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REPORT 2025

WHOLE OF GOVERNMENT APPROACH

PUNJAB STATE OF ENVIRONMENT



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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AD	Assistant Director
ADP	Annual Development Programme
ADRS	Animal Disease Reporting and Surveillance System
AI	Artificial Intelligence
AMR	Antimicrobial Resistance
AQI	Air Quality Index
AQMS	Air Quality Monitoring Station
BOD	Biochemical Oxygen Demand
BoD	Burden of Disease
CASS	Carbonaceous Aerosol Speciation System
CDC	Centre for Disease Control
CDD	Continuous Dry Days
CCTV	Closed-Circuit Television
CEMS	Continuous Emission Monitoring Systems
CETP	Common Effluent Treatment Plant
CFY	Current Financial Year
CIS	Climate Intelligence Systems
CCHF	Crimean-Congo Hemorrhagic Fever
CM	Chief Minister
CMPGCP	Chief Minister Punjab Green Credit Program
COD	Chemical Oxygen Demand
CO_2	Carbon Dioxide
CPEC	China-Pakistan Economic Corridor
CPTC	Climate Policy and Technology Centre
CRP	Chrome Recovery Plant

CSR	Compliance Status Report
DALYs	Disability-Adjusted Life Years
DHIS2	District Health Information System 2
DLI	Disbursement Linked Indicator
DMWCCs	District Multi-sectoral Workforce Coordination Committees
EAMS	Environmental Assessment Management System
EDH	Environment, Dengue and Health
EDEP	Environmental Data Exchange Platform
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Agency
EP&CCD	Environment Protection & Climate Change Department
EPO	Environmental Protection Order
EPPIC	Ecosystem Services, Pathogen Transmission, Pollution, Innovations from Nature & Climate Change
EPF	Environmental Protection Force
EPR	Extended Producer Responsibility
EQS	Environmental Quality Standards
ETS	Emissions Trading System
FETP	Field Epidemiology Training Program
FIC	Full Immunization Coverage
FIRMS	Fire Information for Resource Management System
FY	Financial Year
GDP	Gross Domestic Product
GHGs	Greenhouse Gases

GHSA	Global Health Security Agenda
GIS	Geographic Information System
GMO	Genetically Modified Organism
GPS	Global Positioning System
HWMR	Hospital Waste Management Rules
IAD	Internal Accountability Dashboard
IDSP	Integrated Disease Surveillance Programme
IEC	Information, Education and Communication
IEE	Initial Environmental Examination
IHR	International Health Regulations
ILES	International Labour and Environmental Standards
INC	Intergovernmental Negotiating Committee
IPC	Infection Prevention and Control
IRSA	Indus River System Authority
IU	Implementation Unit
IUCN	International Union for Conservation of Nature
JEE	Joint External Evaluation
KTWMA	Kasur Tanneries Waste Management Authority
LAIF	Lahore Air Improvement Framework
LSM	Large-Scale Manufacturing
LWMC	Lahore Waste Management Company
MAF	Million Acre Feet
MERS-CoV	Middle East Respiratory Syndrome Coronavirus
MLD	Million Liters per Day
MoU	Memorandum of Understanding
NAPHS	National Action Plan for Health Security
NASA	National Aeronautics and Space Administration
NCDs	Non-Communicable Diseases
NDMA	National Disaster Management Authority

NDMC	National Drought Monitoring Centre
NEOC	National Emergency Operations Centre
NEQS	National Environmental Quality Standards
NGOs	Non-Governmental Organisations
NZDs	Neglected Zoonotic Diseases
OH	One Health
PCAP	Punjab Clean Air Program
PCRWR	Pakistan Council of Research in Water Resources
PDMA	Provincial Disaster Management Authority
PEPA	Punjab Environmental Protection Act
PEQs	Punjab Environmental Quality Standards
PERI	Punjab Economic Research Institute
PERL	Punjab Environmental Reference Laboratory
PET	Punjab Environmental Tribunal
PET	Polyethylene Terephthalate
PFA	Punjab Food Authority
PGDP	Punjab Green Development Program
PHRL	Provincial Public Health Reference Laboratory
PHWMR	Punjab Hospital Waste Management Rules
PKR	Pakistani Rupee
PLMIS	Plastic License Management Information System
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter (≤2.5 µm)
PM_{10}	Particulate Matter (≤10 µm)
PMD	Pakistan Meteorological Department
PMHWS	Pakistan Multi-sectoral Health Workforce Strategy
PMIS	Plastic Management Information System

PPE	Personal Protective Equipment
PPP	Public Private Partnership
Provincial Agency	Environmental Protection Agency Punjab
PSCA	Punjab Safe Cities Authority
PVS	Performance of Veterinary Services
QRCs	Quick Response Centers
QRU	Quick Response Unit
RNA	Rapid Needs Assessment
RVM	Reverse Vending Machine
RWH	Rainwater Harvesting
SARS	Severe Acute Respiratory Syndrome
SCC	Strategic Communication Cell
SDG	Sustainable Development Goal
SDGs	Sustainable Development Goals
SDPI	Sustainable Development Policy Institute
SEZ	Special Economic Zone
SLCPs	Short-Lived Climate Pollutants
SME	Small and Medium Sized Enterprises
SMR	Site Monitoring Report
SMS	Short Message Service
SOE	State of Environment (Report)
SP&IU	Strategic Planning & Implementation Unit
STAGL	Sialkot Tannery Association (Guarantee) Limited
STZ	Sialkot Tannery Zone
SUP	Single-Use Plastic
SUPARCO	Space and Upper Atmosphere Research Commission
TDS	Total Dissolved Salts
TSS	Total Suspended Solids
TSDF	Treatment, Storage and Disposal Facility

UHI	Urban Heat Island
UN	United Nations
UNEP	United Nations Environment Programme
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
VIC	Vehicle Inspection Centre
VICS	Vehicle Inspection and Certification System
WASH	Water, Sanitation and Hygiene
WQMS	Water Quality Monitoring Stations
WWF	World Wildlife Fund
WWTP	Wastewater Treatment Plant

Message of Senior Minister
Government Of The Punjab For
Punjab State of Environment Report 2025



The environment shapes our health, prosperity and everyday lives by influencing the conditions in which we live and work. In this regard, the Government of Punjab is prioritizing efforts to improve and protect the province's environment. The progress in 2025 gives a brighter image of how Punjab's Government is working for the betterment of the Environment. The State of Environment Report 2025, serves as a vital resource for understanding environmental challenges, tracking progress and inspiring collective action toward a healthier and more sustainable future.

Over the past year, I have witnessed firsthand the dedication of EPA Punjab teams, local authorities and community partners working tirelessly to address pollution and strengthen climate resilience of the province. Their efforts are truly shaping a cleaner, safer and more sustainable Punjab for all of us.

This report is more than a collection of data, it tells the story of our province, its environmental challenges and the solutions we are building together. Progress comes when government, citizens and institutions act in unison, guided by evidence, technology and a shared vision for the future.

As we move forward, I urge all stakeholders, policymakers, communities and individuals to see environmental stewardship as an integral part of daily life. Each action, from reducing pollution to supporting clean energy initiatives, contributes to the broader goal of a resilient Punjab.

I extend my congratulations to the teams behind this report for their dedication. I am confident this document will serve as both a guide and an inspiration for collective action. Together, we can ensure that Punjab remains vibrant, healthy and sustainable for generations to come.

Marriyum Aurangzeb
Senior Minister
Government of the Punjab

Message of Secretary
Environment Protection and Climate Change Department For State of Environment Report 2025



As Secretary, Environment Protection and Climate Change Department (EP&CCD), Government of Punjab, I am pleased to present the Punjab State of Environment Report 2025.

The report reflects a year of significant institutional advancement in environmental governance across the province. Punjab continues to face complex environmental challenges and addressing these challenges requires not only effective regulation but also stronger integration of environmental considerations into planning, development and public policy.

During 2025, the EP&CCD continued to strengthen environmental management through improved regulatory oversight, digital transformation, scientific monitoring and enhanced coordination with public and private stakeholders. These efforts reflect our commitment to building governance systems that are responsive, transparent and capable of addressing emerging environmental risks.

The report provides an evidence-based account of Punjab's environmental condition, key policy interventions and institutional initiatives undertaken during the year. It also highlights the importance of collective action in advancing environmental sustainability and climate resilience across all sectors of society.

I commend the officers, technical experts, partner organisations and contributors whose dedication have made this publication possible. It is my hope that this report will support informed policymaking, strengthen public awareness and serve as a useful reference for all.

Silwat Saeed
Secretary
Environment Protection and Climate Change Department
Government of Punjab

Message of the Director General Environmental Protection Agency (EPA) for Punjab State of Environment Report 2025



The State of Environment Report 2025 presents a comprehensive account of Punjab's environmental landscape and the evolving governance mechanisms designed to address it. Environmental management in Punjab is undergoing a decisive transition from reactive enforcement to preventive, data-driven governance. Through the integration of digital systems, real-time monitoring and geo-spatial tools, the Environmental Protection Agency (EPA) Punjab is strengthening its capacity to deliver evidence-based, transparent and outcome-oriented regulation. This report outlines the province's key environmental challenges, shaped by urbanisation, industrial growth and climate stress. It assesses critical sectors including air quality, water and wastewater management, waste and plastics and environmental health risks. At the same time, it documents the institutional strengthening of EPA Punjab through improved enforcement frameworks, specialised units and enhanced inter-departmental coordination. A notable feature of this report is its integrated approach, particularly through the One Health framework, which recognises the interlinkages between environmental conditions and public health outcomes. It also highlights the importance of collective action and coordinated governance in achieving sustainable results. While progress is evident, the challenges remain substantial. This report serves both as a reflection of where we stand and a guide for the road ahead. EPA Punjab remains committed to advancing a preventive, technology-enabled and collaborative model of environmental governance to ensure a cleaner and more resilient Punjab.

Dr. Imran Hamid Sheikh (PAS)
Director General
Environmental Protection Agency, Punjab

Message of the Chief Editor Environmental Protection Agency (EPA) for Punjab State of Environment Report 2025



The ***State of Environment Report 2025*** is the result of a collective effort to bring clarity, structure and meaning to the complex environmental realities of Punjab.

This report has been carefully developed to go beyond presenting data it aims to tell a coherent story of the province's environmental condition, the pressures shaping it and the systems responding to it. Each chapter has been designed to connect evidence with action and challenges with institutional response, so that readers can not only understand the issues but also see the direction of change.

One of the key objectives of this report is to make environmental information more accessible and meaningful for a wider audience. Covering areas including air quality, wastewater, industrial compliance, plastics, hospital waste, agriculture and environmental approvals, the report presents a clear picture of environmental governance in Punjab. Emphasis has also been placed on the evolving governance landscape, highlighting the shift towards data-driven systems, integrated approaches and preventive regulation as emerging practices across the sector.

This publication is also an acknowledgment of the collaborative effort behind it. It brings together contributions from technical teams, field formations and institutional partners who are working continuously to strengthen environmental management in Punjab.

We hope this report serves as a useful reference for policymakers, practitioners, researchers and citizens alike encouraging informed dialogue, critical thinking and collective action.

Ifrah Ali
Editor-in-Chief
State of Environment Report 2025

EXECUTIVE SUMMARY

The year 2025 marked a defining period for environmental governance in Punjab, evidencing a significant shift in the scale, pace, and maturity of response by the Environment Protection & Climate Change Department (EP&CCD) and the Environmental Protection Agency (EPA) Punjab. Despite the vast demographic, industrial, agricultural, and urban pressures confronting the province, EPA Punjab demonstrated strong institutional performance through expanded enforcement, digital transformation, real-time monitoring, improved service delivery, and coordinated field operations. The Department transcended routine regulatory functions, positioning environmental protection as a data-driven, technology-enabled, whole-of-government agenda. Throughout the year, Punjab not only reinforced its traditional regulatory roles but also introduced new systems, expanded intervention sectors, and implemented novel accountability mechanisms—making 2025 a year of measurable progress, institutional innovation, and forward-looking reform.

Punjab commenced 2025 with a complex environmental profile shaped by population growth, transport expansion, intensified industrial activity, agricultural pressures, and rising consumption patterns. These stresses were further exacerbated by extreme climatic events, including record pre-monsoon drought and severe flooding across multiple districts. As Pakistan's most populous and economically significant province, Punjab's environmental challenges are intricately linked to air quality, water resources, ecosystems, public health, and urban infrastructure. Against this backdrop, EP&CCD and EPA Punjab excelled by adopting a coordinated, technology-driven, evidence-based governance model rather than relying on reactive, fragmented enforcement.

The EP&CCD transformed its operational model from manual and reactive processes to digital and proactive systems anchored by real-time monitoring, data integration, AI-assisted surveillance, public dashboards, and focused field interventions. This technological and institutional shift became the hallmark of environmental governance efforts in 2025.

Air pollution remained the foremost public health challenge. Emissions from vehicles, industries, brick kilns, crop residue burning, dust, and winter temperature inversions continued to degrade air quality, particularly in Lahore and other key urban-industrial centres. Punjab's fleet of 22.2 million vehicles, over 9,000 brick kilns, thousands of industrial installations, and extensive agricultural burning zones contribute heavily to this burden. Nonetheless, 2025 saw measurable improvements: the province-wide average $PM_{2.5}$ concentration declined from 118 $\mu g/m^3$ in 2024 to 78 $\mu g/m^3$ in 2025—a reduction nearing 33%. Lahore registered an 18–19% improvement in average AQI during the October–December peak smog season, accompanied by a sharp decline in hazardous pollution days.

These gains were facilitated by large-scale enforcement, enhanced monitoring, and coordinated field operations. EPA Punjab conducted more than 81,000 brick kiln inspections, sealed non-compliant units, carried out extensive vehicle emission tests, deployed fog cannons for localized particulate control, and planted over 448,000 trees in brick kiln belts, industrial zones, and public spaces. A combination of satellite and ground-based surveillance monitored crop residue burning, supported by 67 Quick Response Centres along motorway corridors, resulting in a 65% reduction in fire anomalies compared with 2024. The Air Quality Monitoring System expanded to 41 stations across 18 districts, providing live air quality data to the public via government platforms.

Water stress and wastewater pollution represented another significant challenge. Excessive groundwater extraction, particularly in Lahore and Faisalabad, has accelerated the decline of aquifers, while southern Punjab grapples with salinity intrusion. Untreated municipal and industrial wastewater continues to contaminate drains and water bodies, notably the Ravi River and the Hudiara Drain. EPA Punjab responded by strengthening wastewater regulation through the establishment of a specialised wastewater Unit, issuance of enforcement notices and Environmental Protection Orders, monitoring of critical water bodies, and addressing pollution in industrial hotspots such as the Kasur tannery cluster. Water conservation was promoted by mandating over 2,200 water recycling plants at commercial car wash stations and requiring rainwater harvesting in new construction projects.

Waste management, plastic pollution, health care waste, and hazardous waste attracted heightened regulatory focus. Punjab generates approximately 57,000 tonnes of municipal solid waste daily, necessitating improved regulatory oversight and inter-agency coordination. EPA Punjab conducted over 113,000 inspections related to plastic pollution, seized 419 tonnes of banned plastics, and certified major public and commercial spaces as plastic-free zones. The Plastic Management Information System was established to register producers, collectors, and recyclers, while health care waste management systems were upgraded with certified firms and enhanced treatment facilities—improving handling of high-risk hospital waste.

2025 was distinguished by the introduction of new sectors and the strengthening of existing regulatory functions. Areas such as Environmental Approvals, air quality monitoring, wastewater regulation, plastic control, health care waste management, climate finance, digital enforcement, citizen services, and international climate engagement were all expanded. Existing processes—including EIA/IEE reviews, inspections, complaints management, adjudications, and compliance monitoring—were digitised and scaled. New tools such as AI-powered CCTV monitoring, geo-tagged industrial databases, QR code-based verification systems, and online adjudication platforms were deployed to enhance transparency, traceability, and operational efficiency.

The Environmental Assessment Management System revolutionised approval workflows, enabling proponents from all 41 districts to submit applications digitally, obviating the need for travel to Lahore. EPA Punjab processed a record 2,317 environmental applications and issued 2,013 approvals in 2025. The Eco Watch application digitised enforcement actions across seven operational modules, recording over 150,000 field interventions. More than 14,000 industries were assigned unique identification numbers and geo-located for systematic surveillance. AI-enabled CCTV cameras installed on industrial stacks allowed for continuous remote monitoring from EPA headquarters, reducing dependency on physical inspections. The Online Adjudication Hub resolved over 1,000 compliance cases, many within seven days. The 1373 Helpline was upgraded and

linked with internal complaint dashboards via the Project Monitoring and Development Unit (PMDU), boosting public accountability.

A whole-of-government approach characterised 2025's environmental governance. Air quality, crop residue burning, wastewater management, plastic pollution, public health, urban development, agriculture, transport, industry, and disaster response were no longer the sole domain of one agency. EP&CCD collaborated extensively with district administrations, transport authorities, agriculture departments, industries, local governments, health institutions, development agencies, and international partners. This coordinated endeavour aligned enforcement, monitoring, public education, investment, and emergency response initiatives under a unified environmental agenda.

Climate finance and global environmental engagement were also significantly strengthened. The EP&CCD development budget tripled from PKR 5 billion in 2023–24 to PKR 15 billion in 2025–26, marking a 200% increase. Punjab's climate-tagged budget reached approximately PKR 795 billion, encompassing mitigation, adaptation, and supporting sectors. Large-scale programmes such as the Chief Minister's Saaf Pani Programme, Punjab Clean Air Programme, renewable energy expansion, Green Credit Programme, and multilateral partnerships exemplify a shift from fragmented projects toward system-level investments. Punjab further enhanced its international presence through participation in COP-30, UNFCCC observer engagements, World Economic Forum meetings, WHO platforms, ICIMOD workshops, and regional forums.

Overall, the State of Environment Report 2025 portrays a province under considerable environmental strain that has begun to respond with seriousness, scale, and institutional innovation. The year demonstrated that Punjab's environmental challenges are complex and interlinked, yet they can be addressed through data-driven governance, digital systems, rigorous enforcement, inter-agency collaboration, community engagement, and sustained investment.

Looking ahead, the priorities for 2026 include targeted enforcement in pollution hotspot districts, province-wide expansion of air quality monitoring networks,

predictive governance through AI and Internet of Things (IoT) sensing, enhanced wastewater regulation, climate-resilient water management, introduction of a provincial emissions trading scheme, expansion of digital environmental services, and development of a centralised Environmental Data Exchange Platform. The fundamental challenge is to sustain and scale the improvements achieved in 2025 across all districts and institutionalise environmental governance as a shared responsibility of government, industry, communities, and citizens. The progress made in 2025 should be regarded not as an exceptional response to extraordinary circumstances but as the new normal for a cleaner, healthier, and more climate-resilient Punjab.

NEW IN SOE 2025

Compared with the State of Environment (SOE) Report 2024, SOE 2025 adopts a broader, more integrated, and action-oriented approach to environmental governance. It implements a Whole-of-Government framework that consolidates environmental data, priorities, and interventions across multiple departments and institutions. The report enhances pollution assessment through comprehensive industrial emission inventories, hotspot mapping, and risk analysis, while broadening its scope to include ecological pressures and emerging environmental threats. SOE 2025 additionally emphasises digital monitoring, fosters interdepartmental coordination, encourages community engagement, and focuses on measurable environmental outcomes. By doing so, it transcends traditional environmental status reporting, establishing a coordinated, data-driven, and results-oriented framework for governance and environmental action.

Touching New Horizons

Punjab Environmental Protection

Beneath the same sky, on this cherished land,
A determined Punjab now takes a stand.
The Earth still breathes and so must we,
With clearer visions for all to see.

Can you feel it? A new pulse in the air,
A wave of change, a proactive care.
The Environment weeps not in vain
We answer now with mindful strain.

This is not just a hopeful tale,
It's technology set to prevail.
With AI chatbots to guide and explain,
And real-time data on wind and rain.
Smog cannons roar where grey skies loom,
To clear the haze, to make room for bloom.

For every child who'll someday roam,
We're building Punjab a healthier home.
So let us care with sharper sight,
Using innovation's gentle might.

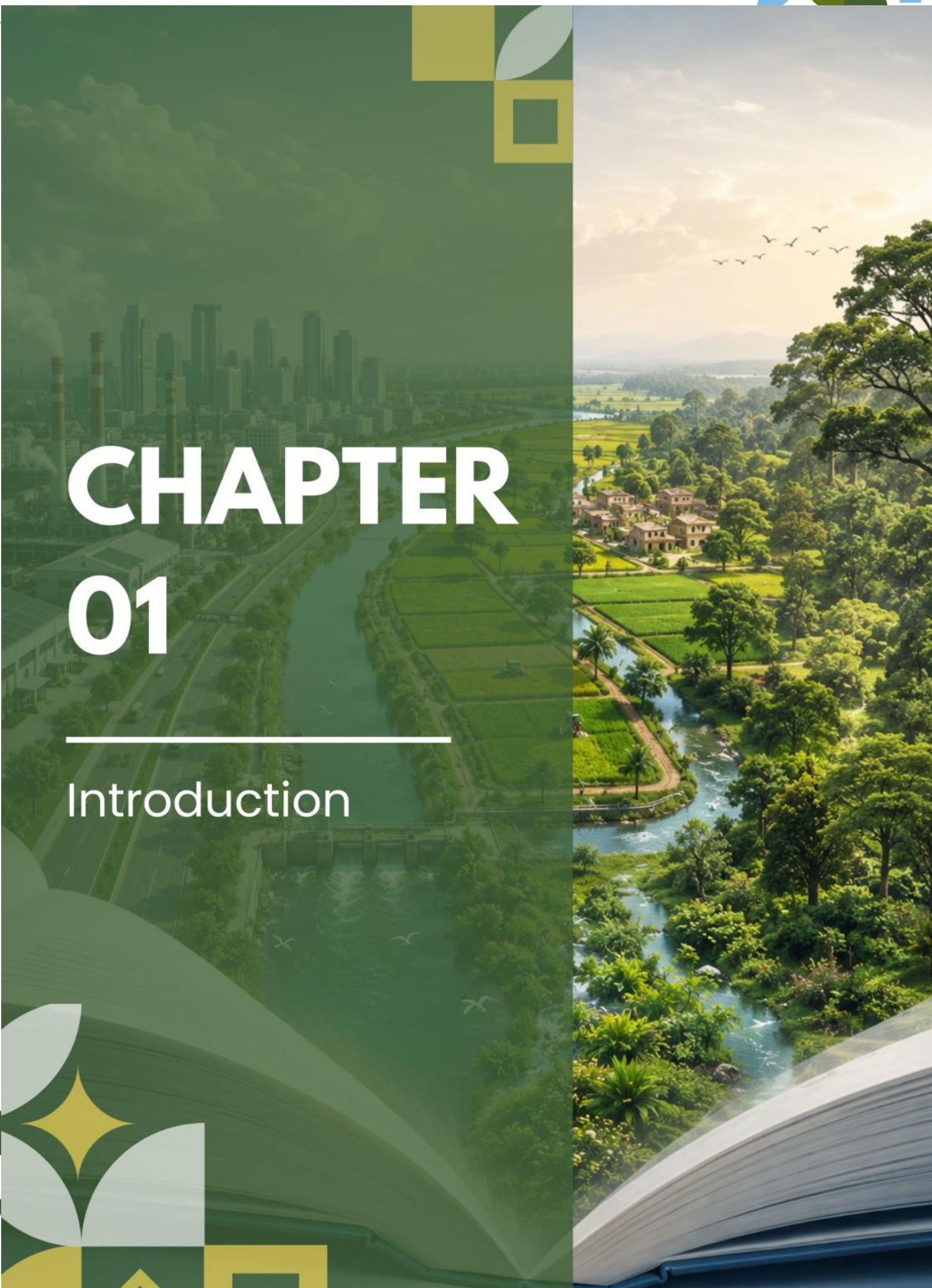
For in her health, our future's free

The Earth's heartbeat is you and me and EPA.

