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Critical Review and Comparative Analysis of the Government of Punjab's 'Policy on Controlling Smog, 2017' with Counterpart Strategies in London, Beijing and Los Angeles

Khizr Imran Tajammul[*]

ABSTRACT

Lahore, the capital of Punjab, Pakistan, has experienced worsening episodes of smog since the early 2000s. Poor air quality reduces the life expectancy of its population by roughly seven years and results in 128,000 premature annual deaths. According to various emissions inventories, Nitrogen Oxides (NO_x) and Particulate Matter (PM) frequently exceed World Health Organization (WHO) standards, more than other air pollutants in the city. In 2017, the Government of Punjab developed the 'Policy on Controlling Smog' to mitigate the effects of air pollution across Punjab, including Lahore. This paper critically examines the policy. First, it establishes a scientific baseline to describe smog to justify a comparison between Lahore, London, Beijing, and Los Angeles. Second, it establishes a positive correlation between poor air quality and negative public health outcomes. Next, it points out scientific, data and other concerns in Punjab's smog policy, and then compares it and draws lessons from counterpart policies in the same cities. The paper argues and concludes that while the 'Policy on Controlling Smog, 2017' is a useful blueprint to organise efforts in Pakistan's Punjab province, it is not leveraging lessons from other cities nor is it consistent with the latest scientific research on air quality in general and Lahore in particular. Hence, it is ill-equipped to maximise public health outcomes.

Keywords: Smog, Policy, Air Quality Management, Public Health, Lahore, Pakistan.

JEL Classification Codes: I18

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1. INTRODUCTION

Poor air quality claims an estimated nine million lives across the globe every year, mostly in developing countries like Pakistan (Landrigan et al., 2018). More than 11 million people in Lahore, Pakistan, are exposed to poor air quality (Colbeck et al., 2010; Hamid et al., 2019; PBS 2017). The Global Alliance on Health and Pollution estimated that roughly 128,000 people die in Pakistan from air pollution related illnesses each year, which means an estimated 6,400 deaths in Lahore (GAHP 2019). Robust government policy on air pollution, among other things, is an essential prerequisite to combat the problem (Molina and Molina 2004).

Cities like Beijing, Los Angeles, and London have confronted air pollution and developed policies to improve public health outcomes (Table 1):

Table 1: Air Quality Management Policies across Beijing, Lahore, London and Los Angeles

City	Author. Policy. Year	Highlights
Beijing	Clean Air Alliance of China. *Air Pollution Prevention and Control Action Plan.* 2013	10-point agenda; claims are not cited; identifies highest polluters; claims are backed by high-level data; penalises high polluter; largely focused on governance, transition to clean energy, phasing out coal power, development of a circular economy; target PM2.5 levels clearly articulated.
Lahore	Government of the Punjab. *Policy on Controlling Smog*. 2017	11-point agenda; policies not backed by science; no citations; lack of verifiable or reliable data; no budget implications; high level policies largely on transportation and industry – role of other sectors is missing; no articulation of existing or target PM2.5 levels.
London	City of London. *Air Quality Strategy 2019-24*. 2019	65-point agenda with a corroborating budget implication; policies grounded in science and based on historical air quality data; policies centred around buildings and transportation; higher concerns about NO2 than PM2.5.
Los Angeles	Southern California Air Quality Management District (AQMD). *Air Quality Management Plan*. 2022	The most detailed and data rich policy document; all pollutants meticulously catalogued and identified; clear mitigation strategies for each pollutant thoroughly described and detailed; health impact of poor air quality prioritised.

Source: Author's own.

Landrigan et al. (2018) suggest that there are many lessons these cities offer Lahore.

The Government of Punjab's *'Policy on Controlling Smog, 2017'* is an 11-point agenda to curb emissions across Punjab, including Lahore. This paper will review and compare four policies on air pollution across four distinct cities - London, Lahore, Beijing, and Los Angeles (Table 2) - that are experiencing, or have experienced, the same air pollution problem, interchangeably identified in scholarly literature as either haze or smog.[1] To ensure the comparison is grounded in science, the paper will rely on a chapter 'The Chemistry of Ground-Level Air Pollution' from the book *Environmental Chemistry* (Baird and Cann 2012) - to establish the fundamental ingredients of haze and smog. This will also help establish a scientific baseline and commonality for air pollution across the cities under discussion. Next, the paper will explore the relationship between air pollution and public health outcomes, both in and beyond Lahore and then analyse and directly compare Government of Punjab's *'Policy on Controlling Smog, 2017'* to its equivalent or near equivalent policies in the cities under discussion followed by relevant recommendations and some final thoughts.

Table 2: Demographics of Cities Under Discussion

City	**Population** (million)	**GDP** (USD billion)	**Size** (km^2)
Beijing	20	591	16,411
Lahore	13.9	58	1,772
London	9.6	978	1,572
Los Angeles	3.7	1,124	1,214

Source: Author's own.

Note: The population data is sourced from World City Populations, 2023. The GDP data is sourced from Visual Capitalist. The size data is sourced from official census results of the respective cities.

