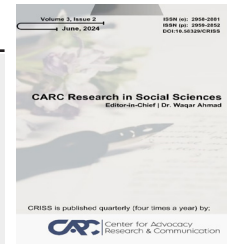




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Assessment and Analysis of Public Perception of Environmental Pollution: A Case Study of Lahore

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ABSTRACT

This study carried out an assessment and analysis of the perception of public about the extent of environmental pollution in the city of Lahore. The city has been ranked as one of the most polluted cities globally every year from October to December over the past five years thereby posing health challenges for the public due to smog. The study conducted a survey of 120 respondents from different income and age groups. Multinomial logistic regression technique was being used in order to see the impact of income, age and gender on an individual's Willingness To Pay (WTP) in order avoid pollution while the method of contingent valuation was used to measure the WTP. The survey results showed that 94% of the respondents were concerned about the deteriorating environmental quality and expressed WTP a proportion of their income for better environmental quality. Results from regression analysis showed that there was a high probability of WTP up to five percent of their household income in a month, irrespective of their age and income. The study suggests the government to promote public transport network, improve the collection and monitoring of air quality data and take the WTP into consideration while designing tax policies.

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1. INTRODUCTION

One of the greatest global concern for humanity today is increasingly polluted environment and polluted air has become one of the biggest health hazard today. There is wide range of diseases that are primarily caused due to pollution and public is forced spend money to fight against these diseases. An alarming number of premature deaths are attributed to air pollution every year and sadly a large proportion of these deaths occur in poor countries. World Bank (2022) estimated that about 6.4 million people died of air pollution 2019 and about 95% of those deaths took place in countries that are categorized as 'low and middle income countries' where approximately 70% of those deaths took

place in South Asia, East Asia and the pacific regions of the world.

People in poor countries are forced spend significant proportion of their low incomes to fight illness caused by air pollution. Myllyvirta (2020) informs that the cost of air pollution in 2018 was estimated to be \$ 2.9 trillion which was 3.3% of the global GDP. World Bank (2022) estimated that global cost of mortality and morbidity due air pollution in 2019 was \$ 8.1 trillion that was more than 6% of global GDP in that year. There are numerous causes of deteriorating air quality ranging from excessive use of pesticides and fertilizers in agriculture to uncontrolled urbanization on one side and inadequate attention granted to the design and development of waste management systems to excessive deforestation on the other. A blend of inability to understand and irresponsibility to act has led to growing deterioration of global environment with increasingly alarming consequences of this deterioration on human health. There is a growing demand to deal with this situation to avoid the negative consequences of environmental hazards, especially for the poor people around the world, in general and people living in poor countries, in particular.

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Environmental Goods and Services (EGS) are required to be incentivized in order to make them available at a cheaper rate in the country. Trade policies can play a vital role in providing green solutions with EGS by lowering import duties on them. An effective trade policy about EGS useful to facilitate the task of environmental damage control. Figure 1 shows the import duties on environmental goods in Pakistan during 2021 and 2022. It is interesting to note that average duties on the import of environmental goods in Pakistan were lower than the average import duties imposed on rest of the goods during the study duration. However, there were significant variations within some categories of environmental goods. Sugathan & Varela (2021) found such variations within the categories of environmental goods in Pakistan where irrigation systems were imported duty-free whereas water filtration machinery were imported at higher duties. The Finance Act of the fiscal year 2022 slightly reduced import duties on environmental goods, however the reduction was quite uneven across the categories as seen in Figure 1.

Category	Minimum Import Duty	Maximum Import Duty	Average import duty (%)	
			Before Finance Act (FY21)	After Finance Act (FY22)
Electric Vehicles	0	67	29.3	29.1
Renewable Energy Equipment	0	42	13.6	12.9
Onshore Wind	0	42	15.6	15.3
Solar PV	0	31	13.1	11.5
Solar Thermal	0	0	0.0	0.0
Hydropower	0	5	2.0	2.0
Cross-cutting RE equipment	0	26	16.0	15.3
Energy Saving Equipment	0	51	16.3	15.7
Air Pollution Control	0	42	16.8	16.3
Water-Use efficiency and Safe Drinking Water	0	46	17.8	17.1
Wastewater Treatment	0	26	12.0	11.7
Solid Waste Management	0	42	7.0	6.7
Environmentally Preferred Products	0	76	19.0	16.2
Miscellaneous Product Categories	0	26	9.8	9.5
Plastic Waste and Scrap	26	26	27.0	26.0
Fuelwood, Woodwaste and Scrap	0	0	0.0	0.0
All Environmental Goods	0	76	16.6	15.7

Fig.1. Import Duties on Environmental Goods
Source: World Bank

The Pakistan Environmental Act was passed in 1997 which aims to protect and improve the environment in the country. It sets out the responsibilities of government agencies and individuals in curbing the problem of environmental pollution through the establishment of an environmental protection agency. The Act deals with all kinds of pollution including air and water quality, the protection of natural habitats, waste management, and biodiversity.

A cross-sample of earliest studies on the perception of environmental pollution in 1960s in the US found that around 48% of the public surveyed thought of air pollution to be “somewhat serious” (Groot, 1967). Inglehart (1995) proposed the objective problems subjective values hypothesis in the domain of post-materialism theory, which suggested that concern for the environment in lower income countries comes from the objective local environmental problems and necessity to overcome them, while in developed countries it comes from subjective values such as a need for improvement in quality of life.