(By: Ms. Shehr Bano, CLDI Batch III)

PART 01

Environmental Governance Framework & Provincial Context



CHAPTER 01

Introduction

1.1 Background

The State of Environment Report is prepared by the Environmental Protection Agency (EPA) Punjab as part of its ongoing public mandate to systematically document, interpret, and communicate the province's environmental condition in a transparent and accessible manner. This mandate arises from the statutory functions conferred upon the Agency under clause (d), subsection (1) and section (6) of the Punjab Environmental Protection Act 1997, which stipulates that: "**The Provincial Agency shall prepare and publish an annual Punjab Environmental Report on the state of the Environment**." Accordingly, the Agency is tasked with collecting, compiling, and disseminating environmental information, monitoring environmental quality, and preparing reports to inform policy formulation, implementation, and public awareness.

Within this legal framework, the present report constitutes a formal mechanism through which environmental data and trends are consolidated and communicated, ensuring that environmental governance in Punjab is underpinned by credible and organised evidence. Consequently, the report serves not merely as a descriptive account but as a statutory instrument supporting transparency, regulatory oversight, and informed decision-making.

The present report builds upon the foundation established by the State of Environment Report 2024, which provided a significant basis for provincial environmental reporting by integrating major environmental themes, institutional developments, and regulatory concerns into a single public document. The current report advances this undertaking with enhanced policy maturity and heightened institutional purpose, reflecting EPA Punjab's evolving role not only as a regulatory authority but also as a custodian of environmental knowledge, public accountability, and evidence-based governance.

Punjab's environmental condition is shaped by multiple interrelated pressures—including urban expansion, industrial growth, agricultural intensification, ecological stress, resource depletion, and climatic variability—that increasingly interact in complex and inseparable ways. In such a context, a comprehensive environmental report is indispensable, offering a coherent framework to

understand the dynamics of environmental change across the province and the responses of public institutions thereto.

1.2 Purpose

The State of Environment Report 2025 has been prepared to provide a comprehensive overview of Punjab's environmental status and to document the activities undertaken by the Environment Protection and Climate Change Department (EP&CCD) during the reporting year. Serving as the Department's official annual progress report, it consolidates environmental data, monitoring outcomes, regulatory interventions, and institutional developments into a singular reference document.

The primary purpose of the report is to record and communicate the state of the province's environment alongside the Department's responses to critical environmental challenges. By integrating information across various sectors and programmes, the report presents a structured account of environmental trends and management actions undertaken throughout the year. Furthermore, it contributes to the body of institutional knowledge and serves as a valuable resource for government agencies, academic researchers, development partners, and other stakeholders interested in Punjab's environmental milieu.

1.3 Objective

The State of Environment Report aims to provide a comprehensive assessment of environmental conditions and trends across Punjab by integrating information from monitoring systems, departmental records, and relevant scientific studies. Through the consolidation of these diverse sources, the report endeavours to present environmental data in a coherent and accessible format, facilitating a clearer understanding of the province's environmental status and the factors influencing it.

Furthermore, the report documents environmental monitoring results, regulatory actions, enforcement activities, and departmental initiatives undertaken during the reporting year. By systematically recording these developments, it

establishes a reliable account of the environmental management efforts and the challenges addressed by the respective authorities.

Another key objective of the report is to facilitate access to environmental information for policymakers, researchers, development partners, and the general public. By providing a factual and organised evidence base, the report supports the evaluation of environmental pressures, emerging challenges, and priority areas requiring attention. It also serves as a vital resource for future environmental planning, policy formulation, and management interventions by highlighting key trends, knowledge gaps, and areas necessitating further action.



1.4 Structure

The State of Environment Report 2025 is organised into four integrated thematic parts that collectively illuminate the institutional, environmental, technological, and strategic facets of environmental governance in Punjab.

Part I: Environmental Governance Framework & Provincial Context outlines the regulatory and institutional foundations. It details the governance structure under the Punjab Environmental Protection Act (PEPA) 1997, the evolving mandate and role of EPA Punjab, the transition towards preventive and evidence-based governance, judicial oversight mechanisms, and provides an overview of

Punjab's environmental profile—including demographic growth, urbanisation, industrial expansion, climate stress, and ecological pressures.

Part II: Environmental Quality Assessment & Pollution Management offers a comprehensive evaluation of environmental conditions across key sectors such as air quality, water resources, wastewater, plastic and solid waste management, environmental safeguards, the One Health risk nexus, bird strike risk reduction, and stubble burning and smog mitigation. It further examines pollution sources, ecological hotspots, monitoring systems, enforcement activities, remediation efforts, and environmental outcomes across the province.

Part III: Digital and International Linkages highlights the integration of digital technologies, geospatial tools, real-time monitoring platforms, digitised regulatory processes, interdepartmental coordination, and international engagement in enhancing transparency, institutional efficiency, evidence-based enforcement, and integrated environmental management.

Part IV: Institutional Performance, Public Outreach and Strategic Outlook focuses on mainstreaming environmental considerations across development schemes, public and media engagement, behavioural change initiatives, and future strategic priorities. It also includes acknowledgements, success stories, and achievements that reflect the maturation of governance and institutional preparedness in Punjab.

Collectively, these four parts provide a comprehensive framework covering environmental governance and provincial context; environmental quality and pollution management; digital transformation and international collaborations; and institutional performance, public outreach, and strategic planning for environmental management in Punjab.

1.5 Scope

The State of Environment Report 2025 offers a comprehensive assessment of Punjab's environmental conditions, governance frameworks, pollution trends, and regulatory responses across key sectors. The report covers air and water quality monitoring, solid and hazardous waste management, biodiversity

conservation, climate change adaptation, environmental enforcement, and institutional capacity building. It evaluates the effectiveness of regulatory structures, policy interventions, and programmatic initiatives implemented by the Environment Protection and Climate Change Department (EP&CCD) Punjab and its functional arm, the Environmental Protection Agency (EPA) Punjab, throughout the reporting year. By synthesising field data, monitoring results, and governance indicators, the report functions both as an accountability document and as a strategic reference to inform evidence-based environmental policymaking in Punjab.

1.5.1 Significance for Environmental Governance

The significance of this report lies in its contribution to fostering a more transparent, evidence-based, and accountable model of environmental governance. In a province as vast and complex as Punjab, effective environmental protection cannot depend solely on isolated interventions; it demands continuity in observation, rigour in analysis, and clarity in public communication. This report addresses all three critical dimensions.

By systematically presenting environmental data, the report enhances transparency and bolsters public confidence in the integrity of institutional processes. By documenting environmental conditions alongside official actions, it reinforces accountability and provides a platform for reflection on both achievements and persistent challenges. By integrating diverse environmental themes within a unified framework, the report promotes policy coherence and enables institutions to engage with environmental issues in a more holistic and coordinated manner.

Consequently, the report occupies a pivotal role within provincial environmental governance. It transcends its function as a mere publication, embodying an integral component of the governance process itself.

1.5.2 Public Value and Policy Relevance

The report's value extends beyond fulfilling institutional documentation requirements; it holds broader public and policy significance by establishing a

common evidentiary foundation for environmental understanding. It serves as a credible reference point enabling policymakers, researchers, academic institutions, development partners, industry stakeholders, and citizens to engage meaningfully with environmental issues.

For policymakers, the report provides a structured framework to comprehend provincial environmental priorities and to identify domains necessitating enhanced coordination, more rigorous regulatory oversight, or improved institutional responsiveness. For researchers and academic institutions, it offers an organised gateway into environmental inquiry. For the general public, the report affirms that environmental information is a legitimate matter of public concern and a fundamental public right.

Thus, the report contributes not only to the enhancement of governance but also to civic awareness. It fosters recognition of the environment as a shared societal concern intricately linked with health, livelihoods, quality of life, and the enduring sustainability of development.

1.5.3 Instrument of Transparency and Accountability

One of the foremost functions of the State of Environment Report is to enhance transparency within environmental governance. The legitimacy of environmental regulation is reinforced when it is accompanied by open communication, systematic evidence, and clear institutional reasoning. By making environmental information publicly accessible, the report actively advances this objective.

Simultaneously, the report serves as an instrument of accountability, documenting environmental conditions, institutional challenges, and public sector responses in a transparent and comprehensible manner. As noted, “this form of documentation is, in itself, a public responsibility.” It ensures that environmental governance is conducted not in secrecy but within a framework of disclosure and explanation.

Thus, the report contributes to building institutional credibility, reflecting the understanding that environmental governance must not only take action but also clearly and responsibly communicate the rationale behind such actions.

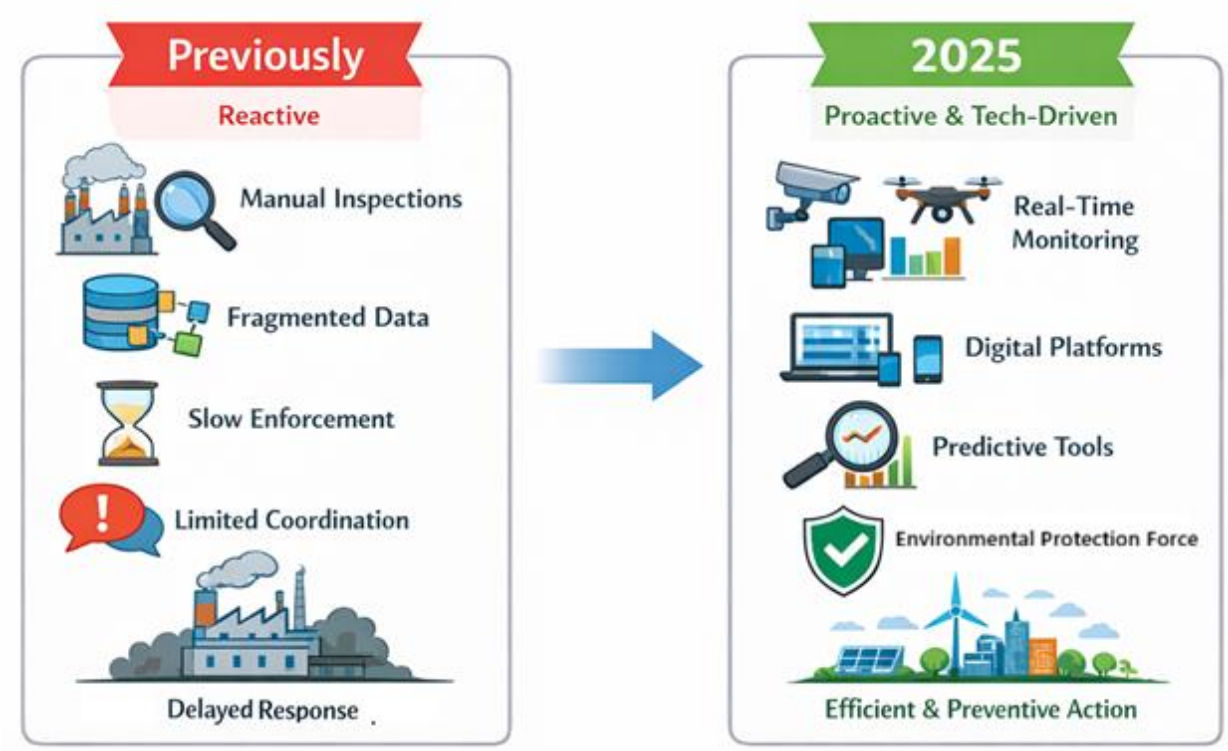
1.6 Practical Applications of the Report

This report functions as a practical governance instrument that transcends the mere documentation of environmental conditions. It consolidates environmental data, monitoring results, and institutional actions into a coherent, policy-relevant framework that directly facilitates decision-making across multiple administrative levels. The report enables institutional prioritisation by identifying sectors where environmental pressures necessitate sustained regulatory focus. Furthermore, it strengthens policy formulation by integrating environmental trends with governance challenges, thereby supporting coordinated and evidence-based responses.

By grounding public discourse in verified data, the report fosters informed community engagement and enhances environmental accountability. It also advances preventive governance by illuminating early signs of environmental degradation, allowing for timely interventions before issues become critical. Most significantly, the report represents a paradigmatic shift in environmental governance—from reactive, fragmented responses to proactive, coordinated, and informed stewardship of Punjab's natural resources and ecological systems.

1.7 2025 at a Glance

The environmental governance landscape in Punjab experienced a marked transformation between 2024 and 2025, shifting from conventional, reactive enforcement towards a structured, technology-driven, and proactive regulatory framework. In 2024, environmental management predominantly depended on manual inspections, fragmented data systems, limited monitoring infrastructure, and delayed enforcement actions, which collectively hindered timely decision-making and diminished overall effectiveness. Interdepartmental coordination was comparatively weak, compliance verification processes were protracted, and public engagement mechanisms remained insufficiently integrated, resulting in persistent gaps in transparency and accountability.



In contrast, 2025 marked a transformative phase characterised by the integration of advanced IT infrastructure, real-time monitoring systems, and automated regulatory processes. Digital platforms such as online adjudication systems, environmental approval management systems, and centralised dashboards supplanted manual workflows, significantly enhancing efficiency, traceability, and responsiveness. Monitoring evolved from periodic inspections to continuous surveillance facilitated by AI-enabled CCTV systems, drone-based inspections, and real-time emissions tracking. The deployment of predictive tools, including advanced Air Quality Index (AQI) forecasting models, shifted the focus from reactive responses to proactive interventions, empowering authorities to anticipate and mitigate environmental risks in advance.

Institutionally, 2025 demonstrated strengthened governance through the implementation of structured accountability mechanisms, performance-based evaluations, ISO-certified quality management systems, and improved interdepartmental coordination. Enforcement capacities were notably enhanced by the establishment of a dedicated Environmental Protection Force and the adoption of zero-tolerance compliance policies. Furthermore, industrial

regulation, waste management, and resource conservation initiatives became more standardised, technology-enabled, and enforceable.

The findings presented in this report indicate that 2025 constituted a significant transition towards a mature, integrated, and data-driven environmental governance model, emphasising prevention, transparency, and sustainability. This conclusion is supported by evidence throughout the subsequent chapters, which include environmental data, regulatory outcomes, institutional performance reviews, and documented achievements.

1.8 Limitations and Implementation Challenges

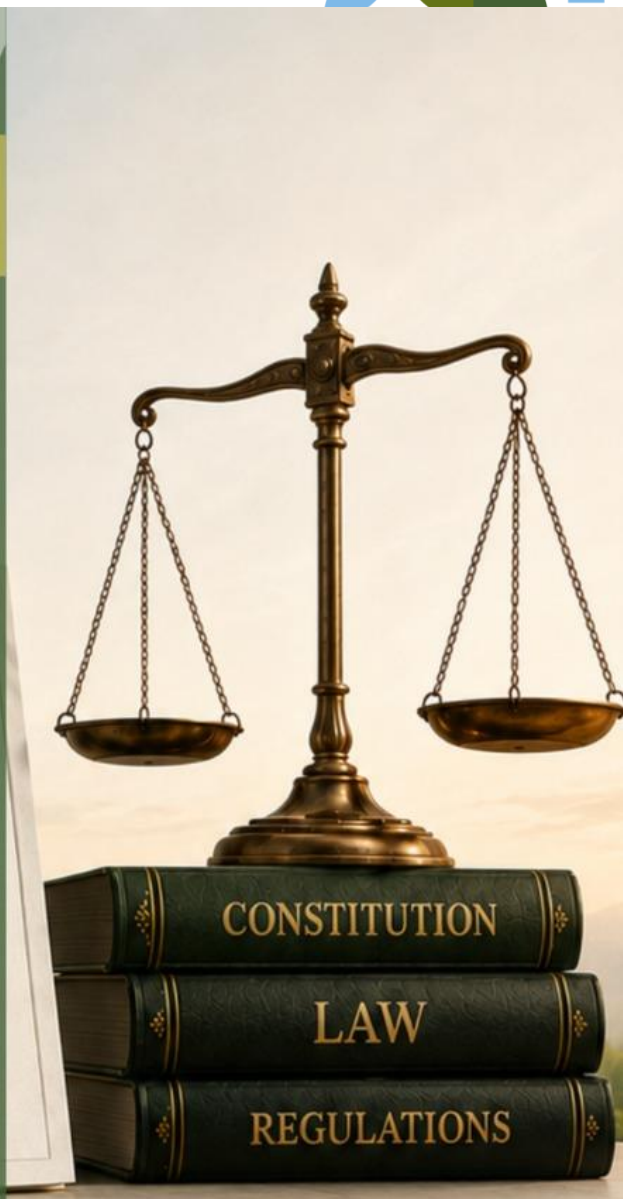
This report presents the most credible and comprehensive environmental overview of Punjab currently attainable through existing systems. It has been prepared with care, rigour, and a genuine commitment to accuracy. However, intellectual honesty necessitates clearly stating its limitations. Environmental monitoring networks are not yet uniformly established across all districts of the province, and data collection in certain areas remains irregular or incomplete. Critical environmental indicators—particularly those relating to groundwater quality, soil health, and biodiversity—lack consistent baseline data necessary to support reliable trend analyses. Where such data gaps exist, this report openly acknowledges them rather than relying on assumptions or estimations.

The challenges extend beyond data collection. Translating sound environmental policies into consistent, field-level outcomes remains a complex task. While interdepartmental coordination has improved, it is not yet seamless across all relevant institutions. Technical and human capacities at the district level continue to develop but have yet to reach sufficient maturity for fully integrated environmental management. Verifying compliance in remote or rapidly industrialising areas remains difficult. The rapid pace of urbanisation and industrial expansion in parts of Punjab continues to strain regulatory systems that are still adapting to meet increasing demand. These are not merely administrative deficiencies but structural challenges shaped by decades of underinvestment, demographic shifts, and the inherent complexity of governing a province as large and diverse as Punjab.

It is equally important to recognise the progress achieved. The institutional landscape in 2025 is markedly stronger than in previous years. Digital monitoring systems, real-time data platforms, and enhanced enforcement mechanisms have all contributed to greater transparency and responsiveness in environmental governance. Yet, advancements in some areas do not negate persistent gaps in others. EPA Punjab acknowledges both with equal candour. An honest appraisal of limitations is not a weakness but a prerequisite for improvement. This report is presented in that spirit. Future editions will endeavour systematically to narrow these gaps, enrich the evidence base, and develop a progressively more comprehensive and reliable account of Punjab's environmental condition.

CHAPTER 02

Regulatory Framework & Governance Paradigm





2.1 Statutory Mandate & Core Functional Framework

The Punjab Environmental Protection Act, 1997, provides the foundational legal framework for environmental governance within the province, establishing institutional authority, regulatory mechanisms, and enforcement powers essential for the protection, conservation, and enhancement of the environment. The Act aims to prevent and control pollution, regulate the use of hazardous substances, and promote sustainable development by integrating environmental considerations into planning and decision-making processes. It articulates a comprehensive framework encompassing policy oversight, regulatory authority, project-level environmental assessments, ongoing monitoring, and enforcement, thus enabling the provincial government to systematically address environmental challenges.

By delineating the roles and responsibilities of the Environmental Protection Council and the Punjab Environmental Protection Agency, the Act provides both strategic guidance and operational capacity, ensuring that environmental management is not only legally mandated but also practically enforceable. Over time, this legislation has underpinned the evolution of an institutional environmental governance framework in Punjab that harmonises environmental protection with economic and social development objectives, constituting a vital pillar of the province's environmental management and regulatory system.

2.2 Key Legal Provisions

Within this framework, the Punjab Environmental Protection Act, 1997, translates environmental objectives into enforceable legal provisions by explicitly delineating institutional roles, authorities, and accountability mechanisms. These statutory provisions enhance the Punjab Environmental Protection Agency's (EPA) implementation capacity by conferring legal authority for regulation, enforcement, monitoring, and interdepartmental coordination. By embedding compliance and enforcement mechanisms within the law, the Act empowers the EPA to undertake effective on-the-ground environmental management, thereby establishing a structured and legally binding governance regime aimed at pollution control and the promotion of sustainable development.

2.2.1 Establishment of Environmental Governance Bodies (Sections 3 & 5)

Section 3 of the Punjab Environmental Protection Act, 1997, establishes the Environmental Protection Council as the province's apex policy-making body. This Council provides strategic direction on environmental protection, approves policies, and sets priorities for sustainable development, serving as a platform for coordinated policy formulation and cross-sectoral oversight.

