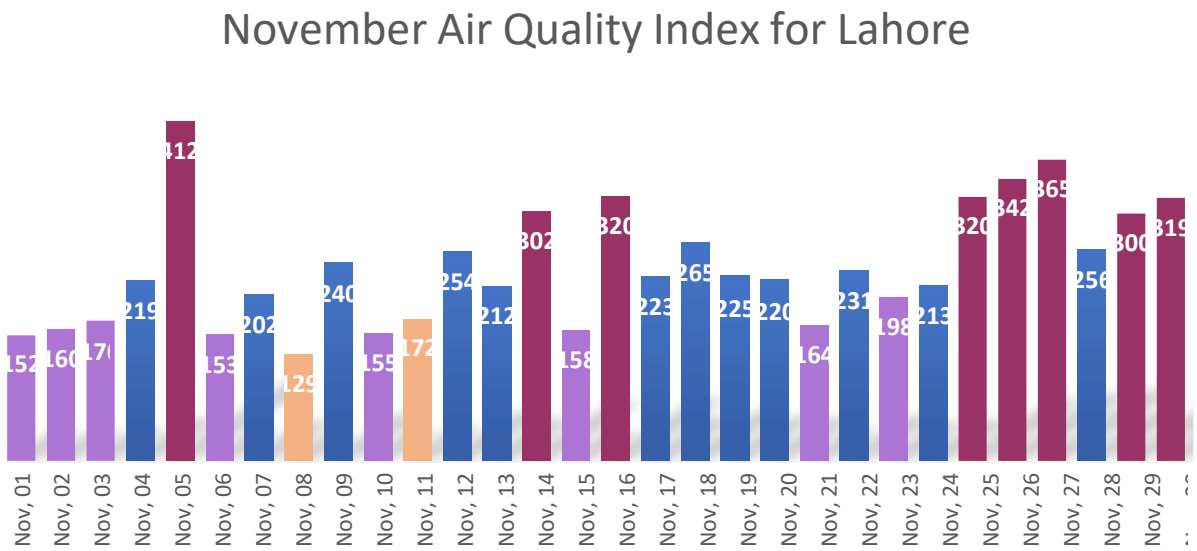
The AQI is often used by government agencies and health organizations to provide air quality alerts and guide public health responses, such as recommending that individuals stay indoors or limit outdoor activity during periods of high air pollution.

Lahore is a metropolitan area which is considered very vulnerable for air pollution as Lahore has been recorded as most air polluted city with AQI levels more than 400 AQI level of 2.5 particulate matter. Smog has been seen in Lahore since November 2016. With the increase in years, smog has been increasing gradually in city. The study emphasizes on smog risk reduction by studying risk

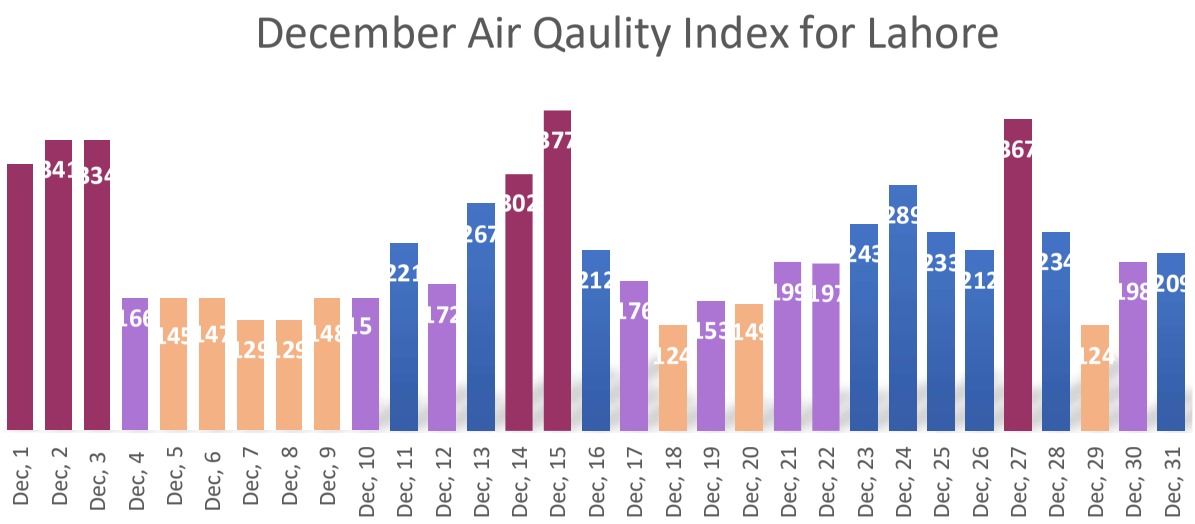
perception, vulnerability and preparedness of the community, while studying these, the data has been gathered on daily basis of AQI record by using AQI+ application from October 2022 to February 2023.