Developing countries like Pakistan are also facing issues from environmental pollution. It was estimated that approximately 128,000 people in the country die each year due to air pollution related illnesses (Ali, 2021). On one hand, the country has to bear the economic burden from the deteriorating ambient quality but on the contrary, the increasing economic activity is one of the causes for pollution. Metropolitan cities like Lahore have become highly polluted. Lahore has received negative attention for

its worst global air quality rankings in the last quarter of every calendar year for the last several years.

In the absence of an effective mass transit traffic system, there is a growing number of vehicles entering in to the city, every year, not only from other parts of the province of Punjab but also from other provinces of Pakistan. This was further deteriorated allegedly by unplanned land development and illegal land acquisition in the city of Lahore for the last several years. Another dangerous trend was converting buildings meant for residential needs in to structures used for commercial and industrial activities which led to an adverse impact on urban congestion, dangerous emissions, deteriorating air quality index and presence of harmful pollutants in the atmosphere surrounding the city according to Smog Commission Report (2018). Ali (2021) argued that industrial emission, power plants run with fossil fuels, irresponsible disposal of waste materials and burning low quality coal in brick Kline factories has exacerbated the problem of pollution in the city of Lahore.

AQI	Air Pollution Level	Health Implications	Cautionary Statement (for PM2.5)
0 - 50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk	None
51 - 100	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
101-150	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
151-200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects	Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion
201-300	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected.	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.
300+	Hazardous	Health alert: everyone may experience more serious health effects	Everyone should avoid all outdoor exertion

Fig. 2. About the Air Quality Levels
Source: The World Air Quality Project

Figure 2 shows the breakdown of the air quality levels and the resulting health implications. It can be seen that if the air quality index (AQI) is above 100, it is considered unhealthy. Before 2017, there was no real time data monitoring on air quality which meant that the people were unaware of the severity of the pollution. The first data was published through citizen-operated sensors in early 2017 (IQAir). Lahore’s High Court took action and ordered the government authorities to publish daily pollution updates. However, the data is still limited.

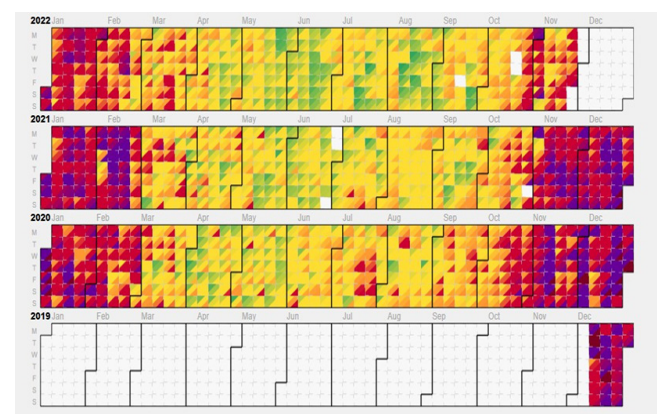


Fig. 3. Historical AQI data for Lahore Cantonment
Source: The World Air Quality Project

Figure 3 shows the historical air quality data for Lahore Cantonment which is one area of the city. This is chosen as a reference for the air quality of Lahore as other sensors

do not show complete data for the last two years. It can be clearly seen, taking Figure 2 into account as key for the color coding, that the air quality is “very unhealthy” or “hazardous” from November to December while mostly moderate through the rest of the year. During this time, the city gets covered under dense smog which leads to closure of businesses and schools (Bilal, 2022). An environmental lawyer, Ahmad Rafay Alam, pointed out that these punitive measures are not the long term solutions and therefore, they should be addressed (Ali, 2021). This shows that this is a significant issue for the local government and public. Hence, this should be dealt with.

The purpose of this study is to carry out an analysis of public perception on the issue of environmental pollution in the city of Lahore. The study aims to undertake an analysis of public perception and awareness with regards to environmental pollution in Lahore by gauging peoples’ WTP for living in a setting endowed with improved environmental quality. Since environment is a non-marketed good, this paper uses a method to measure the WTP of the public that is called Contingent Valuation Method (CVM). Wang & Mullahy (2006) provide reasons that qualify the use of CVM to determine WTP of the people. The respondents were directly asked through a survey, the percentage of their monthly income they were willing to pay or accept to be compensated. The respondents of the survey were asked about the proportion of their monthly income that they would be willing to give away to avoid the adverse effects of pollution.

The organization of the rest of the paper is such that the next section will discuss the prior research being carried out on this issue with a view to better understand and explain the issue. Section 3 discusses the methodology of this study and section 4 provides the results of the study. Section 5 is dedicated to discuss and analyze the results whereas section 6 provides conclusions drawn from this study.

LITERATURE REVIEW

The following chapter of this research paper focuses on the studies conducted around the world. It is significant to understand what the past researchers have done in order to create a clear picture of how the public generally perceives environmental pollution in their areas of residence. Hence, this chapter is divided into multiple sections which include different perspectives and approaches used by the researchers in different parts of the world which will be discussed through the methodologies used by the authors. Moreover, the literature will include sections on source of pollution, studies conducted on noise pollution specifically, the awareness levels of the public regarding environmental pollution, the differences in perception on socio-demographic differences, the perceived health risks, and WTP of the people to improve the environmental quality.