Section 5 of the Act concerns the establishment of the Provincial Environmental Protection Agency (EPA) as the principal executive authority responsible for administering and implementing the Act, along with associated rules and regulations. In conjunction with Sections 6 and 7, the legislation empowers the Provincial Agency to enforce environmental laws, monitor environmental quality and compliance with Punjab Environmental Quality Standards (PEQS), regulate activities with actual or potential environmental impacts, coordinate with government agencies, and initiate enforcement proceedings in cases of non-compliance. Collectively, these provisions constitute the policy-making and regulatory framework fundamental to effective environmental governance in Punjab.

The authority to delegate functions is granted under Section 5(5), empowering the Provincial Environmental Protection Agency to delegate any of its functions, by general or special order, to any other officer appointed under Section 5(3) of the Act.

2.2.2 Administrative and Standard Setting Provisions (Section 6 & 7)

Section 6 of the Punjab Environmental Protection Act (PEPA), 1997, defines the functions of the Provincial Agency and authorises EPA Punjab to administer and implement the provisions of the Act, along with the rules and regulations framed thereunder. The Section empowers the Provincial Agency to establish and enforce Punjab Environmental Quality Standards (PEQS), conduct environmental monitoring, inspections, investigations, and research, coordinate with

government agencies and local authorities, and promote measures for pollution control, environmental protection, and sustainable development. Furthermore, the Agency is authorised to publish environmental reports, certify laboratories, provide technical guidance, and facilitate environmental compliance across various sectors.

Section 7 of PEPA, 1997, confers regulatory and enforcement powers upon the Provincial Agency necessary for the effective implementation of the Act. This Section empowers EPA Punjab to conduct inquiries and investigations, obtain information and documents, enter and inspect premises in accordance with the law, collect and analyse samples, and initiate enforcement proceedings in cases of environmental violations. Additionally, it authorises the Provincial Agency to exercise regulatory oversight and take enforcement measures required to ensure compliance with PEQS, environmental laws, and associated rules and regulations promulgated under PEPA, 1997.

2.2.3. Core Functional Sections (Sections 12, 14, 15 & 16)

Sections 12, 14, 15, and 16 of the Punjab Environmental Protection Act (PEPA), 1997, constitute the operational backbone of EPA Punjab. Section 12 mandates that projects likely to cause adverse environmental effects undergo an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) and obtain prior approval, thereby ensuring preventive environmental regulation. Section 14 regulates hazardous substances by requiring prior approval for their handling, storage, transportation, and disposal to protect human health and the environment.

Section 15 addresses motor vehicle regulation, prohibiting the operation of vehicles that emit air pollutants or noise levels exceeding permissible Environmental Quality Standards. It empowers the Provincial Agency to implement measures such as mandating pollution control devices, maintenance protocols, and emission testing to ensure compliance, and prohibits the operation of vehicles that fail to meet emission limits.

Section 16 authorises the Agency to issue Environmental Protection Orders (EPOs) to enforce remedial actions, suspend operations, or mandate environmental restoration, providing a flexible administrative enforcement mechanism.

Collectively, these sections integrate environmental assessment, regulatory oversight, risk management, and enforcement, forming a comprehensive legal framework for environmental governance in Punjab.

2.2.4. Delegation and Rule Making Authority (Sections 31–33)

Sections 31 to 33 of the Punjab Environmental Protection Act (PEPA), 1997, empower the provincial government and the Environmental Protection Agency (EPA) Punjab to promulgate rules, regulations, and delegations necessary for effective implementation of the Act. Section 31 authorises the Government to formulate rules to fulfil the objectives of the Act. Section 32 provides the authority to amend the Schedule to the Act, allowing for updates and adaptations as required. Section 33 empowers the Provincial Agency to issue regulations that are consistent with the Act and the rules. Collectively, these provisions confer the necessary flexibility, technical capacity, and mechanism for coordinated governance throughout the province.

Category	Section	Body/Provision	Primary Function & Power
Governance & Institutions	**3**	**Environmental Protection Council**	**Policy & Strategy:** The apex body that sets the strategic direction and approves provincial environmental policies.
	5	**Punjab Environmental Protection Agency (EPA)**	**Executive Authority:** The main body responsible for implementing the Act, monitoring quality and enforcing laws.
Administration & Standards	**5(5)**	**Delegation of Powers**	**Administrative Efficiency:** Section 5(5) empowers the Director General of Provincial Environmental Protection Agency to delegate, through **general or special order**, any of the functions

			Provincial Agency to any other officer appointed under Section 5 (3) of the Act ibid.
	6	**Agency Functions, Establishment and enforcement of PEQS**	**Administration & Coordination:** Assigns functions to the Provincial Agency, including administration of the Act, establishment and enforcement of Punjab Environmental Quality Standards (PEQS), environmental monitoring, laboratory certification, coordination with relevant authorities and promotion of environmental awareness and research.
Core Operations & Regulation	**7**	**Regulatory and Enforcement Powers**	**Compliance & Enforcement:** Authorises the Provincial Agency to undertake inspections, obtain information, collect and analyse samples, conduct inquiries and initiate enforcement proceedings for implementation of the Act and rules
	12	**IEE & EIA Approvals**	**Prevention:** Section 12(1) mandates that no proponent shall commence construction or operation of a project likely to cause an adverse environmental effect unless an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA), as applicable, has been filed with and approved by the Provincial Agency.
	14	**Hazardous Substances**	**Risk Management:** Regulates the handling, storage and disposal of hazardous substances to prevent ecological damage.
	15	**Motor Vehicle Regulation**	**Pollution Control:** Prohibits vehicles exceeding noise/emission limits and mandates pollution control devices.
	16	**Environmental Protection Orders (EPO)**	**Enforcement:** Empowers the Provincial Agency to issue directions, including orders for closure, prohibition, regulation or

			suspension of operations, and to require remedial or corrective measures for protection, rehabilitation and improvement of the environment.
Legal Flexibility	**31-33**	**Rule-Making, Schedule Amendment & Regulations**	**Implementation:** Empowerment to the Government for making rules for carrying out the purposes of the Act (31). Authorisation to amend the Schedule to the Act (32), while Section 33 empowers the Provincial Agency to make regulations consistent with the Act and rules.

Table 2. 1: Summary of Key Sections: PEPA 1997

2.3. Rules and Regulations Notified under PEPA, 1997

Under the Punjab Environmental Protection Act, 1997, the Government of Punjab has promulgated various rules and regulations to safeguard the environment, control pollution, and promote sustainable development within the province. These legal instruments establish the regulatory framework for overseeing industrial activities, managing waste, controlling air, water, and noise pollution, and ensuring compliance with prescribed environmental quality standards. They guide the Environmental Protection Agency (EPA) Punjab in conducting inspections, monitoring activities, enforcement actions, and data collection, thus enabling consistent and effective implementation of the Act and its subsidiary regulations throughout the province. The major rules and regulations enacted under this legislative framework, which collectively form the operational foundation of environmental governance in Punjab, are detailed below.

2.3.1. Punjab Environmental Protection (Smog Prevention and Control) Rules 2023

Parent provision: The Punjab Environmental Protection (Smog Prevention and Control) Rules 2023, promulgated under Section 31 of the Punjab Environmental Protection Act, 1997, prescribe regulatory and operational requirements for

industries, brick kilns, resource recovery units, and vehicles to control and mitigate emissions contributing to ambient air pollution. The rules explicitly prohibit the open burning of waste, crop residues, and other pollutants, and impose administrative penalties for non-compliance. These measures aim to prevent and control air pollution and to safeguard public health.

Regulatory Significance: The Punjab Environmental Protection (Smog Prevention and Control) Rules 2023 aim to improve air quality by reducing emissions from industries, vehicles, and brick kilns, while prohibiting the open burning of crop residues, waste, and other pollutants. These rules serve to protect public health broadly, promote cleaner industrial and transportation practices, and enforce accountability through administrative penalties for non-compliance, thereby fostering a healthier and more sustainable environment. Reports from the current year indicate a general improvement in air quality across Lahore and other regions of Punjab, reflecting the positive outcomes of these regulatory measures.

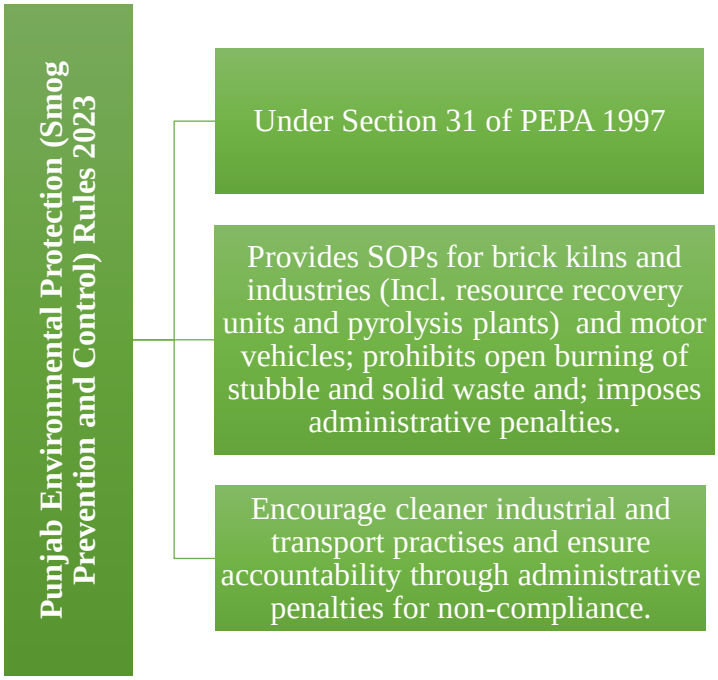
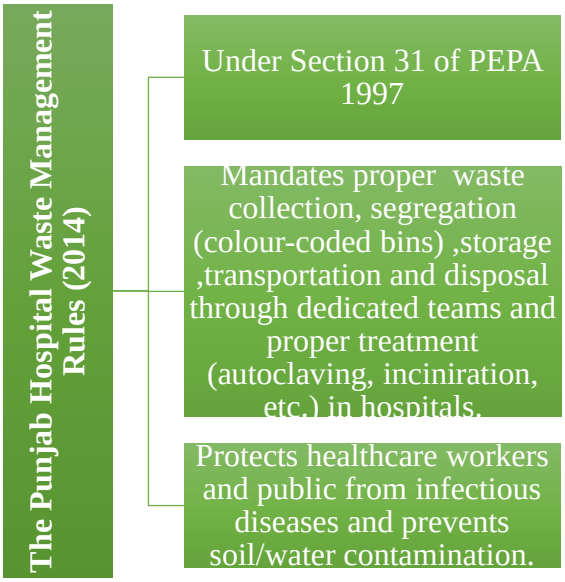


Figure 2.1: Overview of the Punjab Environmental Protection (Smog Prevention and Control) Rules 2023

2.3.2 The Punjab Hospital Waste Management Rules, 2014

Formulated under Section 31 of the Punjab Environmental Protection Act, 1997, the Punjab Hospital Waste Management Rules, 2014, mandate that every healthcare facility develop and implement a Hospital Waste Management Plan. Facilities are required to establish dedicated waste management teams and ensure the proper segregation, collection, storage, transportation, treatment, and disposal of hospital waste in accordance with prescribed procedures. These Rules provide a regulatory framework for the environmentally sound management of infectious and hazardous healthcare waste, aiming to minimise environmental contamination, protect public health, and ensure the safe handling of hazardous medical materials.

Regulatory Significance: The Punjab Hospital Waste Management Rules, 2014, establish a comprehensive legal and operational framework for the safe management of hospital waste across healthcare facilities in the province. These Rules aim to protect healthcare workers, patients, and the general public from exposure to infectious and hazardous waste, reduce contamination of soil, air, and water resources, and reinforce environmental and public health safeguards through mandatory waste segregation, treatment, and disposal procedures. By delineating institutional responsibilities and compliance requirements, the Rules



also strengthen regulatory oversight and promote environmentally responsible healthcare waste management practices.

2.3.3. The Punjab Environmental Protection (Motor Vehicles) Rules, 2013

Formulated under Section 31 of the Punjab Environmental Protection Act, 1997, the Punjab Environmental Protection (Motor Vehicles) Rules, 2013, prohibit the operation of motor vehicles that emit air pollutants or noise levels exceeding the prescribed Punjab Environmental Quality Standards (PEQS). These Rules authorise officers of the Punjab Environmental Protection Agency (EPA) and other designated authorities to inspect motor vehicles, conduct emissions and noise testing, and initiate enforcement proceedings against non-compliant vehicles in accordance with established legal procedures. The Rules provide a regulatory

Figure 2.2: Overview of the Punjab Hospital Waste Management Rules (2014)

framework for the monitoring of vehicular emissions and ensure compliance with environmental standards aimed at preventing and controlling air and noise pollution.

Regulatory Significance: The Punjab Environmental Protection (Motor Vehicles) Rules, 2013, establish a statutory mechanism for controlling vehicular air and noise pollution through inspection, monitoring, and enforcement measures. By prescribing emission and noise limits and enabling comprehensive regulatory oversight of motor vehicles, the Rules contribute to the safeguarding of ambient air quality, public health, and the environment. Additionally, they promote compliance with environmental standards through periodic inspections and emissions testing, thereby fostering environmentally responsible transport practices and reinforcing the enforcement mandate of the Punjab Environmental Protection Agency under the Act and associated regulations.

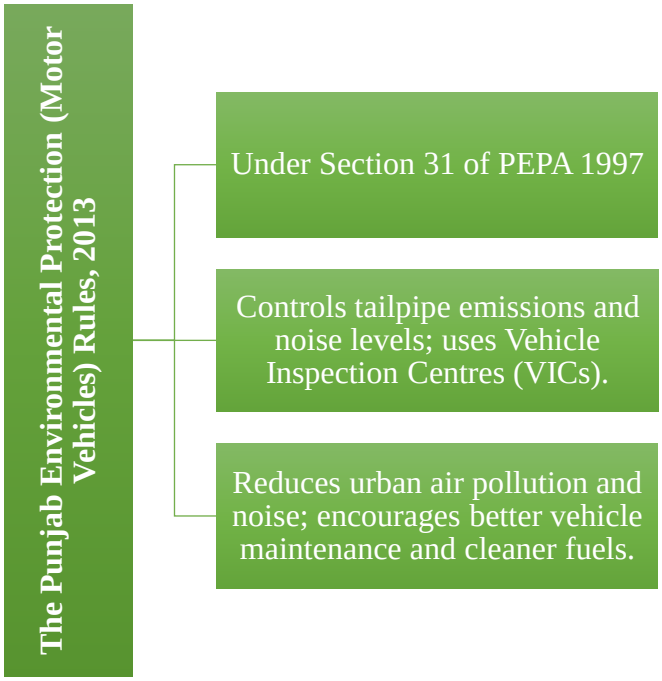


Figure 2.3: Overview of the Punjab Environmental Protection (Motor Vehicles) Rules, 2013

2.3.4 The Punjab Bio-Safety Rules, 2014

Formulated under Section 31 of the Punjab Environmental Protection Act (PEPA), 1997, these Rules regulate the handling, risk assessment, approval, and monitoring of genetically modified organisms (GMOs) and related biological materials. The Rules establish institutional biosafety oversight mechanisms and committees tasked with evaluating and managing potential biosafety risks associated with research, handling, commercial applications, and industrial usage of such organisms and materials. Furthermore, the Rules aim to ensure biosafety compliance, safeguard human health and the environment, and enforce adherence to prescribed regulatory standards.

Regulatory Significance: The Punjab Biosafety Rules, 2014, establish a regulatory framework for the handling, use, transport, storage, and management of Genetically Modified Organisms (GMOs) and hazardous biological materials. These Rules are designed to protect human health and the environment by regulating potential biosafety risks arising from misuse, accidental release, or unauthorised handling of such materials. They prescribe rigorous risk

assessment, containment, and laboratory safety measures for research, industrial, and commercial applications. Additionally, the Rules mandate the establishment of biosafety committees and institutional oversight mechanisms to ensure monitoring and compliance with regulatory requirements. These provisions also facilitate responsible scientific research and technological development within the bounds of prescribed biosafety and environmental safeguards.

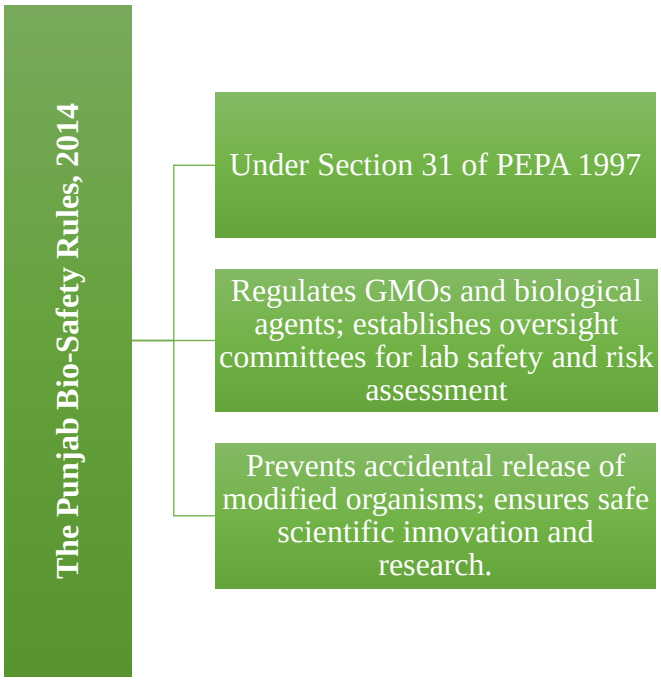


Figure 2.4: Overview of the Punjab Bio-Safety Rules, 2014

2.3.5 The Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Product) Regulations, 2023

Formulated under Section 33 of the Punjab Environmental Protection Act, 1997, the Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Products) Regulations, 2023, establish a regulatory framework governing the production, sale, distribution, and use of specified single-use plastic products within the province. These Regulations prohibit the manufacture, import, sale, supply, and commercial use of designated single-use plastic items, including

cotton bud sticks, balloon sticks, disposable cutlery, and other specified products. Furthermore, the Regulations mandate the online registration of producers, importers, brand owners, distributors, collectors, recyclers, and bulk consumers. To facilitate coordination, monitoring, and enforcement at the district level, District Plastic Management Committees are established as part of the regulatory framework.

Regulatory significance: The Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Products) Regulations, 2023, establish a statutory mechanism aimed at reducing plastic pollution and promoting environmentally sound waste management practices across the province. By restricting the production and consumption of designated single-use plastic products, the Regulations seek to minimise the accumulation of non-biodegradable waste in urban areas, water bodies, and agricultural lands, thereby safeguarding the environment and public health.

The Regulations further encourage the collection, segregation, recycling, and responsible management of plastic waste through registration, monitoring, and compliance obligations imposed on relevant stakeholders. Moreover, the regulatory framework promotes the adoption of sustainable and environmentally friendly alternatives to single-use plastics and reinforces institutional enforcement capabilities through inspections, monitoring, and regulatory actions in accordance with the Act and associated regulations.

Collectively, these measures advance sustainable environmental governance and contribute to the reduction of plastic-related environmental degradation within the province.

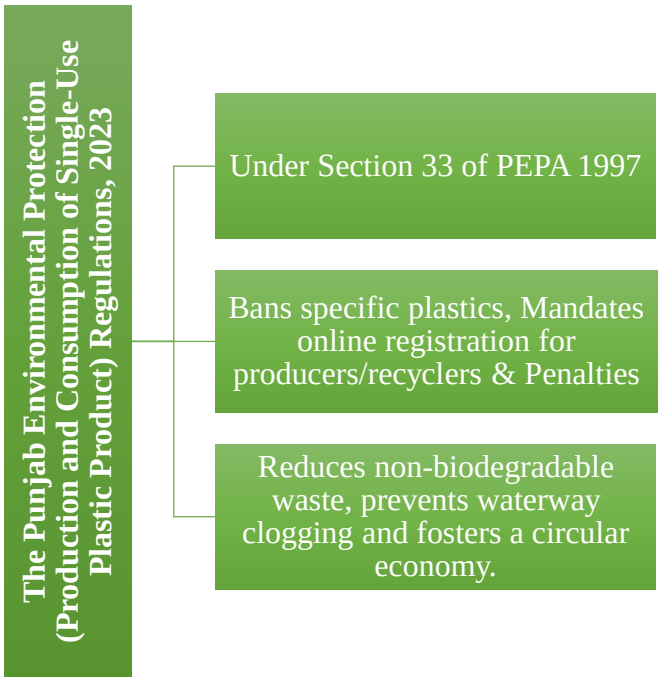


Figure 2.5: Overview of the Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Product) Regulations, 2023

2.3.6. The Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations 2022

Parent Provision: Section 33 of the Punjab Environmental Protection Act, 1997, empowers the Punjab Environmental Protection Agency (EPA) to promulgate regulations, consistent with the Act and associated rules, to fulfil the objectives of the legislation.

The Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2022, establish a procedural and regulatory framework governing the review and approval of Initial Environmental Examinations (IEEs) and Environmental Impact Assessments (EIAs) for scheduled development projects. Under these Regulations, project proponents within the prescribed categories are required to submit an IEE or EIA, as appropriate, prior to commencing construction or operation and before

obtaining any relevant approvals where applicable. The Regulations detail procedures concerning submission, scrutiny, public participation, review timelines, issuance or denial of approvals, and adherence to environmental management and mitigation measures.

This regulatory framework is designed to ensure that potential adverse environmental impacts of proposed projects are effectively identified, assessed, and mitigated in compliance with the requirements of the Act and the regulations promulgated thereunder.

Regulatory Significance: The Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2022, provide a legally structured environmental assessment framework for infrastructure, industrial, and other development projects within the province. By mandating the review of Initial Environmental Examinations (IEEs) and Environmental Impact Assessments (EIAs), the Regulations enable the Punjab Environmental Protection Agency (EPA) to evaluate potential environmental impacts during the planning phase and ensure the integration of appropriate mitigation and environmental management measures before project implementation. Furthermore, the Regulations reinforce environmental decision-making through prescribed processes for technical review, public participation, and post-approval compliance monitoring, thereby fostering sustainable development and environmental protection in alignment with the objectives of the Punjab Environmental Protection Act.