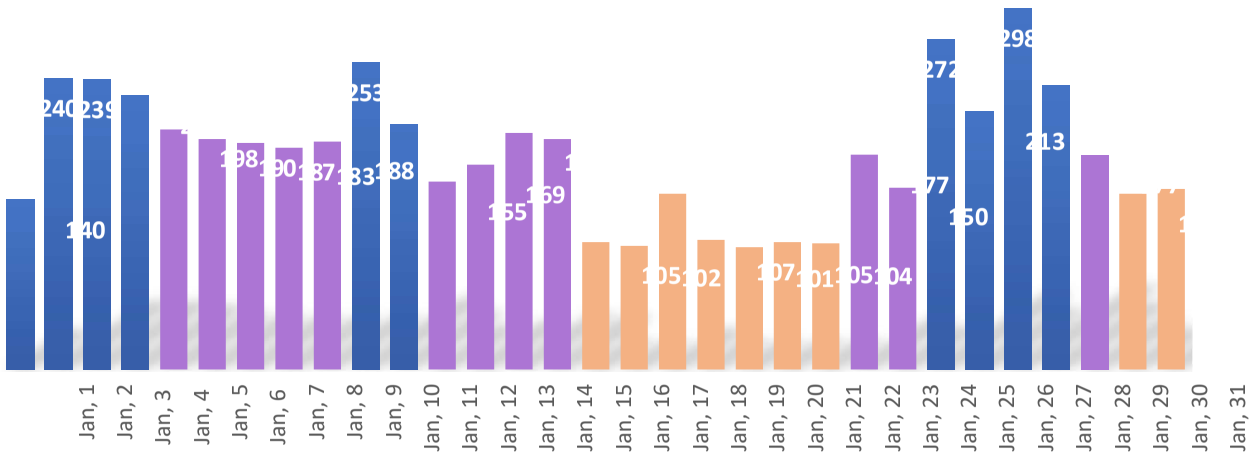
Graph 58 October Air Quality Index for Lahore



Graph 59 November Air Quality Index for Lahor



Graph 60 December Air Quality Index for Lahore



Graph 61 January Air Quality Index for Lahore

CHAPTER 9

CONCLUSION

9. Conclusion

Lahore, like many other cities in Pakistan, faces a significant risk from smog, which is a serious threat to public health and the environment. To reduce the risk of smog in Lahore, a comprehensive and integrated approach is needed that involves both short-term and long-term measures.

In the short term, measures such as promoting public awareness, implementing emergency response plans, and reducing emissions from industrial sources and vehicles can help to mitigate the impact of smog. Additionally, individuals can take measures such as reducing outdoor activity during periods of high smog levels, wearing masks, and using air conditioning with high-efficiency filters to reduce exposure to smog.

In the long term, measures such as promoting cleaner energy sources, building green spaces, implementing building codes and standards, and improving urban planning and design can help to reduce emissions and improve air quality. These measures will require collaboration between government agencies, private sector organizations, and community groups to achieve significant results.

Overall, reducing the risk of smog in Lahore will require a sustained effort and commitment to improving air quality and protecting public health. By taking a comprehensive and integrated approach that involves multiple stakeholders, Lahore can work towards a healthier and more sustainable future.

The study shows that many of the respondents don’t know or have knowledge about the AQI based application, where AQI levels of every day has been informed through notification with a message of not going out or avoid going out. This app can help a lot of people to keep in touch or to have daily basis knowledge related air pollution quality.

9.1. Recommendations

- Improve public awareness: Increase public awareness about the health impacts of smog and ways to reduce exposure, such as limiting outdoor activity during periods of high smog levels and using masks.

- Implement emergency response plans: Develop and implement emergency response plans for periods of high smog levels, including measures to protect vulnerable populations.
- Reduce emissions from industry: Implement measures to reduce emissions from industrial sources, such as promoting cleaner production methods and enforcing emission standards.
- Reduce emissions from vehicles: Encourage the use of cleaner transportation options, such as public transport and electric vehicles, and enforce emission standards for vehicles.
- Promote cleaner energy sources: Promote the use of cleaner energy sources, such as renewable energy, and phase out the use of coal and other fossil fuels.
- Increase green spaces: Increase the number of green spaces in urban areas to absorb pollutants and improve air quality.
- Implement building codes and standards: Implement building codes and standards that promote energy efficiency and reduce emissions from buildings.
- Improve urban planning and design: Improve urban planning and design to reduce the need for private vehicle use and promote walking, cycling, and public transport.
- Support research: Support research to better understand the causes and impacts of smog and to develop new strategies for reducing emissions and improving air quality.