Background

The earliest studies conducted on the perception of environmental pollution date back to the 1960s in the United States of America where public opinion surveys were conducted by the State of California Department of Public Health (Bickersta & Walker, 1999). A collection of these studies was taken and the trends in the public attitudes towards air pollution were discussed by De Groot (1967).

The public in New York, Los Angeles, St. Louis and Nashville were asked about their concerns for the air pollution in their area (De Groot & Samuels, 1966; Van Arsdol et al. 1966; Schusky 1965; Smith et al., 1963).

Sources of Pollution

Sources of pollution are different and they vary from place to place. Therefore, in order to address the problem, the source of pollution must be identified. Research shows the highest correlation was found between soil chemical contamination and air pollution by industries which was moderate and positive Cortes et.al (2021). Chemical contamination of food and air pollution by vehicles was observed to be positively moderate while industrial emission and motor vehicle emissions were considered as the major contributors of air pollution. Research by (Fan et al., 2017; Maione et al.2020) revealed that the main sources for pollution perceived by the public are motor vehicles exhausts and dust from construction sites as well as industrial emissions.

Awareness

It is given that the public perceives environmental pollution in a different way than the scientific community (Noel et al., 2021). This is generally due to the fact that the public may perceive environmental quality in terms of how it affects their personal well-being which may differ from how it is interpreted by the scientists through the environmental monitoring indicators (B.Liu et al.,2021). Hence, there are different levels of awareness and perception by the public which means that there will be a variation in the responses of the public. This was seen in the study by B.Liu et al. (2021), as the results showed that majority of the respondents in Beijing believed that the air quality was decreasing and there were only slight improvements which were considered to be inconsistent with the data by existing monitoring indicators. In Nigeria, majority of the public believed that pollution caused partial damage to the surrounding air (Obafemi et al., 2013). The study conducted by Cobbold et al. (2022) showed that in both circumstances, before and after COVID-19, the response of the public was similar, and majority of the respondents perceived air quality as either ‘somewhat acceptable’ or ‘completely acceptable’. Those who actively took care of their health showed more concern for air quality (Cobbold et al., 2022).

Willingness to Pay

The willingness to pay to improve the quality of the environment also depends on how severe people perceive the pollution in their surroundings. Zhang et al. (2020) found a strong correlation between the increase in the PM 2.5 and the willingness to pay. People who are environmentally aware showed greater signs of paying for environmental protection. This was generally seen in economically developed areas (Zhang et al., 2020). People in rural areas perceived air quality to be normal and were less willing to contribute proportion of their income (Ain et al., 2021). This could be due to lower income levels as a study by Liu et al. (2016) reported that people who were aware of the low levels of urban air quality were less willing to pay taxes as one of the reasons was low income. Hence, people are reluctant to pay additional taxes. Moreover, another reason was that the public believes that this is the responsibility of the government. The results from

Noel et al. (2021) also claimed that people did not have confidence in government's efforts to deal with the effects of environmental pollution. On the contrary, some people believe that this is not just the government's duty and that they too have to be blamed for the situations that we face (Ahsan et al., 2020).

Studies from China (Liu et al., 2018; Wang & Mullahy, 2006; Xie & Zhao, 2018; Yu et al., 2015; Ito & Zhang, 2019; Shao et al., 2017; Sun et al., 2015) estimated the relationship of WTP with income, age and educational levels. The results from the study by Liu et al. (2018) showed that age, educational level and annual household income were significantly correlated with WTP. Similar results were seen in studies by Wang & Mullahy (2006) and Sun et al. (2015). A study in Sweden also showed that the willingness to pay increased with income, wealth, and education (Carlsson & Stenman, 2010). However, WTP does not always increase with income (Shao et al., 2017). The reason could be that the public feels that it should be the duty of the government to use the tax money and have the responsible authorities control the effects instead of asking for more money (Akhtar et al., 2017).

The literature gives us an idea of how the public perception on environmental pollution can be measured. Moreover, it provides us with insights into how the public perceives and changes their behavior depending upon the level of awareness and demographic factors such as income and education levels of the individual. On a country level, it varies between rural and urban settings which is also due to differences in income levels. Furthermore, the willingness to pay differs according to the level of severity and awareness of the public.

Perception of Noise Pollution

Although noise pollution is not the most significant form of environmental pollution, it still has a considerable impact on the people's lives, especially in urban cities like Lahore where the resulting construction work for development and expansion of the city due to increasing population is causing a possible increase in the noise pollution.

Abraham et al. (2022) and Filho et al. (2016) studied the perception of noise pollution in Nigeria and Brazil, respectively, with the former taking place amongst residents and the latter taking place in a school. Hence, differences in the perception of the respondents in both studies can be seen. Only 20% of the total students surveyed in Brazil, considered noise to be an environmental issue while people in Nigeria felt that noise pollution leads to increased stress levels. Moreover, according to Abraham et al. (2022), the noise from traffic and generators were considered the most significant source of noise. Furthermore, majority of the respondents in Nigeria felt that they feel annoyed due to the noise levels. 85% of the respondents felt that the government needs to do more to mitigate these effects (Abraham et al., 2022).

Although, the study by Filho et al. (2016) targets a very specific demographic, it can be seen how the youth would perceive noise pollution. The justification provided for the students not being affected by noise pollution is that majority of the students (79%) were actively involved in leisure activities which meant that they were generally around noisy environments and probably, they themselves

were considered a source of increased noise levels. Hence, they don't consider noise as a negative factor in their surrounding environment (Filho et al., 2016).

Demographic Factors

There are differences in public perception based on demographic factors. While evidence from China showed that there is high attention paid to environmental pollution in the developed regions (H.Liu et al., 2022). People with higher educational and household income levels also paid more attention to air quality, especially parents as they prefer a healthy lifestyle not only for themselves but for their children as well (Fan et al., 2017). Hence, it backs the evidence from China as people in developed regions are considered to have higher educational and income levels. Moreover, A study in India found out that people with lower education and socio-economic status were less aware and concerned about the air pollution in their area (Mukherjee, 1993).

On the contrary, other studies showed that people residing in high-status neighborhoods expressed the least concern (Noel et al., 2021). Furthermore, there are differences in perception between genders too as female participants were considered to have better awareness of environmental pollution (X.Liu et al., 2016). Results from Ruan et al. (2022) did not show a significant impact of gender on the environmental governance satisfaction. However, household income and age, both showed significant impacts. It is believed that in urban areas of most developing countries, there are high levels of visible and invisible forms of air pollution which may cause a saturation effect. This results in an insignificant variation in the perception across social and demographic groups (Saksena, 2007).

Health Risks

The most common health risks associated with poor environmental quality were cough, breathing difficulties, eye irritation (Noel et al., 2021) which affected their outdoor activities as some feel that they jog faster but for a shorter time or walk faster and feel aggressive on hazy days (Ullah et al., 2021). Children in rural areas are at higher risk of adverse effects from poor environmental quality as they are more likely to be directly or indirectly in contact with dust, infectious bacteria and disease-carrying insects (Fan et al., 2017).

Public Perception on Environmental Pollution: Methodological Approaches Used Around the World

Recent studies conducted in different parts of the world including Latin America, Europe, Australia, Africa, and Asia also aimed to look at how the public perceives environmental pollution. The authors used various possible approaches to collect based on the resources available to them.

For example, Obafemi et al. (2013) assessed the public perception on environmental pollution in a small town in Nigeria. The sample size was small; however, it provides us with some insights into how people perceive pollution in a less developed country similar to Pakistan. Research by Cobbold et al. (2022) studied the associations between the estimated level of air pollution and the perceptions and concerns of the public in Australia. This was a comprehensive study as it compared the results of the survey conducted

before the bushfires and COVID-19 pandemic with the survey conducted after these events. Since our study is also conducted after the pandemic, it is possible that the perception of the public may have changed, and the results won't be the same as they were before. Boso et al. (2019) used a different approach and divided the respondents into three clusters according to their behavior and awareness about the air quality in Chile. It was then used to point out the differences between the defined groups using nonparametric Kruskal-Wallis tests. Another study in Latin America was conducted by Cortes et al. (2021) which aimed at determining the health risk perception on environmental pollution. A questionnaire based on Likert-scale was used and correlations were estimated.

In China, Liu et al. (2022) studied the perceptions of environmental pollution on multiple stakeholders using data mining techniques. The study used search engines to see how the different stakeholders were paying attention to the problem of environmental pollution. The data comprised over four years and it included media, general public and government websites. This study showed how people generally think without being directly asked about the environmental pollution. However, there are some limitations related to the information provided on the internet. First, this study mostly, included people from the younger age group so does not account for all ages. Second, it is believed that the perspective of government may not be fully understood due to different levels of openness of information on government websites (H.Liu et al., 2022).

Furthermore, a study by B.Liu et al. in 2021 compared the public perceptions on environmental quality with the environmental monitoring indicators in Beijing, China, to develop a better understanding. The public was asked about their inherent feelings on the overall environment and which environmental problems they felt had the most significant impact on their lives using a Likert scale. The scale was then used to calculate contribution ratio of each environmental problem. Fan et al. (2017), studied the perspective of parents, specifically on air pollution and its impact on children's respiratory health. The data provided by parents, caretakers and caregivers was then used to apply chi-square tests to compare the results of parents' perception of air quality with parents' perception about children's health according to the respondents' general demographic characteristics (Fan et al., 2017). China has the largest population hence, it's very vital to look at the people's perspective on environmental pollution especially when China is one of the countries facing high risk of poor air quality. Therefore, a comprehensive study by Pu et al. (2019), used a spatial analysis to do a nationwide study. The authors believed that there are spatial differences in risk perception due to different economic and social conditions across regions (Pu et al., 2019). The large sample size increases the credibility of the results and provides a stronger information on the public's perception on environmental pollution.

Research by Ain et al. (2021) in Pakistan, studied the economic impact of air pollution in the city of Faisalabad using OLS and ordered logit model. The treatment cost of related illness to air pollution was considered as the economic cost and a Likert-scale was used to ask the respondents about their willingness to pay to contribute to programs that would help in decreasing air pollution.

However, one of the limitations of the study was that the sample size used was a bit small (120 respondents). Ullah et al. (2021) on the other hand, did a comprehensive study in the division of Malakand and administered questionnaires to students across six districts. The respondents were selected randomly from different areas to understand the perceived physical and psychological effects of air pollution and the preventive measures taken by the community. Ahsan et al. (2020) provides a local perspective as their study looked at the socio demographic factors of the people living in Lahore in determining the level of awareness and measures taken to prevent smog.

Contingent valuation method has been used by researchers in determining the willingness to pay of the public. There are two ways to ask the respondents, one is to ask an open-ended question and the other is to ask a close ended question. Liu et al. (2016) and Liu et al. (2018) asked closed ended questions to measure the willingness to pay and used multinomial logistic regression model to estimate the relationship between WTP and demographic variables such as income, age, and education levels. Other studies also used logit models (Shao et al. 2017; Ito & Zhang, 2019; Yu et al. 2015; Xie and Zhao, 2018) while some studies used probit and tobit models to find the effect of income, age, and education levels on the respondents WTP (Wang & Mullahy, 2006; Xiong et al. 2018, Yu et al. 2015; Carlsson & Stenman, 2010).

These studies help in devising the methodology of this research which will be discussed in the next section. Studies from China (Liu et al., 2018; Wang & Mullahy, 2006; Xie & Zhao, 2018; Yu et al., 2015; Ito & Zhang, 2019; Shao et al., 2017; Sun et al., 2015) have helped the country in improving its environmental quality. In the case of Pakistan, there aren't many studies that look at the public perception of environmental pollution and their response. As discussed above, the environmental quality has deteriorated over the years which means that there is a need to resolve these issues and for that, it is important to see the level of concern and awareness of the public.

METHODOLOGY

This study performs analysis based on the data collected through a questionnaire. The survey contained 53 questionnaires, divided into 5 sections; perception of air pollution, perception of noise pollution, perception of land pollution, willingness to pay and willingness to compensate, and general demographics. The focal area of study was the people located in Lahore, Pakistan. The questionnaire was administered through online platforms to the population and the reach of the questionnaire was 350, however, the complete recorded responses were 80 while partial recorded responses were 120. The respondents had the option in some questions to provide extra information for better understanding. Moreover, the type of questions were also mixed including questions based on Likert scale, multiple choice, binary or multiple checkboxes. The respondents were asked questions on the effects of the three chosen types of environmental pollution on their health and well-being as well as general effects on the economy. Furthermore, the respondents were also directly asked about their concern for the pollution based on a Likert scale.

Contingent valuation method is used to measure the public's willingness to pay or to be compensated. CVM is a survey-based economic technique used to estimate the value that individuals place on non-marketed goods and to assess the willingness of the public to improve the environmental quality. Individuals are directly asked about their willing to pay for a particular good or service, or how much they would accept as an amount to be compensated for its loss. The respondents are supposed to choose the percentage of their monthly household income that they were willing to pay to overcome the environmental damage.

Analytical Tools

This study is based on multinomial logistic regression, a statistical method used to predict the probability of a categorical dependent variable based on one or more independent variables. In multinomial logistic regression, the dependent variable is assumed to have a multinomial distribution, which means that it can take on multiple possible values or categories. To predict the probability

of the dependent variable taking on each of its possible categories, multinomial logistic regression uses a series of independent variables that are used to construct a model that estimates the probability of the dependent variable taking on each of its possible categories, given the values of the independent variables.

The model was estimated using multinomial logistic regression. It takes willingness to pay as the dependent variable and demographic factors as independent variable which include gender, age, and monthly household income. The following is a generalized reduced form of the logistic regression model.

$$r_i = \ln \left(\frac{P}{1 - P} \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_9 X_9$$

Table 1 below shows how they are assigned in the model.

Table 1
Possible factors associated with willingness to pay (WTP) and their assignment

Factors	Variables	Assignment	Control Group
X1	Gender	Female = 0, Male = 1	Female = 0
X2, X3, X4,	Age	≥18<25: X2 = 1, X3 = 0, X4 = 0	≥15<18: X2 = 0, X3 = 0, X4 = 0
		≥25<40: X2 = 0, X3 = 1, X4 = 0	
		≥40<65: X2 = 0, X3 = 0, X4 = 1	
X5, X6, X7, X8, X9	Monthly Household Income	>15,000 ≤30,000: X5 = 1, X6 = 0 X7 = 0, X8 = 0, X9 = 0	≤ 15,000: X5 = 0, X6 = 0 X7 = 0, X8 = 0, X9 = 0
		>30,000 ≤ 80,000: X5 = 0, X6 = 1, X7 = 0, X8 = 0, X9 = 0	
		>80,000 ≤200,000: X5 = 0, X6 = 0 X7 = 1, X8 = 0, X9 = 0	
		>200,000 ≤400,000: X5 = 0, X6 = 0 X7 = 0, X8 = 1, X9 = 0	
		>400,000: X5 = 0, X6 = 0 X7 = 0, X8 = 0, X9 = 1	

Hence, this study uses both qualitative and quantitative approach to assess and analyze the public perception of environmental pollution in the city of Lahore.

RESULTS

The questionnaire was based on 53 close ended questions in order to collect precise data. The survey was divided into sections namely, demographics, perception on air pollution, perception on land pollution, perception on noise pollution and willingness to pay. The results for the demographics are tabulated in Table 2 below. This section of this study presents the data collected from the responses.

Demographics

The demographics data provides us with an overview of the respondents which can help us understand how different age groups or income groups respond. As seen in table 1 provided below, the majority (60%) of the

respondents were female. Since, the focal area of the data collection was Forman Christian College, which is why most of the respondents' age falls in the two categories, 18-25 and 25-40. The monthly household income was also kept as a close ended question for the convenience of the respondents as well as to ensure that the respondents were more comfortable in answering this question. The results show that 33% of the respondents' household income was between Rs. 200,000 and Rs. 400,000 whereas 29% of the respondents' income fell between Rs. 80,000 and Rs. 200,000. 92% of the respondents have had more than 11 years of schooling which is explained by the fact that majority of the people were either students or employed in private sector. Moreover, the respondents were asked about their mode of transport and 73% responded that they use a car to commute to their work, school, college, or university.

Table 2
Demographics results

Demographics	Categories	Response Percentage	Response Count
Gender	Male	40.00%	42
	Female	60.00%	63
Age	≥ 15 < 18	9.52%	10
	≥ 18 < 25	46.67%	49
	≥ 25 < 40	29.52%	31
	≥ 40 < 65	14.29%	15
	≥ 65	0.00%	0
Monthly Household Income	≤ 15,000	2.86%	3
	> 15,000 ≤ 30,000	3.81%	4
	> 30,000 ≤ 80,000	13.33%	14
	> 80,000 ≤ 200,000	29.52%	31
	> 200,000 ≤ 400,000	33.33%	35
For how long have you been living in your current house?	> 400,000	17.14%	18
	less than a year	8.57%	9
	1 to 3 years	21.90%	23
	3 to 5 years	11.43%	12
Years of schooling	More than 5 years	58.10%	61
	0 to 5 years	1.90%	2
	6 to 10 years	5.71%	6
Job / Occupation	11 to 16 years	92.38%	97
	Student	48.57%	51
	Self-employed	11.43%	12
	Employed - NGO	2.86%	3
	Employed - Government /Public Sector	0.95%	1
Employed - Private Sector	35.24%	37	
Unemployed / Retired	0.95%	1	

Table 3
Demographic Results Continued...

Demographics	Categories	Response Percentage	Response Count
How do you commute to work / school / college / university?		4.76%	5
	Walk	8.57%	9
	Bus	73.33%	77
	Car	11.43%	12
	Motorbike	0.95%	1
	Bicycle	0.95%	1
What is your daily average traveling time?	Auto-rickshaw		
	less than an hour	48.57%	51
	1 to 3 hours	48.57%	51
	more than 3 hours	2.86%	3

Perception of Air Pollution

The respondents were asked questions regarding their knowledge about the air quality, particularly of the Lahore city and their area of residence. These questions were related to their concern regarding the air pollution, their source of information, the perceived psychological, health and economic effects and the steps they had taken to improve the air quality. When it comes to looking for information about the air quality of Lahore, to no surprise in this technological age, the most popular source is the internet and the mobile phone applications. 66% of the respondents are most interested in checking the current air quality index while 16% of them even look for the forecast for the next day.

Only 5% of the respondents were not interested in finding any information on the air quality. Those who check the air quality index of Lahore vary in how frequent they check. 18% of the respondents said they check it everyday while 25% said that they check it once a month. 16% provided opted to provide their own information and majority of these said

that they mostly check it during winters when there is smog. Furthermore, an open-ended question was asked to get a general feeling of how the public feels about the air quality of Lahore and majority responded that it's very bad. The responses were in line with a close-ended question based on Likert scale which asked to compare the current air quality of Lahore with the quality last year. The mean rating was 2.5 indicating that the majority public believes that the conditions have worsened since last year. More than 70% of the respondents believe that they are affected by air pollution with an average rating of 4 on the Likert scale when asked about the extent to which they are affected by air pollution. This shows that the people living in Lahore consider air quality as a big concern.

The public believes that breathing contaminated air is the most common way of being exposed to the toxic air pollutants. The most common health effects of air pollution that the public believes they face include breathlessness or having difficulty in breathing and irritation to eyes, nose, and throat. People also reported that they have had asthma

incidences and skin problems due to the poor air quality. Furthermore, 60% of the respondents feel the need to relocate to less polluted places. Other psychological effects reported include worrying about the living environment for their children and feeling mentally upset about the situation of the air quality.

The poor condition of air pollution brings problems for the economy as well as the public believes that the deteriorating environmental quality and the resulting health effects lead to increased health costs for the public. Moreover, in the case of Lahore, businesses get closed due to heavy smog. 32% of the respondents also believe that the external costs produced by pollutants result in higher prices as the environmental tax is partially passed on to the consumers. However, 95% of the public thinks that the polluting companies should be fined even though it may put some workers at the risk of losing their jobs. 92% of the respondents are willing to pay higher prices and utility bills if power stations and factories switch to cleaner processes. Improving the environment requires collective effort but only 60% of the respondents reported that they are actively involved in cleaning up the environment. 96% of the total respondents think that the public transportation should be promoted while only 26% think or try using the public transportation. Moreover, 85% believe that it is the duty of the government to promote and encourage a better environment and they are willing to pay slightly higher taxes. The results from the survey provide a good overview of how the public perceives the air pollution of Lahore. It can be said that the majority of the public is concerned about the deteriorating air quality and believe that it has gotten worse than last year. Moreover, the effects faced by public whether, they are health related, psychological or economic, are serious and the majority of the respondents are willing to play their part in improving the air quality of their city.

Perception of Land Pollution

The respondents were asked a few questions on their perception of land pollution in their area of residence. When asked about the awareness of land pollution in their residential area, 80% responded that they are aware and approximately 78% people responded that they are aware of the effects of land pollution. According to the public who responded, outbreak of diseases, contamination of water sources, and less attractive environment were considered the leading effects of land pollution. The survey also contained questions related to waste collection and dumping. Approximately, half of the respondents said that the residential area authorities are responsible for waste collection while for 20%, the government or the Lahore Waste Management Company (LWMC), is responsible for the collection of waste. 83% of the respondents already pay for waste collection while 97% are willing to pay for waste collection services. Majority of the respondents are willing to pay between 200 and 2000 rupees per month for the collection of waste. Lack of funds and poor management are considered the leading problem for waste management authorities in maintaining a clean environment. However, a few people believe that the residents are mainly to be blamed for the poor environment in their neighborhood. The results from the survey mainly show that the residents are

concerned for the land pollution in their area, and they are willing to pay to improve the collection services. However, when asked about their satisfaction on the efficiency and the ways in which waste is collected, the average rating on the Likert scale was 3.27 which showed that the public is generally neutral and partially satisfied.

Perception of Noise Pollution

The majority of the respondents believe that the motor vehicles and the traffic noise is the major source of noise pollution in their residential area. Moreover, 97% of the respondents have observed an increase in the flow of traffic in recent times. Majority of the respondents experience the most noise pollution between 3pm and 9pm. When asked about the problems faced due to noise pollution, majority of the public experience general disturbance or a headache while some also face hypertension, stress and loss of sleep. Therefore, the results mainly show that the increase in traffic is causing problems for the public.

Willingness to Pay

The respondents were asked about their willingness to pay for improvement in environmental quality. This was a close-ended question, and the respondents were given options to choose from. 57% of the respondents were willing to pay 0 to 5% of their monthly income while 35% were willing to pay 5 to 10% of their monthly income. There were no responses for willingness to pay over 20% of the respondent's total monthly income and only 3 people were not willing to pay at all. Although, this gives us an idea of the attitude of the public towards willingness to pay, this study applied multinomial logistic regression with demographic variables to further see how the behavior towards willingness to pay is affected by income, age, and gender. Table 3a and 3b below show the values for the logit coefficients and the associated p-values for each category respectively. Statistical software R version 4.2.1 was used to carry out the analysis. The category of " >0 and $\leq 5\%$ " willingness to pay was used as a reference category to which the coefficients are compared. This category was chosen by default by the software based on the frequency of responses in that category.

The coefficients show how change in level of each independent variable compared to its reference category will effect the change in the level of the dependent variable relative to the base category of the dependent variable. The logit coefficient for age " $\geq 18 < 25$ " is -1.05 for willingness to pay " $>5\% \leq 10\%$ " which means that with a one unit increase in the respondents age between 18 and 25, the logit coefficient for WTP " $>5\% \leq 10\%$ " relative to the base category which is WTP " $>0\% \leq 5\%$ " will go down by 1.05 units. In other words, the chances of staying in the base or reference category are higher as compared to WTP " $>5\% \leq 10\%$ ". It can be seen that all the coefficients for WTP " $>5\% \leq 10\%$ " are negative which indicate that people are inclined towards the base category. Additionally, the p-values also support this as the values are less than 0.5 which show that there is a low probability of staying in the WTP " $>5\% \leq 10\%$ " category.

Table 6 above shows the relative risk ratio which is the exponentiated value of the logit coefficients. It can also be used to predict the behavior of the respondent's willingness to pay based on their demographic. For the

Table 4
Logit Coefficients for Multinomial Logistic Regression

	Dependent Variable: Willingness to Pay		
	0	>5% ≤ 10%	>10% ≤ 20%
Intercept	-26.43315	20.41892	-30.96771
Age ≥ 18 < 25	15.373751	-1.053044	-2.035579
Age ≥ 25 < 40	-8.8137570	-1.6356271	-0.9853675
Age ≥ 40 < 65	-16.487351	-1.488666	-22.551569
Gender Male	0.8122593	-0.1632046	22.8955995
Income >15,000 ≤ 30,000	-2.700504	-17.906829	-8.272704
Income> 30,000 ≤ 80,000	8.422233	-20.856524	-21.407514
Income>80,000 ≤ 200,000	-9.094202	-19.532177	-17.109642
Income>200,000 ≤ 400,000	9.752876	-19.365381	8.256350
Income > 400,000	-23.415700	-20.202851	8.396582

Table 5
Associated p-values of Logit Coefficients for Multinomial Logistic Regression

	Dependent Variable: Willingness to Pay		
	0	>5% ≤ 10%	>10% ≤ 20%
Intercept	0.904	0	0
Age ≥ 18 < 25	0.948	0.301	0.018
Age ≥ 25 < 40	0	0.127	0.2659
Age ≥ 40 < 65	0	0.191	0
Gender Male	0.559	0.7698	0
Income >15,000 ≤ 30,000	0.998	0	0
Income> 30,000 ≤ 80,000	0.985	0	0
Income>80,000 ≤ 200,000	0.243	0	Na
Income>200,000 ≤ 400,000	0.983	0	0
Income > 400,000	0	0	0

Table 6
Relative Risk Ratio for Multinomial Logistic Regression

	Dependent Variable: Willingness to Pay		
	0	>5% ≤ 10%	>10% ≤ 20%
Intercept	0	737607953	0
Age ≥ 18 < 25	4,750,454	0.349	0.131
Age ≥ 25 < 40	0.0001	0.195	0.373
Age ≥ 40 < 65	0	0.226	0
Gender Male	8,778,747,202	0.849	2.253
Income >15,000 ≤ 30,000	0.0003	0	0.067
Income> 30,000 ≤ 80,000	0	0	4547
Income>80,000 ≤ 200,000	0	0	0.001
Income>200,000 ≤ 400,000	3852	0	17,203
Income > 400,000	4431.89	0	0

Table 7
Chi-square test of independence

Variables	Chi-square value	P-value
Gender	5.1699	0.1598
Age	6.4864	0.6904
Income	12.954	0.6059

income categories, we can see that the values for 5 to 10% willingness to pay is equal to zero which indicates that the odds for the individual with the given levels of income, to stay in the 5 to 10% category is zero which means that they are more likely to move to the base category which is 0 to 5%. Keeping all other variables constant, males have 0.849 odds of 0 to 5% willingness to pay compared to 5 to 10% compared to females.

DISCUSSION & CONCLUSION

Past studies have explored the relationship of WTP with income and age (Liu et al., 2018; Wang & Mullahy, 2006; Sun et al., 2015) and found a significant correlation. However, this study is unable to confirm this relation as by running the chi-square test of independence (Table 7), we can see that the p-values are greater than 0.05 which show that the null hypothesis is accepted meaning that WTP is independent of gender, age and monthly household income. However, we can still observe the effect of the dependent variables on WTP through the logistic regression model. The frequency of the respondents choosing 0 and >10% and ≤20% WTP was low therefore, a fair conclusion cannot be drawn from the results shown in table 3 and 4 for the respective columns. The data for WTP is mostly concentrated between >0 ≤5% and >5% ≤10% categories which we can compare. WTP does not necessarily increase with income (Shao et al., 2017) which is in line with the results of this study as there were no respondents who were willing to pay more than 20% of their monthly income and there were only 3 people who were willing to pay more than 10% of their income.

The results of the multinomial logistic regression generally show that the public irrespective of their age and income, are willing to pay between 0 to 5% of their monthly income. Moreover, the survey results from this study show that the public is significantly affected by the deteriorating environmental quality particularly, air and land pollution. There is higher concern for the environment in Lahore as compared to last year. The health risks associated with environmental pollution especially, air pollution, which is visually experienced in the form of smog, are in line with the findings of Noel et al. (2021) which include breathlessness, cough and eye irritation. The public generally believes that the risk is higher during the months of October till December which is the period of highest deterioration in air quality. A reasonable explanation for the public from different demographics showing similar WTP could be due to the saturation effect discussed by Saksena (2007). Since the study is based in the urban area of Lahore, the perception is based on the visible signs of pollution. Therefore, the response is similar.

The findings from the survey also emphasize that the government needs to do more to improve the environmental quality by imposing fines on polluting factories. The Environmental Protection Act has been in place since 1997 which has been responsible for imposing tax on industrial emissions and has set the emission standards for the motor vehicles (EPA). However, more work needs to be done in its effective implementation. The government also needs to improve the monitoring of air quality data as that is considered the first part of breaking down the problem. There are multiple privately installed sensors, but the government needs to enhance its monitoring of data which

will help in determining the areas with the worst air quality within the city.

The public of Lahore believes that improving the environment is a collective effort which is why they are willing to pay higher taxes to support the government in improving the environment. As established, the majority of the public is willing to pay between 0 and 5 percent of their monthly income. This can be taken into consideration by the government or policy makers in designing a policy that charges a specific environmental tax which can be spent towards improvement of the environmental quality. Moreover, the people are also willing to use public transport provided that the service is improved.

This study aimed to assess and analyze the public perception on environmental pollution in Lahore. Key findings from this research show that there is no significant relationship of WTP with income, gender or age. However, the results from the multinomial logistic regression show that majority of the people regardless of their gender, age and income tend to fall towards WTP between 0 and 5%. This provides useful information for the policy makers in imposing environmental taxes to improve the deteriorating environmental quality of Lahore. Moreover, the results also signify that the public is aware and concerned about the effects of environmental pollution and want to play their part in resolving this issue by willing to pay for it. Furthermore, the public also expects the government to play their part as well and find solutions one of which include the promotion and improvement of the public transport which can not only help in decreasing vehicular emissions but also reduce traffic noise which is considered the major source of noise pollution.

Conflict interests

The authors has declared that no competing interests exist.

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