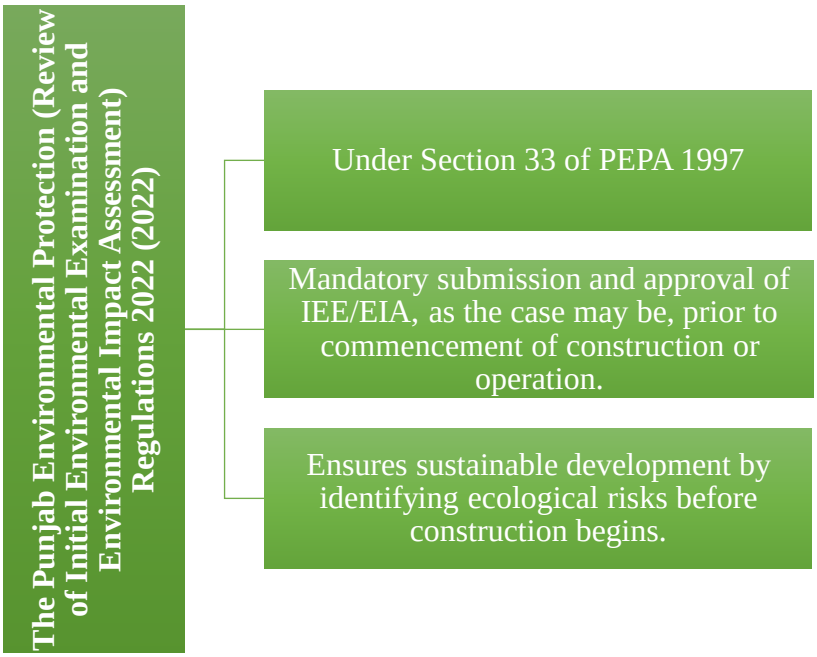


Figure 2.6: Overview of the Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations 2022

2.3.7. Punjab Environmental Quality Standards: Legislative Overview

The Punjab Environmental Quality Standards (PEQS) are the legally mandated environmental quality benchmarks established under the Punjab Environmental Protection Act, 1997 (PEPA). Pursuant to Sections 6(1)(e), 6(1)(f), and 6(1)(g) of PEPA, 1997, the Punjab Environmental Protection Agency (EPA) is authorised to develop, establish, and enforce PEQS governing the discharge or emission of effluents, wastes, air pollutants, noise, and standards for ambient air, water, and land quality, subject to the approval of the Punjab Environmental Protection Council where stipulated by the Act. These standards set the permissible limits aimed at preventing and controlling pollution within the province.

To date, seven sets of Punjab Environmental Quality Standards have been notified under PEPA, addressing various environmental media, emissions, and regulated activities, namely:

Sr. No.	Title of Standards	Notified On	Key Parameters
1	**Punjab Environmental Quality Standards for Ambient Air**	12th of August. 2016	Nine key parameters to track air pollution
2	**Punjab Environmental Quality Standards for Drinking Water**	12th of August. 2016	Thirty seven parameters across biological, physical, chemical, organic and radioactive categories.
3	**Punjab Environmental Quality Standards for Municipal and Liquid Industrial Effluents**	12th of August, 2016	Thirty two parameters with specific standards for different discharge destinations, expanded in 2024 to include textile, leather/tannery, sugar, paper/pulp, ethanol/distillery and chemical industries.
4	**Punjab Environmental Quality Standards for Motor Vehicle Exhaust and Noise**	12th of August, 2016	Two exhaust parameters: (a) smoke opacity/Ringelmann number (diesel vehicles); (b) CO and HC concentrations (petrol vehicles). State applicable noise limits by vehicle category (e.g., 85 dB(A) for heavy vehicles). Cross-reference PEQS notification date (12.08.2016) and prescribed vehicle noise limits, enforceable under the Act.
5	**Punjab Environmental Quality Standards for Noise**	12th of August, 2016	Prescribed Limits for residential, commercial, industrial and "silence" zones, with separate day and night values.
6	**Punjab Environmental Quality Standards for Treatment of Liquid and Disposal of Bio-medical Waste by Incineration, Autoclaving, Microwaving and Deep Burial**	12th of August, 2016	Standards Governing treatment and disposal, by incineration, autoclaving, microwaving and deep burial.
7	**Punjab Environmental Quality Standards for Industrial Gaseous Emissions**	12th of August, 2016	Sixteen parameters for emissions from factory stacks, with additional sector-specific standards introduced in 2024.

Table 2.2: Punjab Environmental Quality Standards

EPA Punjab ensures compliance with environmental regulations through rigorous inspection, monitoring, and enforcement actions exercised under its statutory authority. The Agency is empowered to impose administrative penalties in accordance with the Punjab Environmental Protection (Administrative Penalty)

Rules, 2013. Judicial matters, including offences and appeals arising under environmental laws, are adjudicated by the Punjab Environmental Tribunal. This integrated system combines executive enforcement with judicial oversight, thereby upholding the Punjab Environmental Quality Standards (PEQS) throughout the province.

2.4 Environmental Adjudication and Tribunal Framework in Punjab

2.4.1 Punjab Environmental Tribunal

The Punjab Environmental Tribunal is a specialised judicial body established under Section 20 of the Punjab Environmental Protection Act (PEPA), 1997. Following devolution to the province through the 18th Constitutional Amendment, the Tribunal was adapted for Punjab via the Punjab Environmental Protection (Amendment) Act, 2012. The Government of Punjab is authorised to establish multiple Tribunals as necessary, through Gazette notifications that define the territorial jurisdiction or categories of cases for each tribunal. The Tribunal operates under the procedural framework of the Punjab Environmental Tribunal Rules, 2012.

The Environmental Tribunal comprises a Chairperson and two Members, one of whom must have technical or scientific expertise. A quorum for Tribunal proceedings is constituted by the presence of the Chairperson and at least one Member. Decisions are rendered by majority vote.

2.4.2 Functions of the Punjab Environmental Tribunal

The Punjab Environmental Tribunal (PET) exercises exclusive jurisdiction over all matters arising under the Punjab Environmental Protection Act (PEPA), with its proceedings carrying the full legal weight of judicial actions under the Pakistan Penal Code and the Code of Criminal Procedure, thereby rendering it legally equivalent to a court of law. Complaints may be lodged before the Tribunal by the Punjab Environmental Protection Agency (EPA), other authorised bodies, or aggrieved individuals concerning violations such as unlawful discharge of effluents, excessive emissions, mishandling of hazardous substances, and non-compliance with Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) approvals. The Tribunal also possesses the authority to impose

compensatory costs of up to Rs. 100,000 against complainants found to have submitted false or vexatious claims.

Beyond adjudication, the PET fulfils a broader enforcement function by directing government departments to ensure compliance with IEE and EIA requirements. It operates as the judicial arm of Punjab's environmental governance system, functioning alongside the Punjab Environmental Protection Council (the apex policy-making body) and the Punjab EPA (the regulatory authority). Together, these institutions constitute a comprehensive system of checks and balances underpinning environmental management across the province.

2.4.3 Progress of PET throughout the Year 2025

The Punjab Environmental Tribunal maintained an active judicial calendar throughout 2025, addressing two primary categories of cases: Departmental Complaints and Environmental Appeals. The following provides a general overview of the Tribunal's performance, based on the official statement covering the period from 1 January 2025 to 31 December 2025.

i. Departmental Complaints

The Punjab Environmental Protection Agency (EPA) actively initiates and pursues departmental complaints before the Punjab Environmental Tribunal to enforce compliance with environmental regulations. These complaints predominantly address violations of mandatory Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) requirements, exemplifying the Agency's proactive enforcement role.

At the beginning of 2025, there were 49 pending cases. During the year, 288 new complaints were filed, bringing the total caseload to 337. Of these, 327 complaints were resolved by 31 December 2025, leaving a balance of only 10 pending cases. A total of Rs. 14,585,000 in fines was imposed across 299 cases for violations of Section 12 of PEPA, 1997, reflecting vigorous enforcement of environmental standards related to IEE/EIA compliance.

Among the remaining 28 cases, 5 resulted in acquittals, 4 were dismissed, 11 were resolved through other final orders, 2 were abated, and 2 were filed for record. Additionally, 4 cases remain pending due to sine die adjournments.

ii. Environmental Appeals

Under the provisions of the Punjab Environmental Protection Act, 1997, aggrieved proponents and members of the public may file appeals before the Punjab Environmental Tribunal challenging enforcement actions taken by the Punjab Environmental Protection Agency (EPA). These appeals commonly contest penalties, Environmental Protection Orders (EPOs), and enforcement measures enacted under the Smog Rules, thereby exercising legal rights and ensuring transparency and accountability in environmental regulation.

The year commenced with 236 pending appeals. Throughout 2025, 624 new appeals were instituted, bringing the total caseload to 860. Of these, 747 appeals were resolved, leaving 113 outstanding at year-end. Notably, 609 of the disposed appeals pertained to cases filed under the Smog Rules 2023, while 46 related to appeals against EPO violations under various provisions of PEPA 1997, indicating that smog-related enforcement constituted a predominant focus during the period.

Overall, these data illustrate that the Punjab Environmental Tribunal maintained a high level of activity throughout 2025, successfully disposing of the vast majority of cases within both categories. The imposition of fines through departmental complaints further underscores the meaningful financial accountability enforced for environmental violations.

2.5 Specialised Units

In recognition of the increasing complexity and technical demands of environmental enforcement, EPA Punjab has established a series of specialised units that substantially extend the Agency's operational capacity beyond traditional regulatory functions. These units integrate expertise in strategic analysis, information technology, and aerial surveillance to form a multifaceted enforcement and intelligence architecture. Collectively, they equip EPA Punjab

with the tools, data, and situational awareness required to address environmental violations with enhanced precision, agility, and strategic foresight.

2.5.2.1. Strategic and Analysis Wing (SAW), EPA Punjab

The Strategic and Analysis Wing (SAW) functions as the analytical core of EPA Punjab's operational framework. Situated at the nexus of data, strategy, and enforcement, SAW provides leadership with the strategic insights essential to transition from reactive measures to a proactive, evidence-driven model of environmental governance. This approach enables the Agency to address Punjab's increasingly complex pollution challenges with institutional precision and foresight.

i. Performance Evaluation and Data Analysis

The Strategic and Analysis Wing's (SAW) foundational mandate involves the systematic collection and analysis of environmental data from various divisions of EPA Punjab, including field offices, EPA laboratories across the province, and different sections within EPA Headquarters. Additionally, SAW incorporates data from external sources such as field inspections, industrial compliance reports, air quality sensors, and satellite imagery. This wealth of information is synthesised into clear, accessible insights that empower EPA leadership to make well-informed decisions.

These analyses enable EPA Punjab to pinpoint pollution hotspots with spatial accuracy, monitor enforcement trends over time, prepare comprehensive situational assessments, and anticipate emerging environmental risks before they escalate into crises.

Among SAW's most notable achievements in 2025 was the production of a comprehensive, data-driven report that provided compelling scientific justification for replacing the traditional Site Inspection Report (SIR) with a more robust, analytically based monitoring mechanism. This marked a decisive advancement towards evidence-based environmental enforcement. Building on this success, SAW developed and launched an interactive Internal Accountability

Dashboard (IAD), formally acknowledged as a key instrument of institutional transparency and mature data governance within EPA Punjab.

Moreover, SAW forged a landmark inter-organisational collaboration with the Punjab Safe Cities Authority (PSCA), which established, for the first time, a dedicated environmental monitoring desk in coordination with EPA Punjab. This milestone signifies the expanding institutional influence of SAW beyond EPA's internal operations, integrating environmental data governance into broader provincial governance frameworks.

ii. Execution of New Initiatives and Operational Horizons

The Strategic and Analysis Wing (SAW) leads the conceptualisation and implementation of landmark programmes that push EPA Punjab into new operational frontiers. Among SAW's most significant contributions is the Air Quality Index (AQI) Forecasting System, which delivers real-time and predictive air quality monitoring in Lahore, equipping policymakers and the public with timely information to facilitate informed decision-making. The Emission Testing System (ETS) enhances EPA Punjab's capacity to accurately measure and regulate vehicle emissions. Employing scientific methodologies and reliable instrumentation, ETS ensures that vehicles comply with environmental standards, thereby aiding in the reduction of air pollution and enforcing accountability among vehicle owners.

Anti-Smog Gun operations coordinate enforcement activities in Lahore during periods of anticipated sharp rises in air pollution. These efforts involve surveillance of pollution sources, enforcement of environmental regulations, and timely interventions to safeguard public health, particularly for vulnerable populations such as children, the elderly, and individuals with respiratory conditions. Similarly, Anti-Stubble Burning Operations undertake ground-level actions to mitigate crop residue burning in agricultural areas. Complementary to these initiatives are specialised sand trolley squads targeting dust emissions from construction transport.

Through these multifaceted domains, SAW has effectively transformed the Provincial Environmental Protection Agency into a truly strategic environmental regulatory authority—one that governs with foresight, precision, and institutional confidence.

2.5.2.2. IT Support Unit

The IT Support Unit functions as the digital backbone of the Environmental Protection Agency (EPA) Punjab, advancing the agency's mission through technology across three pivotal domains: internal efficiency, regulatory oversight, and citizen empowerment. By integrating modern digital tools into all aspects of its operations, EPA Punjab ensures that environmental governance is not only effective but also transparent and accessible to all stakeholders.

i. Internal Efficiency

On the internal front, the IT Support Unit administers an array of digital tools designed to optimise administrative and operational processes throughout the agency. The Internal Accountability Dashboard (IAD) fosters transparency and accountability across departments, while the E-Pay Integration system streamlines the imposition and collection of environmental fines via a secure digital payment platform. The E-Biz System facilitates core business functions, and an Inventory Dashboard enables efficient tracking of assets and resources. Collectively, these tools reduce reliance on paperwork, enhance interdepartmental coordination, and enable EPA Punjab's personnel to focus more effectively on the agency's primary mandate: environmental protection.

ii. Regulatory Oversight

For regulatory oversight, the IT Support Unit underpins a comprehensive suite of monitoring and enforcement systems that bolster EPA Punjab's capacity to regulate industries and track environmental conditions throughout the province. The Unique Identification (UID) and E-Mapping system facilitates detailed industrial baselining by digitally cataloguing and mapping operational industries across Punjab, providing regulators with an accurate and current overview of the industrial landscape. The Private Laboratory Portal enables the verification of

environmental testing data submitted by accredited laboratories, safeguarding the integrity of compliance reporting.

The Air Quality Monitoring System (AQMS) continuously monitors ambient air quality at key sites in Punjab and disseminates real-time data via its dedicated public platform (aqi.punjab.gov.pk), making environmental information accessible to both regulatory authorities and the general public. Augmenting this capability, the AQI Hourly Forecasting system delivers predictive air quality updates, thereby supporting proactive regulatory decision-making.

Eco Watch streamlines and coordinates field operations, empowering ground teams to efficiently document and report environmental violations. Complementing these tools, the Live Plastic Confiscation Tracking System provides real-time oversight of plastic seizure operations across the province, enhancing supervisory control, operational transparency, and data-driven enforcement coordination amid Punjab's ongoing crackdown on illegal plastic use.

Collectively, these integrated systems extend EPA Punjab's regulatory reach well beyond conventional inspection methods, enabling faster, data-driven, and more effective environmental enforcement.

iii. Citizen Empowerment

Recognising that environmental protection is a shared responsibility, the IT Support Unit has developed several accessible platforms to engage citizens and foster public trust in EPA Punjab's operations. The Plastic QR system facilitates public traceability of plastic waste, thereby promoting accountability across the plastic supply chain. The 1373 Helpline offers citizens a direct and convenient channel to report environmental concerns and receive prompt feedback from the Agency. The E-Library provides the public and relevant stakeholders with easy access to environmental legislation, guidelines, research, and educational resources, enhancing environmental awareness.

The Confirmation of Compliance tool enables regulated entities to transparently verify and demonstrate their compliance status. Additionally, the Eco Chatbot

delivers instant, round-the-clock assistance to citizens navigating EPA Punjab's digital services, ensuring support is readily available.

Collectively, these systems illustrate EPA Punjab's commitment to establishing itself as a digitally empowered institution—one capable of efficient internal management, real-time environmental monitoring, proactive enforcement, and meaningful, ongoing public engagement throughout the province.

2.5.2.3. Drone Surveillance Unit

The Drone Surveillance Unit represents one of the most transformative innovations within EPA Punjab's enforcement framework, utilising thermal drones to detect, document, and deter environmental violations—particularly in remote or expansive areas where ground inspections face logistical constraints.

EPA Punjab employs the DJI Mavic 3T, a professional-grade thermal drone equipped with a wide-angle 4/3 CMOS visual camera and a high-sensitivity infrared thermal sensor, enabling simultaneous optical and thermal imaging. With a flight endurance of 45 minutes, a transmission range of up to 15 kilometres, and wind resistance of up to 12 m/s, the drone is optimally designed for sustained field reconnaissance. Its thermal imaging capabilities are especially effective in identifying heat-emitting industrial violations, illegal burn sites, and effluent discharge anomalies that are undetectable by conventional cameras.

These advanced assets are deployed across industrial zones, brick kiln clusters, waste disposal sites, agricultural burn areas, and riverbanks, capturing real-time visual and thermal data over extensive geographical territories with unparalleled detail. The aerial presence of the unit also serves a significant deterrent role, discouraging non-compliance without necessitating a commensurate increase in field personnel. Furthermore, drone surveys of flood-affected zones and industrial accident sites provide rapid situational awareness, supporting both immediate emergency response and informed long-term remediation planning.

2.5.2.3.1 Hawk Eye Surveillance Squad

Complementing the drone-based aerial operations, EPA Punjab's Hawk Eye Surveillance Squad provides a fixed, continuous, and wide-area environmental

monitoring capability. Unlike drone deployments, which are mission-specific and time-limited, Hawk Eye functions as a persistent surveillance network, delivering uninterrupted visual monitoring of high-risk environmental zones, including industrial clusters, brick kiln belts, and major waste disposal sites. This system enables EPA Punjab to remotely observe, record, and flag environmental violations in real time, thereby significantly reducing reliance on physical field presence while maintaining round-the-clock oversight.

By streaming live footage and alerts directly into EPA Punjab's centralised monitoring framework, Hawk Eye enhances the continuity of environmental surveillance and ensures that enforcement actions are initiated based on verified, real-time evidence rather than solely on periodic inspections. Together, the Drone Surveillance Unit and Hawk Eye Surveillance System embody EPA Punjab's commitment to developing a technologically advanced, data-driven enforcement apparatus, which has been a defining feature of the Agency's broader governance transformation by 2025.

2.6 Governance Shift Observed by 2025

EPA Punjab exhibited a clear and discernible evolution in its approach to environmental regulation in 2025. This transformation was gradual, shaped by mounting environmental challenges, heightened public awareness, increased judicial oversight, and growing expectations that environmental protection must be integrated into development processes rather than relegated to an afterthought. The Agency's governance strategy has matured in tandem with broader institutional reforms and sustainable development paradigms, marking a definitive shift away from ad hoc interventions towards more systematic, anticipatory regulatory frameworks.

From Reactive to Preventive Governance: EPA Punjab has transitioned from crisis-driven reactive measures to structured, forward-looking planning. The introduction of an Air Quality Index (AQI) Forecasting Calendar allows for the prediction of periods of poor air quality well in advance, facilitating the strategic allocation of enforcement resources and timely dissemination of public

advisories. Pre-smog season assessments of major districts enable the identification of high-risk industrial zones, brick kiln clusters, and stubble-burning areas prior to the onset of the season.

Advanced monitoring systems—including real-time sensors and predictive modelling—support continuous tracking of emissions, while an inspector-less inspection mechanism at the Smog Control Room provides round-the-clock surveillance of industrial chimneys. Digital dashboards enhance accountability and support data-driven decision-making throughout the enforcement process.

From Manual to Digital Administration: EPA Punjab has transitioned from paper-based, in-person regulatory procedures to a fully digital workflow through the Environmental Assessment Management System (EAMS) and e-FOAS. Project proponents now submit Initial Environmental Examinations (IEEs), Environmental Impact Assessments (EIAs), and compliance documentation online, while permits, compliance certificates, and Environmental Protection Orders are issued and tracked digitally in real time. This transformation has substantially enhanced efficiency, transparency, and regulatory oversight throughout the province.

From Siloed to Coordinated Governance: EPA Punjab has moved beyond institutional isolation by actively collaborating with key provincial entities, including planning departments, local governments, health and industry departments, the Agriculture Department, Punjab Disaster Management Authority (PDMA), Traffic Police, the Transport Department, and the Punjab Safe Cities Authority. This interdepartmental coordination aligns environmental regulation with public health imperatives, sustainable development goals, and real-time urban surveillance, thereby enabling a more integrated and effective regulatory response.

Transitioning to Evidence-Based Environmental Stewardship: EPA Punjab has progressively transitioned from complaint-driven, manual enforcement towards a model driven by scientific data, aerial surveillance, satellite imagery, digital inspection tools, and centralised data capture systems. This evidence-based approach empowers the Agency to anticipate environmental risks, detect

pollution trends, prioritise high-risk activities, and ensure enforcement decisions are grounded in verified, real-time empirical evidence, rather than isolated field reports alone.

2.7 Conclusion

Punjab's environmental governance framework, anchored in the Punjab Environmental Protection Act, 1997, provides a comprehensive legal and institutional foundation for regulation, enforcement, and sustainable development. This framework is underpinned by key provisions relating to environmental standards, impact assessments, hazardous substances, and compliance mechanisms, complemented by targeted rules on plastics, smog control, biosafety, hospital waste, and vehicle emissions that facilitate practical implementation through rigorous monitoring and enforcement. Over time, the system has evolved from a reactive, siloed approach to a preventive, digital, coordinated, and evidence-based model. This transformation is driven by tools such as the Environmental Assessment Management System (EAMS), e-FOAS, smart monitoring technologies, and enhanced interdepartmental collaboration, collectively enhancing transparency, efficiency, and accountability. Consequently, this evolution enables proactive risk management and fosters better integration of environmental protection with public health and sustainable development priorities.

CHAPTER 03

Judicial Oversight and Institutional Support in Environmental Governance



(This section is based on proceedings in Writ Petition No. 227807/2018, Haroon Farooq vs. Government of Punjab etc., adjudicated and monitored by the Lahore High Court during the period 2018–2025.)