REFERENCES

Alam, A. R. (2019). No Title. *IF YOU HAVEN'T SEEN LAHORE...'*.

Ali, Y., Razi, M., De Felice, F., Sabir, M., & Petrillo, A. (2019). A VIKOR based approach for assessing the social, environmental and economic effects of "smog" on human health. *Science of the Total Environment*, *650*, 2897–2905. https://doi.org/10.1016/j.scitotenv.2018.10.041

Andrews, F. M., & Herzog, A. R. (1986). The quality of survey data as related to age of respondent. *Journal of the American Statistical Association*, *81*(394), 403–410. https://doi.org/10.1080/01621459.1986.10478284

Ashraf, M. F., Ahmad, R. U., & Tareen, H. K. (2022). Worsening situation of smog in Pakistan: A tale of three cities. *Annals of Medicine and Surgery*, *79*(May), 103947. https://doi.org/10.1016/j.amsu.2022.103947

Barry, E. (2016). No Title. *Smog Chokes Delhi, Leaving Residents 'Cowering by Our Air Purifiers.'* https://www.nytimes.com/2016/11/08/world/asia/india-delhi-smog.html

Cheng, P., Wei, J., Marinova, D., & Guo, X. (2017). *Adoption of Protective Behaviours : Residents Response to City Smog in Hefei , China*. https://doi.org/10.1111/1468-5973.12148

Clarke, K., Ash, K., Coker, E. S., Sabo-Attwood, T., & Bainomugisha, E. (2022). A Social Vulnerability Index for Air Pollution and Its Spatially Varying Relationship to PM2.5 in Uganda. *Atmosphere*, *13*(8), 1169. https://doi.org/10.3390/atmos13081169

Grzywa-celińska, A., Krusiński, A., & Milanowski, J. (2020). *' Smoging kills ' – Effects of air pollution on human respiratory system*. *27*(1), 1–5. https://doi.org/10.26444/aaem/110477

Jabeen, F., Ali, Z., & Maharjan, A. (2021). Assessing health impacts of winter smog in lahore for exposed occupational groups. *Atmosphere*, *12*(11), 1–14. https://doi.org/10.3390/atmos12111532

Jahan, Z., Sarwar, F., Younes, I., Sadaf, R., & Ahmad, A. (2019). Assessment of Smog Pattern and its Effects on Visibility in Lahore Using Remote Sensing and GIS. *International Journal of Economic and Environmental Geology*, *10*(2), 55–59. https://doi.org/10.46660/ojs.v10i2.263

Khan, N. A., Gao, Q., & Abid, M. (2020). Public institutions' capacities regarding climate change adaptation and risk management support in agriculture: the case of Punjab Province, Pakistan. *Scientific Reports*, *10*(1), 1–12. https://doi.org/10.1038/s41598-020-71011-z

Lee, J.-B., Lee, H.-J., Moon, K.-J., Hong, S.-C., Kim, D.-R., Song, C.-K., & Hong, Y.-D. (2012). Vulnerability Assessment of Human Health Sector due to Climate Change: Focus on Ozone. *Journal of Korean Society for Atmospheric Environment*, *28*(1), 22–38. https://doi.org/10.5572/kosae.2012.28.1.022

Lin, C. C. (2010). *A Spatial Econometric Approach to Measuring Pollution Externalities : An Application to Ozone Smog*. *40*(2), 1–19.

Mehiriz, K., & Gosselin, P. (2019). *Evaluation of the Impacts of a Phone Warning and Advising System for Individuals Vulnerable to Smog . Evidence from a Randomized Controlled Trial Study in Canada*.

Ortwin Renn. (2008). *No Title*. https://www.researchgate.net/publication/279187565_Risk_Governance_Coping_With_Uncertainty_in_a_Complex_World

Paterson, J., Berr, P., Ebi, K., & Varangu, L. (2014). Health care facilities resilient to climate change impacts. *International Journal of Environmental Research and Public Health*, *11*(12), 13097–13116. https://doi.org/10.3390/ijerph111213097

Pinheiro, E. G., Garcias, C. M., Ferentz, L., & Da Fonseca, M. N. (2021). Disaster preparedness indicators: An application in the state of Paraná, Brazil. *Cidades*, *April*, 105–119. https://doi.org/10.15847/CCT.20450