2. AIR POLLUTION: ESTABLISHING A SCIENTIFIC BASELINE

To justify a comparison of air pollution control policies across Beijing, Lahore, London, and Los Angeles, it is important to establish commonality across the problems they face or faced. The word *smog* has been widely used to describe the air pollution problem in the cities under discussion. Baird and Cann (2012, p. 76) recognise that smog can be complex, however, the chief original reactants include 'Nitric Oxide (NO), unburned hydrocarbons and partially oxidized hydrocarbons.' Within hydrocarbons, Volatile

[1] A term that was first used in the early 1900s and described as a mix of smoke and fog; it can also be described as air pollution that alters or blocks light and reduces visibility.

Organic Compounds (VOCs) easily vaporise and are critical to a discussion on smog. The authors recognise the role of coal power plants, emitting Sulfur Dioxide (SO_2) and particulate matter (PM), as major sources of haze. They explain that both smog and haze interfere with light and alter the colour of the sky, but the former originates from NO_x (giving the sky a brownish-yellow color) whereas the latter originates from SO_2 (giving the sky a whitish-gray colour). For clarity, this paper will examine air pollutants at the molecular level.

Baird and Cann (2012) provide additional insights. Based on the case study, *The Effect of Urban Air Particulates on Human Mortality*, Baird and Cann (2012, pp. 145-151) note that the primary pollutants of smog (NO and VOCs are much less harmful than secondary pollutants, particularly PM2.5 (produced from a reaction between primary pollutants). The authors also broadly help connect anthropogenic activities to pollutants: NO_x (NO_2 and NO) to vehicular emissions; SO_2 to incomplete combustion of coal and smelting; partially oxidised hydrocarbons and VOCs to incomplete combustion of biofuels and fossil fuels; additional VOCs to specific industries (paint, carpets, cosmetics, wood products, upholstery and foam); secondary fine particulate matter to nitrates and sulfates. The aforementioned connections can be seen at a glimpse in Table 3:

Table 3: Anthropogenic Activities and Associated Pollutants

Anthropogenic Activity	**Pollutants**
Vehicular Emissions	Nitric Oxides (NO_x: NO_2 and NO); Particulate Matter
Coal Power Plants & Smelting	SO_2
Incomplete Combustion of Fossil Fuels & Biofuels	VOCs and Hydrocarbons
Industry: Paint, Carpets, Cosmetics, Wood Products, Upholstery & Foam	Additional VOCs
Nitrates and Sulfates stemming from Anthropogenic Activities	Secondary Fine Particulate Matter

Source: Author's own.

Having identified primary pollutants of smog, its secondary chemical outcomes, and anthropogenic sources, the study will now use emissions inventories and pollutant data across Beijing, Lahore, London, and Los Angeles to establish commonality. Furthermore, breaking the discussion down to the molecular level will help avoid ambiguities that could arise by varying interpretations of the competing terms - smog and haze.

2.1. Comparing Air Pollutants and their Anthropogenic Sources

Molina and Molina (2004) share detailed emissions inventories for Beijing and Los Angeles, showcasing higher than usual levels of NO_x, VOCs, and ozone (O_3). This confirms Baird and Cann's (2012) description of smog, establishes commonality across Beijing and Los Angeles, and highlights vehicular emissions as a major source of pollution in both cities.

The air pollution in London in the early 1950s resulted from the incomplete combustion of coal in power plants and home stoves, leading to an excess of SO2 and PM – also referred to as smoke, soot, dust and black carbon – in the atmosphere (Davis 2002). High SO_2 levels in recent times for both Beijing and Lahore (Haider et al., 2017; Hamid et al., 2019; Molina and Molina 2004) help establish commonality with London's air quality predicament in the 1950s (Davis 2002), identifying the incomplete combustion of high sulfur fossil fuel as a major source of air pollution.

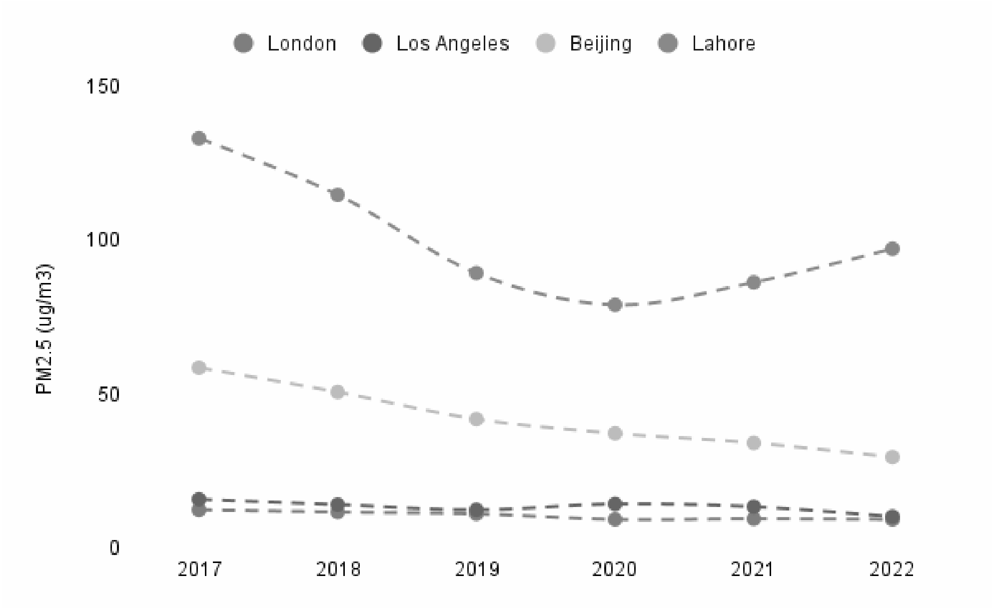
Considering air pollutant data cited in this section (based on high concentrations of NO, NO_2 and PM), it can be concluded that the air pollution problem in Lahore is comparable to the ongoing issue in Los Angeles, London, and Beijing. Furthermore, these studies also indicate higher than standard levels for SO_2 in Lahore, which means lessons can be drawn from London's efforts to curb air pollution in response to high SO_2 and PM levels in the early 1950s, and Beijing's efforts to reduce the same pollutants in more recent years (given its dependence on coal).

Another noteworthy study, Colbeck et al. (2010) compiled results from air quality studies across Pakistan, spanning over a decade, specifically monitoring PM, SO_2, Carbon Monoxide (CO), NO_2, O_3 and Lead (Pb). They showed that all pollutants, with the exception of O_3, were many times above World Health Organization air quality standards. The study also showed that PM ten micrometers in diameter or less (PM10) and NO_2 emerged as the highest and second highest pollutants, respectively. This broadly establishes commonality between Pakistan and the other cities under discussion. More importantly, this study identifies nitrates (linked to vehicular emissions) as the largest source of air pollution in Pakistan (Baird and Cann 2012; Colbeck et al., 2010).

In 2018, the Food and Agriculture Organization (FAO) conducted a detailed geospatial study of Punjab, reinforced lessons from Colbeck et al. (2010), and revealed the following: 43% of all emissions in Punjab, Pakistan, came from transportation; 25% from industry; 20% from agriculture (including crop burning); and 12% from power generation. The report also made detailed and rigorously cited technical 'recommendations' (FAO 2018, pp. 74-76) tailored for the province.

The FAO report is a high-level inventory of air pollutants across Punjab and can help the Government of the Punjab prioritise across different smog prevention and control policies. Given how transportation contributes the most to emissions across the province, Lahore must prioritise road emissions reduction policies (Ibid.) and perhaps Los Angeles can offer the best template for that. Similarly, policies to reduce emissions across industry, agriculture and power generation are also important (Ibid.), and both Beijing and London have had success in these areas. A comparison of historical PM2.5 levels across the cities under discussion (as per Figure 1) visually reinforces the idea that Lahore can learn from the success of other cities that have experienced the same problem.

Figure 1: Historical PM2.5 Levels across Lahore, Los Angeles, Beijing & London



Source: IQAir

2.2. Variance and Limitation Regarding Air Pollution Data

The daily air quality reports for Punjab, published by the Environment Protection Department (EPD), minimises the dangers of air pollution, and lacks information on key air pollutants. For example, early reports across 2019 share metrics on a mix of primary and secondary pollutants (NO, NO_2, SO_2, O_3, PM10 and PM2.5), while data on VOCs and CO is missing. In more recent reports, since 2021, metrics are shared on CO, SO_2, PM2.5 and Air Quality Index (AQI), while data on NO, NO_2, O_3 and PM10 is absent, even though VOCs and NO_x are integral to any discussion on smog (Baird and Cann 2012).

Furthermore, AQI limits in these reports are inconsistent with the United States Environmental Protection Agency (U.S. EPA) that developed the globally recognised AQI. For example, AQI levels between 101 and 150 are considered ‘unhealthy for sensitive groups’ according to the U.S. EPA standards, yet the same level is marked ‘moderate’ on the EPD, Government of Punjab website. Subsequently, all AQI categories are similarly mislabelled on the EPD website. This under-represents the dangers of air pollution.

For context, the AQI was developed in the US to identify health hazards and ensure public safety, regardless of air pollutants. Basically, any single air pollutant in excess, above its prescribed limit, can drive the AQI level up. Therefore, a discussion on AQI alone is not granular enough to identify anthropogenic sources of pollution, or to shape public policy. This is why London, Los Angeles, and Beijing focus on monitoring and reporting data on primary and secondary air pollutants in their air quality policies (City of London 2019; Clean Air Alliance of China 2013; AQMD 2022) and it would benefit the Government of the Punjab to follow suit.

The major primary and secondary air pollutants in excess across Punjab that demand monitoring include NO_x, SO_x, PM10, PM2.5, CO and VOCs (Aslam et al., 2020; Colbeck et al., 2010; Haider et al., 2017; Hamid et al., 2019). The Government of Punjab should monitor and report data on the aforementioned pollutants to help inform policy development and track progress on pollution control efforts. A related and important observation is that while the provincial government recognises nitrates, sulfates and PM across various action plans and policy papers, VOCs are absent from both daily air quality reports and the *‘Policy on Controlling Smog, 2017’*, despite their importance to smog (Baird and Cann 2012).

Lastly, all EPD daily air quality reports are published with a disclaimer: ‘Any other data from any source presenting ambient air quality of any city of Punjab is neither verified nor approved by the EPA Punjab.’ Considering this, externally obtained data to challenge government policy may present a problem. Hence, an important first step is to seek government cooperation before discussing and submitting policy recommendations.

3. RELATIONSHIP BETWEEN SMOG AND PUBLIC HEALTH OUTCOMES

The Lancet commission on Pollution and Health (Landrigan et al., 2018) attributed roughly nine million premature deaths to air pollution related illnesses in 2015. The article highlights the scale of the air pollution problem, recognises that the developing world is suffering more than the developed world (92% of the reported deaths occur in developing countries), and suggests that air pollution is a problem the world has successfully dealt with before, offering lessons to developing countries. The Commission discusses air pollution in the global context, which means it is limited in its scope to indicate specific public health outcomes for Lahore.

Conversely, the Air Quality Life Index (AQLI, n.d.)[2] and GAHP (2019) help narrow the health problem down in Pakistan and Lahore specifically. The Index estimates that prevailing air pollution rates in Lahore are reducing life expectancy of its residents by nearly seven years. GAHP estimates that air pollution in Pakistan causes at least 128,000 premature deaths every year. Considering that roughly 5% of Pakistan's population resides in Lahore, and the city is amongst the worst polluted, one can extrapolate that air pollution in Lahore leads to at least 6,400 premature deaths every year (GAHP 2019; PBS 2017). These are significant numbers and yet there is no acknowledgement of air pollution in the *'Policy on Controlling Smog, 2017'*.

Beyond life expectancy and premature deaths, there are several other possible health complications that are not well researched. Ashraf et al. (2019) identify the scarcity of research, push for more research, and share the impact of smog in Lahore on ocular surface diseases. They show that an increase in NO_x and PM levels between 2015 and 2016 corroborate with a 60% increase in ocular surface diseases. This is an important finding because it identifies air pollution as a public health concern with immediate consequences, not just a problem that reduces life expectancy in the long term. This also adds a sense of urgency to the work needed to update the *'Policy on Controlling Smog, 2017'*. Furthermore, Dockery et al. (1993) establish that each increment of 10 $\mu g/m^3$ in PM2.5 levels (above the recommended level) increases chances of cardiovascular disease in the affected population by 9%. Considering Lahore's average annual PM2.5 level in 2022 was 147.8 $\mu g/m^3$ (Ilyas and Nissar 2023), nearly ten times higher than the limit set by the Government of Punjab (15 $\mu g/m^3$), poor air quality in the city is likely connected to dire consequences on the cardiovascular health of the population.

While Landrigan et al. (2018), Ashraf et al. (2019), and the AQLI (n.d.) focus on the public health problem of air pollution, Carnell et al. (2019) make the important connection between reduced emissions and improved health outcomes. They studied pollutant data (NO_2, PM2.5, O_3, SO_2, Ammonia (NH_3) and Non-Methane Volatile Organic Compound (NMVOC)[3] across the United Kingdom (UK), between 1970 and 2010. The said study offered two key insights. First, it showed that emissions reductions for London were gradual, spanning over decades, suggesting that even successful air quality policies could take significant time to provide health benefits. Second, it showed that NO_2, PM2.5 and SO_2, all reduced across the UK over four decades, but the most

[2] A Global Interactive PM2.5 pollution map with hyperlocal resolution displaying the years of life lost resulting from breathing unsafe levels of PM2.5.

[3] NMVOCs are identical to VOCs but with methane excluded.

significant health impact (reduction in mortality effects) was connected to reductions in two pollutants – NO_2 and PM2.5. This builds on Baird and Cann's (2012) assertion that PM has the greatest impact on human health. Unfortunately, the '*Policy on Controlling Smog, 2017*' fails to acknowledge this crucial scientific fact and minimises the danger of air pollution in Punjab to the 'burning of eyes and foul smell' (p.1).

4. POLICY REVIEW: GOVERNMENT OF PUNJAB'S 'POLICY ON CONTROLLING SMOG, 2017'

4.1. Scientific Concerns

Nitrates, emanating from vehicular emissions, are the largest source of air pollution in Pakistan (Baird and Cann 2012; Colbeck et al., 2010). In 2018, the FAO conducted a detailed geospatial study of Punjab, reinforcing lessons from Colbeck et al. (2010), revealing that 43% of all emissions in Punjab, Pakistan, came from transportation; 25% from industry; 20% from agriculture (including crop burning); and 12% from power generation. Air pollutants, in excess, in Punjab, are the same as those in excess across London, Beijing and Los Angeles, establishing commonality and basis for comparison across cities under discussion (Colbeck et al., 2010; Haider et al., 2017; Hamid et al., 2019; Molina and Molina 2004).

4.2. Data Concerns

Punjab only operates six air quality monitors for a province that is home to roughly 110 million people (Government of the Punjab 2017; PBS 2017). Beijing, London, and Los Angeles have more extensive monitoring setups and yet they express the need to do more (City of London 2019; Clean Air Alliance of China 2013; AQMD 2022).

Since 2021, the EPD only shares metrics on CO, SO_2, PM2.5 AQI, while data on NO, NO_2, O_3 and PM10 is absent. VOCs are integral to any discussion on smog (Baird and Cann 2012), yet absent from the policy and EPD air quality reports.

4.3. Underrepresenting Health Impact of Air Pollution

All current AQI categories on the EPD website (https://epd.punjab.gov.pk/aqi) are independent of any air quality standard in the world and inconsistent with the AQI standards. The current categories downplay the dangers of air pollution. Air pollution in Lahore results in at least 6,400 premature deaths every year (GAHP 2019; PBS 2017). Any commentary on public health is entirely missing from the 2017 policy. Ashraf et al. (2019) showed that an increase in NO_x and PM levels between 2015 and 2016 corroborate with a 60% increase in ocular surface diseases in Lahore. The authors also suggest there are a plethora of other immediate public health outcomes related to air pollution that are not well researched.

4.4. Omissions and Inconsistencies

In its background section, the 'Policy on Controlling Smog, 2017' emphasises that crop burning in Pakistan and India are major sources of smog in Punjab, Pakistan. The FAO (2018) report rejects this idea. The FAO report identifies transportation as the largest contributor of emissions, and smog, in Punjab, Pakistan. Furthermore, the policy indicates that the smog in Punjab, Pakistan, historically lasted '10 to 25 days' (p. 1) in the winter months. This is an understatement for any winter period in Punjab between 2000 and 2017 (Colbeck et al., 2010; Haider et al., 2017; Hamid et al., 2019). The policy also fails to recognise the public health implications of air pollution in Lahore. This includes a reduction in life expectancy by roughly seven years (AQLI 2022) and an estimated 6,400 premature annual deaths (GAHP 2019).

Any discussion on identifying or controlling VOCs – a key ingredient of smog (Baird and Cann 2012) – is entirely missing from the policy. In fact, the Government of the Punjab suggests that only the biggest polluters – cement, steel and thermal power generation industries – can afford to curb emissions and will be asked to do so. Hence, the policy is not based on any source or area monitoring air pollution data (Government of the Punjab 2017).

Across fossil fuels, coal power plants are the most polluting and the worst for the environment (Appenzeller n.d.). One oversight of the FAO (2018) study, relevant to point 10 in the '*Policy on Controlling Smog, 2017'* is that while it identifies oil and natural gas thermal power plants across Punjab, and their contribution to deteriorating air quality, it fails to incorporate any commentary or numbers on coal power plants. Even though power generation accounts for a significant 12% of all emissions across Punjab (FAO 2018), it is clubbed with the cement and steel industry in the policy document.

5. AIR POLLUTION POLICIES ACROSS LOS ANGELES, LONDON AND BEIJING

Wang and Liu (2014) identified the air pollution problem in Beijing as haze, not smog. This distinction is important because it helped identify a major anthropogenic source of pollution in Beijing - coal power plants (Baird and Cann 2012; Wang and Liu 2014). Wang and Liu also compared Beijing to London to further illustrate this: both cities heavily relied on coal to generate power, especially to power heating systems in winter; both cities experienced air pollution because of rapid economic development.

Given that coal combustion contributed to 87% of all SO_2 emissions and 76% of all NO_x emissions in China in the mid-90s (Almond et al., 2009), it is plausible to suggest that Beijing's success combating air pollution was largely based on policies that phased out coal power plants (Jin et al., 2016). The latter also credit temporary traffic control for major reductions in air pollutants without discounting the importance of coal power plant closures. In *Beijing's Battle to Clean Up its Air* (UNEP n.d.), Joyce Msuya also celebrates Beijing's success in implementing its 2013 five-year action plan. According to UNEP, between 2013 and 2017, the budget on smog control for Beijing jumped from USD 434 million to USD 2.6 billion. Consequently, NO_2, SO_2, and PM2.5 levels dropped considerably (Ibid.).

Interestingly, Wang and Liu (2014) identified the air pollution problem in Los Angeles as smog, not haze, highlighting vehicular emissions as the major anthropogenic source of air pollution. Similarly, and not surprisingly, the most effective policies to combat air pollution in Los Angeles were largely based on controlling vehicular emissions (USC Environmental Health Center 2015). More specifically, the policies that were most successful governed the production and promotion of efficient automotive combustion engines, cleaner fuel standards, and the adoption of electric vehicles (Ibid.).

In the London of the 1950s, policies that phased out and replaced coal with natural gas succeeded (Brimblecombe 2006).

Based on the commonality of air pollutants established across the cities under discussion above, the lessons from London, Beijing, and Los Angeles are highly relevant and applicable to Lahore.

6. COMPARING AIR POLLUTION POLICIES

6.1. Identifying the Right Policies

The air quality in London, Lahore, Beijing, and Los Angeles are not governed by counterpart government bodies. For example, in London, the government body responsible for monitoring and regulating air quality is the City of London. This section, therefore, examines the '*Air Quality Strategy, 2019-24'*, (City of London 2019) as opposed to a national policy of the UK on air quality. Further, China has issued multiple laws and policies that influence Beijing's air pollution control, but this section will limit the discussion to China's widely celebrated policy, the *'Air Pollution Prevention and Control Action Plan (2013)'* that arguably led to the greatest improvement in its air quality (Jin et al., 2016; Shi et al., 2016; UNEP n.d.; Clean Air Alliance of China 2013). For Lahore and Los Angeles, this study examines policies developed by provincial governments: the *'Policy on Controlling Smog, 2017'* (Government of the Punjab 2017) and the Southern California Air Quality Management District's *'Air Quality Management Plan, 2022'* (AQMD 2022) respectively.

6.2. Broad Comparison: Lahore versus Los Angeles, London and Beijing

Compared to Government of Punjab's 2017 smog policy's 11-point agenda the *'Air Quality Strategy, 2019-24'* (City of London 2019) has a 65-point agenda. The latter also has an estimated administrative budget unlike the former. In general, London's strategy is based on detailed air quality data. Furthermore, it is meticulously cited and grounded in scientific evidence. In comparison, there is sufficient data gathering capacity available with the Government of Punjab (as it mentions in the policy under discussion) to follow suit, but the use of that data in the policy document itself, is lacking. Also, in terms of limitations, it is important to note that even though London has had significant experience developing and implementing policies to combat air pollution, it still struggles to keep pollutants like NO_2 below European Union (EU) air quality standards (City of London 2019).

The policy document governing air quality in Beijing is a national policy for China that offers a ten-point agenda to govern three major regions of the country, including Beijing. Like Punjab's policy document, China's *Air Pollution Prevention and Control Action Plan* is not well referenced. Unlike Punjab, it identifies key pollutants and shares quantifiable metrics to help government and industry measure progress. There is no budget for, or reference to, public health outcomes in this policy. This policy is similarly detailed as the Punjab policy but considerably less detailed compared to policies identified for London and Los Angeles.

The most detailed and robust policy document amongst the four compared in this paper is the Southern California Air Quality Management District's *'Air Quality Management Plan, 2022.'* It includes independent chapters dedicated to environmental justice and public health – arguably, two of the most important issues connected to air pollution. This is the kind of thought and detail policymakers in London, Lahore and Beijing should emulate.

6.3. Fine Comparison: Lahore versus Los Angeles, London and Beijing

The Government of Punjab's *'Policy on Controlling Smog, 2017'* places special emphasis on smog control efforts in the capital of the province, Lahore. The merits of each of the 11 points and other sections of the policy are discussed in Table 4:

Table 4: Fine Comparison across Policies Under Discussion

Policy on Controlling Smog, 2017	**Analysis**
1, 2, 3, 4	These points are centred around curbing on-road emissions and are titled as follows: 'Introduction of Low-Sulfur fuels; Adopting Euro-II Standards for Vehicular Emission; Installation of Vehicular Pollution Control Devices; and Better Traffic Management' (Government of the Punjab 2017, pp. 2-3). To summarise, the major policy initiatives within these

	points include: upgrade or retrofit refineries across Pakistan to produce low sulfur fuel; reduce sulfur content in fuel from 10,000 ppm to 500 ppm; mandate a minimum prerequisite Euro-II standard on the import of all vehicles in the country; install catalytic converters in all vehicles; and create alternative low-carbon intensive transportation options to reduce the number of vehicles on the road.
5	This point is about 'Controlling burning of municipal waste and crop residue' (Government of the Punjab 2017, p. 4). This section shares a broad target for all municipalities across Punjab to collect at least 75% of all solid waste within their jurisdiction(s) and to prevent this waste from burning. The policy acknowledges that municipalities are not currently meeting this target but fails to quantify the gap in services. Therefore, it cannot be used to set targets or to track progress. The same policy relegates all responsibility regarding crop burning to the Agriculture Department. There are no details or references to plans about how this department will curb crop burning. The FAO (2018) report notes several useful insights that could inform policy development: on average, farmers in Punjab are willing to forego crop burning if they are paid PKR 8,800 per acre; non-basmati rice crop residue is the most difficult to dispose off and therefore gets burnt the most; almost half the farmers across Punjab are willing to adopt environmentally friendly practices to dispose agricultural waste if the government supports them with the necessary infrastructure, technologies and incentives. Interestingly, neither Beijing, London nor Los Angeles have any policies on crop burning (City of London 2019; Clean Air Alliance of China 2013; AQMD 2022).
6	Point 6 is about 'Building capacity to monitor and forecast episodes of high air pollution' (Government of the Punjab 2017, p. 4). The policy acknowledges that its capacity to monitor air quality in only six locations across the province is inadequate, and that it plans to set up new monitoring stations in at least eight major cities of the province; a province that is home to 109.9 million people (PBS 2017). According to the EPD, three of the six monitoring stations are located in Lahore, where roughly a tenth of Punjab's population resides. In comparison to Lahore, London has four continuous air quality monitoring stations measuring NO_2, PM2.5 and PM10 across the city and 50 diffusion tube monitoring stations that determine long-term NO_2 averages (City of London 2019). Across all cities under discussion, Los Angeles has the most comprehensive pollutant monitoring setup and standard, identifying trends

	in O_3, Pb, Carbon Monoxide (CO), NO_2, SO_2, PM10, PM2.5, Sulfates and Hydrogen Sulfide (H_2S) concentrations. Los Angeles maintains emissions inventories across a staggering 2588 point sources and 400 area sources (AQMD 2022). The data gathered allows the city to pinpoint source(s) of air pollution, which is evident in its Air Quality Management Plan, 2022. Lastly, Beijing does not refer to any emissions inventory source but provides targets to significantly reduce SO_2, NO_2, PM and VOCs from the atmosphere (Clean Air Alliance of China 2013).
7	Point 7 is on ‘Creation of woodland in and around major cities’ (Government of the Punjab 2017, p. 5). The provincial government identifies the power of trees in ‘fixing dioxides’ (p. 5) and estimates that a single tree can fix up to 20 kilograms of emissions per year. In this section, the government also shares the intent to collaborate with the Board of Revenue and the Forestry Department to identify state-land that can be converted into woodland. However, there are no references to detailed plans, or goals, identifying potential locations for woodlands; minimum number of trees required to make an impact on the province’s overall air quality; nor the tree species most appropriate and effective for sequestering carbon. Compared to Lahore, London has a detailed and dedicated ‘Tree Strategy’ that takes stock of natural assets and articulates an overarching goal: ‘The City of London Tree Strategy aims to increase City Corporation owned trees by 5% by 2019’ (City of London 2012, p. 18). It also covers key topics such as a Cost-Benefit Analysis for different tree sizes; commentary on the most appropriate species for the city; management and maintenance protocols for existing trees; a ‘Community Engagement Strategy’; and a ‘New Tree Planting Plan.’ While London focuses on identifying and planting large canopy trees, Los Angeles recognises that trees also emit VOCs - a major precursor to ground level ozone. Hence, tree planting activities in are centred around identifying trees that have the lowest VOC emissions (AQMD 2022). Lastly, the Air Pollution Prevention and Control Action Plan governing air quality in Beijing does not elaborate on any forestation initiative nor does it list any references or links to a plan. On trees and reforestation, the document states, ‘Promote forestation; increase the green area in the cities and the suburbs’ (Clean Air Alliance of China 2013, p. 2).
8	Point 8 is ‘Controlling fugitive dust from road shoulders and construction sites’ (Government of the Punjab 2017, p. 5). The government recognises that no road in Punjab is designed to minimise fugitive dust from road

	shoulders and that all new and old road construction projects will be required to modify road design to minimise dust. This section of the policy also mentions that the Communications and Work (C&W) department will collaborate with road construction companies and real estate developers to control dust both on the road and on construction sites. Comparatively, Los Angeles recognises fugitive dust can emanate from vehicles on the road, strong natural winds, and construction sites (AQMD 2022). Beijing and London almost squarely focus on addressing dust emanating from construction sites and do not refer to strong natural winds or road shoulders. While Beijing offers broad solutions without any details or references to plans (for example, construction sites should be fully enclosed; sediment transport should be sealed; roads should be swept through automated machines; and storage facilities should be covered), London refers to its 'Code of Practice' as the source of all details on construction regulations for the city, including laws governing dust management (City of London 2019; Clean Air Alliance of China 2013).
9, 10	Points 9 and 10 focus on industry and are titled as follows: 'Planned urban and industrial development and Greening of industrial processes' (Government of the Punjab 2017, pp. 5 -6). Point 9 is mainly concerned with shifting industrial units in major cities to new locations outside the city zones. The same point is also concerned with directing all new industrial activity to new dedicated zones outside the city zones. Under point 10, the policy states that small and medium-sized industries face insurmountable challenges to reduce emissions. Therefore, it will not demand emissions reductions from them. Alternatively, it is recognised that amongst the bigger polluters, the cement, steel and thermal power generation industries can afford to reduce emissions and would be asked to do so. In 2017, four coal power plants went live across Pakistan, collectively generating 4.62 GW of power; one such plant was inaugurated in Sahiwal, Punjab, on 28 October 2017 (Ebrahim 2021; Isaad 2021). In fact, nine of 18 priority energy projects envisioned under the China-Pakistan Economic Corridor (CPEC) authority were coal-fired, implying an even greater increase in SO_2 and NO_x emissions for Punjab since the smog policy and the FAO report were published in 2017 and 2018, respectively (Baird and Cann 2012; Ebrahim 2021; Isaad 2021). Conversely, policies across London, Beijing, and Los Angeles are centred on pollution abatement technologies; source pollution monitoring and emissions inventory; shutting down and phasing out fossil fuel use, especially coal power plants; and accelerating the transition to renewable

	energy sources for power generation (City of London 2019; Clean Air Alliance of China 2013; AQMD 2022). For example, in 2018, California passed a new law (SB 100), requiring that the state's energy mix by 2026 must be 50% renewable, 60% renewable by 2030, and 100% renewable by 2045 (AQMD 2022 Appendix IV-A, p. 136). Beijing and London have similar albeit less ambitious goals in terms of transitioning to renewable energy sources (City of London 2019; Clean Air Alliance of China 2013). Regarding industrial air pollution control policies, Beijing's overall policy focus is largely industry heavy in any case, including the following themes, goals, and initiatives: phasing out coal-powered boilers; accelerating denitrification, desulfurisation and dust removal projects and retrofits in key industries; implementing VOC control in various industries; restricting the entry of energy-intensive, high polluting industries, especially in excess capacity areas; accelerating the restructuring of 21 key high polluting industries - including iron, steel, cement and electrolytic aluminum among others; enhancing pollution reduction technologies; reducing emissions in key industries by 30%; conducting emissions audit in key industries by 2017; developing a 'circular industrial system'; reducing dependence on coal power to less than 65% by 2017; building and exporting air pollution control equipment; accelerating the transition of coal to natural gas power projects; prohibiting the use or import of high sulfur coal; washing locally obtained coal to minimise air pollutants; implementing zoning to build mutually beneficial industries contiguously; imposing strict NO_2, SO_x, dust and VOC emissions limits on new industries in industrial zones; scientifically developing the layout for industrial parks to optimise air pollution diffusion; restricting capital to industries that fail to meet environmental criteria; making industries pay for excess pollution and ensuring the highest polluter pays more; and subsidising denitrification to ensure thermal power producers remain viable (Clean Air Alliance of China, 2013). Unlike Beijing, air pollution policies for Los Angeles and London reflect a higher concern for (and subsequent response to) emissions resulting from land and sea-based transportation (City of London 2019; AQMD 2022). This is not surprising given mobile sources of pollution account for significantly higher emissions for Los Angeles and London compared to stationary sources of emissions (City of London 2019; AQMD 2022).

11	Point 11 is titled 'Regional environmental agreement' (Government of the Punjab 2017, p. 6). The policy notes that the problem is not strictly local, and that air pollution does not adhere to national boundaries. Hence, it specifically refers to Punjab's eastern border, indicating the importance of establishing air quality standards in collaboration with Indian Punjab without explicitly mentioning any government department in India. In comparison to Lahore, policies governing air quality in Los Angeles and Beijing also lay significant emphasis on regional cooperation to solve the air pollution problem (Clean Air Alliance of China 2013; AQMD 2022). London is the anomaly across the cities under discussion; it does not highlight the need for regional cooperation towards effective policy development (City of London 2019).

Source: Author's own.

7. RECOMMENDATIONS

- FAO (2018) uses geospatial technology to rank pollution by sector in Punjab, Pakistan. In decreasing order of pollution, the sectors are ranked as follows: transportation; industry; agriculture; power generation. Given case studies of London, Los Angeles, and Beijing, the Government of Punjab should prioritise air pollution control efforts to address the biggest polluters first and be mindful not to ignore other polluters.
- Beyond its current policies to reduce emissions from transportation, the provincial government could raise the vehicle emissions standard to Euro-VI instead of Euro-II; impose a congestion tax on vehicle owners in busy city centres; incentivise and reward car-pooling; incentivise the production, use and purchase of electric vehicles; develop clean public transportation infrastructure to facilitate both cyclists and pedestrians; and invest in emissions testing and certification centres (City of London 2019; Clean Air Alliance of China 2013; AQMD 2022)
- Air pollutants consistently in excess in Punjab include NO_x, SO_x, PM10, PM2.5, CO and VOCs (Aslam et al., 2020; Colbeck et al., 2010; Haider et al., 2017; Hamid et al., 2019). The government should monitor and report data on all aforementioned pollutants to help inform policy development and to track progress on pollution control efforts.
- There are no references to detailed plans, or goals, identifying potential locations for woodlands, the minimum number of trees required to make an impact on Punjab's overall air quality, or the tree species appropriate and effective for sequestering carbon. According to the Capital Greening Office in China, '100

million people have participated in Beijing's voluntary afforestation campaign, planting a total of 210 million trees from 1980 to 2020' (The Tribune India 2021). Lahore should draw lessons from Beijing's experience; and for each point within its smog policy, involve relevant government departments to design and implement detailed action plans. These action plans should be referenced in updated policy documents.

- The provincial government should study public health outcomes of air pollution and make serious efforts to protect communities most vulnerable to illness and disease (Ashraf et al. 2019).
- The government should be transparent about poor air quality in the province. Instead of confronting or avoiding citizens demanding clean air, it should collaborate, and ultimately even seek citizen support, using something like the U.S. EPA's 'Environmental Violation Reporting' portal (U.S. EPA n.d.).

8. CONCLUSION

The Government of Punjab's *'Policy on Controlling Smog, 2017'* succeeds in developing useful ideas that could potentially reduce on-road, industry, agricultural, and power generation emissions. The 11-point agenda of the policy, however, does not identify the need to monitor VOCs that are critical to a discussion on smog. The daily air quality reports of its EPD also lack data on other primary pollutants like NO and NO_2. Furthermore, the policy document fails to recognise air pollution as a public health crisis; inaccurately prioritises crop burning over other sources of air pollution; and does not entirely substantiate its policies with the latest scientific findings and emissions data.

The biggest concern, however, and this is outside the policy document but governed by the EPD, is the lack of transparency with the citizens of Punjab: the misrepresentation of air quality emissions standards, downplaying the ill effects of poor air quality, suggesting that high AQI levels are not harmful.

Beijing, London, and Los Angeles offer key lessons in curbing emissions across transportation, industry, and power generation sectors. For crop burning, however, the Government of Punjab could benefit more from collaborating with its counterparts in India (World Bank 2023).

Given the need for substantial revisions and updates to the *'Policy on Controlling Smog, 2017'*, it becomes clear that the existing policy framework falls short in effectively enhancing public health outcomes in Lahore, Punjab. Consequently, it is imperative that the analysis and recommendations outlined in this paper be taken into account to effectively address and ameliorate the prevailing conditions.

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