Writ Petition No. 227807/2018
Haroon Farooq vs. Government of Punjab etc.

The Lahore High Court has been seized of Writ Petition No. 227807/2018, titled Haroon Farooq vs. Government of Punjab etc., since 2018. Over the ensuing years, these proceedings have evolved into one of the most consequential and comprehensive judicial interventions in the history of environmental governance in Punjab. The Honourable Court, through the Judicial Water and Environmental Commission constituted in connection with this case, has continuously monitored environmental compliance, issued directives to governmental departments, overseen the enforcement of environmental legislation, and supported the Environmental Protection Agency (EPA) Punjab and the Environment Protection & Climate Change Department (EP&CCD) in their efforts to control smog, air pollution, industrial emissions, vehicular pollution, water conservation, waste management, urban greening, and the protection of natural resources.

This chapter provides a sector-wise account of the judicial interventions and directions issued by the Honourable Court from the inception of the petition through 2025. The orders reproduced and summarised herein are drawn directly from the proceedings and reflect the breadth and depth of the Court's engagement with the environmental challenges confronting Punjab, with particular focus on the city of Lahore.

3.1 Judicial Water and Environmental Commission

The Honourable Court constituted the Judicial Water and Environmental Commission on 31 October 2019 as part of these proceedings. The Commission was entrusted with monitoring environmental compliance, conducting inspections, coordinating with relevant departments, and submitting comprehensive reports to the Court. Over the years, the Commission members have provided detailed reports addressing a wide array of environmental issues,

including smog control, industrial emissions, vehicular pollution, groundwater depletion, tree plantation, waste management, traffic congestion, urban planning, brick kiln conversion, water recycling, and compliance with environmental requirements in development projects.

The Honourable Court has consistently commended the Commission's efforts and directed all departments and authorities to offer full cooperation to support the implementation of environmental measures. The Commission has convened regularly, engaged with pertinent government agencies, and served as the principal mechanism through which the Court has supervised adherence to its directives.

In its order dated 3 May 2024, the Court clarified that all actions undertaken by the Judicial Water and Environmental Commission are executed under the Court's directives, with hearings conducted every Friday under the Court's constitutional jurisdiction. Furthermore, the Court directed the Environmental Tribunal to refrain from intervening in these matters, as they pertain to broader issues of public interest currently being overseen by the Court through the Commission established pursuant to its constitutional orders.

Note: "The constitutional jurisdiction exercised by the Hon'ble Lahore High Court in writ proceedings is vested under Article 199 of the Constitution of the Islamic Republic of Pakistan, 1973."

In its order dated 14 February 2025, the Court directed that the names of the Members of the Judicial Water and Environmental Commission be submitted by the Awards Recommending Committee for the conferment of suitable civil awards in recognition of the most meritorious and distinguished services rendered by these Members. Subsequently, by letter dated 6 March 2025, the names of the Commission Members were recommended for civil awards, with the letter forwarded to the Secretary of Industries and Commerce, Government of Punjab.

3.2 Smog Control and Anti-Smog Measures

The Honourable Court has played a pivotal role in shaping Punjab's anti-smog governance framework by issuing a series of directives aimed at enhancing institutional coordination, emergency response, public health protection, and emission control. The Court emphasised that smog must be recognised not as a routine environmental issue but as a public health and environmental emergency necessitating coordinated action across multiple governmental departments. Through sustained judicial oversight, the Court issued directions concerning crisis management protocols, temporary closure of educational institutions during severe smog episodes, regulation of commercial activities, enforcement of industrial emission controls, and adherence to environmental compliance requirements.

Moreover, the Court underscored the critical importance of interdepartmental coordination, real-time air quality monitoring, public safety measures, and rigorous implementation of mitigation strategies during the smog season. Various institutions—including the Punjab Disaster Management Authority (PDMA), Environment Protection Department, district administrations, law enforcement agencies, industries, and business sectors—were mandated to undertake both immediate and long-term measures to reduce pollution levels and effectively manage smog-related emergencies.

3.2.1 Declaration of Smog as Calamity and Crisis Management

In its order dated 7 October 2022, the Honourable Court directed the establishment of a Crisis Room within the Environment Department, headed by the Secretary of Environment, to facilitate continuous monitoring and coordination of anti-smog measures. The Court further emphasized that smog and climate emergencies be addressed with particular focus on the city of Lahore.

A significant directive was issued on 27 December 2022, wherein the Court, having reviewed the report concerning PTZ (Pan-Tilt-Zoom) cameras, instructed the members of the Judicial Water and Environmental Commission to coordinate with the Punjab Safe City Authority to determine whether the existing PTZ

cameras across Lahore could be effectively utilised and oriented towards regions identified as significant contributors to air pollution. The Court also summoned the Director General of the Provincial Disaster Management Authority (PDMA) to appear at the subsequent hearing date.

In the same order of 27 December 2022, the Court observed that, given the official declaration of smog as a calamity, it would be appropriate for the PDMA to assume the lead role in coordinating the overall smog control response.

Note: The declaration of smog as a calamity was not made by the Court but had been officially notified by the Provincial Government of Punjab under Section 3 of the Punjab National Calamities (Prevention and Relief) Act, 1958, via Relief Commissioner's Order No. Smog-2020/10/Coord-I dated 14 October 2020. The Court's directions were issued in recognition of this pre-existing executive declaration, aiming to operationalise institutional coordination and strengthen implementation mechanisms for environmental governance.

3.2.2 Closure of Schools, Colleges and Educational Institutions during Smog Season

The Honourable Court acknowledged the profound public health impacts of smog, particularly on children and vulnerable populations. Accordingly, it issued directives to regulate educational activities during periods of severe air pollution, aiming to minimise public exposure and reduce mobility.

Court Order dated 17.11.2023

Accordingly, it is directed that any notification regarding the regulation of educational activities during severe air pollution episodes whether issued by the Secretary of the Primary and Secondary Healthcare Department, Government of Punjab, or by the office of the Deputy Commissioner, Lahore must be issued in consultation with the Members of the Judicial Water and Environmental Commission. Furthermore, such notifications shall mandatorily include the closure of public schools, colleges, universities, and all educational institutions on each Saturday until the end of January 2024. Additionally, the Government is

instructed to implement measures to declare two days per week as work-from-home days within the private sector across the Province of Punjab.

3.2.3 Closure of Markets, Restaurants, Hotels and Commercial Activities

The Court also issued directives concerning the regulation of commercial and business activities during the smog season, aiming to curtail unnecessary emissions and alleviate urban congestion during periods of elevated pollution. Enforcement agencies and district administrations were instructed to ensure the strict implementation of these operational restrictions.

Court Order dated 24.11.2023

At the request of the learned Members of the Commission, a directive was issued to the Capital City Police Officer (CCPO) to enforce the Court's order concerning the closure of markets and hotels during specified hours. This order has been formally settled by the Court. The directive is also to be communicated to the Secretary to the Chief Minister, who will issue the necessary instructions to the CCPO to ensure its implementation. The Court emphasised that smog control restrictions should not be limited to Fridays and Saturdays but must be observed consistently across all days of the week, as previously directed.

3.2.4 Installation of Catalytic Converters and Emission Control Devices

The Honourable Court underscored the imperative of industrial emission reduction and directed industries and commercial sectors to adopt pollution control technologies, including catalytic converters, emission control devices, and effluent treatment systems. The Court's directions also emphasised the responsibility of industrial and trade associations to ensure compliance among their members.

Court Order dated 26.04.2024

A directive has been issued mandating the installation of effluent treatment plants, emission control devices, and catalytic converters on generators

operated by industries throughout Punjab. Corresponding instructions will be conveyed to the Chambers of Commerce and industry associations across the province, requiring them to ensure compliance among their members. These Chambers are also tasked with reporting to the Members of the Commission on the actions taken to enforce adherence to these directives within four weeks of the Court's order.

Court Order dated 20.06.2025

A report has been submitted by the learned Members of the Commission, referencing a letter dispatched to various trade organisations concerning the installation of catalytic converters on generators. The learned Members have been instructed to follow up on this communication and provide an update to the Court at the next hearing. Similarly, letters have been sent to cooperative societies regarding the installation of groundwater recharge wells.

3.2.5 Working Hours for Markets and Business

The Court further directed regulatory authorities to maintain vigilant monitoring of commercial activities and to ensure strict implementation of operational regulations aimed at minimising congestion, emissions, and environmental violations in major business districts.

Court Order dated 07.06.2024

The Court directed that the Lahore Development Authority (LDA) and other relevant departments continue to monitor activities at Tollington Market to ensure compliance with the regulations established for that area.

3.2.6 EPA Appreciation and Support during Smog Season 2025

During the smog season of 2025, the Punjab Environmental Protection Agency (EPA) played a pivotal role in the implementation, coordination, and enforcement of anti-smog measures across the province. EPA Punjab's efforts were widely recognised at various administrative and operational levels, owing to its continuous field monitoring, emergency response coordination, scientific surveillance, and rigorous enforcement actions against environmental violations. Specialised monitoring squads, emission testing operations, industrial

inspections, and real-time air quality monitoring systems were actively deployed to support the provincial anti-smog strategy. Additionally, EPA Punjab collaborated closely with district administrations, law enforcement agencies, the Punjab Disaster Management Authority (PDMA), and other relevant departments to ensure the timely execution of directives aimed at protecting public health and controlling pollution during severe smog episodes.

3.3 Control of Environmental Stressors

Since the commencement of the smog proceedings, the Honourable Lahore High Court has diligently monitored key environmental stressors contributing to the degradation of air, water, and ecological quality across Punjab. Through a series of comprehensive judicial directives issued over multiple years, the Court has progressively developed an extensive framework for environmental governance encompassing industrial emissions, brick kilns, stubble burning, vehicular pollution, groundwater depletion, waste management, afforestation, environmentally sustainable infrastructure, and agricultural land protection. These directives have not only amplified the enforcement responsibilities of the relevant departments but have also fostered long-term structural reforms aimed at environmental sustainability, enhanced institutional coordination, and strengthened public compliance.

3.3.1 EPA Operations against Industrial Units

Industrial emissions and non-compliance with environmental standards remained central concerns consistently addressed by the Honourable Lahore High Court throughout the proceedings. The Court repeatedly directed the Punjab Environmental Protection Agency (EPA) to intensify enforcement actions against polluting industrial units across the province, utilising measures such as inspections, sealing operations, installation of pollution control technologies, and rigorous regulatory oversight. Particular emphasis was placed on holding enforcement officers accountable for lapses and ensuring that dry scrubbers, effluent treatment plants, and other pollution mitigation systems were installed within industrial facilities prior to authorising their continued operations.

From the inception of the proceedings, the Court issued clear directives mandating EPA Punjab to enforce environmental standards stringently against industrial units throughout the province. These orders encompassed sealing non-compliant facilities, initiating action against enforcement officers who failed in their duties, and mandating the installation of dry scrubbers, effluent treatment plants, and other pollution control devices.

Court Orders dated 17.11.2023 and 03.11.2023

In respect of EPA, directions were issued for Multiple Violations of Industrial Units and Action against non-compliant officers. Sealing of Industrial Units was also directed.

Court Order dated 04.12.2023

EPA was directed regarding multiple violations of industrial units and action against non-compliant officers. Sealing orders were also issued with respect to several units.

Court Order dated 11.11.2022

EPA is directed in respect of installation of dry scrubbers in steel rerolling mills. Directions were also issued for strict action against industrial units causing environmental pollution.

3.3.2 Brick kilns

Brick kilns operating on conventional Bull Trench technology were identified by the Court as a major contributor to smog and particulate emissions in Punjab. Consequently, the Court continuously monitored the province wide conversion of brick kilns towards Zig Zag technology, recognising it as an essential environmental intervention for reduction of emissions and fuel consumption. The judicial directions emphasised phased regional implementation, strict administrative enforcement and personal responsibility of district administrations in ensuring compliance by kiln owners.

3.3.2.1 Brick Kilns — Conversion to Zig Zag Technology

Control of brick kilns operating with the traditional Bull Trench technology has been a persistent concern of the Honourable Court since the inception of these proceedings. Through numerous orders over the years, the Court has closely monitored and advocated for the conversion of brick kilns across Punjab to the more environmentally friendly Zig Zag technology.

Court Order dated 31.01.2020

It is therefore imperative that brick kilns be converted to the latest Zig Zag technology within prescribed timelines, which vary according to geographically defined zones. Kilns located within the designated red zones have been directed to transition to Zig Zag technology, with government officials tasked to take stringent enforcement action against those violating the mandate within their jurisdiction. In particular, Deputy Commissioners and other relevant authorities are required to provide full assistance to ensure compliance with these directives.

3.3.3 Stubble Burning — Enforcement and Imposition of Fines

The issue of crop residue burning has been repeatedly emphasised by the Honourable Court as a major seasonal contributor to smog formation in Punjab. The Court directed stringent administrative coordination among the Environment Protection Department, district administrations, and other provincial agencies to prevent stubble burning during peak smog months. These directives focused on

preventive enforcement measures, the issuance of district-level circulars, public awareness campaigns, and regulatory actions against violations, with the objective of reducing agricultural emissions during the winter season.

Court Orders dated 05.08.2020, 22.10.2020,03.12.2020,

The Court directed the issuance of a circular to all Deputy Commissioners of districts across Punjab regarding the prohibition of stubble burning. The Environment Protection Department was mandated to ensure that stubble burning activities are not conducted during the period commencing in early October. The implementation of measures to prevent such practices by farmers is to be coordinated in collaboration with other departments of the Government of Punjab.

3.3.4 Vehicular Emissions and Transport Sector Reforms

Vehicular emissions have been consistently identified by the Honourable Court as one of the most significant anthropogenic contributors to urban air pollution and smog in Punjab. In response, the Court issued multiple directives aimed at enhancing regulation of the transport sector through stricter vehicle inspections, impounding of vehicles emitting excessive smoke, deployment of electronic enforcement mechanisms, promotion of eco-friendly transportation systems, and strengthened inter-agency coordination for roadside emissions monitoring. Collectively, these measures underscore the Court's commitment to facilitating a transition towards cleaner and more environmentally responsible transport systems across Punjab.

3.3.4.1 Impounding of Smoke Emitting Vehicles

Court Order dated 05.10.2023

The Court has unequivocally directed that any vehicle found emitting hazardous smoke beyond prescribed limits shall be impounded, emphasising that issuing challans or imposing fines alone is insufficient. Vehicles will only be permitted to resume operation upon demonstrating full compliance with the required emission standards for roadworthiness.

3.3.4.2 E-Challan on Vehicular Smoke Emission

Directions were issued to the Environmental Protection Agency (EPA), the City Traffic Officer (CTO), and the Punjab Safe Cities Authority (PSCA) regarding the enhancement of fines for non-use of helmets and the implementation of e-challans for vehicular smoke emissions. EPA, CTO, and PSCA have been directed to impose fines on smoke-emitting vehicles, with enforcement measures in place since as early as 2020. Similarly, EPA, CTO, and the Vehicle Inspection and Certification System (VICS) were instructed to strengthen control over vehicular emissions, vehicular inspections, and certification processes across Punjab.

3.3.4.3 Eco-Friendly Buses and Transport Policy

Court Order dated 15.11.2024

The Learned Advocate General Punjab has informed the Court that administrative approval has been granted for the introduction of eco-friendly buses in Lahore. Relevant documents have been submitted on record, and the associated budgetary allocation is duly reflected in the Finance Department's budget documents for the financial year 2024–25. This initiative is a commendable step that is expected to contribute significantly to the reduction of environmental pollution and, consequently, the mitigation of smog.

3.3.4.4 Motorway Police Coordination with EPA for Vehicle Inspection

Court Order dated 16.05.2025

A report on behalf of EPA has also been submitted, referencing a meeting between the Director General of EPA and representatives of the Motorway Police to constitute a joint team tasked with taking action against smog-emitting vehicles and deploying monitoring units at toll plazas. The Court directed that the Motorway Police coordinate with EPA to designate appropriate locations for monitoring teams at all entry and exit points of the toll plazas. This directive is to be communicated by the learned Deputy Attorney General to the Inspector

General of Motorway Police. Initial vehicle inspections will focus on heavy transport vehicles. Furthermore, EPA's monitoring instruments are to be stationed at motorway entry and exit points to inspect vehicles of various categories and ensure compliance with emission standards.

3.3.5 Water Conservation and Groundwater Protection

The depletion of groundwater reserves and unsustainable water consumption emerged as a significant environmental concern repeatedly highlighted during the proceedings. Acknowledging the increasing stress on groundwater aquifers in Lahore and throughout Punjab, the Honourable Court issued various directives concerning groundwater recharge, water conservation, installation of treatment systems, and regulation of wasteful domestic water practices. The Court emphasised the importance of both long-term sustainability measures and rigorous enforcement actions aimed at curbing excessive water use and promoting environmentally responsible urban development practices.

3.3.5.1 Installation of Recharge Wells

From the earliest stages of the proceedings, the Honourable Court has expressed profound concern regarding groundwater depletion in Lahore and across Punjab. Consequently, directives were issued mandating the installation of recharge wells in parks, housing societies, and public spaces to facilitate the replenishment of groundwater resources.

Court Order dated 20.06.2025

Letters have been dispatched to cooperative societies urging the installation of recharge wells. The learned Members of the Commission have noted reports concerning construction work on the Yellow Line running along Canal Road, expressing apprehension over the potential removal of a significant number of trees. The learned Additional Advocate General (A.A.G) has been directed to obtain instructions from the relevant department on this matter and to submit a formal report to the Court.

Court Order dated 31.01.2025

The report also references a list of recharge wells that have already been installed, with an additional ten recharge wells currently in the process of being constructed. These measures are scheduled to be highlighted at the forthcoming meeting presided over by the Chief Secretary of Punjab.

3.3.5.2 Prohibition on Use of Water Pipes for Car Washing

The Honourable Court maintained persistent concern over declining groundwater levels and directed various government departments and housing societies to implement groundwater replenishment initiatives through the installation of recharge wells. These directives reflect the Court's overarching emphasis on sustainable urban water management and the protection of natural hydrological systems across Punjab.

Court Order dated 20.10.2023

The Members of the Commission shall instruct the Deputy Commissioner's office to issue a circular to all cooperative housing societies regarding the Court's orders prohibiting the use of water pipes for washing cars and irrigating gardens within the jurisdictions of those societies. A corresponding notice shall be issued by the Registrar of Cooperative Housing Societies, while the Director General of the Lahore Development Authority (LDA) shall ensure that residents of LDA-managed societies are duly informed. The notices must explicitly inform society management that failure to control this practice will result in personal accountability.

Court Order dated 04.12.2024

With regard to water conservation, it was directed that upon the first violation involving the use of water pipes for washing in commercial or residential premises, a fine of Rs. 10,000 shall be imposed on residential properties and Rs. 20,000 for commercial properties. In the event of a second violation, the water

supply to the offending premises shall be disconnected. This directive shall be communicated by WASA to all its officers for strict enforcement.

3.3.5.3 Water Conservation — Ban on Hose Pipes

To discourage unnecessary wastage of potable water, the Court issued stringent directives restricting the use of water pipes for washing vehicles and irrigating residential lawns. The Court further emphasised the importance of administrative enforcement through housing societies, district administrations, and Water and Sanitation Agencies (WASA), alongside the introduction of financial penalties and disconnection measures for repeat offences.

Court Order (2025)

Simultaneously, a broad public awareness campaign will be launched under the direction of the Chief Secretary, Punjab, to educate the general population on the importance of water conservation and to communicate the Government's decision to impose a complete ban on the use of water for washing vehicles and hosepipe usage in households. Individuals found violating these directives will be subject to a fine of Rs. 10,000. Additionally, Local Governments and Development Authorities across Punjab will be mandated to incorporate regulations requiring the installation of wastewater treatment plants in all future residential and commercial construction projects.

3.3.5.4 Grey Water Treatment Plants in Residential Houses

The Court also encouraged the integration of environmentally sustainable infrastructure within residential developments by directing the installation of greywater treatment systems in larger residential properties. These directives underscore the Court's emphasis on wastewater reuse, the reduction of freshwater dependency, and the promotion of environmentally compliant construction standards within urban housing sectors.

Court Order dated 23.02.2024

Installation of greywater treatment plants is mandated for residential houses of one kanal and above. It is directed that the relevant regulations be approved expeditiously by the competent authority. Furthermore, rules and incentives applicable to buildings constructed in accordance with environmental standards shall be presented for consideration at the next hearing.

3.4 Tree Plantation, Miyawaki Forests and Protection of Green Areas

The protection and expansion of urban green cover remained a pivotal concern throughout the proceedings. The Honourable Court consistently emphasised the importance of plantation drives, preservation of public green spaces, and the introduction of Miyawaki forests as integral components of urban ecological restoration efforts. Through these directives, the Court fostered a strong sense of institutional responsibility among public authorities, educational institutions, and private sector entities to increase urban tree cover and safeguard environmentally sensitive green areas from encroachment or conversion.

3.4.1 Miyawaki Forests

Court Order dated 05.10.2023

Learned Counsel for the Lahore Development Authority (LDA) is directed to explore, in collaboration with the Parks and Horticulture Authority (PHA), the establishment of Miyawaki forests at various locations within Lahore. Additionally, Counsel representing the restaurant sector has undertaken to sponsor and initiate the development of one such Miyawaki forest through the Association of Restaurants in Lahore.

3.4.2 Tree Plantation in Public Schools and Colleges

Court Order dated 05.10.2023

The learned Member of the Commission responsible for trees and parks across Lahore has submitted a report outlining significant progress in tree plantation efforts. The report indicates that public colleges have initiated the establishment

of Committees for each institution, to be designated as the "Botany Association of the College," with their terms of reference specified in official notifications issued by the respective colleges. It is anticipated that these associations will promptly undertake actions to implement their prescribed mandates. Similar directives will be issued to all public and private schools in Lahore, accompanied by corresponding notifications, and the Court's order shall be circulated widely among these institutions.

Furthermore, it is directed that open spaces and playgrounds under the supervision of public colleges and schools shall no longer be converted for alternative uses. Should such conversion be deemed necessary, a formal application must be submitted to this Court to obtain prior permission.