Rana, I. A., Jamshed, A., Younas, Z. I., & Bhatti, S. S. (2020). Characterizing flood risk perception in urban communities of Pakistan. *International Journal of Disaster Risk Reduction*, *46*. https://doi.org/10.1016/j.ijdrr.2020.101624

Rana, I. A., & Routray, J. K. (2016). Actual vis-à-vis perceived risk of flood prone urban communities in Pakistan. *International Journal of Disaster Risk Reduction*, *19*, 366–378. https://doi.org/10.1016/j.ijdrr.2016.08.028

Reid, C. E., O'Neill, M. S., Gronlund, C. J., Brines, S. J., Brown, D. G., Diez-Roux, A. V., & Schwartz, J. (2009). Mapping community determinants of heat vulnerability. *Environmental Health Perspectives*, *117*(11), 1730–1736. https://doi.org/10.1289/ehp.0900683

Riaz, R., & Hamid, K. (2018). *Existing Smog in Lahore , Pakistan : An Alarming Public Health Concern Disclosures*. *10*(1), 1–3. https://doi.org/10.7759/cureus.2111

Sajjad, A., Chu, J., Azfar, M., & Asmi, F. (2020). Between green and gray : Smog risk and rationale behind vehicle switching. *Journal of Cleaner Production*, *244*, 118674. https://doi.org/10.1016/j.jclepro.2019.118674

Society, C., By-nc-nd, C. C., Great, L., Smoke, B., London, A., Cities, H. S., Cancer, A. C. S., & Ii, P. (2017). *Is smog innocuous ? Air pollution and cardiovascular disease*. *69*, 425–429. https://doi.org/10.1016/j.ihj.2017.07.016

UNU-EHS Expert Working Group on Measuring Vulnerability. (2013). Measuring Vulnerability to Natural Hazards. In *Measuring Vulnerability to Natural Hazards : Towards Disaster Resilient Societies*. https://collections.unu.edu/eserv/UNU:2880/n9789280812022_text.pdf

Wang, S., Wang, J., Ru, X., & Li, J. (2019). Public smog knowledge, risk perception, and intention to reduce car use: Evidence from China. *Human and Ecological Risk Assessment*, *25*(7), 1745–1759. https://doi.org/10.1080/10807039.2018.1471580

Yang, L. E., Hoffmann, P., & Scheffran, J. (2017). Health impacts of smog pollution: the human dimensions of exposure. *The Lancet Planetary Health*, *1*(4), e132–e133. https://doi.org/10.1016/S2542-5196(17)30067-0

Zhou, L., & Dai, Y. (2017). *How Smog Awareness Influences Public Acceptance of Congestion Charge Policies*. https://doi.org/10.3390/su9091579

Zhu, Q., Liu, T., Lin, H., Xiao, J., Luo, Y., Zeng, W., Zeng, S., Wei, Y., Chu, C., Baum, S., Du, Y., & Ma, W. (2014). The spatial distribution of health vulnerability to heat waves in guangdong province, China. *Global Health Action*, *7*(1), 1–10. https://doi.org/10.3402/gha.v7.25051

Zhu, W., & Lu, S. (2021). Predicting public smog reduction behavior: Exploring the role of perceived risk and financial incentive policy. *Human and Ecological Risk Assessment*, *27*(7), 1808–1822. https://doi.org/10.1080/10807039.2021.1908114

ANNEXURE

1. Questionnaire

Questionnaire Sr. No: _____ Date: _____ Area: (City Centre/Private Housing Schemes/Peri-Urban)

The purpose of this study is to examine "***Smog Risk Reduction for Lahore Metropolitan, Pakistan***". This study is being conducted at National University of Sciences and Technology (NUST) Islamabad. The survey should only take 4-5 minutes to complete. Be assure that all answers you provide will be kept in the strictest confidentiality.

1. Age: _____

2. Household Income: _____

3. Education:_____

4. Gender: *Male* ☐ *Female* ☐

5. Household size: _____

6. Number of elderly (60+ yrs.) in the household: _____

7. Number of adolescents (12-16): _____

8. Number of children: _____

9. Number of women: _____

10. People earning in household: Males _____ Females_____

11. Employment type: _____

12. How long have you been living in your community? _____

13. Education level of household head _____

14. Type of Dwelling	*Owned*	*Rented*	15. Construction Type	*Pakka*	*Katcha*
16. Type of residence	*Shared*	*Independent*	17. Family system	*Joint*	*Nuclear*

18.	School/Education attendance affected by smog	*Yes*	*No*
19.	Do you have access to piped water	*Yes*	*No*
20.	Do you have access to the borehole	*Yes*	*No*
21.	Access to toilet facilities	*Yes*	*No*

