Command, Control, and Assuasive Measures: Policy-Based Information Dissemination in Environmental Governance of Pakistan

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Smog is a significant environmental and public health issue in Pakistan, particularly in Punjab, where the intensity of seasonal haze events has increased since 2016. The study analyzes government policies and initiatives from 2017 to 2025, focusing on three mitigation measures: command-and-control, economic, and assuasive, and identifies the weakest link in the current framework. A qualitative content analysis was conducted using national and provincial legislation, policy strategies, implementation reports, and media coverage, guided by the OECD (Organization for Economic Co-operation and Development) environmental policy classification. The findings reveal that Punjab's smog control measures are primarily based on command-and-control measures, including industrial inspections, emission caps, and bans on high-pollution practices. Economic measures, including targeted subsidies for cleaner agricultural machinery, electric vehicle installment schemes, and initial proposals for an Emission Trading System, are emerging, but their scope is limited. Assuasive measures, which involve awareness campaigns and participatory tools, are underdeveloped, seasonal, and poorly integrated with enforcement and incentives. The absence of long-term environmental literacy programs and behavioral change initiatives hinders compliance with regulatory and market-based tools, thereby reducing the effectiveness of the policy. The study concludes that Punjab's long-term smog reduction necessitates a balanced approach to policy, prioritizing continuous, well-funded assuasive measures alongside legal enforcement and economic instruments, to foster a lasting environmental responsibility culture and improve air quality outcomes.

Keywords: Smog Mitigation, Environmental Policy, Air Quality Management, Public Awareness Campaigns, Policy Integration

Introduction:

Air pollution is a significant environmental and public health issue, with the World Health Organization (WHO) estimating that 99% of the global population breathes air that exceeds safety standards [1], leading to nine million premature deaths annually [2]. Smog, a harmful mixture of particulate matter (PM2.5 and PM10), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), ozone, and volatile organic compounds, is particularly harmful and persistent [3]. Its impacts include increased respiratory and cardiovascular diseases, disrupted transportation and outdoor labor, and significant ecological damage, affecting human health, economic productivity, and environmental health [4].

South Asia's smog issue is escalating due to rapid urbanization, heavy fossil fuel reliance, inadequate pollution control technologies, and widespread agricultural residue burning [5]. These issues are not limited to national boundaries but are often exacerbated by transboundary pollution, such as the Indian-Pakistani Punjab issue during rice harvest season [6]. This is evident in recurrent smog episodes affecting India and Pakistan, such as the November 2016 crisis in Delhi and Lahore [7]. These events highlight the need for integrated policy responses to address regional drivers of air pollution, going beyond local interventions.

The Punjab province in Pakistan is experiencing a smog crisis, with Lahore being one of the world's most polluted cities during winter [8], with AQI readings often exceeding 300, exceeding safe limits [9]. The "fifth season" from October to January is characterized by meteorological conditions that trap pollutants close to the ground [10]. The causes of this smog crisis include vehicular emissions from the expanding transport sector [10], industrial output from brick kilns and steel furnaces [11], and agricultural burning of rice stubble [6]. Climate variability and weather patterns further intensify the accumulation of pollutants during the smog season [7].

Pakistan has implemented various legislative, regulatory, and programmatic responses to address the smog issue over the past three decades. The Pakistan Environmental Protection Act of 1997 [12] was the first comprehensive law addressing environmental protection, introducing National Environmental Quality Standards (NEQS) and mandating Initial Environmental Examinations (IEE) and Environmental Impact Assessments (EIA) for industrial projects, with penalties of up to PKR 1 million for violations. The focus was not on smog sources specifically.

The *2005 National Environmental Policy* primarily targeted the transportation sector, with 60% of actions focusing on reducing vehicular emissions, improving fuel quality, and promoting cleaner modes of transportation [10]. Around 20% of the measures tackled industrial pollution through environmental quality standards, cleaner production technologies, and the phase-out of high-sulphur fuels. The policy emphasized the importance of sustainable agricultural practices to prevent soil degradation and minimize environmental impact. The lack of explicit mention of agricultural burning suggests a significant gap in addressing this significant source of air pollution. The policy also aimed to promote the National Clean Air Act, ambient air quality standards, and cleaner production technologies, with financial incentives provided.

Pakistan's *2012 National Climate Change Policy* aimed to decrease greenhouse gas emissions and tackle air pollutants like methane, ammonia, nitrogen oxides, and particulate matter through improved fertilizer use, manure management, biogas production, livestock feeding, and sustainable farming practices [13]. The policy also aimed to improve air quality and promote sustainable agriculture by enhancing indigenous knowledge and capacity building, reducing transport emissions through fuel efficiency enhancement, enforcement of emission standards, and encouraging non-motorized travel, and developed an institutionalized system for monitoring GHG (Greenhouse Gases) emissions.

In November 2016, a committee was established to investigate the severe weather conditions characterized by dense smog in Punjab. In 2017, the Agriculture Department was directed to develop environmentally friendly crop residue disposal plans, educate farmers on fertility losses caused by burning residues, and introduce alternative technologies for quick and safe disposal, as part of a comprehensive policy on controlling smog [14]. The Additional IG Traffic, C&W Department, Transport Department, and LG & CD Department implemented measures to reduce PM emissions from vehicles, including controlling traffic flow, restricting private car circulation, improving road infrastructure, organizing public awareness campaigns, and developing supportive infrastructure. Around 33% of the measures targeted the transport sector, focusing on traffic management, Euro-II vehicle standards, catalytic converter installation, and road infrastructure improvement. Twenty-seven percent targeted the industrial sector, focusing on smoke-emitting industries shutdown, low-Sulphur fuel introduction, greening, and pollution control through urban and industrial development. Thirteen percent of the actions in the plan focused on agriculture, aiming to eliminate crop residue burning and promote alternative waste disposal methods, while 27% included public health advisories, air quality monitoring, woodland creation, and regional environmental cooperation to tackle transboundary pollution.