3.5 Agriculture Sector — Super Seeders and Mechanised Farming

The agriculture sector remained a focal point of the Honourable Court's attention, particularly concerning the control of stubble burning and the reduction of seasonal smoke emissions contributing to smog formation. Recognising that enforcement alone would be insufficient without practical alternatives for farmers, the Court consistently emphasised the adoption of mechanised agricultural solutions, including the procurement and distribution of super seeders. Through continuous monitoring of progress reports, financial approvals, and coordination among government departments, the Court ensured advancement towards the widespread implementation of sustainable crop residue management practices throughout Punjab.

The Court played a pivotal role in overseeing the procurement and distribution of super seeders by the Agriculture Department, facilitating their provision to farmers as an effective alternative for field clearing. Over multiple hearings, the Court scrutinised the purchase summaries, their submission to the Finance Department, and the subsequent allocation of necessary funds.

3.6 Environmental Compliance of Development Projects

3.6.1 No Conversion of Agricultural Land

The Court expressed grave concern over the rapid urban expansion and conversion of fertile agricultural land into commercial and residential developments across Punjab. To safeguard agricultural resources and avert environmentally unsustainable land use changes, the Court issued strict directives to district administrations and relevant authorities prohibiting the conversion of agricultural land for commercial purposes and housing schemes.

Court Order dated 16.08.2024

It is reiterated that, throughout Punjab, the use of agricultural land for commercial purposes and the establishment of housing schemes on such land is strictly prohibited.

3.6.2 Green Standards in Building Regulations

The Court also emphasised the imperative to integrate environmental sustainability into future urban construction and building regulations. Directions were issued for the development of environmentally compliant building standards, including the mandatory incorporation of wastewater treatment plants and the promotion of environmentally sustainable construction incentives in forthcoming residential and commercial developments across Punjab.

Court Order dated 27.06.2025

Learned counsel for the Lahore Development Authority (LDA) has informed the Court that the rules and concessions pertaining to buildings constructed in accordance with environmental standards will be presented at the next hearing. It is directed that local governments, as well as development authorities across Punjab, are required to incorporate regulations mandating the installation of treatment plants in all future residential and commercial construction projects.

3.7 Waste Management and Plastic Pollution

Waste management and plastic pollution have emerged as significant environmental concerns repeatedly addressed throughout the proceedings. The

Honourable Court issued numerous directives relating to garbage disposal, recycling mechanisms, plastic waste management, landfill gas collection, and sanitation practices in urban areas. Through these orders, the Court aimed to strengthen institutional accountability, enhance public cleanliness, reduce environmentally detrimental waste disposal methods, and promote sustainable waste management systems across Punjab.

3.7.1 LWMC — Prohibition on Garbage Burning

Improper disposal and burning of municipal waste were identified as major contributors to urban pollution and environmental degradation. The Court directed the Lahore Waste Management Company (LWMC) and relevant authorities to intensify public awareness campaigns and enforce proper waste disposal practices, aiming to maintain urban cleanliness and prevent environmentally harmful garbage burning.

Court Order dated 25.11.2022

An order has also been issued instructing employees to counsel the owners of houses, shops, and other premises on proper garbage disposal practices to ensure cleanliness of roads and green spaces.

3.7.2 Recycling of Solid Waste and Reuse of Plastic

The Court also advocated for environmentally sustainable waste management practices by promoting the recycling and reuse of plastic materials. These directions reflect a broader objective of mitigating environmental pollution caused by unmanaged solid waste and fostering circular waste management approaches throughout Punjab.

Court Order dated 07.07.2022

"It is also reported that Members of the Commission are engaged in negotiations with certain multinational companies concerning the recycling of solid waste and the reuse of plastic. A further report will be submitted at the next hearing."

3.7.3 Ban on Polythene Bags

Court Orders dated 07.02.2020, 24.09.2020, 22.10.2020, 11.12.2020, 14.04.2022, 26.04.2024

Plastic pollution, particularly the use of polythene bags, has been a recurrent environmental issue highlighted throughout the judicial proceedings. The Honourable Court has consistently directed strict enforcement of the ban on polythene bags, the imposition of penalties, and the development of district-level waste collection and disposal mechanisms to mitigate plastic pollution and improve environmental conditions across Punjab.

These directives have been issued through multiple orders, including those dated 7 February 2020, 24 September 2020, 22 October 2020, 11 December 2020, 14 April 2022, and 26 April 2024, specifically instructing the Punjab Environmental Protection Agency (EPA) to enforce the ban on polythene bags and ensure the imposition of fines for violations. Furthermore, the order dated 26 April 2024 mandated the formulation of a comprehensive district-level policy for the collection and disposal of polythene bags.

Regarding the regulatory framework, enforcement of restrictions on single-use plastics is now governed by the **Punjab Environmental Protection (Single-Use Plastic) Regulations, 2023**. These constitute the current statutory instrument regulating the manufacture, sale, distribution, and use of polythene and other single-use plastic items. Consequently, all enforcement actions are to be interpreted and implemented in conjunction with these Regulations, which operationalise the policy intent articulated in the Court's directives.

3.7.4 Land Fill Gas Collection — Environmental Concern

The Court also addressed the environmental risks posed by landfill gas emissions and their contribution to air pollution. Expressing concern over the adverse impacts of unmanaged landfill gases, the Court directed the Environmental Protection Agency (EPA) and the Lahore Waste Management Company (LWMC) to jointly investigate the issue and submit detailed reports outlining mitigation measures and environmental safeguards.

Court Order dated 21.02.2025

Another matter of significance concerns the landfill gas collection efforts undertaken by the Lahore Waste Management Company (LWMC), a primary source of environmental concern regarding air pollution. The Court directed the Environmental Protection Agency (EPA) to examine this issue thoroughly and submit a joint report, in collaboration with the Members of the Commission, at the next hearing.

3.8 Public Awareness, Technology-Based Monitoring and PEMRA

The Honourable Court consistently emphasised that environmental protection and smog control cannot be realised through enforcement measures alone, but require robust public awareness, active citizen participation, and technology-driven monitoring systems. Throughout the proceedings, the Court issued multiple directives encouraging the deployment of digital applications, surveillance technologies, media campaigns, and inter-agency coordination frameworks to enhance environmental governance and public engagement. These measures embody the Court's broader strategy of integrating technological innovation, community outreach, and institutional collaboration within the province's environmental management and compliance monitoring systems.

3.8.1 PITB Application

The Court recognised the critical role of citizen engagement and technology-enabled complaint management systems in enhancing environmental governance and enforcement. Consequently, it issued directions for the development and promotion of a digital complaint registration application, developed by the Punjab Information Technology Board (PITB), designed to facilitate public reporting of environmental and water-related violations across Punjab.

Court Order dated 11.08.2022

A report has been submitted by the Judicial Water and Environmental Commission referencing a smartphone application developed by the Punjab Information Technology Board (PITB). This application, integrated within the Punjab Performance Management Framework, enables the general public to register complaints concerning violations of the Court's orders related to various water and environmental issues subject to prior judicial directions. The application is available for download on smartphones, and complaints submitted through it are received by the Commission. The Commission is then empowered to take appropriate action and direct relevant departments to initiate proceedings based on the registered complaints.

The Director General of Public Relations Punjab has been directed to promote the application extensively through all available print and electronic media channels, thereby raising public awareness of the application's existence and enhancing knowledge about water conservation and environmental issues.

3.8.2 PEMRA—Smog Awareness Campaign

Court Order dated 26.05.2023

The Members have reported that billboards displaying essential information regarding smog awareness have been erected. The Pakistan Electronic Media Regulatory Authority (PEMRA) has also been notified about the necessity of issuing directives to all media outlets to ensure smog awareness advertisements are broadcast without fail. The learned Deputy Attorney General (D.A.G) has been directed to coordinate with PEMRA to facilitate this process.

3.9 Inter-Departmental Coordination

A distinctive hallmark of these proceedings has been the Court's consistent emphasis on inter-agency coordination. The departments and agencies regularly summoned to present reports and comply with directives include: EPA Punjab, the Environment Protection & Climate Change Department (EP&CCD), District Administrations, Capital City Police Officer (CCPO), Traffic Police, City Traffic Officer (CTO), Lahore Development Authority (LDA), Water and Sanitation Agency (WASA), Parks and Horticulture Authority (PHA), Lahore Waste

Management Company (LWMC), Punjab Disaster Management Authority (PDMA), Agriculture Department, School Education Department, Higher Education Department, Transport Department, Regional Transport Authority, Pakistan Electronic Media Regulatory Authority (PEMRA), Punjab Information Technology Board (PITB), Pakistan Railways, Metropolitan Corporation Lahore (MCL), Pakistan Food Authority, Irrigation Department, Forest Department, and the Ministry of Climate Change and Environmental Coordination.

The Court has also mandated that meetings be convened among relevant departments to address and resolve specific issues. The Commission has conducted meetings with key officials, including the Secretary of Transport, Secretary of Environment, Secretary of Agriculture, Agriculture Minister, Chief Secretary Punjab, and other senior government representatives. The Court further directed that the Commission be granted full access to pertinent departments and that all agencies extend their full cooperation to support the Commission's mandate.

3.10 Institutional Strengthening and Enforcement Support to EPA

The proceedings have offered crucial institutional support to EPA Punjab in executing enforcement operations. The Honourable Court has consistently endorsed EPA's enforcement activities and directed both police and civil administrations to extend full assistance during environmental inspections.

Court Order dated 12.07.2024

Police assistance shall be provided to the officers of EPA for environmental inspections and enforcement activities across Punjab.

Court Order dated 11.11.2023

A commendable action was undertaken by the Capital City Police Officer (CCPO) and the Superintendent of Police (Operations) through the raiding of warehouses at multiple locations in Lahore, resulting in the seizure of a substantial quantity of old tyres being utilised as fuel in industries within and around the city. The Court directed that these godowns shall remain sealed until further order.

3.11 Conclusion

The proceedings in Writ Petition No. 227807/2018, Haroon Farooq vs. Government of Punjab et al., represent the most sustained and comprehensive judicial engagement with environmental governance in Punjab's history, spanning from 2018 through 2025. The Honourable Lahore High Court, through continuous monitoring and the issuance of periodic directives, has significantly reinforced the implementation of environmental laws and provided critical, sustained support to the Environmental Protection Agency (EPA) Punjab and the Environment Protection & Climate Change Department (EP&CCD). These efforts have been pivotal in controlling smog, reducing air pollution, promoting water conservation, ensuring environmental compliance, encouraging the adoption of cleaner technologies, and safeguarding natural resources within Lahore and across Punjab.

The judicial interventions have facilitated coordinated interdepartmental action, strengthened environmental enforcement mechanisms, and ensured accountability in environmental protection matters. Notably, the Court's support during the smog seasons of 2022, 2023, 2024, and 2025 enabled EPA Punjab to undertake decisive enforcement measures that contributed substantively to air quality improvements during critical periods. Court directives concerning the conversion of brick kilns, deployment of EPA teams along motorways, coordination between EPA and Motorway Police, impounding of smoke-emitting vehicles, and sealing of non-compliant industrial units have been effectively operationalised through EPA Punjab's enforcement actions.

The Court has also commended EPA Punjab's initiatives and acknowledged the commendable contributions of the Judicial Water and Environmental Commission, whose members have rendered meritorious and distinguished service. The recommendation for civil awards to be conferred upon these members recognises their pivotal role in advancing environmental governance in Punjab.

These proceedings demonstrate that sustained judicial oversight, in partnership with a proactive and dedicated regulatory body such as EPA Punjab, can yield

tangible and measurable improvements in environmental protection. The Honourable Court's continued engagement in the coming years is poised to remain an integral pillar of environmental governance in Punjab.

CHAPTER 04

Punjab's Environmental Profile



4.1 Introduction

Punjab's environmental profile reflects the cumulative impact of intense human activity and evolving climatic conditions on a resource-constrained landscape. As one of the most densely populated and economically productive regions, Punjab faces significant pressures on its natural systems arising from rapid urbanisation, industrial concentration, and intensive agricultural practices. These dynamics have increasingly strained the province's air, water, land, and ecological resources.

A comprehensive understanding of Punjab's environmental profile is essential for contextualising the nature and magnitude of environmental stress in the region. Examining demographic trends, climate-related stressors, and key environmental pressure points provides a foundational overview of the factors driving environmental change in Punjab, thereby establishing the contextual basis for detailed analysis in subsequent sections.

4.2 Population, Urbanisation and Industrial Density

Population growth, accelerating urbanisation, and increasing industrial density are deeply interconnected factors shaping Punjab's environmental profile. High population density amplifies demand for land, water, energy, and infrastructure, while rapid urban expansion often outpacing planning and service provision has altered land use patterns and strained environmental resources. Concurrently, the concentration of industrial activities in urban and peri-urban areas intensifies pressure on air, water, and land systems, especially in regions where industrial zones overlap with residential and agricultural spaces. Collectively, these dynamics generate compounded environmental stress, providing a critical context for understanding the environmental challenges facing Punjab.

4.2.1 Population & Demographic Overview

Punjab is among the most populous regions globally, with a large and steadily increasing population that exerts substantial pressure on environmental sustainability. Population growth in Punjab results from both natural increase and migration patterns, intensifying demands on land, water, and public services. The

province's substantial population size escalates the need for food production, housing, and energy, thereby amplifying environmental stresses across diverse sectors.

According to the Pakistan Population and Housing Census 2023, Punjab remains the most populous province in Pakistan, with a total population of 127.68 million. Assuming a prevailing annual growth rate of approximately 2.53%, Punjab's population is projected to reach around 134.3 million by 2025, imposing significant demands on environmental resources, infrastructure, and public services. Lahore continues to be the most densely populated city within the province, with an estimated population of approximately 15.23 million, followed by Faisalabad, which hosts roughly 3.98 million inhabitants. These urban centres face heightened environmental and sustainability challenges as a consequence of their demographic scale.[1]

Sr. No.	Cities	Population
1	Lahore	15237800
2	Faisalabad	3988600
3	Gujranwala	2608940
4	Rawalpindi	2545590
5	Multan	2313390
6	Bahawalpur	995494
7	Sialkot	808547
8	Sargodha	793255

Table 4.1: Population wise Big Cities of Pakistan[2]

Punjab's population density and spatial distribution exhibit considerable variation across the province, influenced by geographic, economic, and

[1] National-Census-Report-2023.pdf
[2] Pakistan Cities by Population 2026

infrastructural factors. Overall, Punjab is densely populated relative to many other regions of Pakistan, with the highest concentrations found in and around major urban centres such as Lahore, Faisalabad, Rawalpindi, and Gujranwala. These urban corridors attract significant internal migration driven by employment opportunities, education, and access to services. Conversely, southern districts like Rajanpur and Layyah exhibit lower population densities, primarily due to arid conditions and limitations on agricultural productivity. Many central and northern districts are situated along fertile river plains, supporting sizeable rural populations and moderate population densities.

4.2.2. Urbanisation

The urbanisation trajectory of Punjab reflects a profound demographic and spatial transformation that has fundamentally reshaped the province's landscape. Historically, Punjab's urbanisation commenced from a modest base—only 17.4% of the population resided in urban centres in 1951. By the time of the 7th Population and Housing Census in 2023, this proportion had surged to 40.71%, representing approximately 51.97 million urban inhabitants.[3]

This demographic surge has been accompanied by rapid physical expansion of built-up environments. Spatial analysis presented in The Urban Unit's Punjab Cities Growth Atlas reveals that the contiguous urban extent of Punjab's fifty largest cities nearly tripled between 1995 and 2015. The built-up area increased from approximately 891 square kilometres to 2,589 square kilometres during this twenty-year period, representing a substantial land conversion of 1,698 square kilometres. This outward "sprawl" indicates that the urban footprint is expanding at a rate exceeding population growth, encompassing roughly 1.26% of the province's total land area as of 2015. The growth is markedly concentrated, with

[3] pbs.gov.pk/wp-content/uploads/2020/07/Provincial-Census-Report-2023-Punjab.pdf

primary urban hubs such as Lahore accounting for a disproportionately large share of this spatial expansion.[4]

With an average annual urban growth rate of approximately 3.67%, Punjab is rapidly approaching a demographic tipping point. Projections from the Punjab Economic Research Institute (PERI) and the Asian Development Bank (ADB) indicate that, if current trends persist, the urban population in Punjab could surpass the rural population by the early 2030s. Mega cities such as Lahore and Faisalabad serve as the primary engines of this growth, while secondary cities including Rawalpindi, Gujranwala, and Sahiwal are also experiencing accelerated expansion.[5]

District	Total Population (2023)	Urban Population (%)	Annual Growth Rate (2017–2023)
Lahore	13,004,135	100%	2.65%
Rawalpindi	6,118,911	68.82%	2.10%
Faisalabad	9,075,819	48.40%	2.38%
Multan	5,362,305	46.62%	2.06%
Gujranwala	5,959,750	44.80%	2.94%

Table 4.2: Top 5 Most Urbanised Districts in Punjab (2023 Census)[6]

Ultimately, Punjab's urbanisation is a dual-edged phenomenon: demographic, with millions migrating into urban areas, and spatial, with cities physically expanding into rural hinterlands. This unplanned urban growth generates a reinforcing cycle of heightened resource demand and escalating environmental stress. If left unmanaged, the persistent conversion of fertile land and the

[4] 1-Drivers-for-Change-1.pdf
[5] Punjab Economic Report | CH-7
[6] table_1_punjab_districts.pdf

increasing costs of providing infrastructure to sprawling settlements will pose significant threats to the province's long-term economic growth and environmental sustainability.

4.2.3 Industrial Density

The industrial architecture of Pakistan has been fundamentally anchored in the province of Punjab. This predominance stems from a high density of industrial clusters strategically situated around major urban centres. Gujranwala, Gujrat, and Sialkot, along with Faisalabad, collectively form a continuous belt of manufacturing activity. This industrial density has been further reinforced by large-scale infrastructure developments such as the Allama Iqbal Industrial City in Faisalabad, which serves as a principal Special Economic Zone (SEZ) under the China-Pakistan Economic Corridor (CPEC) framework. These clusters are interconnected by an advanced network of motorways including the M-2, M-3, and M-4—that enable the rapid transport of raw materials and finished products, effectively transforming these transit routes into dynamic industrial corridors.

i. Textile and Apparel Industries

Faisalabad remains the undisputed "Manchester of Pakistan," hosting the country's highest concentration of textile manufacturing. According to the Pakistan Economic Survey 2024–25, the textile sector sustained the largest share in the Large-Scale Manufacturing (LSM) index, with garment exports demonstrating a year-on-year growth of 7.14%. Beyond Faisalabad, significant textile clusters are also present in Lahore and Sheikhupura, as illustrated in Figure 4.1. These regions experience considerable water resource pressures, with textile dyeing and processing units identified as primary consumers of groundwater.

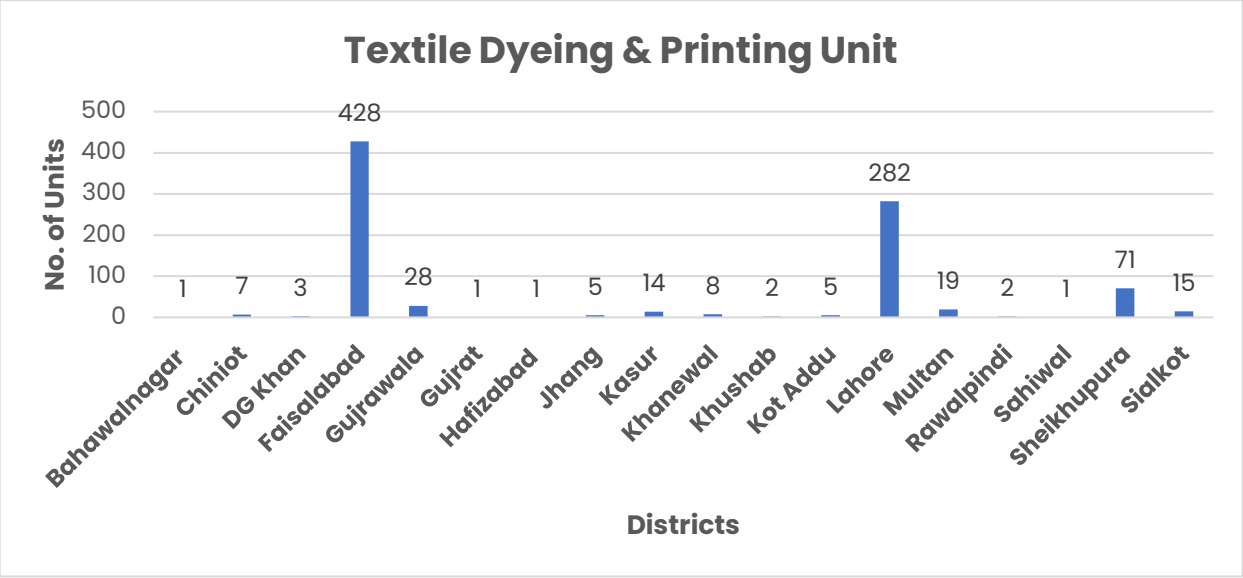


Figure 4.1: Textile Industry Network across the Punjab (Data source: EPA Punjab)

ii. Rice Mills and Agro Processing

Concentrated primarily in the Basmati Belt—comprising Gujranwala, Sialkot, Sheikhupura, and Hafizabad—rice milling has long been a cornerstone of Punjab's export economy. In 2025, these districts experienced a surge in high-technology milling units designed to meet stringent international sanitary standards. This sector exemplifies Punjab's agricultural strength; however, the seasonal nature of rice processing often presents localised waste management challenges, particularly concerning the disposal of rice husks. Rice mills are distributed throughout nearly all districts of Punjab, with a total of 1,399 mills currently operating, as detailed in Figure 4.2.

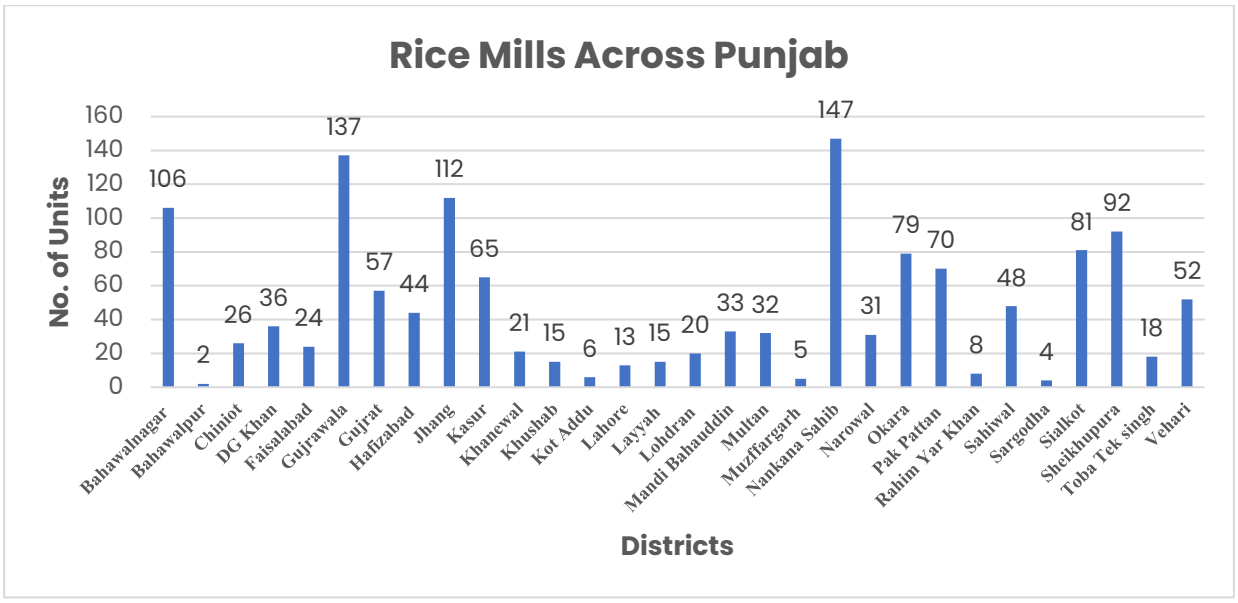


Figure 4.2: District-wise data of Rice Mills in Punjab (Data source: EPA Punjab)

iii. Cement and Construction Industries

The highest density of cement manufacturing in Punjab is concentrated within the Salt Range clusters, specifically in the Chakwal and Khushab districts. Punjab hosts several of Pakistan's largest cement plants, benefiting from the proximity of abundant limestone and gypsum deposits. Currently, the province is home to 16 cement manufacturing plants, with Mianwali leading with five plants, followed by Chakwal and Dera Ghazi Khan with four and two plants respectively, as illustrated in Figure 4.3. As of 2025, this sector has come under increased scrutiny within the framework of the Punjab Green Development Program (PGDP) due to its substantial carbon footprint and impacts on local air quality and groundwater levels across the Pothohar Plateau.

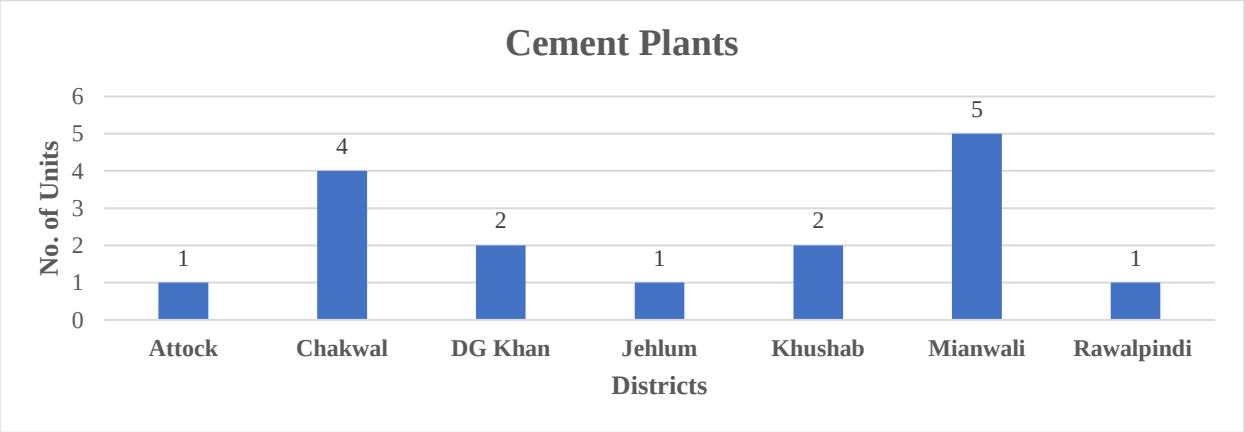


Figure 4.3: Cement Plants across Punjab (Data source: EPA Punjab)

Additionally, cement block manufacturing occurs across various districts in Punjab, with Lahore leading the list, hosting 28 units, followed by Kasur and Sheikhupura with 17 and 12 units respectively. These operations consume substantial quantities of water and contribute to environmental degradation through the generation of dust, particulate matter, solid waste, and noise pollution in surrounding areas. The district-wise distribution of cement plants and cement block manufacturing units is illustrated in Figure 4.4.

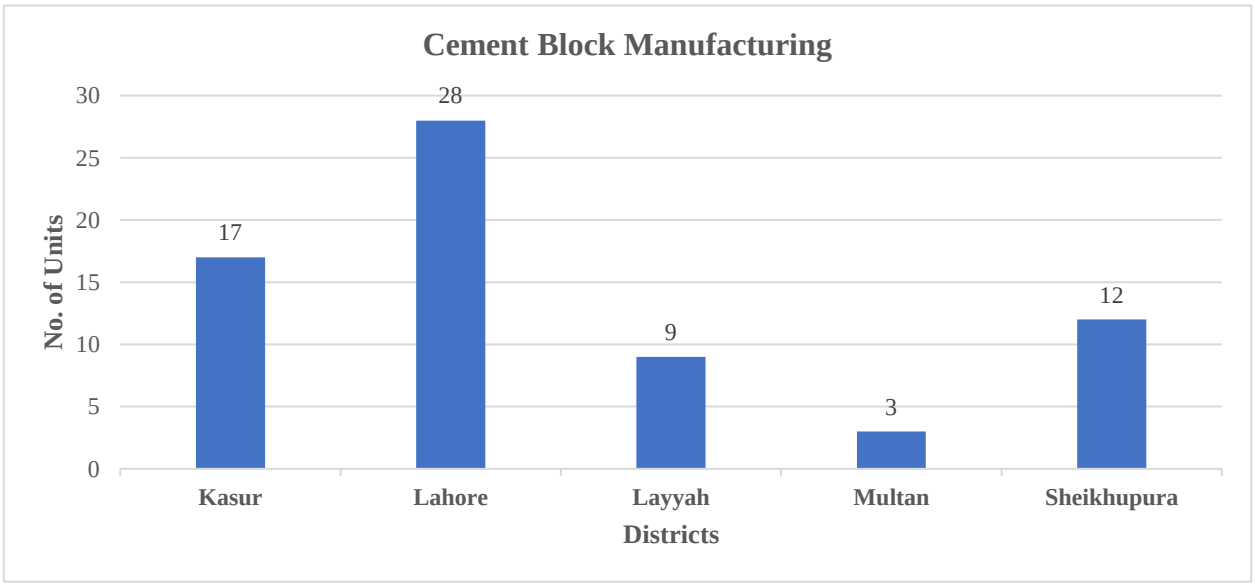


Figure 4.4: Cement Block Manufacturing Units across Punjab (Data source: EPA Punjab)

iv. Leather Tanneries

Within Punjab's industrial landscape, the tanning sector represents a significant environmental concern due to the substantial pollution generated by untreated effluents and hazardous waste. Kasur and Sialkot serve as the principal hubs of the province's leather industry. Kasur leads with 292 tannery units predominantly engaged in the production of heavy leather, while Sialkot hosts 233 units specialising in export-quality leather utilised in the manufacture of sports goods and apparel, as illustrated in Figure 4.5. Industrial clusters in these districts frequently exceed the Provisional Environmental Quality Standards (PEQS), particularly with respect to hexavalent chromium, resulting in extensive groundwater contamination and soil degradation. The reuse of chromium-laden solid waste as poultry feed further exacerbates public health risks by introducing toxic substances into the food chain. In response, the Government of Punjab has mandated the relocation of tanneries to organised zones such as the Sialkot Tannery Zone (STAGL) and is leveraging the Green Punjab framework to enforce stricter monitoring and compliance with wastewater treatment regulations.

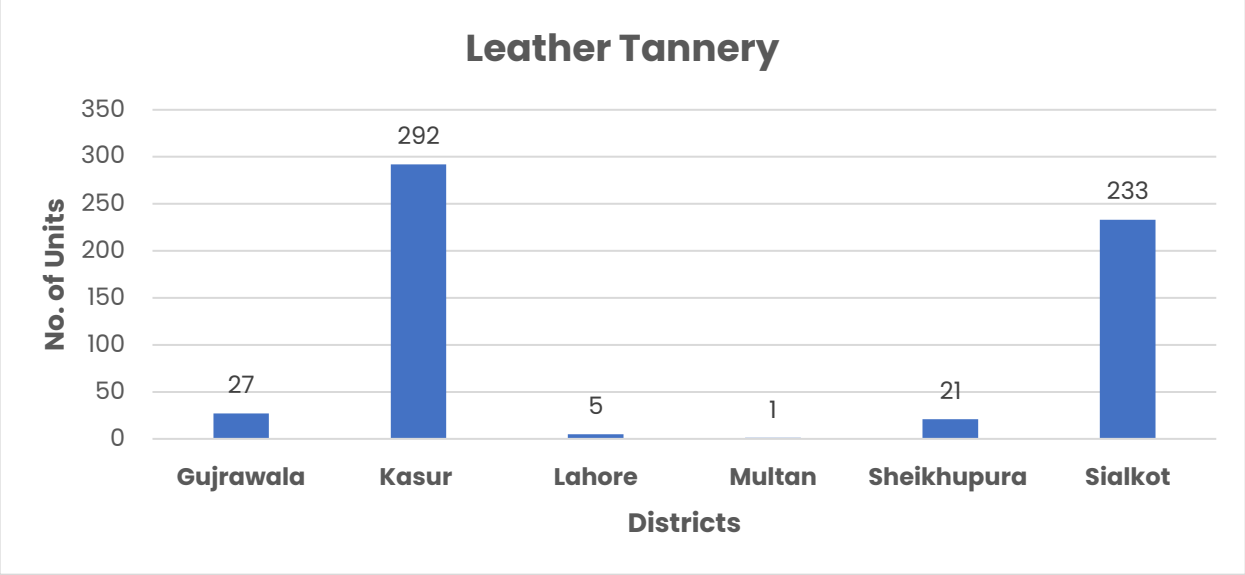


Figure 4.5: Leather Tanneries Profile in Punjab (Data source: EPA Punjab)

4.3. Climate Stressors

Climate stressors encompass environmental and climatic factors that impact ecosystems, agriculture, water resources, and human livelihoods. In Punjab, these stressors arise from a combination of natural phenomena such as temperature extremes, rainfall variability, and natural flooding and anthropogenic activities including deforestation, urbanisation, and overexploitation of water resources that interact synergistically to amplify adverse effects.

4.3.1 Natural Stressors

Natural climate stressors are environmental conditions or events that impact ecosystems, human health, and livelihoods, often occurring independently of direct human action, although anthropogenic activities may exacerbate their severity. In Punjab, these stressors predominantly encompass temperature extremes, variations in precipitation, and extreme weather events.

i. Temperature Extremes
ii. Precipitation Variability
iii. Extreme Weather Events

i. Temperature Extremes

Punjab has transitioned into a high-risk climate zone, with a steady increase in average temperatures fundamentally altering the province's ecological and economic stability. Over recent decades, average minimum and maximum temperatures have risen by approximately 0.97 °C and 1.14 °C, respectively. The year 2025 marked a definitive shift in Punjab's climate trajectory, characterised by a series of high-intensity thermal and hydrological anomalies. Throughout the year, the province experienced a significant departure from historical norms, with average maximum temperatures peaking at 1.14 °C above the long-term mean.

These extreme thermal conditions exerted cascading effects on the agricultural sector; notably, the 2025 wheat harvest suffered an approximate 12% yield

reduction in heat-stressed zones, where the grain-filling stage was truncated by the abrupt onset of elevated temperatures in early March.[7] In addition to thermal stress, 2025 was marked by erratic and intense precipitation patterns. Data from the Provincial Disaster Management Authority (PDMA) Punjab highlighted a marked shift towards concentrated seasonal rains. These extremes exemplify a new climate normal for Punjab, wherein the predictability of seasonal patterns has been supplanted by rapid successions of drought and deluge.

ii. Precipitation Variability

Punjab experienced a transformative and devastating monsoon season in 2025, which cemented a new climate normal for the province. The year was marked by a rapid shift from extreme moisture deficits during the early months to a state of atmospheric saturation. According to the National Disaster Management Authority (NDMA), Punjab recorded a 57% positive rainfall anomaly between July and September, ranking it as the eighth wettest monsoon season in the province's recorded history. This intensified rainfall, driven by a neutral El Niño Southern Oscillation (ENSO) phase and a northward shift of the monsoon axis, was particularly notable in Sheikhupura, which endured a record-breaking 216.8 mm of rainfall in a single day on 16 July 2025.[7]

The human and economic toll of the 2025 floods in Punjab was profound. The Provincial Disaster Management Authority (PDMA) reported that all 23 districts were affected. Catastrophic flooding, exacerbated by both torrential rains and overflowing Chenab, Ravi, and Sutlej rivers, impacted approximately 4.2 to 5.1 million people.[8] Southern Punjab districts, including Muzaffargarh and Rajanpur, suffered the most severe inundation, with breached embankments and upstream water releases inundating entire villages. The disaster necessitated the

[7] PostMoonsoonReport-2025.pdf
[8] Floods affect 4.2m people in Punjab - Newspaper - DAWN.COM

evacuation of over 2.8 million individuals, many of whom sought refuge in relief camps. Additionally, more than 213,000 houses were either damaged or completely destroyed.[9]

Agriculture, the backbone of Punjab's economy, suffered a severe setback due to the floods. Initial assessments by the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) and the Provincial Disaster Management Authority (PDMA) estimate that over 1.3 million acres of standing crops primarily rice, cotton, and sugarcane were submerged. The flooding struck at a critical growth stage for the Kharif crops, resulting in an estimated 15–20% decline in agricultural output. This devastation has generated a ripple effect on food security, with wheat flour prices increasing by approximately 25% in early September. Concerns also mount regarding farmers' ability to obtain seeds for the forthcoming Rabi (wheat) planting season, complicated by damaged irrigation infrastructure and silted fields.

Sr. No.	Impact Category	Statistics	Data Source
1	**Total Population Affected**	4.2 Million - 5.1 Million	UNOCHA RNA Report
2	**Fatalities**	322 Deaths	NDMA Sitrep No. 87
3	**Non-Fatal Injuries**	665 Injuries	NDMA Sitrep No. 87
4	**Displaced / Evacuated**	2,819,767 People	NDMA Final Monsoon Report
5	**Houses Damaged (Total)**	213,097 (157,963 Partial / 55,134 Full)	NDMA 2025 Summary

[9] Rapid Needs Assessment Report: Floods in Punjab (23 September 2025) - Pakistan | ReliefWeb

6	**Submerged Cropland**	1.3 Million Acres	Arif Habib Ltd / Profit
7	**Livestock Perished**	3,992 Animals	NDMA Final Sitrep 2025
8	**Rainfall Event**	216.8 mm (Sheikhupura, July 16)	NDMA Meteorological Overview

Table 4.3: Punjab's 2025 Flood Statistics

iii. Extreme Weather Events

Between September 2024 and May 2025, the province of Punjab experienced a period of acute climatic volatility, transitioning from a severe winter precipitation deficit to an unprecedented spring heatwave. Data compiled by the Pakistan Meteorological Department (PMD) and the National Drought Monitoring Centre (NDMC) indicate that rainfall during these months was approximately 38% below the long-term average, with certain districts experiencing deficits as high as 42%. This prolonged dry spell, lasting over 200 days in several southern districts, resulted in rapid depletion of soil moisture and significant water shortages within the Indus Basin irrigation system. By January 2025, the National Disaster Management Authority (NDMA) classified conditions in the Pothohar region and South Punjab as experiencing a "Mild to Moderate Meteorological Drought," substantially increasing irrigation requirements for the Rabi crop cycle.[10]

As Punjab entered the second quarter of 2025, a deficit in atmospheric moisture precipitated the early onset of a heatwave emergency. According to the Provincial Disaster Management Authority (PDMA) Punjab, April 2025 was characterised by a persistent high-pressure "heat dome" that trapped thermal energy over the plains, elevating daytime temperatures by 4°C to 7°C above seasonal averages. During this period, major urban and agricultural centres—including Multan, Bahawalpur, and Rahim Yar Khan—experienced sustained

[10] Punjab PDMA says prepared to deal with possible drought due to lack of rainfall - Pakistan - DAWN.COM

daytime highs ranging from 44°C to 46°C. The PDMA's assessment highlighted that this thermal intensity was exacerbated by the absence of pre-monsoon showers, culminating in a flash drought scenario that jeopardised the terminal growth phase of the wheat crop and imposed significant heat stress on livestock in the Cholistan region.[11]

The magnitude of this extreme weather event is reflected in the frequency of high-intensity heatwave days recorded by provincial authorities. PDMA Punjab reported approximately 20 to 22 days of severe heatwave conditions in April alone, with temperatures consistently exceeding historical thresholds.[12] The National Disaster Management Authority's (NDMA) Summer Hazards Contingency Plan 2025 highlighted this period as the most persistent spring heat stress recorded in recent years within the region. These severe conditions necessitated the activation of emergency protocols, including the establishment of over 1,500 heatstroke centres and the adjustment of school timings. This progression of events starkly underscores Punjab's increasing vulnerability to compound climatic extremes, where a protracted dry winter directly exacerbates the intensity of a subsequent heatwave.[13]

Category	Indicator	Observed Data	Data Source
Precipitation	Rainfall Anomaly (Punjab)	-38% to -42% (Below Normal)	PMD / NDMC
Drought Status	Continuous Dry Days (CDD)	200+ Days (South Punjab)	NDMA / PMD
Heat Intensity	Max Temperature (Bahawalpur)	46.0°C (Record High for April)	PDMA Punjab
Heatwave Duration	Extreme Temperature Days	20–22 Days in April 2025	PDMA / NEOC

[11] Climate Alert: Escalating Heatwaves Across Pakistan
[12] Pakistan in Crisis: From Burning Heatwaves to Floods | Global Climate Risks
[13] National Disaster Management Authority (NDMA): Summer Hazards & Heatwave Contingency Plan 2025

Thermal Shift	Temperature Anomaly	+5°C to +7°C Above Normal	NDMA Advisory
Water Scarcity	Reservoir Levels (Mangla)	Critical Dead Level (March 2025)	IRSA / NDMA
Health Impact	Heat Related Admissions	67+ Cases (Lahore/Multan - June Start)	Punjab Health

Table 4.4: 2025's Extreme Weather Event Snapshot

These prolonged high temperatures create multiple stress pathways:

- **Agricultural and Water Resource Stress**

Punjab's agricultural heartland experienced severe terminal heat stress during the 2024–2025 season. As temperatures surged to 45°C in late April, crops such as wheat underwent accelerated evapotranspiration, resulting in a shortened grain-filling period and shrivelled seeds. For moisture-intensive crops like rice and cotton, the 38% rainfall deficit compelled farmers to increasingly rely on groundwater sources. However, the National Disaster Management Authority (NDMA) highlighted that the absence of adequate winter recharge caused water tables to decline in districts such as Multan and Khanewal. This necessitated intensified use of tube wells by farmers, substantially inflating production costs, while surface water availability in canal command areas remained 15% to 20% below the required discharge for the early Kharif season.[13]

- **Human Health and Livelihood Stress**

The human toll of the 20–22 days of extreme heat in April was most acutely borne by the province's informal labour force. PDMA Punjab documented a surge in heat-related emergencies among outdoor workers and the elderly, as the "Feels Like" temperature index often exceeded 50°C in the southern belt. Beyond direct health risks such as dehydration and heatstroke, the heatwave precipitated a damaging "economic stress" loop: rural households were simultaneously confronted with diminished agricultural yields and increased expenditures for cooling and emergency livestock feed. The NDMA Summer Hazards Contingency Plan 2025 further noted that livestock in the Cholistan and Thal deserts

experienced reduced milk productivity and heightened mortality rates, attributable to the drying of traditional "tobas" (water ponds), thereby exacerbating the economic vulnerability of pastoralist communities.[13]

4.3.2. Anthropogenic Climate Stressor

The province of Punjab faced a critical escalation of anthropogenic climate stressors in 2025. Human activities, ranging from the conversion of ancient forests into fuel to the unchecked expansion of concrete urban sprawls, continue to fundamentally alter the regional climate. In 2025, these pressures were no longer abstract threats but pivotal drivers behind the record-breaking heatwaves and catastrophic pluvial floods that characterised the year. These climate stressors profoundly impacted Punjab's agriculture, water resources, ecosystems, and human livelihoods.

i. Deforestation and Vegetation Loss
ii. Urbanisation and Infrastructure Expansion
iii. Agricultural Expansion and Irrigation Practises

i. Deforestation and Vegetation Loss

Deforestation and vegetation loss in Punjab have emerged as significant climate stressors, yielding profound environmental, economic, and social repercussions. Extensive clearing of forests for agriculture, urban expansion, and timber extraction has drastically diminished tree cover, thereby disrupting ecosystems and impairing natural climate regulation. Trees, which play a critical role in cooling local environments and sustaining rainfall patterns, have been lost on a scale that contributes to rising temperatures, increased frequency of heatwaves, and more erratic precipitation, thereby exacerbating drought risk. Reports from 2024 to 2025 indicate that the water table in central Punjab is declining by nearly one metre annually, compelling farmers to rely increasingly on costly

mechanization such as the Super Seeder to sustain crop yields.[14] The degradation of forests and rangelands has released significant quantities of stored carbon dioxide, thereby contributing to global warming and exacerbating pressures on water resources, agriculture, and human health. In addition, communities dependent on forest resources face mounting economic challenges. Despite the provincial government's ambitious afforestation initiative to plant 51 million saplings during the 2025–2026 cycle, net forest loss remains substantial due to ongoing illegal logging and land clearing for housing developments. The severity of vegetation loss was tragically highlighted in 2025, when deforestation was identified as a primary factor driving catastrophic floods. The absence of stabilising root systems in Upper Punjab led to extensive soil erosion, resulting in massive siltation of rivers, widespread landslides, and devastating losses of crops and orchards. More than 1.5 million acres of farmland were affected, including an estimated 25–30% of mango orchards in South Punjab that were destroyed.[15] The removal of trees has exacerbated the Urban Heat Island effect, with cities such as Lahore and Gujranwala experiencing surface temperatures 5–7°C higher than those of the surrounding rural areas. This deforestation has also disrupted the hydrological cycle of the Indus Basin, contributing to an annual