22.	Women with special needs, e.g., Pregnant		*Yes*		*No*	
23.	Shared house & using shared facilities		*Yes*		*No*	
24.	Household that does not own a television		*Yes*		*No*	
25.	Household own a smart mobile		*Yes*		*No*	
26.	Household members 18+ not working					
27.	No. of members who possess a bank account					
28.	Do you properly dispose of solid waste		*Yes*		*No*	
29.	Presence of exhaust fans		*Yes*		*No*	
30.	Location of Kitchen		*Indoor*		*Outdoor*	
31.	Is polluting fuel being used for cooking?		*Yes*		*No*	
32.	Do you feel a temperature rise?		*Yes*		*No*	
33.	Is there a shift in rainfall patterns?		*Yes*		*No*	
37.	How much do you think that smog can affect your regular routine work?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
38.	Does smog affect your health?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
39.	What do you believe is the chance of increasing smog in the coming years?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
40.	How harmful was last year's smog to you and your family?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
41.	What do you believe is your ability to cope with a future smog?	*Very high*	*High*	*Moderate*	*Low*	*Very low*

42.	What is the level of understanding of smog-related AQI levels?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
43.	How much do you fear smog and its effects?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
44.	What is the level of understanding of emergency protocols?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
45.	How much do you understand daily readings of AQI?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
46.	Information need about smog		*Yes*		*No*	
47.	Travel time to the workplace (in minutes)					
48.	Workplace Location					
49.	Working Environment		*Indoor*		*Outdoor*	
50.	Do you expose yourself daily to the air?		*Yes*		*No*	
51.	Working Hours		*Day Shift*		*Night Shift*	
52.	Road width in front of house					
53.	How many members with chronic illnesses?					
(i)	Respiratory		*Yes*		*No*	
(ii)	Diabetes		*Yes*		*No*	
(iii)	Hypertension		*Yes*		*No*	
(iv)	Allergy		*Yes*		*No*	
(v)	Cardiac		*Yes*		*No*	
(vi)	Eye Infection		*Yes*		*No*	
(vii)	Other					
54.	Do you know about any app for air quality notification		*Yes*		*No*	

55.	Have you ever subscribed to any channel or app for AQI Levels		*Yes*		*No*	
56.	No. of trees present in the house					
57.	What is your trust level in Government officials working on environmental regulations?	*Very high*	*High*	*Moderate*	*Low*	*Very low*
58.	House structure is concrete		*Yes*		*No*	
59.	Household with access to the nearest medical facility within 1 km		*Yes*		*No*	
60.	Mode of transportation for travelling (multiple modes can be chosen)	*Own car*	*Public transport*	*Rickshaw/ Motorcycle*	*Cycle*	*No access to transport*
61.	Communication assets owned (multiple assets can be chosen)	*Radio*	*Telephone*	*Mobile*	*Television*	*All of the above*
62.	No. of windows in the house					
63.	Adequate ventilation system in the house		*Yes*		*No*	
64.	Presence of a veranda in the house		*Yes*		*No*	
65.	Presence of a park within 1km of the house		*Yes*		*No*	
66.	Household having health/life insurance		*Yes*		*No*	
67.	Household members having access to green spaces at work		*Yes*		*No*	
68.	Do you wear a mask on smog days		*Yes*		*No*	
69.	Avoid going out during smog		*Yes*		*No*	
70.	Do you feel any issues while driving?		*Yes*		*No*	
71.	Any knowledge about smog timings		*Yes*		*No*	
72.	Wearing eyeglasses on smog days		*Yes*		*No*	

73.	Do you change clothes because of smog	*Yes*	*No*
74.	Do you feel any change in your daily routine?	*Yes*	*No*
75.	Do you avoid traveling in smog	*Yes*	*No*
76.	Do you limit going out in the smog?	*Yes*	*No*
77.	Do you use public transport for smog?	*Yes*	*No*
78.	Do you prefer working in a polluted environment?	*Yes*	*No*
79.	Do you check daily air pollution forecasts in your area?	*Yes*	*No*
80.	Do you use fog lights while driving in smog?	*Yes*	*No*
81.	Do you close all windows and doors of your house during smog?	*Yes*	*No*
82.	For people with asthma & / or chronic Obstructive Pulmonary disease, have your inhaler with you at all times.	*Yes*	*No*
83.	Do you stay hydrated during smog	*Yes*	*No*
84.	Do you avoid using gas-powered engines, pesticides, and oil-based paints	*Yes*	*No*
85.	In your opinion, what are the causes of smog?		
86.	What other preventive measures do you usually take against smog?		

87	Suggestions & Comments: