ASSESSING THE KEY CHALLENGES WHILE IMPLEMENTING AIR POLLUTION PREVENTION INITIATIVES IN PUNJAB

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CERTIFICATE

This is to certify that this thesis entitled "**Assessing the Key Challenges While Implementing air Pollution Prevention Initiatives in Punjab.**" submitted by **Malik Muhammad Hamza Aslam** is accepted in its present form by the PIDE School of Social Sciences, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Development Studies.

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Author's Declaration

I, **Malik Muhammad Hamza Aslam**, hereby state that my MPhil thesis titled **"Assessing the Key Challenges While Implementing Air Pollution Prevention Initiatives in Punjab"** is my work and has not been submitted previously by me for taking any degree from 'Pakistan Institute of Development Economics' or anywhere else in the country/world.

At any time if my statement is found to be incorrect even after my Graduation, the university has the right to withdraw my MPhil degree.

Malik Muhammad Hamza Aslam

Dedication

This thesis is dedicated to my beloved parents, whose unwavering support, and endless encouragement have been the foundation of all my achievements. Your sacrifices and constant belief in my potential have been my greatest source of strength and inspiration. Thank you for always standing by me and guiding me through every step of this journey. This accomplishment is as much yours as it is mine.

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ABSTRACT

Air Pollution has been defined as a regional health challenge in Punjab, that leads to many people getting sick, even after so many policies, air pollution is still increasing. This study is conducted to explore the significant obstacles hindering the effective implementation of air pollution prevention policies in Punjab. This study has two objectives, first one is to review the air pollution policies that were formulated during the past three decades to increase air quality in Punjab. The second objective is to get stakeholder narratives, interviews were conducted with stakeholders from the Planning and Development Board, Environmental Protection Department, Transport Department, Agriculture Department, The Urban Unit, and some others. Two methodologies were adopted for the study, policy review and thematic analysis. The study uses a qualitative approach to analyze policy documents and thematic analysis for both objectives. The first objective was the policy review and the review described that the policies are well-formulated and follow international standards with robust frameworks and penalties. But still air quality is decreasing, which means that the real issue lies in the implementation process of policies. The second objective was to get departmental constraints while implementing policies. The stakeholder's narrative identifies that despite a strong framework of air pollution policies in Punjab, their effective implementation remains a persistent challenge and there are systematic hindrances, including insufficient financial facilities to execute environmental laws, lack of human resources, and poor coordination among various organizations. Recommendations made from the findings are that the policies should be made with long-term goals instead of addressing just immediate events, and government should enhance the funding for environmental projects, and inter-department coordination should be increased to align actions, and smooth policy implementation.

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List of Abbreviations

YLL	Year of life lost
DALYs	Disability-adjusted life years
PDHS	Pakistan Demographic Health Survey
EPO	Environmental Protection Ordinance
UNDP	United Nations Development Program
NEAP-SP	National Environment Action Plan-Support Program
NCAP	National Clean Air Policy
WHO	World Health Organization
ESRI	Eco-System Restoration Initiative
NEQS	National Environmental Quality Standards
BTAP	Billion Tree Afforestation Project
TBTTP	Ten Billion Tree Tsunami Project
EPCO	Environmental Pollution Control Association
EPD	Environment Protection Department
PAQI	Pakistan Air Quality Initiative
AQI	Air Quality Index
AQMS	Air Quality Measuring Stations
EPA	Environmental Protection Agency
HEI	Health Effects Institute
NMMAPS	National Morbidity, Mortality, and Air Pollution Study
LEZs	Low Emission Zones
VICs	Vehicle Inspection and Certification System
KIIs	Key Informants Interviews

Chapter 1

INTRODUCTION

As defined by the WHO, over 7 Billion people, making up 95% of the World, live in unhealthy air. Air pollution was considered the fourth leading cause of Death globally according to the "Global Burden of Disease" study. According to one of its reports, in 2019, 192 Billion YLL (years of life lost) were due to air pollution and 48% of deaths were due to air pollution occurring in South Asia. According to the report (World Air Quality, 2019), the majority of the most polluted cities of the world are in South Asia, which had 4 of the topmost five polluted countries and 30 out of 40 world's most polluted cities in 2019. South Asian countries like India, Bangladesh, and Pakistan have remained the most polluted countries in the world facing over 1.5 million deaths annually due to Air pollution. According to the Institute for Health Metrics and Evaluation, air pollution was graded as the main environmental/occupational factor for most deaths and disabilities in Pakistan in 2017, and the fifth highest factor overall. The Punjab Environment and Climate Protection Department has mentioned vehicular emissions, dust falls and industrial emissions as the main causes of air pollution in Pakistan. Instituted health metrics and Evaluation report shows that 105.17 deaths out of 100000 were due to air pollution in 2019. The following figure shows Pakistan's position based on this rate compared to other countries.

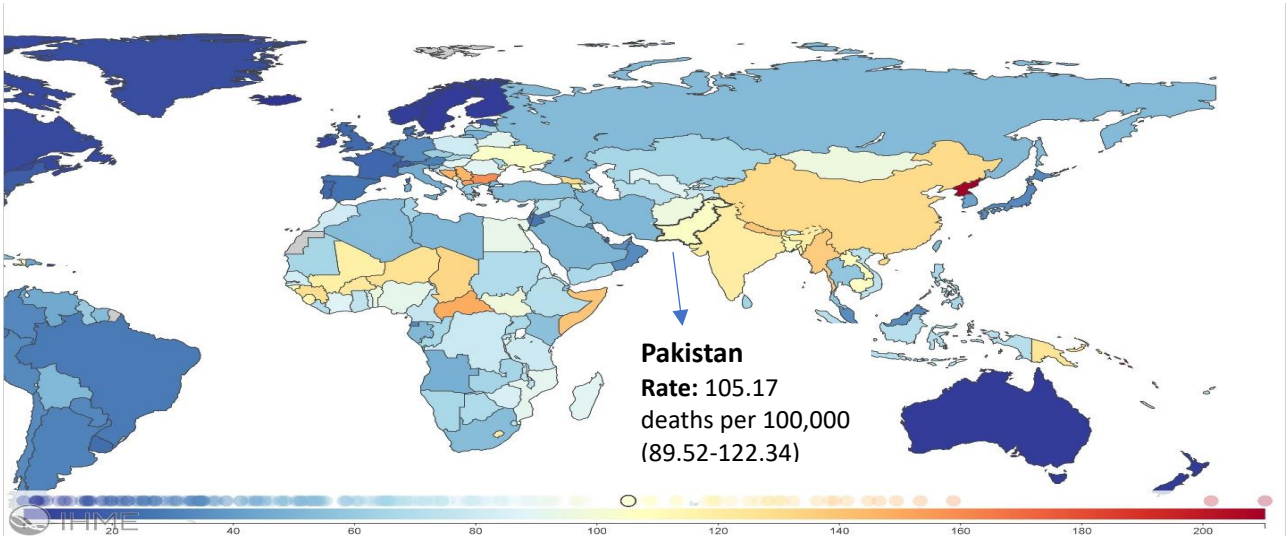

Figure 1. Death Rate per 100,000 due to Air Pollution.

Source: Institute for Health Metrics and Evaluation

Pakistan, due to rapid urbanization and increasing numbers of vehicles on the road, is considered among South Asia's most polluted countries. According to the Air Quality Index, the amount of particulate matter in the air is seven times more than the limit set by the World Health Organization. As Pakistan is also among the most populated countries, with increasing consumption demand, it focused always on achieving self-sufficiency in food demand and energy demand with increasing industrialization. The focus on limiting emissions and other environmental controls was left behind due to other economic and political issues.

Air pollution consists of two types' i.e., outdoor pollution and household pollution. Outdoor pollution is due to the suspension of gases or tiny particles of solids and liquids also known as ambient particulate matter. The sources of this type of pollution are industry and power production, forest fires, dust storms, agriculture, and residential heating and cooking. Ambient particulate matter pollution is a significant reason for premature death and illness worldwide. Housed hold Population is caused mostly in rural areas. The burning of petroleum products like waste, wood, and plant matter causes this sort of pollution. Some causes are constant, like automobile factories, and brick kilns, while others are occasional or periodic, for example, stubble burning during winters and openly burning waste on the roads. Further, below-par maintained construction sites and dust storms increase, dust and silica, which eventually make the concentration of PM 2.5 and PM 10 in the air (Fatima et al., 2023).

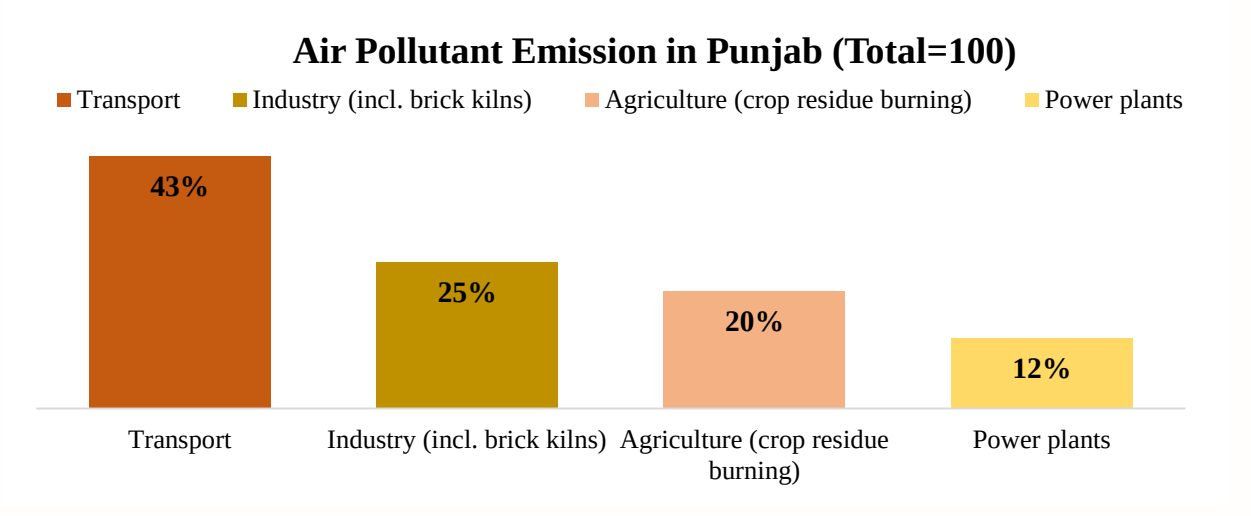

Figure 2. Air Pollution Emission Percentage

Source: R-SMOG Govt. of Punjab, MP Analysis

According to a Global Burden of Disease study, Air pollution is one of the top threats to global health exceeded by blood pressure, tobacco use, and poor diet. Polluted air causes lower respiratory infections (Pneumonia), cardiovascular disease (Ischemic heart disease and stroke), lung cancer, lower birth weight, and premature births. The impact of these risks has increased in developing countries like Pakistan, which have inadequate management systems. Mortality rates are becoming alarming due to exposure to increased levels of air pollutants specifically particulate matter (Muhammad Shehzaib Anjum, 2021). According to a World Bank report, 22000 premature adult deaths and 163,432 DALYs (disability-adjusted life years) lost are due to outdoor air pollution. The majority of households in Pakistan use "polluting fuels" for cooking, which is a significant cause of pneumonia and respiratory disorders. According to the Pakistan Demographic Health Survey report (PDHS, 2017–2018), pneumonia among those under five years had increased to 20% from 16.8% in 2012-13. Along with health issues, reduced visibility, loss of vegetation, damage to material, heritage, and monuments, and Effects on the growth of plants are other major issues, highlighted by the Punjab Environment Protection and Climate Change Department, which are instigated by air pollution.

After the 18th amendment of the 1973 constitution, some of the environmental protection responsibilities were given to the provincial government. Thusly, in 1975 Environmental Pollution Control Association (EPCO) was made under the Public Health Engineering Department but because of its limited scope, detailed work and follow-up were not possible. In 1983, under the Pakistan Environmental Protection Ordinance, an arrangement was made for the foundation of the Provincial Environmental Protection Agency, and the federal government in 1987 was requested to designate the powers to the physical housing and environmental planning department. In 1987, the Environment Protection Agency of Punjab was developed to the best interests of residents. In 1996, a different regulatory unit called as Environment Protection Department (EPD) was formed under the Punjab government. Presently, the Punjab Environmental Protection Department is separated from the physical housing and Environmental Planning and works under the Environmental Protection Department (EPD). IN 1997, the federal government withdrew the Pakistan Environmental Protection Ordinance (1983) and gave the Environment Protection Act (1997) for provincial governments to take functions as delegated in it.

In 2017, the policy on controlling smog was approved and immediately implemented for Control, Mitigation, Advisory, and Protective Measures in Extreme Weather Conditions of Dense Smog in Punjab 2017. The purpose of this policy was to control the smog, especially in Lahore, which was formed during the onset of winter creating difficulties and health problems. The smog was first formed in 2016 winter, after which concerns were generated regarding air pollution, and the matter was taken to the Lahore High Court a result of which this policy was made. The policy however failed to get implemented and the reason put forward by the EPD was the shortage of air quality monitoring stations in the province.

In April 2023, Punjab's Clean Air Action policy was formed due to the alarming rate of particulate matter in the air produced by human activities causing air pollution. The rate of deaths due to air pollution was increasing and smog was another effect of air pollution that was creating difficulties for the citizens regarding health and social activities. This policy was formed with the objectives to protect people from the harmful effects of air pollution, to decrease pollutants in the air and increase air quality, to coordinate among sectors for effecting enforcement against pollutant generating activities, and to encourage sectors to use clean technologies. However, mass awareness and environmental education were the cornerstones of the policy.

Due to the harmful effects of air pollution on different aspects of life and humans, all these steps and measures in the form of policies or plans were taken to control air pollution in Pakistan, especially in Punjab. After all these policies, there has been no improvement in the quality of air. Air pollution is still affecting the health and life of people. One major effect of air pollution i.e. smog has been causing several problems for the people of Pakistan, especially in Lahore. The following table shows how clean the air in which we breathe.

Table 1. Cities and their PM concentration

City	PM2.5 conc.	Health Impact
Lahore	**130**	#Unhealthy 9x above safe limits
Peshawar	**63**	#Unhealthy 4x above safe limit
Islamabad	**42**	#Unhealthy For sensitive crops
Karachi	**40**	#Unhealthy For sensitive crops

Source: Pakistan Air Quality Initiative (PAQI). The WHO set a 10ug/m3 safe limit while the Pakistan Environment Protection Agency recommended 15 ug/m3.

This shows that all the policies implemented so far have been unsuccessful in achieving their target of reducing air pollution. Among the capital cities of Pakistan, Lahore has been the most affected city by air pollution. Smog is mostly formed in the city of Lahore. The following table shows the latest EPA report of January 30, 2024, the Air Quality Index (AQI) of Lahore, recorded with Air Quality Measuring Stations (AQMS) based on previous 24-hour data.

Table 2. Cities and their Current Concentration

Station name & Location	Parameter used to calculate AQI	PEQS value µg/m3	Conc. (µg/m3) used to calculate AQI	AQI
Mobile AQMS (EPA HQs, National Hockey Stadium, Lahore)	Particulate matter (PM2.5)	35	184	241
Punjab University, Lahore (college of earth and environmental sciences)	Particulate matter (PM2.5)	35	166	224
Town Hall, Lahore	Particulate matter (PM2.5)	35	190	246
Shallay Valley Range Road Rawalpindi	Particulate matter (PM10)	150	259	155
Shaheen Villas phase II, Lhr-Fsd bypass Road, Sheikhupura	Particulate matter (PM10)	150	194	122

Source: Air quality index (AQI) and PM2.5 air pollution in Pakistan

These graphs depict the most recent scenario of the cities of Punjab. Most values lie above 200 for AQI whereas different categories set for the level of AQI are given as

Table 3. Limits of EPD Punjab for AQI

Limits of EPD Punjab for AQI	
0-50	GOOD
51-100	SATISFACTORY
101-150	MODERATE
151-200	UNHEALTHY FOR SENSITIVE
201-300	UNHEALTHY
301-400	VERY UNHEALTHY
401-500	HAZARDOUS

Source: Environment Protection and Climate Change Department

According to these limits, Punjab lies in the category of unhealthy. It means that the air of the Punjab region is unhealthy for its people. The point to be noticed is that even with so many policies over time and discussions on the issue in the international world, why Pakistan is not able to improve the quality of its air. This raises concern about the future if the AQI continues to increase in future and converts the air from an unhealthy to a hazardous category. It needs to be investigated with so many policies and strategies, why Pakistan cannot tackle the issue, and why these policies are not implemented or effective in particular case.

1.1. Statement of the Problem

The government of Punjab has enacted various environmental laws and policies aimed at mitigating the air pollution issues and the Punjab Government has also devised a Policy and Action Plan for Control, Mitigation, Advisory, and Protection measures to reduce air pollution (Zafar, 2023). According to IQAir, this persistent issue decline air quality in Punjab to 97.4 micrograms of PM 2. 5 particles per cubic meter which was 86.5 in 2021, making it the most polluted region in Pakistan. It poses serious health risks to the population, as per the WHO report air pollution contributes to over 128,000 deaths each year in Pakistan. The statistics emphasize the need for intervention strategies specifically tailored for Punjab. However, after all the policies and initiatives still air quality is decreasing day by day, and that raises the question where is the gap that caused the inefficiency of policies, either in the formulation of policy or in the implementation of policy. On the other hand, the effectiveness and implementation of 'Air Pollution Prevention Initiatives' remain a subject of concern and demand thorough evaluation. This research aims to critically assess the current state of air pollution prevention initiatives, and their effectiveness in addressing the air pollution crises. It seeks to identify the gaps between policy formulation and execution, examine the enforcement mechanisms, and evaluate the impact of 'Air Pollution Prevention Initiatives' on improving air quality. Additionally, the study will explore the challenges and barriers faced in the implementation process, including social factors.

1.2. Objectives

Based on the literature of past policies to counter the problem of air pollution and a review of the current situation and future probability of low air quality, two objectives have been developed to examine the gap.

1. Comprehensive review of the previous policies regarding air pollution in Punjab.
2. What are the key challenges in the implementation of 'Air Pollution Prevention Initiatives' in Punjab?

1.3. Research Questions

1. How effective are the existing policies regarding air pollution in Punjab in reducing air pollution levels, and what gaps or limitations exist within these policies?

2. What are the primary obstacles faced by departments to the successful implementation of 'Air Pollution Prevention Initiatives' in Punjab?

1.4. Significance of the Study

This study can be significant in many aspects to several people or institutions. It can increase the effectiveness of the policies regarding the environment by providing insights into how far policies have achieved their intended goals and achievements. It can help to improve the efficiency of the policies and departments by examining whether the proper and efficient resources are being used in achieving the outcomes. This evaluation study will provide feedback to the policy-making departments so that they can change their policies in a better way. This way, transparency will be created in the governance, as this study will be publicly available, creating trust and credibility. Further, through this study, different departments of the Punjab province will be investigated, and their constraints will be discussed in a single document, making it a guiding document for all these departments. As air pollution is an increasing health issue in Pakistan, and with all the past policies and strategies, the government cannot improve air quality to a safe level. This increases the significance of the study, it will address the gap in policymaking and implementation.

1.5. Research Gap

Air pollution has always been a problem and has gotten major attention from different governments and international organizations. They are working hard to reduce it by making different policies and taking action but the problem is still there and increasing with the passage of time. This means that no one has identified some challenges and hurdles. I have tried to determine the challenges that caused the inefficient implementation of policies. To determine the challenges, I have reviewed all the policies in Punjab to see whether there are some problems in the formulation of the policies. By interviewing stakeholders, we have tried to identify the hurdles that different departments face during practical operations. It is very crucial for effective policy implementation, and literature lacks this perspective regarding the reduction of air pollution.

Chapter 2

LITERATURE REVIEW

This chapter aims to provide a literature review of existing research by analyzing academic articles, reports, and studies, this review seeks to identify key themes, findings, and methodological approaches as well as to uncover gaps in the current body of knowledge. By examining the various dimensions of air pollution, including its health effects, economic implications, and environmental consequences, this review seeks to provide a comprehensive overview of the current state of knowledge.

Major environmental policies and strategies have been formulated by Pakistan but most of them never entered into practical work or were implanted by the government of Pakistan. The Federal Environment Ministry was established in 1975 based on the declaration of Stockholm in 1972. It was responsible for making the environmental protection ordinance of Pakistan in 1983. The ordinance was made to establish federal and provincial agencies for protecting the environment of Pakistan. The first strategic plan was formulated under the supervision of the Planning Commission of Pakistan named "National Conservation Strategy 1993". It was made to conserve natural resources and implement long-term sustainable development programs. Instead of having huge success in documentation form, it failed to be implemented largely due to 1990 political instability in Pakistan. In 1993, the environmental quality standards were set to examine the environment of Pakistan.

In 1997, the Pakistan Environmental Act was passed after the enactment of the law because of the amendment to the apex body (Environmental Protection Ordinance (PEPO)) of the Environmental Protection Ordinance 1983, which was then led by the president. After converting to the Pakistan Environmental Act, it was given under the supervision of the Prime minister. This Act was passed to provide for the protection, conservation, rehabilitation, and improvement of the environment, for the prevention and controlling of pollution, and elevation of sustainable development. The Act also promotes public participation in environmental decision-making processes, recognizes international environmental commitments, and emphasizes sustainable development and environmental justice principles.

National Clean Air policy was approved in 2023 under the Ministry of Climate Change with the help of international advisors. The policy aimed at reducing air pollution by Implementing Euro-5 and Euro-6 fuel quality standards, enforcing emission standards for industries, Preventing the burning of agricultural residue, preventing open burning of municipal solid waste, and Promoting the use of low-emission cooking technologies. While the policy delivers an opportunity for constructing governmental capability for air quality management, it leaves a lot of room for development and occasionally takes a step back rather than forward.

In 2001, a comprehensive program was proposed under the name of a national action plan to recommend and execute plan to achieving environmental stability and sustainability and diminishing poverty. Its elaborative plan was cheered by the international World. The United Nations Development Program (UNDP) also began a program under the name of the National Environment Action Plan-Support Program (NEAP-SP) to help the action plan of the program for practical implementation along with financial support. The first initiative was successful, and the program had the option to accomplish the formulation of a National Environmental policy, the development of a sanitation policy to handle the issue of waste management, development of a strategy to clean, and development of mechanism procedure. Tackling the problem of deforestation and drafting a national Forest policy handling the issues of energy consumption and driving an energy conservation policy were also achieved successfully under this program. (Naureen, 2009). Under phase II of the initiative, 60 different programs were suggested and approved with the help of UNDP to achieve the accessibility of Clean drinking water, development concerning expanding the limit of the country, and develop very first bio-safety centers in Pakistan. The second initiative was unsuccessful probably due to political instability and terrorism related to World Trade Center in 2001.

In 2010, when Pakistan was hit by floods that caused massive destruction and causalities because of not paying enough practical attention to environmental protection and climate change. Pakistan started to work on its environmental safety measures the very next year to save the people of Pakistan from floods of the same magnitude next year. This becomes the source of origin of the policy “National Climate Change Policy 2012” to save the people of Pakistan from further natural disasters and their destruction (Ahmad, 2022). This policy was related to different sectors like agriculture, forestry water, etc. with protection of their ecosystems and biodiversity. Although this

policy did not get implemented it improved the knowledge about the strengths and weaknesses of Pakistan in avoiding natural disasters. It gave ideas on managing future natural disasters, preparing itself for inevitable disasters, strengthening institutions related to environmental issues, and spreading awareness concerning climate change, environmental issues, natural disasters, and disaster management among public. (Ahmed et al., 2020).

Eco-System Restoration Initiative (ESRI) was taken to strengthen Pakistan against natural calamities by the previous govt. Pakistan Tehreek-e-Insaaf (PTI). The main objectives include programs of plantation with the aim of afforestation, protecting and conserving biodiversity in water bodies as well as in forests, and formulating such initiatives that coincide with the environmental policies of Pakistan and with ESRI. (Chaudhry, 2017). Further, PTI during their governance period of 2013-2018 in KPK, started the program with the name of Billion Tree Afforestation Project (BTAP) to address the issue of deforestation and climate change. The good aspect of this program was that it involved and encouraged people of all ages and backgrounds to take part in activities by planting. The program also encouraged people in other provinces to take part in the activities of the program. After the huge success of the BTAP, it was upgraded to the "Ten Billion Tree Tsunami Project" (TBTTP) on a national level. The Green Pakistan Index was another program started under the leadership of Prime Minister Imran Khan with the collaboration of the Ministry of Climate Change. The program was started to provide services related to municipalities to citizens through local government. It includes services related to drinking water, sanitation, hygiene, solid waste Management, and plantation. Afterward, the voluntary participation of citizens was encouraged through the "Clean Green Champions" program.

Monitoring air pollution is significant for public health and protection of the climate. This requires that the monitoring stations should be strategically situated inside the locale of interest. The use of some specific rules related to numerical models for the spatial and temporal dispersion of pollutants inside the air give a general way to deal the optimal number and areas of monitoring stations. Because of the complexity of the mechanisms involved in the diffusion of air pollution, the plan of monitoring networks has been frequently based on semi-empirical approaches. This study presents another measurable technique for the enhancement of air quality network and applies it to the Venice provincial areas. The outcomes demonstrate that the quantity of stations in

the current network could be decreased without a reduction in the data created. This would reduce the expense of monitoring (Pittau et al., 1999).

In the study conducted by (Noman, 2002), it is argued that due to the increased rate of urbanization as well as industrialization in Pakistan, air pollution has emerged as a serious point in terms of health. Even, if the governmental and other organized bodies incorporate different policies and regulations to better the status of air pollution, the results are not as desirable as it has been expected because of the lack of implementation and inadequate awareness. That is why the article outlines several challenges in air quality management in Pakistani urban areas, such as weak monitoring systems, the lack of awareness, scarce funds, and weak enforcement of rules. Based on this study, this was informed that there is the need to utilize a more holistic approach to help reduce air pollution in the Pakistan's urban areas since they are gravely affected, calling for strict monitoring networks, enhanced public awareness, and enforcement laws. Littered throughout the article, a constant call for the effective management of air quality in Pakistani cities to save the public health and quality life is prominent.

To let the public into the process of the dynamic cycle in environmental management has been one of the major objectives in the Europe and America environmental policy domains. Pearl of example is the US National Academy of Sciences that encourages environmental security associations to address and support citizen participation and public contribution in order to make policy making for environment and managing of hazards more articulate and vote based. It also looks into the need to embrace public and popularity-based thoughts while making policies on the environment and presents a coordinated working model on how the public can be involved in decision making on matters concerning the environment. This study provides the idea that consultation can create new options for actions and solutions for a problem. This innovative procedure can either be plan by identifying similar advantage solutions or by locating similar ethical justifications on which new decisions may evolve. Reasoning may help to draw society's attention to the choices, meanings, and possible activities connected with the object of study (Renn, & O., 2006).

In the study of (Kuylenstierna et al., 2008), ground level ozone is deemed to be one of the severe air pollutants in Asia which leads to crop yield losses, food insecurity, and diseases. It is also a

major contributor to greenhouse effect. Linking of air pollution and climate policy adopted integrated assessment strategies, but there are challenges in developing and implementing these methods at different policy and geographical scales. Mechanisms for integration of air pollution and climate change programs should be improved through the use of the following approaches to their strategies, frameworks, and implementation processes. The Global Environmental Pollution Forum is an international organization established by formal governmental and non-governmental entities that deal with strategies to eliminate air pollution. This relates to people's engagement and commitment to sound strategies that would help solve air pollution issues. The things they speak about can be considered as valuable points to work with in order to create the impactful policy, and the points are the following ones, it is crucial to involve the different levels and types of stakeholders, the governmental as well as the non-governmental ones, to cooperate and collaborate in order to find out the relevant strategies and frameworks for the further integration. To work with the development of powerful strategies and frameworks, create permanent stocks for interchange of information and sale of best practices. Generic assessments on the scientific correlation as well as its impact between air pollution and climate change in order to advance in the most responsible approaches.

The study discusses about the significance of evaluating the usefulness of air quality guidelines in improving public health, also called accountability. Air quality has enhanced in the US and Western Europe because of strict regulations, yet the expenses and the requirement for accountability research highlight the status of evaluating the impact on public health. The Health Effects Institute (HEI) funds current studies on accountability, including initiatives, for example, prohibiting coal sales, replacing old wood stoves, diminishing sulfur content in fuel, and procedures to reduce traffic. HEI additionally supports the development of strategies to evaluate regulations executed over extended timeframes. The availability of pollution and health information from the National Morbidity, Mortality, and Air Pollution Study (NMMAPS) considers extra investigations and possible accountability studies. Study also mentioned that the HEI Accountability Working group developed a conceptual framework for accountability research and recognized the types of evidence required and techniques to get that evidence. The framework considers indicators along the "chain of accountability" and focuses the requirement for quantitative measures of accountability. The HEI supports the development of methods and research to evaluate regulations carried out over different time periods (Erp et al., 2008).

Following 10 years of policy endeavors in Flanders, the everyday air particulate matter PM10 standard, that was implemented by the European Commission (EC) in 1999, is yet being surpassed a larger number than allowed due to lack of pro-active policy execution and poor concentration to accountability of measures taken. Particulate matter air pollution was not important on the political agenda, prompting a lack of focus on accomplishing the PM10 standard that was enforced by European Commission in 1999. The desire of Flanders to turn into the European logistic turntable for transport that might increase PM emissions. The fleet of vehicles in Flanders comprises of a relatively large number of diesels compared with other countries, which might ruin the execution of Low Emission Zones (LEZs) and make it more challenging to reduce PM levels (Buekers et al., 2010).

The study by (Khwaja et al., 2012) examines initiatives to address air pollution in South Asia, focusing on the requirement for technology sharing, exchange, and information spread. The study suggests the establishment of forums for technology sharing and exchange, as well as the development of a legally binding provincial policy instrument for air pollution reduction and control in South Asia. The actions made by South Asian nations, for example, Bangladesh's emphasis on awareness building activities, and administrative measures. It specifies the difficulties faced by all South Asian countries in executing international conventions and settlements, including lack of financial and technical support, coordination issues, and inefficient legitimate and administrative frameworks. It emphasizes the significance of addressing point source pollution producers, and requires a local framework to diminish the air pollution and improve air quality in South Asia.

(Lin et al., 2014) reviews the ‘China’s National Air Pollution Policies in the Early 12th Five-Year’ and found the major development and improvements in their measures and amendments in implementation process, and suggested under developed countries to adapt their way to mitigate air pollution. He mentioned amended measures in his study i.e. to plan reinforcing the monitoring framework and publicizing emissions information to build transparency and awareness of air pollution levels. Setting up early warning systems to give timely information and cautions about air quality conditions. Reinforcing different local standards and guidelines to control and mitigate air pollution. Implementing stricter emission standards for thermal power plants, for example, GB13223-2011, which were more severe than standards in different nations. Establishing a

national environmental air monitoring network development project, including for Beijing, with subsidizing from a special fund for significant pollutants emission reduction. Emphasizing the requirement for energy conservation and emission reduction policies, as well as measures for complete emission index for recently built industrial projects.

Air pollution in China has been exceptionally serious, causing health damages and social losses for quite a while. For the time being air pollution control polices have over the last two decades experienced massive changes, especially an advancement from powerless to strong execution. As of late air pollution in China has advanced into an issue of wide and politically focused on concern. National polices have been begun and executed, similar to the Air Pollution Prevention, and Control Action Plan. It is notable that energy is the primary source of air pollution and carbon emission in China, and the closely related energy and climate polices are also experiencing prominent changes. The early policies in China primarily focused on project management and emission release by enterprises, missing the broader aspects of air pollution prevention and control. This absence of an extensive approach, together with the absence of an administrative purpose of conserving human healthiness and environmental rights, contributed to their ineffectiveness in decreasing the emission (Jin et al., 2016).

Air pollution is a significant risk factor for sickness in South Asia, adding to some place in the scope of 13 and 21.7% of all demises and around 58 million disability adjusted life years (DALYs) through chronic and serious respiratory and cardiovascular diseases. South Asia has one of the best concentrations of dark fossil fuel emissions from vehicles and trucks, cooking ovens, and industrial facilities, which influence wellbeing as well as potentially affect the Himalayan glacier system. South Asian nations have figured out how to address different classifications of emissions, but there is no reasonable methodology for air quality and regular monitoring. To handle the health burden of air pollution, an organized and, multisectoral reaction is required, utilizing a "health in all policies" structure, and combined provincial action, to monitor air quality and execute proof-based policies. Comprehensive health focused strategies are missing, and deliberate activity across sectors is expected to accomplish suggested air quality standards in South Asia (Krishna, B., 2017).

Poor air quality is developing worldwide challenge because of its health and socio-economic risks, and Pakistan is affected because of lacking early warning, protection, and the management

frameworks. Epidemiological researches have connected poor air quality to different health problems and expanding death rates. World Bank had assessed that Pakistan's yearly weight of disease from open air pollution is responsible for around 22,000 premature adult deaths and 163,432 DALYs lost. The concentration for major air poisons like NOx, O3, and SO2 has expanded over the last two decades, and a few studies have revealed examples of air quality surpassing national rules. The city of Lahore, for instance, had pretty much every day in 2019 with PM2.5 concentrations surpassing WHO and national air quality standards. The study emphasizes on the basic difficulties related with poor air quality in Pakistan, including the absence of air quality monitoring frameworks and poor initiatives by policymakers and authorization organizations. The way forward incorporates the advancement of adaptable monitoring, new technology, and monitoring approaches, as well as improved communication among public, private agencies, and all relevant stakeholders (Anjum et al., 2021).

The study by (Mir et al., 2022), investigates the expected advantages of integrating air pollution control measures with climate change mitigation strategies in Pakistan. It features Pakistan's extreme urban air pollution and its impact on public health and the economy. Utilizing the GAINS model and the EnerNEO Pakistan model, the review evaluates the results under different situations, including benchmark and alternative policy situations including advanced control technologies and sustainable development measures. The findings propose that ongoing measures are inefficient to fulfill air quality standards. Implementing sustainable development strategies could significantly decrease PM2.5-related mortalities by 24% in 2050 compared to the baseline scenario. Advance control measures, when joined with sustainable development strategies, could divide greenhouse gas emissions and save on emission control costs by roughly 0.32% of Gross domestic product by 2050. This study highlights the significance of integrated approaches to address air quality and climate change simultaneously, emphasizing the co-benefits in terms of environmental, health, and economic savings.

We normally utilize ex-post evaluation strategies to evaluate the effectiveness of air pollution control policies, for example, empirical analysis, bottom-up approaches, emission inventory, and content analysis. Analysts are dedicated to establish powerful models for evaluating air pollution control measures. These evaluation strategies help in grasping the impact of policies on air pollution and guide future actions. The utilization of these evaluation strategies has developed over

time, with a shift from a basic examination of pollutants to a more enhanced methods, policies, and health suggestions. The comprehensive sector is the most frequently addressed in air pollution policy research, demonstrating the emphasis on evaluating policies across different areas. The systematic review of research in this field gives important experiences into the patterns and gaps in air pollution policy research, informing future inquiries and policy-production (Feng et al., 2024).

Chapter 3
METHODOLOGY

This chapter offers detailed information about the methods to operationalize the study objectives. Secondly, it explains the unit of data collection, name of policies to be reviewed, key stake holders to be interviewed and analysis procedures. In this research, the qualitative methods of data collection and analysis were used to profoundly answer the research questions and objectives. For analysis of first objective, it was decided to carry out the policy review. Thus, the policy review enabled a precise approach towards identifying information in the existing documents. For analysis of second objective, thematic analysis was used so that the study would get qualitative results from the data and it helped in identifying the themes in the data that was collected through interviews. These methods were used purposely because each of them has its strength in dealing with the richness and depth of the research subject.

3.1. Unit of Data Collection

There are two units of data collection have been used to achieve the objectives. For first objective, we conducted a thorough review of relevant literature and previous policy documents of Punjab to identify governmental bodies responsible for environmental regulations, air quality monitoring, and policymaking. For second objective, identifying key stakeholder involved a systematic approach to ensure comprehensive representation. Two units of data collection are the following:

UDC-1: Air Pollution Prevention Policies of Punjab

UDC-2: All the Key Stakeholders involved in implementing air pollution prevention initiatives in Punjab.

3.2. Method for 1st Objective

3.2.1. Policy Review

Environmental policies in Punjab have been developed over time to tackle the air pollution issue, but air pollution is still increasing in the region. The first objective of this study is to comprehensively review previous air pollution prevention policies and policies formulated in the

last 30 years. For policy review, we used a content review approach. List of reviewed policies is given below

Table 4. Reviewed Policies

Sr.	Policy Name	Year
01	National Environmental Quality Standards (NEQS)	1993
02	Environmental Protection Act	1997
03	Punjab Environmental Protection Act	1997
04	National Environmental Quality Standards - Revised (NEQS)	2000
05	Punjab Smog Policy and Action Plan	2017
06	Punjab Clean Air Action Plan	2018
07	Punjab Green Development Program	2018
08	Punjab Smog Control Ordinance	2021
09	Punjab Environmental Protection Act (Amendment)	2022
10	National Clean Air Policy (NCAP)	2023

3.3. Method for 2nd Objective

For second objective, to see the challenges in implementing the policies, we have interviewed key stake holders related to the air pollution prevention initiatives.

3.4. Key Informant Interviews (KIIs)

Key Informant Interviews (KIIs) play a pivotal role in qualitative research, offering a depth of understanding often unattainable through other methods. One of the main data collection techniques in qualitative studies is the key informant interviews, which give detailed and more profound information (Franklin, 2024). In this study, key informant interviews were conducted with government officials from different departments, including environmentalists, monitoring experts, and policymakers to achieve the second objective. Stakeholders were selected based on their department's contribution to prevent air pollution. These interviews can help to understand the implementation process and the hurdles that different departments face in executing the laws and policies. The total number of interviews conducted were 12, and all of them were semi-structured. The list of key informants is given below

Table 5: Stakeholder Departments

Sr.	Name	How will these departments help to get data?
1	Planning and Development Board	Planning and Development Board can assist in policy assessment for air pollution through information on budget expenditures, economic analysis, integration of environment into development plans, infrastructural data, coordination between policies and development goals, setting up a monitoring system, encouraging public private partnership and data on socioeconomic factors.
2	Environmental Protection and Climate Change Department Punjab	The Provincial Environmental Development Department in Punjab can offer various data sources for evaluates of air pollution policy. This involves the flowing of pollutant concentrations from monitor stations, quantitative emission data on various pollutants from different sources data on industries and emission levels.
3	Regional Meteorological Centre	The Regional Meteorological Centre also plays an important role in the evaluation of air pollution policies because they supply necessary data concerning meteorological conditions that affect the air pollution. This comprises data for air quality modeling, climate, weather conditions, and early warning systems. PMDs working with research institutions, evaluating regional data, and sharing data regarding air quality.
4	The Urban Unit	The Urban Unit is working for the generation of a positive change in the way urban areas are planned and managed applying data science, digital tools, Integrated and Innovative approaches. The task of the Urban is to enhance the well-being of citizens of different cities thorough development, management, and social involvement.

5	Punjab Industries, Commerce & Investment Department	The Directorate of Industries in Punjab can complement air pollution policy assessment by providing data on industrial emissions.
6	Energy Department	The Energy Department of Punjab plays a pivotal role in mitigating air pollution through the promotion of cleaner and more sustainable energy solutions. By prioritizing the transition to renewable energy sources such as solar, and wind.
7	Environmental Protection Agency	The Environmental Protection Agency (EPA) in Punjab plays a crucial role in reducing air pollution and ensuring environmental protection that includes Regulation and Enforcement, Pollution Control, Mitigation, Monitoring, and Data Collection.
8	Agriculture Department	The Agriculture Department in Punjab plays a crucial role in reducing air pollution, particularly through managing agricultural practices that contribute to pollution.
9	Transport Department	The Transport Department in Punjab plays a major role in reducing air pollution by implementing various strategies and measures aimed at controlling vehicular emissions and promoting sustainable transportation.

3.5.Data Analysis

Data analysis involves inspecting, cleansing, transforming, and modeling data to discover useful information, inform conclusions, and support decision-making. Here are some key steps and techniques in the data analysis process

For first objective we have done policy review and thematic analysis, while for the second objective we have used only thematic analysis to get themes from the stakeholder's narrative.

3.6.Thematic Analysis

Thematic Analysis as a method was first developed in 1970 by Gerald Holton, a physicist and historian of science, he declared that thematic analysis is an effective method for analyzing interviews data in qualitative research due to its ability to uncover, analyze, and report themes. Thematic analysis is employed to systematically identify, analyze, and report patterns within the data related to air pollution policies in Punjab. This qualitative method allows for an in-depth exploration of the key themes emerging from the policy documents, legislative acts, and regulatory frameworks that govern environmental protection in the region.

When we used thematic analysis to scrutinize interview data, they engage deeply with the content, and this method is particularly adept at handling the rich, qualitative depth that interviews provide, allowing us to extract meaningful patterns and insights from the narratives shared by participants (Hecker, & Kalpokas, 2024).

We used thematic analysis because it is accessible method for identifying and interpreting patterns or themes in qualitative data. It allows us to systematically analyze narrative data by organizing and summarizing key findings, while preserving the richness of participants' perspectives. This approach is especially useful when exploring subjective experiences or complex social issues, making it ideal for research work. To be more precise, the data was analyzed to determine the main themes, and trends, of existing measures concerning the prevention of air pollution. Thematic analysis has been done through Nvivo software and the detail is following.

3.6.1. NVivo Software

There are many other softwares for qualitative data analysis, but NVivo is a computer-assisted qualitative data analysis software and a strong choice for narrative data. It allows you to effectively work with unstructured, narrative data by helping you organize, categorize, and analyze the stories or experiences captured in your data. You can generate themes by identifying recurring ideas or patterns within the narratives. NVivo's tools are designed to handle rich, qualitative data, making it easier to draw meaningful insights from complex stories (Dhakal, & Kerry, 2022).

In this research, NVivo (CAQDAS) is used to generate themes and the steps are following, first of all we gathered the data, and that was transcribed data of interviews, and import it into NVivo.

While transcription of data we highlighted the points relevant to the study's objectives. After transcription of data and uploaded into NVivo, NVivo helps to organize those relevant points into broader themes, which represent the main ideas or topics that appear repeatedly across your data, than we review and refine the themes. This step ensures that generated themes accurately represent the data.

Thematic analysis and NVivo software are being used for this study because it allows us for the identification of key patterns and insights from the narrative data, which helps me understanding stakeholders' perceptions. This method is including both inductive and deductive approaches, making it suitable for analyzing diverse data sources such as interviews, and policy documents. By focusing on repeated themes, thematic analysis helps me to uncover the dimensions of the smog problem, facilitating a deeper understanding of the issue through themes.

As for this study qualitative data has been collected and NVivo software is the best choice for analyzing the qualitative data and generating themes from large datasets, it offers tools to organize data, and to create themes. This software allows me to efficiently manage the transcribed data from interviews and identify themes across the narration.

3.7. Research Locale

The Research locale chosen for this research is the province of Punjab. This locale was chosen for better insights because the Punjab province is currently Pakistan's most polluted region, and most of the air pollution combating programs are started by provincial governments. Provincial departments will also assist in assessing the main hurdles faced by different departments in the implementation process. Based on the above information, the government departments that have been selected for data collection through Key Informant Interviews are the Planning and Development Board, the Environmental Protection Department, The Urban Unit, the Energy Department, the Agriculture Department, the Transport Department, the Meteorological Department, and the Punjab Industries Commerce & Investment Department. These departments of Punjab have the major roles in policy formulation and execution of air pollution prevention policies. These departments have certain people with different specialties to tackle the air pollution, some are environmentalists, and some are evaluation experts, different authorities will

be interviewed with specific questions that can better assess the situation regarding the implementation process of environmental policies in Punjab.

Chapter 4

COMPREHENSIVE REVIEW OF THE POLICIES REGARDING AIR POLLUTION IN PUNJAB

The objective of this chapter is to present all the policies systematically and critically, that were made by the Punjab government to tackle air pollution. Analyzing the legislative activity, enforcement approaches, and collaboration between government institutions and other actors, this review employ content review. This chapter focuses on the nature of governance strategies used in addressing air pollution, through a review of policy documents, regulations, and practical reports. The desired outcome is to provide the suggestions on how the air pollution could be addressed in Punjab. The study on the overview of the policies and regulations will focus on assessing the efficiency of the existing policies, as well as discovering possible deficiencies and recommendations.

Environmental policies in Punjab have developed over time to deal with different concerns that are relevant to the region which includes pollution of the air and water, industrial gas and vapor, and smog. NEQS and EPA are the major Acts of legislation, which form the preliminary measures in the field of environmental regulation and protection. It can be summarized as follows, these policies are drawn in order to eliminate the social cost of environmentally degrading our environment and to encourage sustainable industrial processes and sustainable agriculture and manner of transportation. Some of the commendable policies are still facing issues such as weak enforcement, and lack of resource.

4.1.The National Environmental Quality Standards (NEQS) 1993

The National Environmental Quality Standards (NEQS) of Pakistan were established through Statutory Regulatory Order (legal instrument used by the government to issue rules, regulations) on August 24, 1993, under the Pakistan Environmental Protection Ordinance of 1983. These standards were critical framework set by the Pakistan Environmental Protection Agency (EPA) to regulate the discharge of pollutants into the environment. NEQS 1993 covers municipal and industrial effluents, industrial gaseous emissions, and motor vehicle exhaust. NEQS were enforced through monitoring and regulations overseen by the EPA, which ensures that industries and vehicles comply with these standards, contributing to Pakistan's broader environmental protection

efforts. The NEQS became effective immediately, but they gave extra time for factories to meet the rules. Factories that began working after June 30, 1994, had to follow the rules by July 1, 1994. Factories that were already running before this date were given more time until July 1, 1996. These rules were made to protect the environment and people's health by limiting dangerous chemicals in waste and emissions.

Parameters defined in the NEQS include limits on physical, chemical, and biological pollutants. For instance, municipal and industrial effluents are regulated for pH levels (6-10), Biochemical Oxygen Demand (BOD) (80 mg/L), Chemical Oxygen Demand (COD) (150 mg/L), and total dissolved solids (3500 mg/L). In terms of air quality, standards for industrial gaseous emissions regulate pollutants such as particulate matter, sulfur oxides, carbon monoxide, and nitrogen oxides, with different limits depending on the fuel and industrial processes. Additionally, motor vehicle exhaust standards address smoke opacity, carbon monoxide levels, and noise pollution. These standards were part of a broader effort to reduce pollution, improve environmental quality, and ensure public health and safety by holding industries and vehicles to stricter environmental practices.

4.2. Pakistan Environmental Protection Act 1997

The Pakistan Environmental Protection Act (PEPA) of 1997 explains the comprehensive regulations for environmental protection, focusing on key areas such as pollution control, conservation, and sustainable development. It establishes legal frameworks and standards for ensuring environmental quality and reducing harmful emissions across Pakistan. The act empowers the Pakistan Environmental Protection Council (PEPC) and the Pakistan Environmental Protection Agency (PEPA) to supervise and implement environmental policies, as well as to enforce regulations at both federal and provincial levels.

The act established a comprehensive legal framework designed to protect the environment, regulate pollution, and promote sustainable development across Pakistan. One of the foundational aspects of the Act is the creation of two primary bodies the Pakistan Environmental Protection Council (PEPC) and the Pakistan Environmental Protection Agency (PEPA). These institutions are tasked with formulating and enforcing environmental policies, coordinating efforts across federal and provincial levels, and ensuring that laws are adhered to throughout the country. Additionally,

the Act mandates the establishment of Provincial Environmental Protection Agencies, which enable localized management and enforcement of environmental regulations in each province. A key feature of PEPA was the development of National Environmental Quality Standards (NEQS). These standards set limits for the permissible levels of pollutants, including air emissions, industrial effluents, and noise pollution. The NEQS ensures that industries and other pollution sources comply with specific limits to minimize environmental degradation. The Act also allows for flexible application of these standards by establishing different criteria based on geographical areas, types of activities, or sources of pollution, thereby ensuring the regulations are adaptable to various environmental and industrial conditions.

To further reinforce environmental protection, the Act requires project proponents to undergo an Initial Environmental Examination (IEE) or a more comprehensive Environmental Impact Assessment (EIA) before initiating any construction or operation that may affect the environment. This process ensures that all environmental risks and potential impacts are identified, assessed, and mitigated before projects begin. Failure to conduct these assessments can lead to the denial of project approvals or significant legal consequences. The Act also emphasizes public participation in reviewing these environmental assessments, fostering transparency and allowing communities to have a say in projects that may affect them. PEPA places strict controls on hazardous waste management by prohibiting the import of hazardous waste in Pakistan. Furthermore, it regulates the handling of, transportation, and disposal of hazardous substances under licensed conditions to prevent environmental and public health risks. The Act also addresses emissions from motor vehicles, requiring vehicles to comply with National Environmental Quality Standards for pollutants and noise levels. The government can mandate the installation of pollution control devices in vehicles to reduce harmful emissions and ensure compliance with environmental standards. Environmental Tribunals and Magistrates were also established under the Act to handle cases related to environmental violations. These tribunals operate with the same authority as Sessions Courts in criminal matters, enabling them to impose fines, order compensations, and even sentence individuals to imprisonment if necessary. The tribunals and magistrates play a critical role in ensuring that environmental laws are upheld and that violators face consequences for their actions.

To enforce environmental laws, the Act grants significant authority to environmental agencies through Environmental Protection Orders (EPOs). These orders can compel individuals or organizations responsible for environmental damage to cease harmful activities, take corrective measures, and restore the environment to its original condition. If such orders are ignored, the authorities have the legal power to impose penalties or take direct action to rectify the situation, recovering costs from the offending parties. The penalties and enforcement mechanisms also laid out in the Act were stringent. Violations of its provisions, particularly regarding pollution control and hazardous waste management, can result in fines that extend to one million rupees, with additional daily fines for ongoing violations. In severe cases, such as repeated violations or offenses involving hazardous waste, offenders can face imprisonment. The Act also holds corporate entities and government agencies accountable for environmental damage caused by negligence or failure to comply with the law, extending legal responsibility to directors and officers.

4.3. The Punjab Environmental Protection Act, 1997

The Act specifically deals with controlling and managing pollution by establishing the Punjab Environmental Protection Council, the Provincial Environmental Protection Agency, and the Provincial Sustainable Development Fund.

The Council was positioned as a key advisory and policymaking body, tasked with overseeing environmental governance in the province. The establishment of this council highlights the need for a dedicated entity to focus on large-scale environmental policy and ensure provincial alignment with national environmental goals. The council includes the Chief Minister of Punjab, Secretary to the Government of Environment Protection Department, at least three Members of the Provincial Assembly of Punjab, five representatives of the Commerce and Industry Department, one or more representatives of the Agriculture Department, and non-governmental organizations concerned with the environment, this approach was used to consider multi-stakeholder perspectives in decision-making. The Council's role extends beyond policy formulation to include coordination and supervision of implementation measures. It approves environmental policies and integrates sustainable development practices. The council aimed to balance both enforcement and guidance, ensuring sustainable policies are actively applied rather than remaining as mere guidelines. The Provincial Environmental Protection Agency highlights the operational side of

environmental governance. It was responsible for implementing the policies approved by the Council. The focus was on administration and technical execution. The agency was responsible for monitoring compliance and issuing environmental assessments and certifications. It also includes advising government bodies on environmental matters, supporting public awareness campaigns, and ensuring public access to environmental information. The powers granted to the Provincial Agency include entering premises, collecting samples, and issuing orders related to environmental compliance. These powers were crucial for enabling the EPA to function effectively, as the government allowed the agency to respond rapidly to violations, ensure accountability, and enforce the penalties outlined in the Act. The Provincial Sustainable Development Fund was established to support sustainable development initiatives, which signals a proactive approach to financing environmental conservation and pollution control efforts. The establishment of funds was critical to bridge the gap between policy goals and practical implementation, particularly by providing financial backing for necessary projects. The Fund was managed by a board, that includes the Chairman of the Planning and Development Board and the Secretaries in charge of the Finance, from Industries and Environment Departments.

The Punjab Environmental Protection Act of 1997 plays a vital role in establishing a strong regulatory framework for environmental management and sustainable development. To make the successful execution of the environmental standards the Punjab Environmental Protection Council, the Provincial Environmental Protection Agency, and the Provincial Sustainable Development Fund were established. The Council was responsible for providing overall strategic direction, coordinating environmental policies, and ensuring that these policies are effectively enforced. The Provincial Environmental Protection Agency serves as the operational arm of the Act, tasked with administering, monitoring, and enforcing environmental regulations throughout the province. Complementing these efforts, the Provincial Sustainable Development Fund provides essential financial support for projects that focus on conservation, pollution control, and sustainable resource use. These bodies created a solid system aimed at protecting the environment while promoting sustainable growth in Punjab.

4.4.Revised National Environmental Quality Standards (NEQS-2000)

The Revised National Environmental Quality Standards (NEQS-2000) was the extension of NEQS-1993 and the extension was a shift from broad standards to more refined, and sector-

specific standards. The extension made in the NEQS of 2000 compared to the 1993 NEQS was significant, as they were aimed at making the standards more relevant to Pakistan's local industrial and environmental conditions. The 1993 NEQS primarily focused on uniform standards for pollutants in industrial and municipal effluents. In 2000, NEQS was revised to cover 32 parameters for liquid effluents, 16 for gaseous emissions, and 3 for motor vehicle exhaust and noise. These include newly added parameters such as smoke, carbon monoxide, and noise. The 2000 revision introduced more rationalized standards based on Pakistan's local environmental conditions, recognizing that some of the 1993 NEQS parameters were more stringent than in neighboring countries. This included adjusting parameters such as noise, carbon monoxide, and noise levels to better align with local needs and capabilities.

The 2000 revision allowed for some flexibility, especially concerning emissions from power plants operating on oil or coal. This included the introduction of standards specific to sulfur dioxide and nitrogen oxides, with adjustments based on the sulfur content in fuel. The 2000 NEQS introduced a 1:10 dilution ratio for effluent discharge, the recipient water body should have 10 cubic meters of water for dilution. This was a notable extension that aimed to ensure environmental safety based on the dilution capacity of receiving water bodies. The 2000 NEQS extended the scope to include standards for motor vehicle exhaust and noise emissions, which were not part of the 1993 standards. This was a response to the growing issue of vehicular pollution and noise in urban areas.

4.5.Policy on Controlling Smog 2017

Smog Controlling Policy 2017 was a comprehensive framework designed to address the growing issue of smog in Punjab, particularly in Lahore and its surrounding areas. Because Punjab faces poor visibility because of fog, mist, and smog every year between November and February, usually lasting 10 to 25 days. Recently, the situation has worsened, causing people's eyes to burn and creating a bad smell in the air. This problem isn't just limited to Punjab, it affects a large region in South Asia, from Delhi to Faisalabad and surrounding areas. This policy aims to not only provide immediate solutions but also to create a roadmap for long-term air quality improvements. The primary objectives of the policy include identifying the main causes of smog, which are both local and regional, such as crop residue burning and industrial emissions. It also seeks to implement precautionary measures to safeguard public health, ensure safer road usage during low-visibility conditions, and raise awareness among the public regarding smog's harmful effects. A significant

component of the policy was its short to long-term action plan, which includes several targeted measures aimed at reducing pollution levels and mitigating future smog episodes. One key measure was the introduction of low-sulfur fuels, which has been delayed several times but was expected to be implemented by the end of 2017. This shift can significantly reduce the sulfur content in fuels, a major contributor to particulate matter and sulfur dioxide emissions. Similarly, the policy advocates for the adoption of Euro-II standards for vehicular emissions, which can be applied to petrol vehicles immediately, while stricter standards for diesel vehicles will follow once low-sulfur diesel is available.

Policy also emphasize on the installation of pollution control devices, such as catalytic converters in vehicles, was another critical step towards reducing emissions of harmful gases like nitrogen oxides, sulfur oxides, and carbon monoxide. The policy suggests collaborating with the federal government to make sure that car manufacturers and importers follow the necessary rules by the end of 2017.

Better traffic management is also emphasized as a means to reduce emissions, with efforts focusing on controlling traffic flow, promoting alternative modes of transportation such as bicycles and pedestrian pathways, and improving road infrastructure to reduce congestion. In terms of waste and crop residue management, the policy seeks to control the burning of municipal waste and agricultural residues, which are major contributors to air pollution. The Agriculture Department is tasked with educating farmers on the negative impacts of burning crop residues and introducing alternative disposal methods like mulching. Additionally, municipal authorities are expected to ensure efficient collection and disposal of solid waste to prevent open burning and the formation of dust clouds during dry weather conditions.

The policy also highlights the need to expand the existing network of air quality monitoring stations. These stations, located in major cities and in industries, will provide real-time data on air pollution levels, which is crucial for both operational responses to high pollution and long-term policy planning. The policy also calls for the creation of woodlands (where trees will be planted to help improve air quality) around major cities as an environmentally friendly solution to absorb carbon dioxide and other pollutants. In terms of industrial pollution, the policy recommends greening industrial processes (these processes involve adopting cleaner technologies that are energy-efficient and reduce emissions) by requiring new industries to adopt environmentally

friendly technologies. This initiative will initially focus on major polluting industries such as cement manufacturing plants, steel mills, and thermal power plants. The Environment Protection Department will work towards removing technological, financial, and capacity barriers to facilitate the transition to greener industrial processes.

The policy also represents a holistic and collaborative Action Plan to Combat Smog in Punjab, that is following:

Table 6: Action Plan to Combat Smog in Punjab

Sr.	**Activity**	**Explanation**	**Responsibility**
01	Health Advisory	Issue health-related precautions through print and electronic media.	Health Departments, Information Department, EPA
02	Traffic Advisory	Issue travel and traffic-related precautions during smog episodes.	IG Traffic, Information Department, EPA
03	Ban on Crop Residue Burning	Enforce a ban on the burning of crop residue under Section 144.	Home Department, Deputy Commissioners, Police.
04	Smoke-Emitting Industries	Shut down major polluting industries near cities to reduce emissions.	EPA, Deputy Commissioners, Police.
05	Low-Sulfur Fuel Introduction	Ensure maximum sulfur content in fuels is reduced to 500 ppm by the end of 2017.	Ministry of Petroleum, Industries Department, EPA
06	Adoption of Euro-II Standards	Implement Euro-II emission standards for vehicles, supported by a strict inspection regime.	Ministry of Industries, Transport Department, EPA

07	Installation of Catalytic Converters	Mandate catalytic converters in vehicles to reduce harmful emissions of NOx, SOx, and CO.	Ministry of Industries, Transport Department, EPA
08	Better Traffic Management	Reduce PM emissions by better traffic control, promotion of bicycles, and infrastructure improvement.	IG Traffic, C&W, LG & CD, EPA
09	Waste and Crop Residue Control	Prevent the burning of municipal waste and crop residue promote alternatives like converting residue into fertilizers.	Local Government, and Agriculture Department
10	Air Quality Monitoring	Establish air quality monitoring stations in eight cities and major industrial zones	EPA, P&D, Finance Department
11	Creation of Woodlands	Develop woodlands around major cities to fix pollutants and improve air quality.	Board of Revenue, Forest Department
12	Road Shoulder Design	Design and construct road shoulders to reduce fugitive dust from roads.	Punjab Communication and Works Department, Local Gov, P&D
13	Planned Urban Development	Develop master land-use plans, relocate industries to industrial zones, and ensure urban areas follow environmental approvals.	LG & CD, Industries Department, Housing Urban Development & Public Health Department
14	Greening of Industrial Processes	Mandate new industries to adopt greener technologies	EPA, Industries Department

		and remove barriers to greening existing industries.	
15	Regional Environmental Agreements	Approach the Federal Government for environmental cooperation with India on smog and water pollution issues.	Ministry of Climate Change, Ministry of Foreign Affairs, EPA

4.6.Punjab Green Development Program 2018

The Punjab Green Development Program (PGDP) 2018 was launched by the Government of Punjab with the support World Bank, to address environmental challenges in the province. The program has two primary objectives, strengthening environmental governance and promoting green investments, with a focus on air and water pollution, energy efficiency, and industrial resource management. One of the core strengths of the PGDP is its strategic alignment with Punjab's development goals. It acknowledges the urgency of tackling environmental degradation, especially in light of Punjab's rapid industrialization and urbanization. The program emphasizes air and water pollution, which have serious public health implications. It proposes interventions such as improving environmental quality monitoring, supporting green investments, and enhancing institutional capacity. These efforts were aimed to control pollution, especially from industries and vehicles, and promote sustainable development in the region.

The program was particularly notable for its comprehensive approach to environmental governance. The restructuring of the Environmental Protection Department (EPD) and the introduction of new centers such as the Environmental Monitoring Center (EMC) and Environmental Technology Center (ETC) signify a long-term commitment to improving the technical and administrative capabilities of the provincial government. The Environmental Monitoring Center (EMC) plays a critical role in monitoring and analyzing the province's air and water quality. By setting up monitoring stations, and the EMC ensures that accurate environmental data is collected regularly, as data is vital for tracking pollution trends, informing policy decisions, and making the public aware of environmental conditions, ultimately contributing to better

governance and pollution control efforts. While the Environmental Technology Center (ETC) focuses on promoting cleaner production technologies to reduce industrial pollution in Punjab. It provides technical support and training to local industries, helping them adopt resource-efficient and environmentally friendly technologies. By piloting and demonstrating sustainable production methods.

A critical aspect of the PGDP was its focus on promoting green investments, particularly in energy efficiency and cleaner production technologies. This focus not only aligns with global trends toward sustainable industrial practices but also addresses local concerns regarding pollution from industries like leather tanning and brick kilns. The program's support for resource-efficient cleaner production (RECP) technologies is particularly relevant, as it aims to reduce emissions and waste while improving industrial competitiveness. The financial mechanisms were also introduced, such as green financing and the Environmental Endowment Fund (EEF), which were also innovative steps that sought to mobilize both public and private sector resources for long-term sustainability. The PGDP's reliance on a Program-for-Results (P for R) framework, where disbursements are linked to the achievement of pre-defined results, adds a level of accountability. This incentivizes timely and effective implementation of the program's objectives, especially concerning pollution monitoring, green investments, and regulatory reform. The introduction of Disbursement Linked Indicators (DLIs) (specific performance-based targets that must be achieved for funds to be released under a program) related to air quality monitoring, environmental governance, and industrial compliance creates clear performance targets ensuring the program remains result-oriented.

Over the five years that the program is being implemented, it is expected to bring in economic benefits of at least $115 million, while the total support provided for the program is around $100 million. This means the program is generating more value than it costs. Additionally, by reducing 0.339 million tons of carbon dioxide emissions, the program is expected to bring in another $13 million in environmental benefits. During this time, the Government of Punjab will also collect more data to understand the full economic benefits of the program, such as savings from using more efficient production methods and improvements in public health. Since the program's investments will continue to provide benefits even after the five years, the total economic gains are expected to be much higher than the program's costs.

4.7.The Punjab Clean Air Action Plan (2018)

The Punjab Clean Air Action Plan 2018 is a comprehensive strategy aimed at combating the escalating air pollution crisis in Punjab, especially in urban areas. The plan was developed by the Government of Punjab's Environment Protection Department, and it outlines various measures to reduce air pollution, which has severely affected the region, particularly during the winter months. Air pollution in Punjab is a complex, regional issue, worsened by factors such as vehicular emissions, industrial activity, and agricultural practices like crop residue burning. This action plan takes a multi-directional approach, combining short-term, medium-term, and long-term strategies to address different sources of pollution. It emphasizes the need for coordinated efforts across provincial and federal levels, focusing on the most significant contributors to air quality deterioration. The plan also proposes stringent regulations, capacity-building initiatives, technological upgrades, and financial incentives to promote cleaner industrial practices and reduce vehicular emissions.

The policy is not just about reactive measures like addressing smog episodes but also about proactive efforts to improve overall air quality through urban planning, promoting non-motorized transport, and implementing modern technologies in industries like brick kilns and steel mills. The policy also seeks to enhance data collection and monitoring capabilities, which have historically been lacking, to ensure more informed decision-making and better targeting of interventions. The data in the policy highlights the severity and scope of Punjab's air pollution issue, particularly focusing on urban areas like Lahore. For instance, the Air Quality Monitoring Stations in Lahore reveal that particulate matter (PM2.5) concentrations frequently exceed safe levels, with readings of 280 µg/m³ at the Township Station and 175 µg/m³ at Town Hall, far above the standards set by the Punjab Environmental Quality Standards (PEQS).

The Aerosol Optical Depth (AOD) measurements from satellite data further reinforce the extent of pollution. AOD values consistently remain high throughout the year, indicating persistently poor air quality. The data from 2011 to 2016 (mentioned in the policy) shows that pollution levels peak in winter, aligning with smog episodes caused by transboundary pollution from India's crop residue burning, local vehicular emissions, and industrial pollution. The rapid rise in the number of vehicles is another critical factor. From 2008-16, Punjab's vehicle population grew from 6.6 million to 16.2 million, with motorcycles contributing significantly to this increase. Vehicular

emissions are a major source of pollutants like NOx and PM2.5, and the plan suggests interventions like retrofitting diesel vehicles, converting them to CNG, and mandating the use of catalytic converters to mitigate these emissions.

On the industrial side, data reveals that brick kilns and small- to medium-sized industries are major contributors to air pollution. The action plan suggests upgrading 200 brick kilns to Induced Draft Zig-Zag technology, which could reduce emissions by 70% while improving fuel efficiency by 40%. Similar technological upgrades are proposed for steel mills and rice husking mills to reduce their environmental impact. And the impact of crop residue burning is particularly concerning. Punjab generates around 8.5 million tons of rice stubble annually, and 58% is burned, contributing heavily to smog formation. The plan seeks to discourage this practice by promoting alternative methods like crop residue mulching and using biomass for energy production. The burning of rice stubble not only releases greenhouse gases like CO2 but also fine particulate matter, which exacerbates smog conditions in the region.

4.8.Smog Prevention and Control Rules 2023

The Punjab Environmental Protection (Smog Prevention and Control) Rules 2023 was a set of regulations designed to mitigate smog in Punjab by targeting key sources of pollution. Smog, as defined in the document, consists of harmful pollutants including nitrogen oxides, sulfur oxides, and other particulates derived from industrial, vehicular, and agricultural emissions. These rules aim to enforce environmental standards for various sectors such as brick kilns, industrial units, and motor vehicles.

The document specifies operational standards for entities like brick kilns, resource recovery units, and tyre pyrolysis plants. For example, brick kilns must adopt zigzag firing technology, and industrial units are required to have air pollution control systems. Non-compliance with these rules results in administrative penalties as outlined in the Schedule. To ensure compliance, the Director General and authorized officers are empowered to conduct inspections, impose penalties, and order preventive measures. These penalties vary depending on the severity and recurrence of the violation, with specific amounts outlined for first and subsequent offenses. For instance, penalties for operating vehicles that emit smoke or burning stubble are provided in a tiered structure based

on acreage for stubble burning. Violation schedule was also mentioned in the document that is following

Table 7: Violation Penalties Schedule

Violation	**First Occurrence Penalty (Rs.)**	**Penalty for Subsequent Occurrences (Rs.)**
Operating brick kiln on technology other than zigzag.	100,000 to 500,000	Demolition of the brick kiln
Non-conversion of brick kiln to zigzag technology.	100,000 to 500,000	Demolition of the brick kiln
Operating smoke-emitting vehicles.	2,000	4,000
Burning solid, litter, or other waste in open space.	5,000	10,000
Operating excessive smoke-emitting industrial units.	100,000 to 500,000	600,000 to 1,000,000
Emitting toxic or poisonous gases into the atmosphere.	200,000 to 500,000	Demolition of the object emitting toxic gases
Causing damage to human health, safety, biodiversity, or the natural environment.	200,000 to 500,000	600,000 to 1,000,000
Operating tyre pyrolysis plant.	100,000 to 500,000	600,000 to 1,000,000
Stubble burning.	15,000 to 500,000 (depending on acreage)	Double the penalty of first occurrence

4.9.National Clean Air Policy (2023)

The National Clean Air Policy (NCAP) was introduced by the Government of Pakistan in May 2023, to tackle the country's escalating air pollution crisis, particularly in urban areas like Lahore, where air quality has reached hazardous levels. With PM2.5 concentrations in some areas

exceeding WHO guidelines by 24 times, the policy aims to mitigate the harmful impacts of poor air quality on health, the economy, and the environment. The NCAP acknowledges that air pollution is not only a public health issue but also an economic and developmental challenge, leading to reduced life expectancy, increased healthcare costs, and significant productivity losses, as air pollution costs Pakistan up to 6.5% of its GDP, to counter these issue sectoral recommendations were also made in the policy.

The goal of NCAP was to improve air quality in the country through the implementation of various policies, technological, and management actions including air quality monitoring. The NCAP includes four objectives that includes data collection, as NCAP promotes regular generation and compilation of scientific data to establish the baseline and ensure effective monitoring of the policy implementation. Secondly, establishing air quality targets based on NEQS and Provincial Environmental Quality Standards (PEQS), and third objective was identifying key mitigation actions, that can be taken forward and implemented in order to target the major sources of air pollutant emissions, and the last objective was outlining implementation framework by which the air quality management will effectively be coordinated, to ensure that the mitigation actions are implemented, and air quality targets are monitored and achieved.

NCAP was a national strategy aimed at improving air quality through a series of targeted interventions. The policy prioritizes the reduction of emissions from key sectors including transport, industry, agriculture, waste management, and household activities. One of its main goals was to achieve cleaner air by setting measurable targets for pollutants such as PM2.5, PM10, nitrogen oxides (NOx), sulfur dioxide (SO2), and carbon monoxide (CO), in line with WHO guidelines. To achieve these targets, the policy used a multifaceted approach, upgrading fuel quality standards to Euro-5 and Euro-6, enforcing stringent industrial emission regulations, banning the open burning of crop residues and solid waste, and promoting the use of cleaner cooking technologies. The policy also emphasizes the adoption of electric vehicles (EVs), the development of mass transit systems, and the modernization of Pakistan's brick kilns with cleaner technologies. The NCAP proposes a robust implementation framework that leverages both national and provincial governance structures. A National Action Committee, alongside a Technical Committee, will oversee the coordination and execution of the policy. Provincial governments are tasked with creating localized Clean Air Action Plans tailored to their specific challenges. Regular

monitoring and data collection will be essential to the policy's success, with the first-ever National Air Pollutant Emission Inventory created in 2022 serving as a critical tool for tracking progress, as this inventory provides a comprehensive estimate of the emissions from all major pollutant sources across the country. Its primary function was to quantify the magnitude of emissions from sectors such as transportation, industry, agriculture, solid waste management, and residential buildings.

The National Clean Air Policy outlines a series of sectoral recommendations aimed at tackling air pollution across key industries and activities on national level. In the transport sector, the policy recommends the implementation of Euro-5 and Euro-6 fuel standards by 2025 and 2030, respectively, alongside enhancing vehicle inspections and promoting electric vehicles (EVs) through financial incentives and infrastructure development. The industrial sector is urged to adopt stricter emission standards, upgrade technologies, and transition away from highly polluting practices such as traditional brick kilns. For agriculture, the policy emphasizes banning the open burning of crop residues and encourages the use of low-cost alternatives for waste management. Similarly, the waste management sector was recommended to prohibit open burning and implement Integrated Waste Management Systems (IWMS) in major cities. Also, the policy's five prioritized interventions were to reduce PM2.5 emissions by 38% by 2030, with further reductions of up to 81% by 2040 from household, transport, industry, waste, and agriculture sectors. In addition to improving air quality, these interventions were expected to deliver significant benefits, including reduced greenhouse gas emissions, improved public health outcomes, and enhanced agricultural productivity by preventing crop losses associated with ozone pollution.

The table below outlines a list of significant environmental policies, along with their drawbacks. Each policy aimed to address various environmental challenges, from industrial emissions to air quality control. The following table provides a brief review of these policies and the key areas where they fall short.

Table 8: Policies and their Drawbacks

Sr.	Policy Name	Drawbacks
01	National Environmental Quality Standards (NEQS) (1993)	• The NEQS primarily focused on industrial emissions and wastes but did not comprehensively cover other key sectors contributing to pollution, such as transportation, and agriculture (crop burning). • The standards themselves were well-defined, but enforcement and monitoring mechanisms were not mentioned.
02	Environmental Protection Act (1997)	• EPA 1997 addressed broad environmental concerns like water pollution, it lacked specific, actionable frameworks for emerging issues like climate change, air quality, and industrial pollution.
03	Punjab Environmental Protection Act (1997)	• The act did not provide enough provisions for continuous environmental monitoring of industries, vehicles, and other pollution sources.
04	National Environmental Quality Standards - Revised (NEQS) (2000)	• Revised NEQS focused on setting parameters, but the infrastructure and resources for monitoring and enforcing these standards, particularly in the industrial and vehicular sectors, remained inadequate

05	Punjab Smog Policy and Action Plan (2017)	• The focus was more on addressing immediate smog events than preventing future occurrences through sustainable policy and planning.
06	Punjab Clean Air Action Plan (2018)	• Focus was on vehicle emission rather than the adoption of cleaner technologies in the industrial sector, which was a key component for reducing emissions.

4.10. Thematic Analysis of Policies

4.10.1. Policy Evolution Over Time

This theme explores the history and evolution of air pollution policies and legislation in Punjab, showcasing how the legal framework has developed in response to growing environmental challenges. The journey began with the introduction of the National Environmental Quality Standards (NEQS) in 1993, which marked a significant milestone in Pakistan's environmental regulation efforts. The NEQS established the first set of guidelines for acceptable levels of various pollutants, targeting industries and other major sources of emissions. This policy aimed to create a baseline for environmental quality, focusing on protecting the atmosphere, water, and soil from harmful pollutants.

Building on this foundation, the Environmental Protection Act of 1997 was enacted, which provided a more comprehensive legal framework for environmental management across Pakistan. The Act led to the creation of the Pakistan Environmental Protection Agency (Pak-EPA) and provincial bodies like the Punjab Environmental Protection Department (Punjab-EPD). These agencies were empowered to monitor environmental standards, enforce regulations, and ensure compliance with environmental laws. The Act also introduced mechanisms for public participation in environmental decision-making, recognizing the need for community involvement in addressing environmental issues.

Over time, it became clear that the existing regulations needed to be strengthened to address emerging environmental challenges more effectively. In response, the NEQS were revised in 2000 to incorporate more stringent standards for industrial emissions and vehicular pollutants. This revision was part of a broader effort to align Pakistan's environmental standards more closely with international benchmarks, although implementation and enforcement remained significant hurdles.

The evolution of environmental policies continued with the introduction of provincial laws, such as the Punjab Environmental Protection Act, which aimed to tailor environmental regulations to the specific needs of the province. This Act empowered the Punjab-EPA to take a more proactive role in managing local environmental issues, including air and water pollution. The focus was on creating a more robust framework for regulating industrial activities, managing waste, and controlling emissions, particularly in heavily polluted urban areas like Lahore.

Recent amendments, such as those made to the Punjab Environmental Protection Act in 2022, reflect ongoing efforts to improve the regulatory framework and address enforcement challenges. These amendments sought to strengthen the authority of the Punjab-EPA, increase penalties for non-compliance, and enhance the agency's capacity to monitor and enforce environmental standards. The amendments also aimed to address previous shortcomings in resource allocation and to ensure that regulatory bodies have the necessary tools and support to carry out their mandates effectively. Despite these advancements, the effectiveness of the legislative framework has often been undermined by several persistent challenges. Political interference has frequently obstructed the enforcement of environmental laws, allowing industries to bypass regulations without facing consequences. Additionally, the lack of resources, both in terms of funding and manpower, has severely limited the capacity of regulatory agencies to monitor compliance and respond to violations. These challenges have resulted in uneven implementation of policies, with many environmental standards remaining unmet.

4.10.2. Public Health and Environmental Impact

This theme delves into the significant impact of air pollution on public health and the environment in Punjab. Air pollution in the region, primarily caused by vehicle emissions, industrial discharges, crop residue burning, and construction activities, has reached alarming levels. Smog, which blankets cities like Lahore, is a visible manifestation of this issue, leading to severe health consequences for the population. The health impacts of air pollution are far-reaching. High levels

of pollutants such as particulate matter (PM2.5 and PM10), nitrogen oxides, and sulfur dioxide contribute to a range of health problems, including respiratory illnesses like asthma, bronchitis, and chronic obstructive pulmonary disease (COPD). Long-term exposure can also lead to cardiovascular diseases, strokes, and even premature death. Vulnerable groups, such as children, the elderly, and those with pre-existing health conditions, are particularly at risk. The burden on the healthcare system is substantial, with increasing numbers of hospital admissions and healthcare costs related to pollution-induced illnesses.

To address these issues, the Punjab government has implemented policies like the Punjab Smog Policy and the Clean Air Action Plan. These policies are designed to reduce emissions from key sources by enforcing regulations on industrial emissions, promoting cleaner transportation options, and implementing bans on crop residue burning. The goal is to improve air quality and protect public health by reducing the presence of harmful pollutants in the atmosphere. However, these policies face significant challenges in their implementation. Weak enforcement mechanisms mean that industries and vehicles often continue to emit pollutants without facing adequate penalties. Moreover, there is a lack of public awareness about the harmful effects of air pollution and the importance of adhering to regulations. Many individuals and businesses remain unaware of or indifferent to the regulations, leading to widespread non-compliance. As a result, the expected improvements in air quality and public health are not fully realized.

4.10.3. Technological and Sustainable Development

This theme focuses on the critical role that technology and sustainable development play in mitigating air pollution and promoting environmental health in Punjab. The adoption of advanced technologies and sustainable practices is essential for reducing pollution, conserving natural resources, and ensuring long-term environmental and economic stability. One of the key areas highlighted is the transition to cleaner energy sources. Currently, Punjab's energy landscape is heavily dependent on fossil fuels, which contribute significantly to air pollution and greenhouse gas emissions. To address this, there is a pressing need to shift towards renewable energy sources such as solar, wind, and bioenergy. Implementing these technologies can significantly reduce the environmental impact of energy production while also providing a more sustainable and resilient energy infrastructure.

In addition to energy, industrial practices in Punjab also require modernization to minimize environmental damage. Many industries still rely on outdated, polluting technologies that release harmful emissions into the air, water, and soil. Encouraging the adoption of cleaner production methods, such as energy-efficient machinery, waste reduction techniques, and pollution control devices, can help industries lower their environmental footprint. Incentives like tax breaks, subsidies, and technical support can motivate businesses to invest in greener technologies and practices. Sustainable transportation is another crucial aspect of technological development. The transportation sector is a major contributor to air pollution in urban areas, with vehicle emissions being a leading source of pollutants such as nitrogen oxides and particulate matter. Promoting the use of electric vehicles (EVs), developing public transportation infrastructure, and implementing stricter emissions standards for vehicles can significantly reduce the pollution burden from this sector. Additionally, investing in smart traffic management systems and encouraging non-motorized transport options like cycling and walking can further contribute to cleaner air and more sustainable urban living.

Agricultural practices also play a significant role in environmental sustainability. Traditional methods, such as the burning of crop residues, contribute to seasonal smog and poor air quality. Introducing sustainable agricultural practices, such as no-till farming, crop rotation, and the use of biofertilizers, can reduce the environmental impact of farming activities. Additionally, technologies like precision agriculture and smart irrigation systems can optimize resource use, minimize waste, and improve overall farm productivity. Despite the clear benefits of technological and sustainable development, there are several barriers to their widespread adoption in Punjab. Economic constraints, such as the high upfront cost of clean technologies, can deter businesses and individuals from making the transition. Additionally, resistance from industries accustomed to conventional methods, along with a lack of political will and inadequate policy support, further hinders progress. To overcome these challenges, it is essential to develop a comprehensive policy framework that integrates sustainable development into all aspects of environmental management. This includes creating robust incentives for adopting green technologies, investing in research and development, and providing education and training programs to build a workforce skilled in sustainable practices. Public-private partnerships can also play a crucial role in driving innovation and fostering the adoption of sustainable technologies. Ultimately, by embracing technological advancements and sustainable development, Punjab can significantly improve its environmental

quality, reduce its carbon footprint, and pave the way for a healthier and more sustainable future. This approach not only addresses current environmental challenges but also ensures that future generations can get a cleaner, safer, and more prosperous environment.

Despite a robust framework of air pollution policies in Punjab, their effective implementation remains a persistent challenge. Many policies such as the NEQS, Smog controlling policy, and environmental acts have been established to control pollution and protect air quality in Punjab, the persistent decline in air quality highlights that the true challenge does not lies in policy formulation. Even though the policies are well-designed and follow international standards, but enforcement remains inconsistent, allowing industrial emissions, vehicular pollution, and other environmental hazards to go unchecked. It becomes clear that the main issue is not in policy creation, it lies in the implementation process and to get insights from implementation process we have interviewed stakeholders from different departments and the next chapter is all about key challenges of departments that they face while implementation

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Chapter 5

REGULATORY BODIES: ROLES AND CHALLENGES

The purpose of this chapter is to identify roles and key challenges in the implementation of "air pollution preventive initiatives" through stakeholder narrative. Stakeholders of related departments were interviewed to get insights into the department and their role in the implementation process. The gap between policymaking and its implementation can be more deeply understood through it, because they are dealing with it. Incorporating stakeholder narrative not only enhances the quality and depth of the research but also, ensures that it is grounded in real-world relevance and practical implications. This approach leads to more robust, credible, and impactful research outcomes. Understanding stakeholder perspectives helps to formulate recommendations, that are relevant and useful for policymakers, practitioners, and other stakeholders. It promotes inclusivity and diversity in research by incorporating a wide range of perspectives and experiences. In-depth interviews were held in which a wide range of information was gathered from the key Informants related to the second objective of the research study. Among them, some of the major topics covered regarding "Air pollution preventive initiative" was:

- Role of department
- Overall view of the situation and policies
- Key Challenges in Enforcement
- Legal, financial, and technological constraints
- Short-term and Long-term priorities or way forward.

Key Informants were prioritized regarding their designation and level of influence. The following table shows the names of the departments and the key informants, who were interviewed. Afterward, detailed information regarding interviews is provided for each specific department, and thematic analysis has also been used to create themes.

Table 9: Key Informant's Designation and Departments

Sr.	Designation	Department
1.	Chief Assistant Environmentalist	Planning & Development Board
2.	Senior Research Analyst	The Urban Unit
3.	Monitoring & Evaluation Expert	Environmental Protection Department
4.	Assistant Director Legal	Environmental Protection Agency
5.	AD, Environmental Health	Environmental Protection Agency
6.	AD, Approval Section	Environmental Protection Agency
7.	Manager Environment & Social Safeguard	Energy Department
8.	Additional Director Planning Unit	Transport Department
9.	Public Information Officer	Transport Department
10.	Senior Meteorologist	Pakistan Meteorological Department
11	Deputy Director	Agriculture Department

12	Deputy Secretary	Punjab Industries, Commerce & Investment Department

5.1. Planning and Development Board

The Planning and Development Board of Punjab plays a central role in reducing air pollution. According to the interviewer, “We have a role in air pollution reduction, we do funding of the projects, we support them in policymaking and provide them with resources of technical input, and we arrange workshops and stakeholder conferences.” They have a full-fledged role as a principal organization that formulates an annual development program. They work with other departments. PMD is a center point in the smog mitigation action plan and develops a smog monitoring unit, in which focal persons from different departments like agriculture, local government, transport, industry, energy, administration, PHA, etc. are included. Currently, the department is working on a project named “Punjab Green Development Project”, worth 273 US million dollars. Its main role is environmental governance and green investments. This program has eight DLIs. In these eight DLIs, the first four DLIs are of the environmental department, one of the industry departments, one of the energy department, one of the finance department, and one of the PMD department. For the Air pollution part of it, there are PMD programs. One is the environmental quality monitoring station in which PMD will install 29 AQMS in the Punjab province. Of which 24 are stationary while the other five are mobile. The other program is Initiated with the help of SPARCO, initially starting in three cities Lahore, Gujranwala, and Sheikhupura. It will enhance to full Punjab afterward. Contributing factors of PM2.5 and sectors playing role in it will be identified by the specification of the source of curtailment PM2.5.

The challenges faced by the PMD department while implementing policies or taking some steps to reduce air pollution are more a systematic type rather than some legal or technological type. According to the respondent, “The hindrance is not by will, you can call these hindrances systematic for example, the departments do not have the capacity, lack of human resources, lack of resources, and lack of money. Therefore, when systematic hindrances are created, the department feels, they are handicapped. However, when there is a government push-in, as the present government has a push-in, the hindrances are somehow managed”. Respondent also

showed major concern regarding the awareness of people, which is causing the policies to be not implemented properly. He considered not publishing the air quality monitoring data as the cause of this problem. “If a man goes out and takes a breath in the air, and he does not know about the air quality, how will he raise his voice?” The respondent considered air pollution to be a hidden thing. If air quality monitoring data is published, people will be in a position to look at it and control it. In regard respondents also cited that private industries are not voluntarily controlling their emissions. They are using sub-standard fuels and their emissions are unabated. They don’t consider the environment as their own. On the other hand, the regulation system is not capable enough to stop these industries forcefully as the respondent said “Our policies are large in number but there is no enforcement, our deskwork is large but we do not have enforcement”. The provincial government and federal government handle many issues collectively. The respondent says, “Some of the functions are pertained by the government and there a large number of challenges while coordinating with the federal government. After the 18th amendment and the devolving of powers, provinces, and federal government interaction is generated on these types of things.” The use of euro four and five standard fuel is the federal government's domain. PMD has to ask the federal government to provide these standard fuels. Therefore, the things that are related to the federal government, PMD has to face many problems due to coordination and implication level issues. Because when the project goes to the federal level, they value things according to them.

Likewise, euro four and five standard fuel are the federal government domain and we take from the federal government and currently are asking the federal government to provide us with euro four and five standard fuel. Therefore, these types of things, which are related to the federal government, we have to face many issues due to coordination and implication level issues. Because when the project goes to the federal level, they value things according to them. Other than that, our policies are large in number but there is no enforcement, our deskwork is large but we do not have enforcement. We do not have HR to implement. It also agreed section plan of EPD, so the human resources that will come in it will hopefully help to control the issue.

Although given these constraints and hindrances, the department is working on setting its short-term and long-term priorities and making a full-fledged action plan to solve the problem. According to the respondent, “Our short-term priorities are to work on things that are low-hanging fruits for example, how to control the crop residual burning in agriculture, this is our priority in

the short term." In this regard, the department is giving happy seeders and super seeders to the agriculture department. They are launching awareness programs for farmers so that they can understand not to do suburb burning. They are implementing section 144, in which we are taking administrator and right to file an action in our hands. The department have increased the monitoring squad, there are industry department people who are monitoring and rebooting. Satellite images are also generated by SPARCO, which assists and gives hot spots about the place of burning. In the case of Industries, the short-term plan is to first do the mapping of industries. Other than that, they are launching a voluntary dashboard for the industries so that industries can voluntarily report their emissions. Likewise, on the local government level, the department aims to sprinkle on the road shoulder and avoid raising dust trails in our projects. As the respondent says, "We are bringing the concept of grey and green. Where there is a government place it should have a grey structure or grass to avoid dust." In the transport sector, PMD is buying them gas analyzers. They have launched the project of e-bikes, where 1000 e-bikes are to be distributed and similarly eco-friendly buses are introduced. In the long term, the department aims to take sustainable actions and repetitive actions, which are to be repeated every year, to the long-term. In transport, they are trying to take people toward urban transportation. They trying to build our urban transportation system.

The respondents shared their views on these topics and gave many insights into the department and their projects and policies. Their policies are collective and their work is also collective. There are stakeholder conferences, in which people of academia, NGOs, and private sectors are called.

5.2. Environmental Protection Department

The Environmental Protection Department is a key institution for air pollution measurement and enforcement of environmental regulations. The respondent described it, as "Our department in air pollution has a key role. The environmental protection department single-handedly meets the environmental protection criteria, but, in air pollution, the sectors that contribute according to international and local studies are transport, industries, agriculture, housing, and the domestic sector. These departments also play their role." The enforcement against restricted activity is given to a specific department to which the activity relates. For example, enforcement against burning of crop residue is under the agriculture department. Enforcement against vehicles that emit smoke is under the transport sector. Environmental Protection Department does enforcement against

factories or products that are dangerous to the environment. Therefore, air pollution is a multi-sectoral jurisdiction but its focal or central point is the environment department. EPA custodian of air quality monitoring stations. It installs these stations, takes measurements, and based on these measurements generates AQIS. Many people misunderstand these things as the role of the meteorological department. The respondent cleared the role of its department by saying, "As for air quality forecasting and understanding, meteorological data is required, and so where the decision-making is needed we keep the meteorological department with us. Otherwise, this is all done by the environment department, which disseminates the data. We have a portal for it, where updated data has been uploaded on daily basis for the last two years."

As per the question related to data collection and area coverage under air quality measuring stations, the respondent replied, "Till now the priority of the Government of Punjab is to cover the areas where there is the severe issue of air quality and we have to deploy stations on these areas and have covered it almost. However, in the areas that are not covered, remote science data satellite technology, including the US, NASA satellite and European Union sentinel satellite, are used. These are freely available." The data collected by these satellites are only used for the study of the baseline. It is not used for enforcement or reporting. Data from these satellites are not real-time data. The time of data collected depends on the passing frequency of the satellite. Some satellite passes over Pakistan on a daily basis, so they give data on a daily basis, some pass after 15 days, and some after a month, so the reading frequency is different for different satellites. However, this data is only used for qualitative understanding like where the issue is more and where it is less. The EPA department does not issue health advisories based on this data. A health advisory is only an issue based on data that the department measures on their own and they measure it only in the cities where this problem is more. The respondent concluded this part by describing the plan as "However, we are going to cover ten more districts where 25 stationary stations and 5 mobile stations are going to be installed and this will be completed by July or August. Therefore, these 10 (district names to be added) districts are the priorities as they have more industries and more population. Where the question of uncovering areas is concerned, yes, there will be these areas but we will augment it with the help of satellite."

Talking about the resistance and challenges, the respondent identifies two major challenges. First, people do not voluntarily take remedial measures due to two reasons i.e. technical and financial

constraints. When people lack these two things, they resist taking remedial measures. Secondly, the government's ability to mobilize public funds for green development is less. The government's less mobilization of green financing is indirect resistance to tackling this situation. While relevant sectors like transport, industry and, agriculture are directly resisting it because they have to bear the cost of adopting these remedial measures. They do not have radically available technologies nor do they have the finances.

The legal constraints faced by the department are of two types. The respondent identifies the first one as the gap between the nature of activities to be restricted and the nature of enforcement against it. The smog and air pollution are instantaneous, while the laws provided to tackle these situations are not immediate. Respondent explained the situation “If we get to know the cause of peak, for example, the factory runs at the daytime, the laws provided to tackle emergencies of this type are not of immediate nature. They ask you to investigate first, issue a notice then give them some days, and after that, you can close it or take them to court. Therefore, the law is not corresponding according to the situation and legally this is the issue we are facing”. The second constraint identified by the respondent was using a one-yard stick for both a small shop and a large industry, and applying the same standard of regulations. Until now there are no specific industry standards, there is a generic standard. Responded said, “Until we legally do not rectify these things and do not clarify, we will face legal constraints.”

Discussing the technological constraint, the respondent pinpointed the lack of two types of technologies i.e. monitoring technology and pollutant control technology. Until now, the air quality measured only measures two parameters of the air quality. However, the scientific evidence and research tell that only primary sources do not constitute air pollution or smog, secondary sources also cause it. Therefore, until now, the department has only the equipment to measure the primary source. So, measuring secondary sources that make smog is left behind. Respondent said, “Therefore, we need to upgrade the monitoring technology and embrace the new technologies so that we can comprehensively address the technological side of it.” Secondly, there are pollution abatement technologies through which pollution can be curtailed. Until now, the department has conventional technologies that have end-of-pipe solutions. The international world has moved one step ahead by curtailing sources of emission. Developed countries like China only allow the installation of emission-free technologies. While Pakistan is following a classical model in which

only output is monitored regardless of the inputs they are using. The government and the whole environment department is making enforcement according to this mechanism. The respondent said, “Therefore, to control the output, cost and time both are used for enforcement, implementation, field presence, and frequent inspection and ultimately the result are not achieved of high level. So, in the model where we curtail the source of emissions, you can easily handle things. So first, we need monitoring technology, and second pollutant control technology.” The respondent also added, “For the technology that people are required to install, the government should assist them by generating a list, which should tell that the particular technology is cost-effective or better for a specific sector of industry. This is missing which is why people on their own, through R&D or international study, have to identify the equipment, import it from foreign countries, and install it. That is why they are technically deficient to consult the risk”.

When a government makes a policy, it has to give financial equipment for it and design a full supply chain. If a particular technology is not present in the market and people are asked to adopt that particular technology, they will resist it. Until the vendors of that technology do not enter the market, people of operations and maintenance do not enter the market and people of sustainability do not enter the market, people do not prefer to adopt that technology. So that is why, the government has to look full supply chain mechanism while making the policy. The action plan for the policy lacks the technological and financial capacity constraints. Addressing financial constraints, the respondent said, “In case of financial risk. Likewise, there is Zarai Taraqiati Bank to support agriculture, similarly, there is no sustainable source in Punjab but is going to be made shortly by the name of environmental and government fund. Until we do not create financial opportunity or a financial window, the people who are already facing competition locally and internationally are resistant to increased costs and that is why complying with environmental or social standards is their second priority.” Their priority is to generate the maximum product so that they can export it, earn profit, and exist in the market. To make the environment first priority, the government should help them by providing soft loans, and long-term loans with the help of which people will be able to prefer such things. With the help of these measures, people can help to decrease air pollution.

Respondent viewed public awareness of air pollution as very important. The respondent quotes the example of forecasting data of weather, and its impact on people's lives and their decisions

regarding agriculture, traveling even their daily routine. It's all because of awareness. People know that this information is trustworthy coming from a specific source and is available on mobiles. Respondent while quoting another example said, "There is an example that I usually quote is that now people are becoming aware that the food they intake has how many calories and how many they need it. Therefore, this is awareness. As you make people more aware, they will reorganize themselves. The impact will be immediate if the campaign or awareness programs are strong. So yes, I agree that public education is necessary particularly public involving youth, which includes students in universities, colleges, and schools plus the people in other sectors, which are more vulnerable to air pollution." On awareness of people regarding air pollution, the government has made two legal instruments. First, the government has notified a regulation with the name of environmental information disclosure and citizen engagement. The second one was made on December 22 by the name of Health Advisory System for a critical air pollution event. These are made to educate the people and make them aware. The present government has made environment councils in different major schools. Regarding it, the respondent said, "Over officers are visiting these schools. They are lecturing the students, telling them about green and clean practicing and educating them. In addition, the curriculum is also being revised to include these things and for this Punjab Textbook Board and the School Education Department have been taken on board. So the government has adopted the campaign as a major tier and taking it forward."

As transport is considered the leading cause of air pollution, the respondent was asked the question about their restriction in the transport sector and its results. The respondent responded to the answers by elaborating 2-3 major steps taken in this regard by the department. Firstly, the government is designing some chocks, roundabouts, and U-turns, so that, traffic congestion can be curtailed. Where there is more congestion of traffic, vehicles are in an ideal situation and emissions are generated at a particular level. To keep the emissions dispersed the vehicle must be in a mobility state. For this Government has entrusted TEPA (a government institute) with the task of reengineering this. Secondly, the government has introduced a system of VICS (vehicular inspections and certifications system) in which the government has made it necessary for public service vehicles (PBV) to have this certificate. One component of this certificate is to test the emission vehicle and to ensure the standard. If the standard of vehicle is not ensured, a fitness certificate will not be issued. In case of not having a fitness certificate, the vehicle will be fined on any inspection area being caught. According to the respondent, "the government has installed

VIC's stations in more than 29 districts and is working on it. In addition, the government is also involving the private sector and asking them to make their vehicle inspection system. They will be first registered with the government and a license will be issued after that they can also inspect the vehicles. Therefore, until December both government and private systems will be working." This is done to frequent the influx and out plus. Before it, the government was lacking the capacity, the certificate was issued and not renewed frequently. Now the certificate will be issued for 6 to 12 months. Adding to the information, the respondent told, "Moreover, the traffic police and environment protection department are working together to run a campaign, in which, the environment department checks the emissions of vehicles, and if it is above the notified standard, it is fined by the traffic police." On addressing the results of these steps taken for reducing emissions from transportation, the respondent added, "After taking these actions, the ratio of people getting VICS certificates has increased. In addition, when we measured the annual average of air quality, its tendency was decreasing instead of increasing. It is a testimony that the actions government is taking in different sectors are yielding. However, it is not with that high speed because the government itself has not ensured the technical and financial input on that high speed."

In the short term, until the concentration of pollutants in the air is normalized, the department's maximum effort is to make the public less exposed to these pollutants. Maximum efforts include accurate measures of air quality and timely communication of that information to the population. Pollution will be controlled by the involvement of technologies, investment, people, and industries. Respondent said, "Over priority is to save maximum people from exposure to air pollution. To save people from exposure, the health advisory system that I talked about is made after rigorous efforts. A robust system takes specific action according to the range of AQI. Different range AQIs have different sets of measures to take. Then between people, measures are also different for the general public and vulnerable groups." Vulnerable groups are those, that are more affected by the air pollution. The criteria set by the department for vulnerable groups include kids, elderly people, people already having chronic respiratory issues like asthma, and pregnant women. Secondly, the short-term priority is to provide the contributing factors, that help in reducing air pollution, like technologies, support, and financial assistance. In long-term priorities, the respondent said, "In the long term, relevant technologies should be identified and indigenized so that a supply chain can be made, and people can find solutions at affordable prices. Therefore, the government is making an environment technology center, which will be completed after half a year, which will research

the relevant technologies and generate a whole list." Technologies that are imported cause a high cost. If the technology is replicated in Pakistan, it will cost less. For example, the success story of happy seeders. They have now started to manufacture locally. Moreover, emission control systems are being introduced in the steel rerolling sector and, manufactured locally. Rice husking sector, marble cutting sector, stone crushing sector, or whichever sector, the list will provide people with multiple technologies, their local vendors, and local cost approximation. This is the commitment of government, which is to be achieved in the long term. Moreover, the respondent also added by saying, "In addition, the Government is making its fund 10 billion funds have been generated by the name "environment endowment fund". Therefore, facilitating think tanks, R&D departments, and academic research institutes is also included in long-term priority."

Lastly, talking about the policies related to air pollution, the respondent said that the policies are updated and aligned with international commitments. They are made following Pakistan's nationally determined contributions (NDCs). The respondent, while being questioned about the relevance of scientific studies in policy-making, told, "I take the privilege, as I am the lead author of the policy of 2023 named as Punjab clean air policy. If you look at the footnotes of that policy, you will see several Pakistan as well as international studies cited there, which we have used to make policy and refine our things. So definitely, the research guides are decision-makers and policymakers." Moreover, the respondent added, "So the policies that government has made until now are based on best available practice that is being held worldwide. In short, we first identify the problem, then its contributing factors, and afterwards, how to control these contributing factors. To control contributing factors, there are two best available practices and technologies which are the same for all the problems worldwide but, when the problem is seen through a local lens then some of the proportionate have to be changed." Might be in Pakistan air pollution is due to transport and then industry while in India it may be due to industry and then transport. The factors remain the same, and to curtail them, the international organizations and UN bodies have made some guidelines and patterns. These guidelines and recommendations are localized and then the relevant stakeholders are involved. This is the first part of identifying the problem and making the policy, in the second step it is implemented. For this different thing has been identified like which Monitoring systems will be used, which department will implement the policy, which body will spare head it, who will see if the policy has been implemented or not, which institute will make financial arrangements for it and which agencies will be collaborated and all things like that.

5.3. Environmental Protection Agency

The Environmental Protection Agency (EPA) of Punjab addresses the multifaceted issue of air pollution, which is influenced by various sectors including transport, agriculture, and climate conditions. These factors contribute significantly to phenomena like smog, especially during periods of temperature inversion and calm atmospheric conditions. Legally, the EPA has implemented smog rules that provide a framework for action, although there are some gaps that need addressing. Financially, being a government department, the EPA must manage its resources carefully. Technologically, the EPA faces constraints as of 2019, Punjab-EPA had only 15 environmental monitoring stations across the province, which was insufficient to monitor a province with over 110 million people and several industrial hubs but agency is actively working to overcome them by adopting applications, satellite monitoring, and drone technology. The goal is to address these constraints before the onset of the smog season.

Coordination with other departments is streamlined through a control room where focal persons from each relevant department are stationed. Each department has defined roles, such as the Agriculture Department monitoring stubble burning and the Lahore Waste Management Company (LWMC) handling cleanliness and mechanical sweeping. Key performance indicators (KPIs) are established for each department to ensure accountability. This control room operates 24/7 throughout the year, facilitating seamless data sharing and inter-departmental coordination. Addressing the perceived gap between policymaking and implementation, the EPA asserts that policies are made with the intent of application and do not inherently possess gaps. However, the real challenge lies in the acceptance of these policies by the public. For instance, policies like the ban on single-use plastics depend heavily on public adherence. The government involves stakeholders and the public in policy formulation to ensure smooth implementation. The EPA has created straightforward policies such as the air action plan and clean air policies, which are continuously maintained and updated to ensure their effectiveness.

The legal section of the EPA plays a critical role in enforcing policy advisory. When a policy is established, the field force is tasked with its implementation. For example, industries are prohibited from operating without emission control systems, and the field force conducts inspections and imposes fines or seals non-compliant industries. The legal section supports the field force by

providing legal backing in court if necessary. This collaborative effort between the field force, legal section, and judiciary ensures the policies are upheld and successfully implemented. The legal section is integral in defending policies in court and ensuring they withstand judicial scrutiny, thus facilitating effective enforcement and compliance across sectors.

5.4. The Urban Unit

The urban unit is the planning wing and technical arm of the Government of Punjab. The respondent said, “We support the government in data analysis, interpretation, feasibility, and issuing advisories. We have developed a pollution emission inventory and sectoral emission inventories at the Punjab and Lahore levels. Moreover, we take a large number of data from the satellite, which includes several parameters of air pollution, and analyze it.” Punjab and Lahore are areas on a bigger scale, and the equipment installed gives information about the specific areas, therefore, the Urban Unit does an analysis and shares it with other departments. They also have USEP-approved standard equipment that does real-time monitoring. Its data has been uploaded on the website for the last 3 to 4 years and it is issuing advisories on it. On being asked about their collaboration with SPARCO, the respondent answered, “For a project in which had purchased standard equipment, we collaborated with SPARCO. Otherwise, the department on its own analyzes the data from the satellite.

According to the respondent, there was no such resistance for the department to work but highlighted some minor resistances. Explain one of them, the respondents said, “Sometimes when reports are issued mentioning the name of a particular department, they feel pressurized and extra burden or responsibility is added. People ask them questions about it or ask their role. They feel the heat, and to avoid it, they sometimes resist it.” Adding to it, the respondent also highlighted that, every department is involved in a development project of their own. They do not have time or investment for extra projects. For example, smog mitigation needs a heavy investment and finances, so they resist it sometimes due to lack of finances. As said before, these are some small resistances that the department faces otherwise there is no such big hurdle for them as the respondent said, “These are some concerns, otherwise, whenever departments are approached they are willing to help. However, the practical bottlenecks faced are a lack of finance, capacity, or technology, due to which the department sometimes shows resistance.

Taking about constraints, the respondent emphasized financial constraints more as compared to the technical ones. In case of technical constraints, the departments lack technical people and the other hand, have a large number of administrative people. Therefore, they usually rely on other organizations, private sectors, and institutions for their technological demand. Similar is the capacity issue. The legal mandate of the urban unit is of technical arm. The urban unit provides services to other departments. Services are in terms of doing analysis, drawing feasibilities, or doing research. Therefore, there is usually no such legal binding on them. The respondent said, "We share our analysis report with the Environment Department, Planning Department, and other departments. They sometimes accept it and sometimes contradict it. However, it is a part of the process, every department gives its view on the research produced. According to it, it is improved or set to get implemented. So as such, there is no legal burden being a technical arm of the planning and development department of the government of Punjab."

When a project is started, it needs finances, and projects are financed from budget that are fixed. To start a new project on that budget is difficult. Discussing the financial constraints, the respondent said "It is difficult to convince the department for a particular project, especially, the planning department, because they have their budget priorities. Therefore, to bring your project and fix it in that budget is a difficult task." Moreover, the respondent added, "Urban unit is owned by the government, its budget is not fixed. We apply for the project, and with it, we are making our bread and butter. We are now working on the projects, that we have bid bin through our technological and financial proposals." The Urban Unit faces more financial constraints as compared to technological ones. It is unable to do a lot of work that could be possibly done otherwise. They have to rely on another project to take resources from them and publish their reports. These are some constraints faced by the Urban Unit.

There are total 6 to 7 air quality measuring stations in Punjab that also partially work. Data is collected from AQIS. Low-cost equipment gives data on daily basis and has a good dashboard from which data can be collected. Similarly, other private companies have also dashboards regarding air quality data. Other than that, data can be collected from satellite imagery. It does not provide real-time data but is near to real-time like after two to three hours or one day. Instead of all these sources of data, the respondent added, "The problem with this is that regulators like EPA ask for standard equipment to issue advisory for public and this low-quality equipment have

chances of error due to humidity. Therefore, the EPA as a regulator is not using that data but privately people are using it. They are issuing advisories, and internal studies are also being generated." Lahore has a very rich network of this low-cost equipment but in Punjab, this network is very small, and standard equipment is hardly present. As standard equipment is lacking, the respondent said, "We need to work on all three stages. Standard equipment should be installed. Thirty standard equipment are going to be procured under the green development project. Other than those, private companies that have installed their own low-cost equipment, the US consulate has its standard equipment, while we have our standard equipment. Universities have installed their equipment some of which are low cost and some are semi-standard." Information is available in different places. However, as one moves out of Lahore, this network becomes weak. Therefore, where the network is not present, satellite imagery is use to do data analysis.

The respondent highlighted that the main problem of Pakistan not educating their children morally, ethically, and technically. Ninety percent of communities do not consider these issues as serious issues. Adding to this the respondent said, "Pakistan is a developing country so it has financial constraints and many upfront problems to deal with, so that is why, people do not take these issues seriously. We need to add these things to education, especially the environment. Having said this, the last meeting was held in Punjab with the senior minister, who took the environment portfolio. In that meeting, they told the education minister to make environmental-related studies a part of primary-level education. They have drafted the amendments related to the environment in the curriculum, and committee meetings are being held for its approval."

The respondent was asked about the results or restrictions in the transport sector as smog is still increasing. The respondent identified that two years before, their major concern was to stop crop burning because according to the FO report of 2018, it was declared a major issue and needs to be addressed. Later, according to the urban unit studies in Lahore, the transport was a major contributor in large cities. The transport industry did not want to get to high-level contributors and it had different discussions with the department. Still in every report transport is the major contributor whether on provincial or city level. The question is how to solve it. The respondent pinpointed two solutions in this respect. First, he described, "Traffic management should be improved. Lahore High Court led by Justice Shahid Kareem has taken multiple decisions in which he has asked to improve traffic management because only in Lahore, traffic congestion has doubled

in only one year." Traffic Engineering & Transport Planning Agency (TEPA) is considering it and is working hard on their side. The second solution highlighted by the respondent was to increase the quality of fuel, improve the maintenance of vehicles, and, increase the euro model. The respondent said, "Legal provisions for the fitness of two-wheeler vehicles are drafted and forwarded to chairpersons, after which these legal provisions will be made part of the legislature. Google has contacted us, as they have made a module for 13 different cities, where they have worked on optimization of traffic signals to manage traffic congestion." The respondent was very hopeful of these steps. He was positive about its results as he concluded, "We hope that there will be a decrease in the local producers of air pollution, it will not be done in a day or two, it is a lengthy process but after 6 months, a year, or so there will be a significant decrease Insha'Allah."

Asking about the new technologies, the respondent said that they are working on two to three things. Recently they have been doing a survey in which they have mapped out the industries with and without emission control devices. Most of these emission control devices are being manufactured locally and EPA is referring these local producers to industries without emission control devices. When the survey is completed, they will get to know how many industries in Lahore have emission control devices, what is the status of boilers and furnaces, and which quality fuel is being used. The respondent said, "Once the survey is completed, we will be able to propose something based on these analyses." He added, "Different areas and sectors are using different types of technologies. The Municipal Corporation of Lahore is using mist guns to reduce dust particles, the Lahore transport sector is converting toward EV vehicles and proposing catalytic investors. So, interventions are being held in different sectors, obviously, sudden results cannot be expected but once they start to be implemented, they will hopefully show results over time."

There are no specific short-term and long-term priorities of the department. The respondent said, "As a department, we do not have our priorities, priorities are made by the government and we as a technical department prepare feasibilities, analysis, and advisories and share them with the government and private sector." Different meetings are held on smog in which action plans with different departments are shared. Short-term and long-term projects are identified and their budget allocation is fixed in a day or two. It is then made part of the annual development program. Therefore, over time, the priorities and action plans set by all the departments, senior ministers, and the Urban Unit department are made part of this action plan. The respondent said, "The Punjab

government is right on the track. As soon as we get to implement this action plan, a large number of emissions will be offset or reduced."

The policies are broader frameworks that do not specify some specific action plan. They tell which section can play which role, so it is making an overlay framework for working. Different laws, rules, and regulations are devised in it, which have specific information. The respondent reported, "The policies on the provincial level are very broad and most of the time 90 percent of things are covered in it. It depends, that a specific part is falling either in environmental policy, meteorological policy, or transport policy. For example, if the vehicle inspection is to be done. It is a crosscutting theme. The transport department on their end develops legal provisions for it and the environment department on their end develops legal provisions for its monitoring under Punjab Protection Act. Regular meetings are held on implementation regarding smog, projects are being defined and budget allocations are being done so that when October-Nov (the season of smog) comes, the department is well prepared for it. Otherwise, usually, when the season comes, the firefighting gets started. Similarly talking about scientific studies' roles in policy making the respondent addressed that scientific studies are on a limited scale, they work on a limited problem. The department is working on cities level and then on the district and provisional level so their scale is large. "These scientific studies are pilot, they provide us with analysis and information that we upscale. We have made Punjab Special Strategy, in which we have mapped 160 plus parameters, and analyzed it. Therefore, by learning from these research articles and papers we download a large number of data from the satellite, do analysis on it, and provide projections. We share it with other departments and governments. Based on this, government and departments develop action plans and convert them into projects."

There are no specific short-term and long-term priorities of the department. The respondent said, "As a department, we do not have our priorities, priorities are made by the government and we as a technical department prepare feasibilities, analysis, and advisories and share them with the government and private sector." Different meetings are held on smog in which action plans with different departments are shared. Short-term and long-term projects are identified and their budget allocation is fixed in a day or two. It is then made part of the annual development program. Therefore, over time, the priorities and action plans set by all the departments, senior ministers, and the Urban Unit department are made part of this action plan. The respondent said, "The Punjab

government is right on the track. As soon as we get to implement this action plan, a large number of emissions will be offset or reduced."

5.5. Energy Department

In the context of smog, the Punjab Energy Department is focused on advancing renewable energy through various solarizing processes for reducing emissions. Their main goal is to provide electricity across Punjab by harnessing renewable energy, thereby combating climate change and reducing air pollution. To achieve this, they are executing numerous solarizing projects, including the distribution of solar power and the installation of solar power parks. These initiatives aim to solarize public buildings such as schools, colleges, universities (using the ESCO model), hospitals, DHQs, and BHQs, thereby reducing the pressure on the national grid and mitigating negative environmental impacts. Despite the general confidence and agreement among different departments on promoting renewable components, the department faces implementation challenges, particularly legal hindrances related to net metering, gross metering, and net billing, which are significant concerns for public and commercial adoption of solar systems. Technical constraints also arise from the need to import renewable components like batteries, inverters, and panels, which increases costs due to taxes and duties. To address these issues, there is a priority on encouraging local production, which would lower costs and create employment opportunities. Financially, there is equality in terms of loan projects duly funded from the Asian Development Bank or the World Bank, together with the annual development projects overall, the department can implement projects without hitch. Other related policies include clean air policy, climate change policy, as well as renewable energy policies promoting the SDGs and NDCs which ensures one stop fight against air pollution and climate change. Education is also part of the extensive public campaigns and training activities with regard to the environmental problems and the need for renewable energy sources. The department is also looking at introducing latest technologies like EVs, waste-to-energy projects or biogas plants are part of the fight against climate change and poor air quality. In summary, the Punjab's Energy Department is complemented by organizing stakeholder's conferences resolving academicians, NGO and private sector in order to coordinate regarding policies and compliance procedures. These activities are comprehensive and well planned in order to build a social and sustainable energy infrastructure in Punjab regarding the environmental issues.

5.6. Agriculture Department

The Agriculture Department mainly lays its emphasis on counseling the farmers most of the time associated with crop production technology and sometimes air pollution and smog. One aspect particular to the department is the discouragement of burning of residues on farms and urging for decomposition of these residues back to the soil for increased fertility and to reduce on polluting substances as well. There are strict laws and regulations set for this and those farmers who have been burning crop-residues are hammered with fines based on the size of the land. They can be awarded fines in vitro and, in some cases, repeat offenders may even be faced with FIRs. For these purposes, the department organizes massive awareness campaigns with the help of community leaders like patwaris, field assistants, managers of local mosques, etc., for raising awareness of the farmers and for reporting the violations. Also, the government of Punjab partners with SPARCO during tracking of thermal signatures associated with crop burning, actions are conducted using deputy commissioners.

The Agriculture Department notes a major problem in implementing these regulations because of the responsibility of fines and FIRs engulfs the department from an advisory and educational body to an antagonistic authority to farmers and producers. Some of them recommend that enforcement duties should be performed by the Environment Protection Agency or assistant commissioners to retain the consultative authority of the organization to farmers. The department receives adequate financial support for instance, there is provision of vehicles for field officers although there could be minor problems with money for other small expenditures at times.

There have been many awareness campaigns in the recent two years to enlighten the farmers, while the government has launched a scheme regarding 60% subsidy for rice crop shredders to make farming eco-friendly. But the department suggests expanding this scheme to all the Punjab provinces especially, Mianwali, Bhakkar, and Layyah to avail the most of it. In connection with the detrimental health effects of air pollution, agricultural practices that encourage farmers to go green activities are being supported by district administration and several departments. However, the department introducing fines for crop burning underlines that the delivery of subsidized machinery throughout the districts is efficient enough to guarantee proper usage of crop remains, thus, eradicating the need for burning and the can’t-comply excuses.

5.7. Transport Department

Another important department in fighting air pollution in Punjab is the Transport Department in as much as it deals with vehicle emissions, tough standards on emissions, and regular inspection of vehicles. The transport department is trying to encourage people to use public transport to reduce the number of individual transport vehicles on the roadway. It carries out programs to inform the public on the need to control the emission of greenhouse gases. It works with other departments of government to undertake policies meant for the enhancement of the environment's air quality. Some strategies that should be adopted include partnerships with various personnel and organizations like the Environmental Protection Department, Traffic Police, Urban Planning and Development Authority, Public Transport Authorities and Local Government, Non-Governmental organizations, and colleges and universities in Punjab. More precisely, public transport undertakings such as the Punjab Mass Transit Authority, Lahore Transport Company, Punjab Transport Authority, and Regional Transport Authorities perform a significant function in managing and providing public transport, thus decreasing the sharing of private vehicles and improving the situation with air pollution. Many Non-Governmental Organizations including the Pakistan Air Quality Initiative, The World-Wide Fund for Nature- Pakistan, Clean Air Pakistan Campaign, LEAD Pakistan, Pakistan Environmental Pollution Control Association, and Pakistan Environmental Protection Foundation has extended support through creating awareness, lobbying, and mobilizing the communities. Yet, challenges include resistance from stakeholders like vehicle owners, public transport operators, the industrial sector, and fuel providers. These perceptions are mainly aiming at financial costs, loss of job opportunities, or disruption of business or people’s lives. These issues should be met through positive reinforcement such as incentives and subsidies, along with efficient communication on how the strategy will work. The challenges that the department experiences include, resource challenges, observing laws that may be dated, challenges in enforcing laws, coordination challenges, low community sensitization, technological barriers, and economic challenges. These challenges hamper the extent to which legal requirements can be effectively policed and controls on air pollution to be effectively enforced. Some of the technical factors include, availability and maintenance of monitoring equipment, technological advancement, and absence of qualified technical personnel. It includes lack of adequate funds, high costs of undertaking the projects, and lower incentives as well as subsidies available for the projects.

So, linking of previous air pollution control measure with new activities include the process of synchronizing previous policies with the new policies. These are regulation and compliance issues, funding issues, lack of support from stakeholder, bureaucratic issues, technological issues and legal and institutional issues. To overcome these challenges, more review processes, consultations and partnerships, building institutional capacities, raising people's awareness, adequate resources and policies both at national and international levels should be pulled through. Technologies include Continuous Air Quality Monitoring Stations, Vehicle Inspection and Certification System, metrobus systems, Orange Line Metro Train, Intelligent Traffic Management Systems, electric buses and awareness programs. Possible future technologies can be smart sensors related to IoT (It can collect real-time data from multiple locations, which then analyzed to identify the sources of pollution) for air quality, electric and hybrid transport vehicles, clean fuel concepts, extended metro and BRT (Bus rapid transit) systems, and mobile application pertaining to air quality. Among the short-term goals, it is possible to identify the improvement of emission tests, conducting advertising campaigns, optimization of traffic, and applying rules. Long-term priorities include increasing the public transportation system, changing the petrol distribution to clean fuel technologies, employing intensive air quality controls and metering, upgrading existing legislation, and establishing research funds. These priorities are intended to solve the issues of air pollution and contribute to the creation of a long-term sustainability.

5.8. Pakistan Meteorological Department

PMD has a critical position to address the air quality management throughout supplying some useful data and exact meteorological forecast for other agencies linked with air pollution. Nevertheless, PMD does not have direct responsibilities for managing air pollution reduction measures or the regulation of laws pertaining to the matter. The industrial sector is one of the largest opponents for protecting air quality since changes will mean more costs to the industries and many operations will need to be altered, the transportation sector will also have problems since upgrades will cost too much and infrastructure changes are also difficult, the agricultural sector also opposes protection of air quality since changes will affect their ways of farming and lead to extra expenses such as not burning stubbles. The bureaucratic organizations include the public sector and local governments are rigid to change, and resource allocation in the region is also a

problem, people are unaware of health issues caused by air pollution and they do not support changes in behavior for switching to better practices.

The position of PMD exposes the institution to a number of challenges in particular, PMD has scarce legal powers to control air pollution and lacks effective policies that would require the departments' cooperation across the board. In its legal aspect, the principal role of the department is linked not to direct environmental regulation, but to meteorological services provision. In terms of the methodology, the major drawback of PMD is the insufficiency of the number of monitoring stations and the absence of necessary and modern equipment to assess the high concentration of pollutants systematically. In terms of funding, there are restricted funds available for setting up essentially air quality monitoring systems, and studies on the effective technologies to reduce pollution. One common problem is that there is limited compatibility of existing policies with new directions of air pollution controls because organizations still employ old paradigms and agencies do not collaborate sufficiently. Some of the challenges include organization culture that has encouraged bureaucracy, stakeholders' self-interests, and rate at which institutions standardizes new regulation that meets international standards practices.

PMD has very few stations in Punjab for measuring air quality – the conditions of which check basic pollutants and generate information about which advisories to the public and policies are made. But there is a problem that many areas of the environment are not covered, and hence the need to reduce impacts on human health. For the regions where Measuring stations installations are not feasible for PMD, satellite data, various meteorological models, and partnership with other national and international organizations are other options that provide estimations and trends of deterioration of air quality. Thus, public awareness can be effectively targeted via educational campaigns aimed at explaining air pollution problems and changing people's behavior. Campaigns in particular provide incentive for industries and policymakers to change their ways where they need to promote pollution control measures and sustainable practices within the communities where they operate, they should however be well-funded, continuous and culturally sensitive. However, despite the growth of restrictions on the transport sector – vehicle exhaust pipe standards, fuel quality, etc., smog levels remain high because necessary measures are not taken rigorously enough, and the number of vehicles in circulation is continuously on the rise. There are various technologies which can be useful for PMD such as remote sensing technology for better

coverage of monitoring the AQ, IoT instruments for air quality monitoring in real time, data analysis for predicting the pollution rate and for identifying the pollution source through AI technology, Electrostatic precipitators for reducing particulate emissions from industries, catalytic convertors in vehicles and GI for natural filtration of pollutants.

The short-term objectives of the PMD include increasing the air quality stations, improving cooperation with other governmental institutions, and raising the awareness level. Strategic goals for the future concern the enhancement of the machinery with modern technologies, creation of the codified system of legal norms for air quality maintenance, and establishment of the international cooperation in the sphere of effective pollution control measures implementation.

5.9. Punjab Industries, Commerce & Investment Department

Punjab Industries, Commerce & Investment Department has significant role in the control of air pollution through industrial emission standards and cleaner production technologies, and availing of cleaner production technologies and environmentally sound best practices within the context of Industries. This covers actions like observation of the industrial emissions, encouragement of the green technology use and compliance to the environmental laws. On the other hand, the supported implementation process receives opposition from the following stakeholders, some industries claim that the shift to cleaner technologies costs companies more money. In order to meet their legal requirements, Small and Medium Enterprises (SMEs) experience various financial and operational burdens in observing new regulations. Manufacturers of fuel are cautious to change from one type of fuel to another because it is costly and requires an renovation of infrastructure while the public does not appreciate the changes in behavior as a result of pollution effects because they do not know the consequences of pollution. We legally have some limitations when settling our duties in the Department, and here are some of them, here we find infrequent legal sanctions for strict compliance, legal loopholes that are not adequately informative to ensure guarantee measures against air pollution control, and coordination problems with other departments. Adding to this, bureaucratic processes make it hard for new regulations to be applied in an organization due to bureaucratic apathy. Some constraints are these, the existing laws and regulations regarding air pollution are not adequate and severely outdated, modern equipment for pollution measurement and control is hardly available, and there is inadequate funding available for extending the use of contemporary air pollution control (APC) technologies and programs. Also, the environmental

mechanisms should be improved in the cross-jurisdictional combination of laws and the availability of competent data gather/analysing mechanisms.

These policies are sloppy in incorporating the newer air pollution initiatives because their frameworks are outdated, various governmental departments are not well-coordinated and several devolved interests hinder the change. Seasonal changes in policies are necessary in order to meet foreign standards. The Meteorological Department takes control of only a few basic pollutant measuring stations throughout Punjab to support public advisories and policy-related contexts, however, satellite data, meteorological models, and cooperation with other national/international agencies are used to acquire data from areas without measuring stations. These methods offer approximate and more global tendencies of air quality but they do not give as accurate information as ground measurements.

Public education campaigns are essential in ensuring that awareness is made on issues to do with air pollution and people change their behavior. Well executed campaigns can move the community to support pollution control measures, encourage sustainable activities other industries and the policy makers to change their ways. For such change to occur, these campaigns should be adequately funded, sustained and culturally appropriate. Despite measures like emission control on vehicles, upgrade of fuel quality, among others, smog has not reduced rather, it has increased and this is attributed to poor compliance and growth in the number of vehicles in circulation. This calls for increased efforts, implementing the measures more effectively and the encouragement of public and Non-Motorized Transport.

To tackle such challenges, the following new technologies are available and can be of immense help. More elaborate monitoring by using remote sensing technologies, IoT-based multi-sensor air quality monitors for real time monitoring, predictive analytics based on big data analytics to forecast the trends of air pollution and to identify problem areas, Electrostatic precipitators for extraction and scrubbers for removal of particulate matters from emissions and many more green technologies which helps in reducing emissions during various Bureaucratic short-term objectives are within the sphere of emission examination and supplementation, public awareness, and stimulation of cleaner technology implementation. Future objectives are building up the longer-term legal strategy for the improvement of air quality, adopting new technologies within the

relevant legislative acts, enhancing the collaboration among the states, and spreading the long-term concepts for preventing the unfavorable effects of industrialization on the air environment. By implementing these strategic measures and effective staking with the help of engagement along with the constant enhancement of the related policies and practices, we are determined to continue to tackle air pollution in Punjab.

Table 10: Departments and their challenges

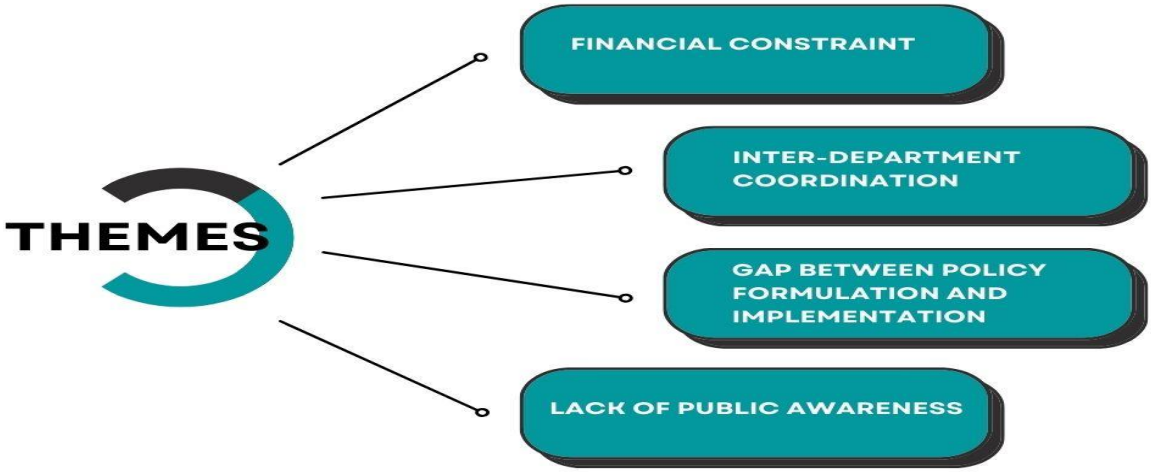
Sr.	DEPARTMENTS	CHALLENGES
01	Planning and Development Board	▪ Coordination with the federal government, particularly regarding procuring Euro 4 and 5 standard fuels, poses significant difficulties, impacting air quality improvement initiatives.
02	Environmental Protection Department	▪ Limited resources and manpower result in inadequate enforcement of air quality standards, compromising public health.
03	The Urban Unit	▪ Dependence on external organizations for technological support and data acquisition. ▪ Resistance from other departments, fearing negative exposure in reports, hampers collaborative efforts.
04	Energy Department	▪ Issues with net metering, gross metering, and net billing complicate renewable energy adoption. ▪ High costs of importing renewable components and limited local production delay the transition to cleaner energy sources. ▪ Slow adoption of solarizing projects and renewable energy technologies affects long-term sustainability goals.
05	Agriculture Department	▪ Enforcing bans on crop residue burning faces resistance because farmers face many underlying issues like often they do not get enough selling prices for crops, and inputs are costly so they follow cost-effective ways. Resource and

		financial constraint to help the farmers with effective machinery.
06	Transport Department	▪ Enforcement of vehicle emission standards and regular inspections face significant challenges because the department has limited resources to cover all the cities, currently Lahore is the focused city but the department is still facing issues because resources allow them to inspect fewer vehicles. For instance, if there are one lac vehicles producing emissions, they can roughly inspect 10,000 vehicles a day. They face in system constraints of human resource and financial constraints.
07	Meteorological Department	▪ Insufficient air quality monitoring stations and advanced technology prevent comprehensive pollutant measurement. ▪ Insufficient monitoring stations with financial limitations to install new monitoring stations.
08	Punjab Industries Commerce & Investment Department	▪ Industries' own financial burdens and operational disruptions deter them from upgrading to cleaner technologies. ▪ Industrialists use political links to avoid inspections.

5.10. Thematic Analysis

Previously we have interviewed different stakeholder departments and the discussion is mentioned in the above sections, utilizing that data we have done thematic analysis to find the major constraints that departments are collectively facing.

Figure 3: Themes



5.10.1. Financial Constraint

In Punjab, where the air pollution rises each year, government's departments were tasked with a challenging mission to clear the air and safeguard public health. However, the journey was not an easy task, as the shadow of financial constraints emerged over their efforts. The Planning and Development Board and the Environmental Protection Department knew that the task is enormous. They were equipped with plans, strategies, and a responsibility to protect the people from the harmful effects of smog and pollution. Official from P & D board stated that "*the board was in the midst of executing the ambitious "Punjab Green Development Project," a $273 million initiative aimed at environmental governance and green investments. However, as they delved deeper into the project, they found themselves grappling with systemic hindrances. Despite their vital role in funding, policymaking, and providing technical resources, the lack of sufficient funds often left them feeling 'handicapped'."* The resources needed to fully realize their vision were simply not enough. They faced a persistent struggle to balance the available budget against the overwhelming demands of comprehensive environmental reforms. The Punjab-EPA faced significant budget constraints, limiting its ability to conduct inspections and enforce regulations. As of 2022, Punjab-EPD's budget was PKR 350 million a small amount considering the province's environmental challenges and for fiscal year 2023-24 it increases to 1550 million, but still department will lack

sufficient air quality monitoring station because significant portion of the budget will be consumed by operational and administrative expenses.

The Urban Unit and Environmental Protection Department faced the similar financial issue. The EPD's respondent stated that the government's *"inadequate capacity to mobilize public funds for green development, which created 'indirect resistance' to tackle air pollution. This resistance was not just about the reluctance to implement measures, it was deeply rooted in the sectors of transport, industry, and agriculture, where "high costs" and the "absence of modern technology" posed significant barriers to reducing emissions."*

The respondent further highlighted that the financial constraints went beyond the lack of immediate funds. The absence of a sustainable financial source such as the environmental endowment fund make the situation worse. Without financial opportunities like soft loans or long-term financial support, industries are unable to prioritize environmental compliance. Instead, their focus remained on "short-term gains" driven by the need to survive in a competitive market. The department struggled with *"limited financial resources to address these systemic issues"* leading to delays in law enforcement and challenges in upgrading essential monitoring technologies. The financial constraints are not just a budgetary issue they are also a fundamental barrier to progress, slowing down every step of the department's efforts to combat air pollution. Similarly, an official from UU said that "*when a project is started, it needs finances, and projects are financed from fixed budget and to start a new project on that budget is difficult. It is difficult to convince the department for a particular project, especially, the planning department, because they have their budget priorities."*

Despite these challenges, the departments are doing their best. They set "short-term priorities" like reducing crop burning and encouraging voluntary emissions reporting from industries. Their long-term vision involved creating a financial ecosystem that could sustain environmental efforts and eventually overcome these financial constraints.

5.10.2. Inter-Department Coordination

Planning and Development Board exemplifies this coordination by working closely with various departments to implement air pollution mitigation strategies. According to a respondent, "*PMD is a center point in the smog mitigation action plan and develops a smog monitoring unit in which*

focal persons from different departments like agriculture, local government, transport, industry, energy, administration, etc., are included." To tackle air pollution on a broader level collaborative efforts are required across departments to address complex environmental challenges. The Planning and Development Board also engages with federal authorities, highlighting the complex relationship between the provincial and federal levels. Challenges increased in this coordination, particularly after the 18th Amendment, which devolved powers to the provinces. The respondent states, *"Some of the functions are affected by the government and there are a large number of challenges while coordinating with the federal government."* This reflects the difficulties in aligning priorities and actions across different levels of government, especially when projects require federal approval or resources.

The Environmental Protection Department (EPD) further underscores the multi-sectoral approach necessary for air pollution control. The respondent explains, *"The environmental protection department single-handedly meets the environmental protection criteria, but in air pollution, the sectors that contribute according to international and local studies are transport, industries, agriculture, housing, and the domestic sector."* This statement points to the need for each sector to fulfill its role while being coordinated by a central authority. While explaining the importance of inter-department coordination, EPD's official quotes the example of collaboration between the Transport Department and TEPA, both departments are currently working on unfit motorized vehicles and not allowing vehicles to move without VIC (Vehicle Inspection and Certification).

5.10.3. Gap Between Policy Formulation and Implementation

In Punjab, addressing the rising threat of air pollution requires well-organized policies. The journey began with a intensive effort to formulate and implement strong policies that could effectively tackle air pollution issue. The success of these policies relied heavily on the involvement and support of various stakeholders, including government officials, environmental experts, and the general public. The Environmental Protection Agency (EPA) and other government bodies recognized that inclusive and participatory policy-making is essential. *"The government should involve stakeholders and the public in policy formulation to ensure smooth implementation,"* stated one official while highlighting the importance of collective effort. This approach not only enhanced the legitimacy of the policies but also ensured that these policies are realistic and actionable. Another strategy was to create the air action plan and clean air policies,

these policies were designed to be dynamic, continuously updated to adapt to new challenges and scientific advancements. *"The government has created straightforward policies such as the air action plan and clean air policies which are continuously maintained and updated to ensure their effectiveness,"* explained another official. This process allowed for adjustments based on feedback and evolving circumstances, making the policies more resilient and effective.

Major environmental policies and strategies have been formulated by Pakistan but most of them never entered into practical work or were implanted by the government of Pakistan because of political instability (Naureen, 2009).

To facilitate smooth implementation, a multi-departmental coordination mechanism was established. The EPA set up a control room where representatives from various departments could collaborate. *"Coordination with other departments is streamlined through a control room where focal persons from each relevant department are stationed,"* stated by official from EPA. This control room became the nerve center for implementing air quality initiatives, ensuring that each department, from agriculture to waste management, played its part effectively. *"Each department has defined roles such as the Agriculture Department monitoring stubble burning and the Lahore Waste Management Company handling cleanliness and mechanical sweeping."*

However, formulating policies was just one part of the challenge. The real test lay in their implementation, which was often hampered by financial and technological constraints. Despite these hurdles, the government and different stakeholders remained committed to finding solutions. On the other hand, efforts were made to optimize available resources and seek alternative funding sources. Public and stakeholder engagement was another critical element of the implementation strategy. The government prioritized educating and involving the public to ensure broad-based support for the policies. Plans were set in motion to establish an environment technology center, envisioned as a hub for research and innovation. One of the respondents from EPD stated that *"The government is making an environment technology center which will be completed after some time which will research the relevant technologies and generate a whole list."* This center aimed to explore and develop cost-effective, locally-replicable technologies to combat air pollution sustainably. *"Technologies that are imported cause a high cost. If the technology is replicated in Pakistan, it will cost less,"* emphasizing the strategic advantage of local innovation.

5.10.4. Lack of Public Awareness

In Punjab, where efforts to combat air pollution were in full swing, one significant challenge persisted that is the lack of public awareness. Despite the strong policies and technological advancements, a critical gap remained in educating the public about the importance of air quality and the actions they could take to contribute to cleaner air. This lack of public awareness was evident in various aspects of the initiatives. Often found that many residents were unaware of the severe health impacts of air pollution and one official stated that *"Many people do not understand the health risks associated with poor air quality."* The lack of awareness made it difficult to gather public support for crucial measures such as reducing vehicle emissions and discouraging the burning of waste. Efforts were made to bridge this gap. Educational campaigns are launched, aiming to inform the public about the causes and consequences of air pollution. These campaigns used various media, and social media platforms, hoping to reach a broad audience. However, the impact was often limited. Official from agriculture department said that *"We have tried to educate the public through different channels, but the message doesn't always get through because the problem is compounded by cultural practices that were deeply ingrained and hard to change."* For instance, the traditional practice of burning crop residues after harvest contributed significantly to air pollution. Despite repeated warnings and fines, many farmers continued this practice due to a lack of viable alternatives and insufficient understanding of its environmental impact. *"Farmers have been burning crop residues for generations. Changing this habit requires not just enforcement but also education and support."*

Moreover, one of the critical reasons why environmental issues go unnoticed in developing countries like Pakistan is a lack of awareness among stakeholders. Such lacking awareness and understanding, along with a reluctance to change, are the primary reasons for pollution and its subsequent health impacts and there is a lack of knowledge about personal actions that could reduce air pollution (Colbeck et al., 2010). Simple measures, such as using public transportation, reducing energy consumption, and properly disposing of waste, were not widely practiced. *"People often don't realize that small changes in their daily lives can make a big difference in air quality"* stated by official from EPD. In response, the government and non-governmental organizations began focusing more on grassroots education.

Chapter 6

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

This study is conducted to explore the significant obstacles hindering the effective implementation of air pollution prevention policies in Punjab. Air pollution poses severe health challenges in the region, and finding the gap in existing policies and understanding the barriers to policy implementation is crucial for enhancing air quality. There are two primary objectives of this study, first one is to review existing air pollution policies in Punjab, and the second objective is to identify the key challenges faced by regulatory bodies in enforcing these policies effectively. Both objectives led the research to discover insights that could help in future policy formulation and implementation strategies.

The study employed a qualitative approach, doing a policy review and thematic analysis. We have reviewed 9 policies and found that while these policies are well-formulated, follow international standards, and include penalties for violators, other than that, policies clearly outline the steps for reducing pollution, including emission limits and the adoption of cleaner technologies but policies have lenient PM standards than international standards for industries sectors. Despite the presence of comprehensive frameworks, air quality in Punjab continues to deteriorate, which means that the root of the problem lies not in the policies, but in the implementation process.

Thematic analysis was used to extract significant themes from interviews to identify the key challenges faced by regulatory bodies in enforcing these policies. The key informants for this study included stakeholders from various government departments, such as the Planning and Development Board, Environmental Protection Department, Energy Department, Agriculture Department, The Urban Unit and Transport Department. Their narrative was vital in understanding the practical challenges that hinder combating air pollution.

The stakeholder departments in Punjab face numerous constraints while implementing policies like P&D is facing a challenge in intergovernmental coordination with the federal government. The P&D has to rely on the federal government for matters like the provision of Euro 4 and Euro 5 standard fuels, which creates delays and complications at the implementation level, after the 18th amendment, many functions have been devolved to provincial levels, which has increase coordination difficulties between federal and provincial governments, slowing down processes and projects the Agriculture department is facing ground-level issues like the traditional practice of stubble burning, and farmers resist the laws because they choose cost-effective ways rather than

shifting to new technologies like happy seeder. The transport department is facing challenges that include resistance from stakeholders like vehicle owners not taking care of their vehicle emissions, public transport operators not expanding the service to all areas, the industrial sector, and fuel providers. PMD is facing a shortage of monitoring stations and relying on other national and international organizations that provide estimations and trends of deterioration of air quality.

After that, we did a thematic analysis through NVivo software, which identified four major themes and the themes are following, first one is financial constraints, which highlights the lack of adequate resources for implementing environmental policies, the second theme is Inter-Departmental Coordination, pointing to the poor communication and collaboration among various departments to combat air pollution, third theme is Gaps between policy formulation and implementation, highlighting the differences between policy formulation and practical enforcement, and the last one is Lack of Public Awareness, emphasizing the need for greater public education and awareness campaigns on air pollution issues.

6.1.Recommendations

1. The policies made till now are appealing but the policies need to be refined and made broader by including more aspects of reducing air pollution, for example in the agriculture sector, not a single policy included the standards or parameters on livestock waste which is a major contributor to methane emissions.
2. Given the current situation of financial constraints in the government, areas should be identified from where maximum emissions can be controlled, and then through carbon credits funding should be acquired to meet the financial needs.
3. The government should establish an official coordination task force that includes representatives from the different departments. The task force should have regular meetings to align actions, and to smooth policy implementation.
4. The government should establish a robust framework to track and evaluate the implementation of air pollution policies, ensuring that all departments and stakeholders are held accountable for their roles. This could include creating regular progress reports and setting clear performance indicators for each department. This mechanism would bridge the gap between policy creation and its practical application.
5. The government should introduce community-based education programs targeting farmers, urban dwellers, and school children, to raise awareness about the causes and effects of air pollution. These programs should focus on practical, actionable steps individuals can take to reduce pollution, such as reducing crop burning or vehicle emissions.

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