In 2018, the Smog Commission Report [15] announced plans to improve the Environmental Protection Department's (EPA) capacity for ambient air quality monitoring in Punjab by purchasing and installing 30 AAQMS (ambient air quality monitoring stations). The EPD also introduced Draught Zig Zag Brick Kiln, an environmentally friendly and cost-effective brick kiln technology, in collaboration with the All-Pakistan Brick Kiln Owners Association. In 2018, the World Bank approved a five-year Punjab Green Development Program (PGDP) with a $273 million budget, including $73 million from the Punjab Government, to enhance regulatory enforcement and promote technology adoption in high-pollution sectors like brick kilns, steel furnaces, rice mills, and transport. The Punjab Green Development Program (PGDP) has implemented a structured environmental governance framework in Punjab, prioritizing industrial emissions from industrial estates and polluting sectors. To address rice stubble burning, a workshop was held with rice exporters to promote the adoption of Sustainable Rice Global Initiative principles and the use of sustainable farming methods and agricultural technologies like the "Happy Seeder" to manage crop residues without burning.

The Punjab Clean Air Policy 2019 [11] outlined a timeline for implementing the Punjab Smog and Clean Air Policy in all key urban areas of Punjab. The National Clean Air Policy (NCAP) 2023 [6] aimed to reduce PM2.5 emissions by 38% by 2030 and 81% by 2040, focusing on agricultural waste burning as one of five key intervention areas and promoting low-cost alternatives like residue integration.

The Punjab Environmental Protection Rules 2023 [16] enforced Provincial Environmental Quality Standards, mandated emission control systems and CCTV monitoring, and banned tire pyrolysis with fines ranging from PKR 100,000 to PKR 1,000,000. The Climate Resilient Punjab Vision & Action Plan 2024 [17] proposed an Emission Trading System (ETS) with annual caps, continuous monitoring, and promotion of biofuels to align with Pakistan's Nationally Determined Contributions.

The Punjab Chief Minister's Roadmap for Smog Mitigation 2024-25 [10] aimed to combine legislative enforcement with technological interventions and public engagement. It allocated PKR 13.43 billion for cleaner technologies, including Super Seeders, Rice Shredders, drone surveillance, and the Green Punjab mobile application. By October 2024, measures led to 12,540 industrial inspections, 594 closures, and Rs. 70 million fines. The transport sector distributed 8,000 bikes to students and introduced 27 electric buses. The Smog Control Strategy 2024-25 [18] addressed new technology uncertainty through awareness campaigns,

targeted farmer training, and training of 471,477 farmers and women. Table 1 provides a comprehensive mapping of key environmental and smog-related policies in Pakistan from 1997 to 2025.

Punjab's Chief Minister Maryam Nawaz announced on 19 May 2025 the establishment of a modern *Climate Observatory* at the *EICT* (Environment and Information Communication Technology) campus, equipped with advanced communication systems for environmental data collection and analysis [19]. The observatory aims to improve scientific research, promote international collaboration, and develop environmental expertise through internship programs, thereby aiding in climate change monitoring and policy-making.

The Environment Protection Department (EPA) Punjab launched a mandatory Vehicle Emissions Testing System in Lahore, consisting of nine strategically placed booths across the city, including locations like Mall Road, Gulberg, and DHA [16]. Modern testing technology enabled booths to offer free emissions testing during a month-long campaign starting on 22 May 2025 to encourage vehicle owners' participation. The initiative, supported by a helpline and Green Punjab App, aims to combat vehicle pollution in Lahore by ensuring emission limits, reducing harmful pollutants like carbon monoxide and nitrogen oxides.

The Punjab Government has launched a *Green Punjab smartphone app* in 2025 [20] to address smog-related concerns among citizens. Users can file complaints against individuals burning hospital waste, operating smoke-emitting kilns and vehicles, and factories without smoke control devices. The app is linked to various institutions such as PDMA, Metropolitan Corporation, the traffic police, the Parks and Horticulture Authority, the agriculture department, and the transportation departments. The "*Smog KO Karo All Out*" campaign was launched during the Pakistan Super League Final in 2025 [21].

The three key policy instruments that provide a framework for understanding initiatives are Command-and-Control, Economic, and Assuasive instruments. *Command-and-Control measures* are legally binding obligations with penalties for any violations. *Economic measures* utilize market-based incentives to encourage compliance, while *Assuasive measures* rely on persuasion, awareness, and voluntary participation.

Objectives of this study:

Examine the evolution of Punjab's smog-related policies and interventions from 2017 to 2025, categorizing them into command-and-control, economic, and assuasive measures.

Evaluate the efficacy and weight assigned to each measure category in addressing smog.

Assess the effectiveness of enforcement-based strategies, incentive-based tools, and awareness campaigns.

Examine the influence of digital communication platforms like YouTube in promoting smog-related policies and influencing public engagement.

Propose a comprehensive framework to enhance the sustainability and long-term effectiveness of Punjab's smog mitigation policies.

This research is unique in its dual perspective, combining policy analysis with an assessment of digital environmental communication. This study combines quantitative data from enforcement reports with engagement data from social media influencers, contrasting previous studies that focused primarily on regulatory or technological interventions. The study identifies policy imbalance in Punjab and underutilization of public engagement channels, offering a comprehensive evaluation of smog governance and providing evidence-based recommendations for policy integration, aligning with international best practices.

Table 1. Mapping of Key Environmental and Smog-Related Policies in Pakistan (1997–2025)

Elements	Policy Objectives & Goals	Target Population	Geographic Scope	Policy Type & Design	Implementation Strategy	Outcomes & Measure	Stakeholder Involvement	Cost & Resources	Evaluation Metrics & Methods	Media Coverage (Total No. of YouTube Videos Considered for Analysis)
Pakistan Environmental Protection Act (1997)	Economic growth, environmental protection, equity, and job creation	All citizens, focus on vulnerable groups, urban & rural	National; provincial adaptation	Regulatory & supportive; prescriptive standards	EPA creation; NEQS enforcement; inspections & penalties	Reduced pollutants; better health; more protected habitats	Communities, businesses, NGOs, and local Governments	Sustainable Development Funds; federal & provincial budgets	Pollution data, audits, case studies	10
National Environment Policy (NEP) 2005	Environmental conservation, integration in planning, poverty reduction, and awareness	Rural & urban communities, industries, farmers	National; local adaptations	Regulatory + incentives; prescriptive & supportive	Multi-level action plans; inspections & penalties	Improved air/water quality, green jobs, better health	Communities, businesses, and local Governments	Federal/provincial sustainable funds	Surveys, admin data, biodiversity metrics	6
Policy on Controlling Smog 2017	Reduce smog, improve health, awareness, and traffic flow	Punjab residents, vulnerable groups, and farmers	Punjab	Regulatory; prescriptive	EPD-led; bans on burning; monitoring; vehicle checks	Smog advisories; reduced emissions (if enforced)	Government departments, police	Existing dept budgets	AQI data, satellite monitoring	1
Smog Commission Report 2018	Health protection, sustainable development, and capacity building	Urban Punjab: vulnerable groups	Punjab	Regulatory & supportive	Multi-agency; green tech adoption; AQI monitoring	Lower AQI; fewer health issues; clean energy jobs	Communities, industries, and Government	$273M (Government + WB)	AQI, PM levels, health data	3
Punjab Clean Air Action Plan 2019	Air quality improvement, clean transport, awareness	Urban residents, students, industries, and farmers	Punjab	Regulatory + incentives	EPD-led; WB-funded; industry & transport upgrades	Cleaner transport, industry, and more monitoring stations	Government agencies, industry, and schools	Rs 12B+ WB funds & provincial co-finance	PM2.5 levels, surveys	-
National Clean Air Policy (NCAP) 2023	National air baseline, WHO targets, sector mitigation, governance	Urban/industrial; commuters, farmers, kiln workers	Provincial; urban/peri-urban	Regulatory + EV/waste incentives	EPAs, inspections, zones, digitized checks	Lower AQI, better health, fewer emissions	Industry, Government, NGOs, PPPs	EVs, transit, landfill upgrades	Real-time data, audits, dashboards	5

Punjab Smog Prevention & Control Rules 2023	Environmental protection, smog reduction, and health	Punjab residents, esp. marginalized urban/peri-urban	Province-wide, Lahore focus	Regulatory + incentives	EPA-led committees, monitoring, and enforcement	Better AQI, reduced emissions, better health	Government, NGOs, academia, communities	Government + green finance	Pre/post analysis, health & compliance data	5
Climate Resilient Punjab Vision & Action Plan 2024	Low-emission growth, climate resilience, protect vulnerable, green economy	Whole Punjab; vulnerable communities, urban/rural	Provincial; district/city actions	Regulatory + incentives (solar, EVs, finance)	Climate cells, committees, and integrated plans	Lower GHG, resilient infra, climate justice	Government, academia, NGOs, UN bodies, GCF	Government + climate funds; finance unit	Dashboard, annual report, audits	6
Roadmap for Smog Mitigation (2024–2025)	Reduce smog via enforcement, incentives, and tech.	Urban Punjab: farmers, youth, industry, transport	Provincial; smog hotspots	Regulatory + supportive	Phase plans, squads, monitoring, and coordination	Better AQI, fewer illnesses, more EVs/trees	CM committees, EPA, departments, and the community	PKR 50B+ (solar, EVs, monitoring)	Apps, sensors, compliance	5
Smog Control Strategy (2024–2025)	Reduce smog via regulation, tech, and awareness.	Urban/peri-urban; industry, farmers	Selected Punjab districts	Mostly regulatory; some incentives	EPA, inspections, fines	Lower AQI & PM2.5, tech adoption	EPA, industries, farmers, NGOs	Monitoring tech, squads, support	AQI/compliance tracking	3

Table 2. YouTube Channels, Influencer Categories, and Engagement Metrics for Punjab Smog and Environmental Policy Content

Element	Media Type	Channel/ Source	Subscribers	Views	Categories of Influencers	Likes	Title/Description	URL	Time Duration	Communication Purpose	Video Aesthetics
Pakistan Environmental Protection Act (1997)	YouTube	General Information	2.97K	15K	Micro Influencer	275	General Information Video	https://www.youtube.com/watch?v=EnNaYYJIq-k	21:34	Lecture Based	Informative
		APIMM Environmental World	1.43K	8.6K	Nano Influencer	238	APIMM Environmental World Video	https://www.youtube.com/watch?v=nxH1wISBonI	13:04	Voice Over Lecture	Instructional
		Environmental Science	970	3.4K	Nano Influencer	91	Environmental Science Video	https://www.youtube.com/watch?v=-xxUNpXR3LM	3:59	Brief Formal Explanation	Instructional
		Environmental Sensei	37	239	Nano Influencer	7	Environmental Sensei Video	https://www.youtube.com/watch?v=TcyB1xpF1YQ	0:39	Voice Over Lecture	Instructional
		Dr. Haroon Rashid	110	367	Nano Influencer	2	Dr. Haroon Rashid Video 1	https://www.youtube.com/watch?v=ruUH_qYYsWo	19:08	Explanatory Narration	Informative

		Dr. Haroon Rashid	104	585	Nano Influencer	10	Dr. Haroon Rashid Video 2	https://www.youtube.com/watch?v=FHc3N4AHOSc	31:59:00	Explanatory Narration	Informative
		Law study with Arsalan	392	1.5K	Nano Influencer	37	Law study with Arsalan video	https://www.youtube.com/watch?v=2ACtwHzlJCg	7:02	Explanatory Narration	Informative
		Rana Fahad Zia	370	112	Nano Influencer	1	Rana Fahad Zia Video	https://www.youtube.com/watch?v=OklEW62xAFo	1:05	Voice Over Lecture	Voice Over Lecture
		Envirotenna Engineering	319	2.9K	Nano Influencer	90	Envirotenna Engineering Video	https://www.youtube.com/watch?v=i9lWzhYsVtc	28:29:00	Explanatory Narration	Informative
National Environment Policy (NEP) 2005	YouTube	General Information	2.94K	3.5K	Nano Influencer	106	General Information video	https://www.youtube.com/watch?v=EtT89FMVvZg	28:20:00	Lecture-Style Narration	Informative
		Tufail Zubedi	120	1k	Nano Influencer	25	Tufail Zubedi	https://www.youtube.com/watch?v=dC77BrXVDIM	10:47	Lecture-Style Narration	Informative
		Quaidian World	1.86K	13	Nano Influencer	1	Quaidian World	https://www.youtube.com/watch?v=83HcewOx8Eo	4:19	Brief Formal Explanation	Instructional
		Daniyal Khan	1	341	Nano Influencer	9	Daniyal Khan	https://www.youtube.com/watch?v=GYe2RDmeQf4	21:55	Lecture-Style Narration	Informative
		HSE STUDY	11	274	Nano Influencer	7	HSE STUDY	https://www.youtube.com/watch?v=FH9SenoJLs4	26:38:00	Lecture-Style Narration	Informative
Policy on Controlling Smog 2017	YouTube	Capital TV	3.3M	72	Mega Influencer	0	Capital TV	https://www.youtube.com/watch?v=X8dccdreaG0	2:14	News-Style Narration	Promotional
Smog Commission Report 2018	YouTube	Nawaiwaqt	185K	33	Macro Influencer	2	Nawaiwaqt	https://www.youtube.com/watch?v=E6wilkPW3hs	1:25	Policy-oriented	Promotional
		Abbtakk News	906lk	73	Macro Influencer	1	Abbtakk News	https://www.youtube.com/watch?v=WOxjZLGqu7U&pp=ygUbU21vZyBDb21taXNzaW9uIFJlcG9ydCAyMDE4	1:07	Policy-oriented	Promotional
		Lahore News HD	2.48M	54	Macro Influencer	3	Lahore News HD	https://www.youtube.com/watch?v=6toeZShD15M	1:54	Policy-oriented	Promotional
Punjab Clean Air Policy 2023	YouTube	(CDPR) Haq Research Centre (MHRC)	4.04K	1. 190	Nano Influencer	2	The Consortium for Development Policy Research (CDPR)	https://youtu.be/Vga0mcolc0E?feature=shared	47:30:00	Formal Academic Lecture	Informative

		(CDPR) – International Growth Centre (IGC) & Mahbub ul	4.04K	210	Nano Influencer	2	The Consortium for Development Policy Research (CDPR) – International Growth Centre (IGC) & Mahbub ul Haq Research Centre (MHRC)	https://youtu.be/Vga0mcolc0E?si=mCn-45xIuQ3U563x	32:45:00	Formal Academic Lecture	Informative
National Clean Air Policy (NCAP) 2023	YouTube	CSS Forum	42.1K	487	Micro Influencer	20	CSS Forum	https://youtu.be/LYeGZirmxsM?si=Ov8scFlFAsVJBOCd	59:04:00	Lecture-Style Narration	Informative
		Clean Air Asia	273	49	Nano Influencer	0	Clean Air Asia	https://youtu.be/CiIR5vWP6mI?si=aNrb0lQsmh6tMPoB	1:12:32	Lecture-Style Narration	Informative
		PSM Made Simple	5.48K	70	Nano Influencer	9	PSM Made Simple	https://youtu.be/2QkP0Shmlgg?si=OLlwssam04RNWEjq	35:42:00	Lecture-Style Narration	Informative
Punjab-environmental-protection-smog-prevention-and-control-rules-2023	YouTube	News Pakistan	68.8K	668	Micro Influencer	9	News Pakistan	https://youtube.com/shorts/kdKvdvTjqFo?si=jueu2KT-05NoG410	0:04	Promotional	Promotional
		DawnNews English	425K	694	Macro Influencer	3	DawnNews English	https://youtu.be/FA4NiTONvqY?si=dO8JSwn4iVw_MlQS	4:47	News-style visuals	Promotional
		FRANCE 24 English	3.4k	14k	Nano Influencer	128	FRANCE 24 English	https://youtu.be/FpCBqWWor6o?si=qRF47a0roT1u8hh9	1:22	News-style visuals	Promotional
		Punjab Safe Cities Authority	341k	1018	Macro Influencer	52	Punjab Safe Cities Authority	https://youtube.com/shorts/Tn59DzFpTB0?si=JHqyWj6LhFYfGwKF	0:36	Informative	focused, advisory, Quick-cut visuals, on-screen text
Climate Resilient Punjab Vision & Action Plan 2024	YouTube	Maryamazing	38	3	Nano Influencer	0	Maryamazing	https://youtu.be/urYQgxGJHNo?si=z_DYNZj32diElkot	33	Lecture-Style Narration	Informative
		Climate Corner	1.13K	70	Nano Influencer	15	Climate Corner	https://youtu.be/TTO_MbTqcv0?si=RZvOC_nfGhvMUTCg	7:54	Lecture-Style Narration	Informative

		Capital TV Central	566	52	Nano Influencer	0	Capital TV Central	https://youtu.be/Od46gUDlTJs?si=9egD2dXzDKGKGk6d	4:20	Lecture-Style Narration	Informative
Roadmap for smog mitigation in Punjab (2024-2025)	YouTube	BOL News	8.08M	968	Mega Influencer	7	BOL News	https://youtube.com/shorts/N0znOTnv6XA?si=QA1B8XvrZkMFCWCM	1:22	Promotional	Promotional
Smog Control Strategy 2024-2025	YouTube	BOL News	8.08M	1.8k	Mega Influencer	3	BOL News	https://youtu.be/by0bs4JkpH4?si=XzaJcv0vNl8RGu1v	1:08	Informative	News-style visuals, on-site reporting, interviews
		GEO News	79.5k	135	Micro Influencer	3	GEO News	https://youtube.com/shorts/JQZoNJik_mk?si=UUc0xLQnX6QHf48D	2:05	Informative	News-style visuals, on-site reporting, interviews

The research presents a structured approach. After the Introduction, the Material and Methods section provides an in-depth analysis of materials and methods, including data sources, policy selection, and the OECD-based analytical framework. The Results and Discussion section presents a comprehensive analysis of various tools, categorized into Command-and-Control, Economic, and Assuasive, and their implementation, integration, and limitations. The conclusion section presents the key findings, policy recommendations, and future research directions.

Material and Method:

The study used a qualitative content analysis method to evaluate Pakistan's smog mitigation measures, focusing on Punjab's policies and initiatives from 2017 to 2025. The analysis utilized various data sources, including legal frameworks like the Pakistan Environmental Protection Act 1997 [12], National Environmental Policy 2005 [10], National Climate Change Policy 2012 [13], Policy on Smog Controlling 2017 [14], National Clean Air Policy 2023 [6], and Punjab-specific regulations and strategies like the Punjab Environmental Protection Rules 2023 [16], Climate Resilient Punjab Vision & Action Plan 2024 [17], Smog Control Strategy 2024-2025 [18], and Roadmap for Smog Mitigation 2024-2025 [10]. The review of implementation reports, including the Smog Commission Report 2018 [15], Punjab Clean Air Action Plan 2019 [11], and annual EPD enforcement updates, was conducted to evaluate progress and measurable outcomes.

The Pakistani environmental communication study analyzed media content, including mainstream newspapers, YouTube videos, and official campaign materials, to assess the visibility and public reception of awareness initiatives. YouTube videos covering smog-related initiatives were coded for engagement using quantitative and qualitative indicators, including views, likes, subscriber base, and duration and frequency of uploads. These metrics were normalized to account for differences in channel size. YouTube channels were categorized into Nano, Micro, Macro, and Mega influencers based on subscriber counts. Influencers play a critical role in environmental governance by shaping narratives, raising awareness, and mobilizing public support for government policies. Nano influencers provide localized, community-specific perspectives and grassroots engagement, while Micro influencers bridge niche communities with moderate reach and credibility. Macro influencers amplify campaigns to a wider audience and connect policies with mainstream debates. Mega influencers offer large-scale visibility but often lack policy depth. This framework helped assess whether government policies were effectively engaging citizens through digital platforms for smog mitigation. By identifying which influencer categories dominate coverage, the study evaluated how environmental narratives are constructed and disseminated in Pakistan's public sphere. Table 2 presents data on YouTube channels, influencer categories, and engagement metrics for Smog and Environmental Policy content in Punjab.

The study then categorized policy measures into three OECD (Organization for Economic Co-operation and Development) approaches: Command-and-Control, Economic, and Assuasive measures. It evaluated each measure's objectives, implementation mechanisms, coverage, and challenges to create an integrated smog mitigation strategy for Punjab, evaluating their individual effectiveness and complementarity. The flow diagram of research methodology is illustrated in Figure 1.

Results:

The review of Pakistan's smog mitigation policies in Punjab from 2017-2025 reveals a significant overreliance on command-and-control measures over economic and assuasive tools. Despite increased regulatory enforcement, economic incentives are slowly introduced, and assuasive measures remain weak.

Command-and-Control Measures:

Pakistan's smog governance has primarily relied on command-and-control since the 1997 introduction of the Pakistan Environmental Protection Act, which established National Environmental Quality Standards and empowered enforcement authorities. The National Environmental Policy (2005) expanded controls on transport and industrial emissions.

Following the 2016 smog crisis, the Policy on Controlling Smog (2017) introduced bans on crop-residue burning, emission checks, and industry shutdowns. The Smog Commission Report (2018) further institutionalized monitoring, recommending new air quality stations and zig-zag kiln technology. The Punjab Clean Air Action Plan (2019) implemented these directives with sectoral targets.

The Punjab Clean Air Policy (2023) and the National Clean Air Policy (2023) have emphasized the need for binding PM2.5 reduction targets, while the Punjab Environmental Protection Rules (2023) mandated continuous monitoring systems, emission caps, and bans on high-pollution practices like tire pyrolysis.

The Roadmap for Smog Mitigation in Punjab (2024-2025) saw a significant increase in enforcement, including 12,540 industrial inspections, 594-unit sealings, Rs. 70 million fines, Section 144 enforcement, and mandatory vehicle emission testing. The Smog Control Strategy (2024-2025) emphasized stricter industrial regulation, but rural districts struggled due to weak institutional capacity, local resistance, and political pressures, despite visible enforcement gains in major cities.
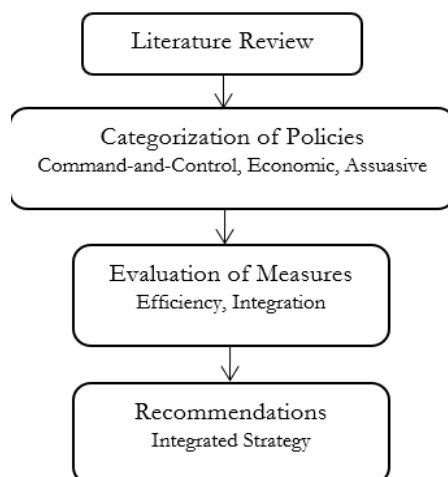
Figure 1. Flow Diagram of the Research Methodology

Economic Measures:

Economic policy tools are gaining recognition, with subsidies introduced for Super Seeders and Rice Shredders under the Smog Commission Report (2018) and strengthened in subsequent plans to reduce stubble burning. The Punjab Clean Air Action Plan (2019) included pilot programs for financial incentives in agriculture and transport.

The Climate Resilient Punjab Vision & Action Plan (2024) proposed an Emission Trading System for industrial emissions, along with broader fiscal tools. The Punjab Chief Minister's Roadmap for Smog Mitigation 2024-25 introduced incentives for electric mobility, including installment-based financing and targeted distribution to students.

Despite efforts, large-scale fiscal mechanisms remain absent. The Punjab Clean Air Policy 2023 and NCAP 2023 lack robust carbon or pollution taxes, with funding largely dependent on the World Bank, and limited green financing channels hindering widespread adoption of clean technologies.

Assuasive Measures:

The least developed of all policy measures are assuasive measures, which are based on awareness and voluntary compliance. The Policy on Controlling Smog (2017) introduced

seasonal public awareness initiatives. The Punjab Clean Air Action Plan (2019) and Policy (2023) also emphasized citizen engagement, but lacked concrete institutional mechanisms.

High-visibility campaigns include the "Smog Ko Karo All Out" campaign which was launched during the Pakistan Super League Final in 2025, and the Green Punjab App which enables citizens to report pollution incidents and book vehicle emission tests (Green Punjab App is referenced in Roadmap for Smog Mitigation (2024–2025) as a tool to engage the public). The "Smog Ko Karo All Out" campaign was seasonal. The Green Punjab App is poorly promoted and under-integrated with enforcement systems.

The study on YouTube videos related to smog and environmental policies reveals significant communication gaps in the public. YouTube videos are categorized into Nano, Micro, Macro, and Mega influencers based on subscriber counts and reach. Figure 2 reveals that Nano influencers are the primary contributors to content creation, accounting for 54.5% of the total videos. Micro influencers produce 9.1% of videos, followed by Macro and Mega influencers who produce 18.2%.
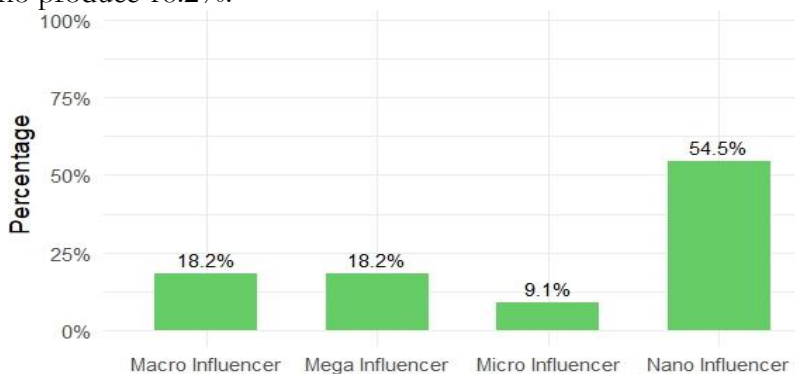
Figure 2. Distribution of YouTube Influencer Categories on Punjab Environmental Policy Content

Nano influencers dominate videos, with an average of 1,238 views and 39 likes per video, and subscriber counts of around 1,063. Examples include APIMM Environmental World and Environmental Sensei, which often cover the Pakistan Environmental Protection Act (1997) (can be seen from Table 2).

Micro influencers, such as CSS Forum, have a subscriber base of 26,894 and record the highest average views per video at 4,682 views and 84 likes, covering the National Clean Air Policy (can be seen from table 2).

The average number of views and likes by macro influencers is 374 and 12, with an average of 1.03 million subscribers. Nawaiwaqt and DawnNews English cover topics like the 2018 Smog Commission Report and Punjab Environmental-rotection-smog-prevention-and-control-rules-2023 (can be seen from table 2).

Mega influencers, with Capital TV, with approximately 3.3 million subscribers, have an average of 72 views per video. BOL News, with approximately 8.08 million subscribers, has an average of 968 views. Despite their extensive reach, their average likes are typically between 0-5 per video (can be seen from table 2).

Figure 3 compares subscriber distributions among Nano, Micro, Macro, and Mega influencers involved in producing smog and environmental policy content. Nano influencers have the lowest median percentile (52%), indicating smaller audience bases, while Micro and Macro influencers have median percentiles of 67%, indicating higher reach and consistency, respectively. The figure does not display a median value for Mega influencers, indicating a significant gap between Nano influencers and larger categories in terms of potential reach and relative subscriber standing.

Figure 4 depicts the popularity distribution of Nano, Micro, and Macro influencers who produce smog and environmental policy content. Nano influencers (red) are at the lower

end of the popularity scale, with scores below 100, indicating their limited reach and audience interaction. Micro influencers (green) exhibit a consistent engagement within a moderate audience size, with a narrow, sharply peaked distribution centered around low hundreds scores.
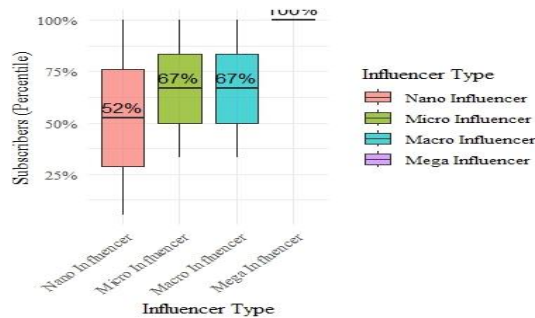

Figure 3. Subscriber Percentile Distribution by Influencer Type

Macro influencers (blue) have a higher popularity range, scoring from thousands to over 10,000, indicating their potential for broad impact. The figure does not include mega influencers, indicating either no data points or exclusion from the popularity score analysis.

Figure 5 displays the relationship between the number of likes and video length for different influencers producing smog and environmental policy content. Nano influencers' video lengths vary, with longer ones receiving fewer likes, indicating a negative correlation between video duration and engagement. Micro influencers, often under five minutes long, consistently garner high likes (frequently above 100), indicating a strong viewer interest in concise, focused content. The Macro and Mega influencers are primarily found in short videos with low like counts, indicating minimal engagement regardless of the duration. Overall, the figure indicates that shorter videos from Micro influencers, attracting the most audience engagement, are more effective, while extended videos, especially from Nano influencers, result in reduced interaction.
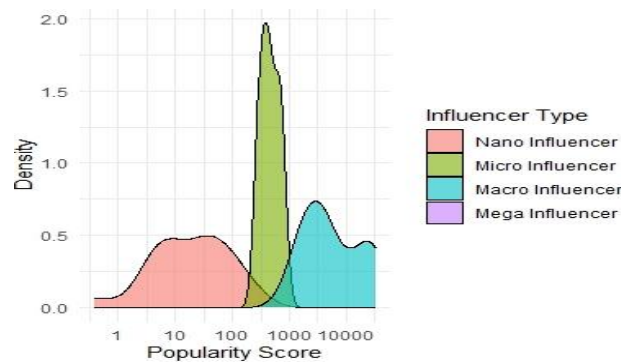
Figure 4. Popularity Score Distribution by Influencer Type
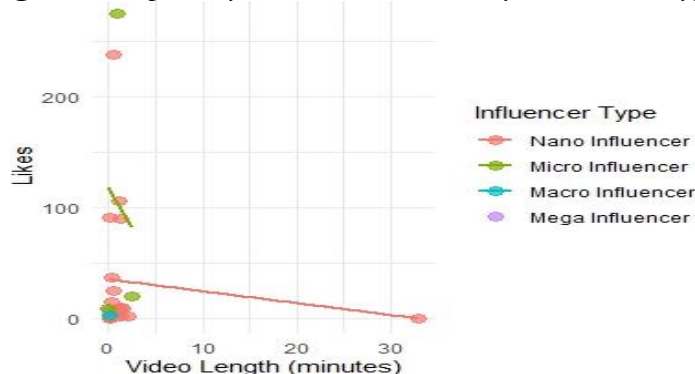
Figure 5. Relationship Between Video Length and Likes by Influencer Type
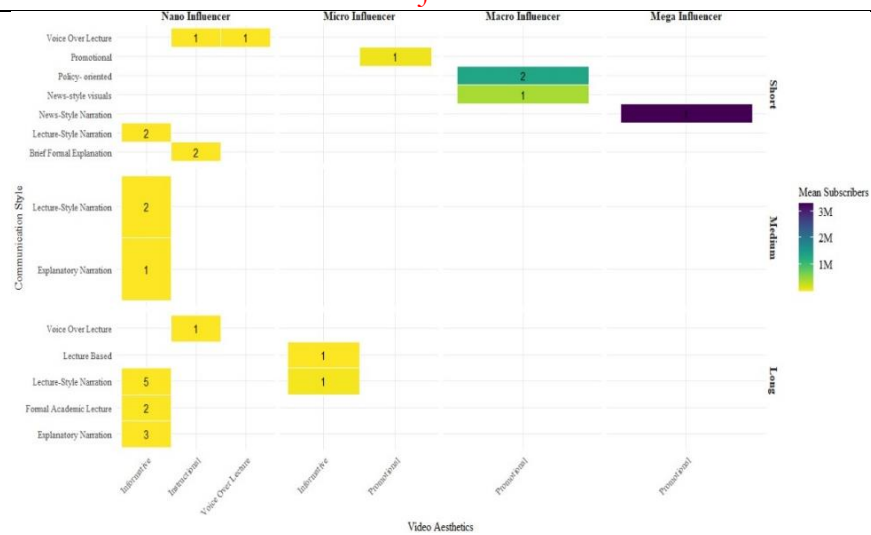
Figure 6. Communication Style and Video Aesthetics by Influencer Type

Figure 6 compares communication styles and video aesthetics of Nano, Micro, Macro, and Mega influencers producing smog and environmental policy content, with video length and subscriber count indicated by color shading. Nano influencers (yellow) exhibit a wide range of communication styles and aesthetics, producing various types of videos including lecture-style narration (5 videos), explanatory narration (3 videos), formal academic lectures (2 videos), brief formal explanations (2 videos), and voice-over lectures (1 video), primarily focusing on information and instructional elements. Micro influencers, primarily yellow, produce informative content in fewer styles, including lecture-style narration (1 video), lecture-based (1 video), and a single promotional video. Macro influencers (green) create short, policy-oriented videos using news-style visuals (2 videos) and news-style narration (1 video), while mega influencers (purple) exclusively produce one promotional video with no variation in style or aesthetic.

The data indicates that Macro and Mega influencers have higher average subscriber counts but less varied content, while Nano influencers offer a wide variety of communication styles and video aesthetics, suggesting content diversity is primarily driven by smaller influencers.

Discussion:

The study reveals a consistent pattern in Punjab's smog governance, primarily focusing on command-and-control measures over participatory or incentive-based methods. Increased administrative resolve is evident in increased enforcement actions, including sealing non-compliant industrial units and imposing substantial fines. This trajectory aligns with Fahim and Ali's (2025) research [22], which indicates that only 10% of Lahore's industries are compliant with environmental control mechanisms, reflecting a reactive governance model rather than a preventive approach. Despite increased efforts, rural areas continue to lag due to weak political will, limited resources, and fragmented institutional capacity. This is in line with Dr. Farzana Zaheer Syed et al.'s (2024) research [23], which reveals that Pakistan's environmental governance is hindered by weak institutions, resource constraints, poor regulatory capacity, and low public awareness.

Economic measures have begun to emerge, but their progress is still limited. The development of an ETS and subsidies for agricultural machinery like Super Seeders and Rice Shredders suggests a shift towards market-based regulation. Punjab's Emission Trading System (ETS) is aspired to achieve measurable emission reductions, unlike China and the European Union, which have implemented ETS frameworks. Rafiq-uz-Zaman et al. (2024) [24] research also highlights the challenges of green adoption due to institutional instability

and insufficient green financing. Subsidies in agriculture also show promise, but their impact is diminished without effective awareness campaigns to educate farmers about the long-term benefits of cleaner technologies.

In contrast, assuasive measures are the weakest and most fragmented pillar in the system. Public awareness campaigns, educational programs, and digital platforms are currently seasonal and underdeveloped. This aligns with Nageen et al. (2024) [25], who found that TV channels were the primary source of information about smog among 58% of the population.

The study on YouTube-based environmental communication reveals additional vulnerabilities. Nano influencers dominate the influencer distribution, producing 54.5% of videos, but their limited subscriber base limits their broad outreach. Micro influencers, despite being only 9.1% of content creators, show significantly higher targeted engagement; this aligns with findings by ILM Pedro (2023), who suggests that mid-tier influencers often foster greater trust and engagement. The median subscriber percentiles reveal a significant visibility gap, with Nano influencers at 52% and Micro and Macro influencers at 67% respectively. The lack of data on Mega influencers indicates a lack of utilization of platforms with potential for mass outreach.

The analysis of popularity scores reveals a similar tiered structure. Nano influencers are found to be clustered at the lower end of the scale, indicating low and inconsistent interaction. Micro influencers consistently maintain low scores, indicating consistent engagement, while macro influencers reach thousands, confirming their potential for broad impact. The study underscores the significance of content design in enhancing audience engagement through the correlation between video length. Micro influencers, who create short videos under five minutes, consistently receive over 100 likes. Nano influencers' longer videos tend to generate weaker responses. Macro and Mega influencers create short, low-engagement videos, emphasizing that content quality and brevity are more important than audience size. Content diversity adds a new dimension to the overall experience. Nano influencers offer a diverse range of content, including academic lectures, explanatory narration, and promotional content, while larger influencers tend to focus on narrower, less engaging formats. The paradox suggests that while innovation often originates from smaller creators, they often lack the necessary reach to generate widespread awareness.

The risks of this imbalance are highlighted through comparative insights from global cases. Beijing's Clean Air Action Plan (2013-2017) effectively integrated industrial shutdowns with transparent public air quality data, promoting accountability [26]. Delhi's air pollution governance in South Asia demonstrates the importance of transparency and citizen engagement for effective management [27]. Punjab has not yet established such practices. Political discourse highlights "smog diplomacy" with India, recognizing transboundary cooperation [28], but concrete mechanisms for cross-border collaboration remain absent.

Taken together, the findings indicate a persistent imbalance in Punjab's policy mix. The dominant approach is command-and-control measures, while economic instruments remain modest and incomplete. Assuasive measures are inadequate, insufficiently structured, and underfunded. The YouTube dataset underscores the need for consistent and integrated communication strategies within governance frameworks, rather than remaining seasonal or ad hoc. To effectively mitigate smog, an integrated model involving legal enforcement, market incentives, and public participation is needed, moving beyond piecemeal implementation. The initiative involves year-round awareness campaigns, influencer partnerships, environmental education integration into school curricula, and enhanced citizen engagement through platforms like the Green Punjab App.

Finally, Punjab's experience demonstrates that legal frameworks and economic tools are insufficient for long-term success without the social legitimacy generated by assuasive measures. The promotion of environmental responsibility through education, communication,

and citizen participation is crucial for achieving long-term smog reductions and fostering resilient environmental governance.

Conclusion:

The study of Punjab's smog mitigation policies from 2017 to 2025 reveals a strong focus on command-and-control measures. Legislative instruments like the Pakistan Environmental Protection Act 1997, Punjab Environmental Protection Rules 2023, and Smog Roadmap 2024–25 have expanded institutional capacity, enabling industrial inspections, closure of non-compliant units, and vehicle emissions control systems. However, persistent enforcement gaps, especially in rural areas, continue to allow high-pollution practices like stubble burning to persist.

Economic measures like subsidies for Super Seeders and Rice Shredders, electric bike schemes, and the ETS are promoting market-based solutions for clean technologies. However, the lack of a fully operational ETS framework, pollution tax mechanisms, and limited green financing options hinders their scalability across key sectors. Institutionalizing economic incentives with clear fiscal mechanisms and broader private sector engagement is crucial for maximum impact.

The weakest link remains assuasive measures. Digital outreach through YouTube shows that Nano influencers dominate, reaching smaller audiences, while Micro influencers achieve high engagement levels. Macro and Mega influencers contribute limited content with lower audience interaction. This imbalance suggests untapped potential for sustained awareness campaigns. Public outreach initiatives like the "Smog KO Karo All Out" campaign and the Green Punjab app are sporadic, short-term, and insufficiently integrated with enforcement systems.
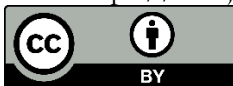
Overall, Punjab's current approach to smog management is partially successful, but still faces limitations due to over-reliance on regulatory enforcement, underdeveloped economic mechanisms, and fragmented public engagement strategies. A balanced mitigation strategy should integrate rural enforcement, economic instruments like ETS, and high-reach awareness campaigns through digital influencers and community-level education programs. This will prevent a reactive approach and ensure the sustainability of air quality improvements.

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