[14] Super Seeder: A Viable Option for Resource Conservation and Productivity Enhancement of Wheat Crop in Punjab, Pakistan | Pakistan Research Journal of Social Sciences
[15] Flood 2025 and Loss of Mango Orchards in Punjab, Pakistan - TheWaterChannel

decline in water tables of nearly one metre in central Punjab, thereby increasing reliance on mechanised irrigation.[16]

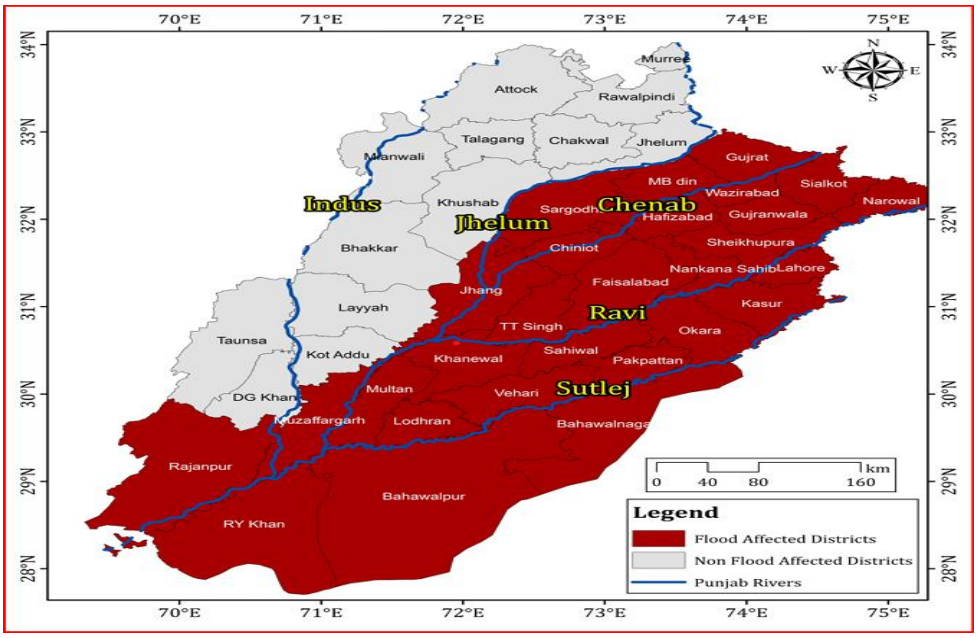


Figure 4.6: Flood Hit Districts of Punjab in 2025[7]

Deforestation in Punjab presents a dual challenge for air quality: trees serve as essential carbon sinks, and their removal not only releases stored CO_2 but also eliminates a natural filtration system that helps cleanse the atmosphere.[17] This loss of vegetation is a primary driver of the smog emergency, with the most heavily polluted areas in Lahore consistently corresponding to zones exhibiting the lowest levels of greenery. Residents of Lahore now face a reduction in life expectancy by an average of 5.3 years due to air pollution—a public health crisis exacerbated by the scarcity of green buffers capable of trapping industrial and vehicular emissions.[18]

[16] Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan - PMC
[17] Decoding carbon sequestration: The impact of agriculture, conservation policies, climate and land use
[18] Current landscape and future directions of policies addressing air quality improvement in Pakistan: a scoping review - PMC

In Punjab, deforestation functions as a multifaceted climate stressor, interacting synergistically with heatwaves, erratic rainfall, and flooding to jeopardise livelihoods, agriculture, and water security. Initiatives such as Pakistan's Billion Tree Tsunami programme aim to mitigate these risks; however, effective enforcement and robust local community participation remain essential for their successful implementation.

ii. Urban Sprawl and Infrastructure Expansion

Urban sprawl in Punjab acts as a significant climate stressor by replacing carbon-sequestering farmland with heat-absorbing concrete surfaces. This horizontal expansion contributes to the formation of Urban Heat Islands, wherein dark surfaces trap solar radiation, leading to elevated local temperatures and increased demand for energy-intensive cooling. Furthermore, the extensive paving over of the Indus Basin disrupts the natural water cycle; impervious surfaces inhibit rainwater infiltration, thereby reducing groundwater recharge, exacerbating aquifer depletion, and intensifying urban flash flooding during the monsoon season.

In addition, urban sprawl extends food supply chains and increases vehicular emissions as residential areas expand further from city centres. The absence of green buffers in these sprawling suburbs facilitates the accumulation of pollutants, significantly contributing to Punjab's recurring smog crises and overall greenhouse gas emissions.

iii. Agricultural Expansion and Irrigation Practices

Punjab's economy is heavily reliant on agriculture, which sustains over 80% of rural livelihoods. However, rapid agricultural expansion and unsustainable irrigation practices have emerged as significant climate-related challenges in the province. Farmers frequently adopt multiple cropping cycles and high-yield crop varieties, substantially increasing water demand. To satisfy this increased demand, groundwater extraction has surged, particularly in districts such as Faisalabad, Multan, Bahawalpur, and Sargodha. Over time, this has led to

declining water tables, reducing the province's resilience to dry spells and droughts, which are becoming increasingly frequent due to climate variability.

Unsustainable irrigation methods such as flood irrigation without adequate drainage exacerbate these problems. Extensive areas of cultivated land suffer from waterlogging and salinisation, which degrade soil fertility and diminish crop yields. These issues are especially pronounced in southern Punjab, where the arid climate restricts natural groundwater recharge. During extended dry periods, such as the September 2024 to March 2025 dry spell, farmers face acute water shortages, imperilling food security and rural incomes.

The situation is further complicated by heavy monsoon rains. Saturated and degraded soils are unable to absorb water efficiently, increasing the risk of flooding and subsequent crop damage. In Punjab, the confluence of groundwater over-extraction, poor irrigation management, and climatic variability has elevated agricultural water management to a critical environmental and socio-economic concern.

Stressor	Anthropogenic Causes	Impacts	Data Source
Deforestation & Vegetation Loss	Conversion of forests to fuel; Illegal logging; Housing scheme expansions; Obsolete Forest Act (1927) loopholes.	25–30% loss of South Punjab mango orchards; Increased landslides; Massive siltation in rivers during monsoon.	Punjab Forest Dept. Plan 2025-26
Urban Sprawl & Infrastructure	Uncontrolled concrete sprawl; Paving over the Indus Basin; Horizontal city expansion in Lahore & Gujranwala.	Urban Heat Island (UHI) effect; Surface temps 5°C to 7°C higher than rural areas; Increased energy for cooling.	The Urban Unit - Heatwave Plan
Agricultural Expansion	Intensive multiple cropping; Water thirsty high yield varieties; Unregulated tube well installation (>1.5M units).	Groundwater table dropping ~1 m annually; High soil salinization in South Punjab.	Punjab Irrigation Dept. Report 2025

Pluvial Flooding	Deforestation in Upper Punjab (loss of soil anchoring); Impervious urban surfaces; Blocked natural drainage.	7.78% rain increase triggered catastrophic runoff; 322 deaths in Punjab; 161k houses damaged/destroyed.	NDMA Final SitRep No. 87 (Oct 2025)
Temperature Regulation Failure	Massive tree removal for infrastructure; Loss of evapotranspiration cooling.	Intensified heatwaves (May–June 2025); Temperatures reaching 45°C by April in southern districts.	PMD / PDMA Heatwave Alert 2025

Table 4. 5: Summary of Anthropogenic Activities and their Impacts

4.4. Environmental Pressure Points

Punjab serves as Pakistan's economic and agricultural lifeline; however, its role as the nation's breadbasket is increasingly imperilled by severe ecological degradation. The province stands at a critical tipping point where intensive farming practices exacerbated by stubble burning and groundwater depletion intersect with rapid, unplanned urbanisation and toxic industrial emissions. These local stressors are further intensified by climate change, manifesting in extreme heatwaves and erratic monsoon patterns that pose significant threats to public health and agricultural productivity. Securing Punjab's future necessitates a decisive transition towards sustainable resource management and climate-resilient policies, which is now a matter of survival.

4.4.1 Pressure on Air Quality

The air quality crisis in Punjab has evolved into a critical environmental pressure point, transitioning from a seasonal nuisance to a persistent, year-round threat to the province's ecological integrity and economic viability. This pressure results from the convergence of stagnant meteorological conditions—particularly temperature inversions—and high-intensity anthropogenic emissions, which trap a toxic mixture of $PM_{2.5}$ and nitrogen oxides close to the ground. Notably, government reports indicate a 56% reduction in peak pollution intensity in

November 2025 compared to 2024.[19] Despite these improvements, systemic pressure remained high, with over 20 million people affected by smog-related respiratory and cardiovascular emergencies throughout the year.[20] This environmental degradation is not merely a public health crisis but also an economic burden, with the World Bank estimating that air pollution costs Pakistan approximately 6.5% of its annual GDP. The cumulative impact has reached a tipping point where natural systems can no longer self-regulate. In 2025, air quality monitoring became more transparent with the installation of 30 new regulatory-grade stations, revealing that Air Quality Index (AQI) levels in cities such as Dera Ghazi Khan and Kasur occasionally soared to 500, surpassing even the traditionally elevated levels observed in Lahore.[21] Experts have noted that, for vulnerable populations in Punjab's most affected districts during 2025, breathing the ambient air was equivalent to smoking nearly a pack of cigarettes per day.[22]

Pressure Source	Impact Mechanism	2025 Status	Data Source
Urban Transport	Heavy duty vehicles and a surge in private two wheelers (7.4M in Lahore) using low grade fuel.	Contributes 43%–70% of urban PM2.5	Business Recorder
Industrial Units	Unregulated emissions from steel mills and coal burning brick kilns.	Over 2,500 units were sealed in 2025 as part of a Zero Tolerance crackdown	EPA, Punjab

[19] SMOG Mitigation | Environment Protection Department
[20] Smog crisis sickens millions across Punjab in 2025 | Pakistan Today
[21] Smog chokes Punjab as air quality plummets to hazardous levels
[22] Breathe Pakistan: Experts bring attention to air pollution's transnational threat, urge greater regional cooperation to tackle issue - Pakistan - DAWN.COM

Agricultural Stubble	Massive release of black carbon during the post-harvest clearing window.	Shifted via 1,000+ subsidized Super Seeders to reduce burning incidents	Agri. Punjab

Table 4. 6: Factor Affecting Air Quality

4.4.2. Pressure on Water Resources

Punjab's water crisis represents a systemic collapse driven by a substantial imbalance between groundwater extraction and natural recharge. According to the Pakistan Council of Research in Water Resources (PCRWR), the province extracts approximately 55–60 million acre-feet (MAF) of groundwater annually, while the natural replenishment rate is only 3–5 MAF. This overextraction has resulted in a decline in the water table of 2.5 to 3 feet per year in major urban hubs such as Lahore and Faisalabad. In Southern Punjab, districts including Bahawalpur and Rahim Yar Khan are experiencing aquifer depletion leading to seawater intrusion and upconing, whereby deeper saline water rises and contaminates freshwater aquifers. This phenomenon has rendered nearly 60% of groundwater unsuitable for irrigation, contributing to a 28% reduction in wheat yields within affected hotspot areas.[23]

The quality of both surface and groundwater in Punjab is critically compromised due to industrial and agricultural negligence. The World Wildlife Fund (WWF-Pakistan) has frequently described the Ravi River as a "biological sewer," given that its dry-season flow largely consists of untreated municipal and industrial effluents. Heavy metals such as chromium and lead, emanating from tanneries in Sialkot and Kasur, alongside elevated nitrate concentrations from agricultural runoff, have led to contamination of the food chain. As a result, over 80% of water samples collected from urban centres including Multan and Lahore fail to meet

[23] Water Quality Reports

safety standards, subjecting residents to water poverty and contributing to higher incidences of waterborne diseases and arsenic poisoning.[24]

These combined pressures have culminated in widespread water scarcity, contamination of drinking water supplies, and significant economic losses for farmers, particularly in southern Punjab districts such as Bahawalpur and Rahim Yar Khan. Urban centres like Lahore and Multan are also impacted, with many residents increasingly reliant on bottled or filtered water due to heightened contamination risks.

4.4.3. Pressure on Soil and Land

Farmers in Punjab often cultivate wheat, rice, and sugarcane year after year, leading to the depletion of essential nutrients and organic matter in the soil. The burning of crop residues destroys beneficial soil microbes, diminishes moisture retention capacity, and releases carbon dioxide into the atmosphere, thereby contributing to climate change. The intensive application of synthetic fertilisers and pesticides further degrades soil structure, compromising fertility and increasing susceptibility to erosion and desertification—particularly in southern districts such as Bahawalpur, Rahim Yar Khan, and southern Multan. Central Punjab, including Faisalabad and Sargodha, faces issues of soil compaction and reduction of arable land due to overirrigation and mechanised farming practices. This land degradation not only lowers agricultural productivity but also compels farmers to increase reliance on chemical inputs, perpetuating a deleterious cycle of environmental deterioration and economic hardship.

4.4.4. Pressure on Biodiversity

Punjab's diverse landscapes, ranging from the salt-crusted ranges to the fertile Indus plains, are approaching a critical ecological tipping point. In urban centres

[24] Freshwater | WWF

such as Lahore, tree canopy cover has diminished by over 70%, resulting in the fragmentation of natural corridors and the increased isolation of endemic species, including the Punjab Urial. This deforestation is further aggravated by a surge in wildfires, with over 1,000 alerts reported in recent years, leading to the destruction of thousands of acres of remaining forested areas.

Punjab's wetlands, often referred to as the "blue lungs" of the province, are likewise in decline. With 60% of Pakistan's inland wetlands already degraded, crucial sites such as Chashma Lake and the Pakpattan marshes are succumbing to the combined pressures of industrial runoff and water diversion. The ecological consequences are profound, as evidenced by a precipitous 99% decline in migratory bird populations at Uchalli Lake. The collapse of aquatic and avian biodiversity disrupts the broader food web, undermining the natural equilibrium and threatening the agricultural productivity that underpins Punjab's economy.[25]

In a proactive response to environmental degradation, 2025 witnessed the launch of the Green Punjab Mission, an ambitious initiative aiming to restore ecological balance through the planting of 51 million trees by 2026.[26] This endeavour is supported by the July 2025 biodiversity survey led by the International Union for Conservation of Nature (IUCN), marking the first systematic attempt to establish a scientific baseline for the province's flora and fauna.[27] While these policy advances offer a measure of hope, the current forest cover of merely 3.1%, compared to the international recommendation of 25%, underscores the urgent need for sustained, data-driven conservation efforts to avert total ecosystem collapse.[28]

[25] https://researcherslinks.com/current-issues/Field-Validation-of-Avian-Diversity-at-Uchalli-Wetland/20/1/6830/html
[26] 51m trees: Largest forest to be grown under Green Punjab Mission
[27] Punjab's flood-affected ecosystems under spotlight in ambitious biodiversity survey
[28] Punjab surpasses 2025 monsoon plantation target despite record flooding

4.4.5. Pressure on Climate and Atmosphere

The climate of Punjab is profoundly influenced by its geography, characterised by a vast, low-lying fertile plain that experiences some of the most pronounced seasonal fluctuations in atmospheric pressure globally. This climatic dynamic is chiefly driven by the thermal contrast between the landmass and the surrounding oceans. During the peak summer months (April to June), intense solar radiation rapidly heats and expands the air over the Punjab plains, creating a persistent thermal low-pressure system. Temperatures during this period have approached record levels, with April 2025 ranking as the second warmest in 65 years, featuring a mean maximum temperature of 38.87°C.[29] This thermal low-pressure system functions as a vacuum, drawing in moisture-laden winds from the Arabian Sea and the Bay of Bengal, thereby initiating the South Asian monsoon. In June 2025 alone, this pressure gradient contributed to rainfall totals of 42.50 millimetres, representing a 44% increase above the historical average for that month.[30]

Conversely, during the winter months (December to February), the air cools and becomes denser, establishing a stable high-pressure system. This heavy, stagnant air often gives rise to temperature inversions, which trap pollutants and moisture close to the ground, thereby precipitating severe smog crises.[31] These atmospheric shifts are becoming increasingly erratic due to the impacts of climate change. For example, blocking high-pressure systems in May 2025 led to prolonged heatwaves, during which night-time temperatures in Dera Ghazi Khan did not fall below 33.5°C. This phenomenon exemplifies how pressure anomalies

[29] Pakistan_Monthly_Climate_Summary_Apr_2025.pdf
[30] Pakistan_Monthly_Climate_Summary_Jun_2025.pdf
[31] SOE

are now exerting a decisive influence on both the agricultural productivity and public health of the province.[32]

Punjab is highly vulnerable to the impacts of climate change, which serve to exacerbate existing environmental pressures. Greenhouse gas emissions from stubble burning, industrial activities, and transportation contribute significantly to global warming. The province has experienced rising average temperatures, erratic rainfall patterns, and prolonged heatwaves, particularly affecting southern districts such as Bahawalpur and Multan. Flooding during the monsoon season in central Punjab has become increasingly frequent, causing extensive damage to crops, homes, and infrastructure. These climatic shifts jeopardise agricultural productivity, food security, and livelihoods, especially among smallholder farmers who often lack the resources to adapt effectively. The interplay between local emissions and global climate change establishes a feedback loop, wherein environmental degradation accelerates climate-related risks, which in turn further intensify environmental harm.

4.4.6. Waste and Resource

Pressure on Waste and resource in Punjab has reached a critical tipping point, as the province's population of approximately 134.3 million generates an unprecedented 57,000 tonnes of municipal solid waste daily. This surge has transformed waste management from a routine municipal service into a significant environmental challenge. According to the Spectreco Waste to Value 2025 Report, this increase is attributable to rapid urban expansion across 36 districts, resulting in an estimated annual financing gap of $860 million required to address the ecological consequences of uncollected waste.[33]

[32] Pakistan Monthly Climate Summary May 2025 | PDF | Natural Hazards | Oceanography
[33] Spectreco Launches Waste to Value 2025 Report

i. Systematic Waste Pressure and Legacy Backlogs

The environmental crisis in 2025 was characterised by a legacy of neglect. Although the provincial government's Suthra Punjab initiative scaled up waste collection to approximately 50,000 tonnes per day, a substantial portion of this volume comprised legacy waste—years of accumulated refuse from streets and vacant plots—integrated into formal management systems for the first time.[34] Despite these interventions, the provincial government confirmed that by late 2025, over 8.15 million tonnes of waste had been disposed of. However, the insufficient availability of engineered landfills has resulted in the continued deposition of much of the daily waste output in inadequately managed sites, thereby exerting significant pressure on the province's soil and air quality.[35]

ii. Resource Inefficiency and the Circular Economy Gap

Throughout 2025, the pressure on resources in Punjab was increasingly recognised as a manifestation of lost economic and environmental value. Despite generating millions of tonnes of plastic waste, the province's recycling rate stagnated at approximately 4–9%, representing a substantial leakage of valuable resources from the economy.[36] The open burning of plastic and municipal waste has been identified as a critical contributor to $PM_{2.5}$ pollution levels. To address this, 2025 witnessed the launch of a $528 million (PKR 150 billion) public investment plan aimed at promoting local manufacturing of waste-to-energy technologies and the development of recycling infrastructure.[37]

iii. Legislative Shifts and 2025 Targets

[34] Suthra_Punjab_Handbook_1ca7000839.pdf
[35] 8.15m tonnes waste disposed of under Suthra Punjab Program
[36] Pakistan generates 3.9m tonnes of plastic waste annually: report
[37] SOE

To address these pressures, the provincial government adopted a data-driven governance model. By the end of 2025, over 30,000 vehicles and 150,000 workers were tracked through GPS and digital platforms to ensure that collection targets were met.[38] Furthermore, the 2025–26 Provincial Budget allocated Rs. 14.4 billion specifically to the Lahore Waste Management Company (LWMC) to initiate low-cost treatment and waste-to-energy pilot projects. These measures signify the commencement of a transition from a traditional sweep-and-dump approach towards a circular waste management model, aimed at reducing methane emissions from landfills by 75%.[34]

Simultaneously, resource pressure is most acutely manifested in the depletion of the Indus Basin aquifer, now recognised as the second most overstressed groundwater reserve globally. In Punjab, agricultural activities consume over 90% of available groundwater through approximately 1.5 million tube wells, resulting in an annual decline in water table levels of 4 to 5 feet, particularly in southern districts such as Dera Ghazi Khan and Rajanpur. This excessive extraction, coupled with deteriorating water quality, indicates that salinity and industrial runoff have adversely affected nearly 70% of groundwater resources in certain areas.[39]

4.4.7. Pressure on Human Health

Environmental degradation in Punjab exerts direct and severe impacts on human health and livelihoods. During the 2025 flood events, the province experienced significant loss of life and an estimated financial loss of PKR 326.777 million, highlighting the devastating consequences of climate-induced disasters.[40] Such extreme events not only cause immediate fatalities and economic damage but also exacerbate existing environmental and public health vulnerabilities.

[38] Suthra Punjab programme achieves major milestone at global level - Daily Times
[39] Punjab's Groundwater Crisis - Daily Times
[40] PDMA| Punjab Post Moonsoon Flood Report 2025

Poor air quality, stemming from stubble burning, industrial emissions, and vehicular pollution, contributes to respiratory and cardiovascular illnesses, particularly affecting vulnerable populations such as children, the elderly, and individuals with pre-existing health conditions. Contamination of water supplies and flood-affected sanitation systems elevates the risk of gastrointestinal diseases, skin infections, and other waterborne illnesses. Rural communities reliant on canals or shallow wells face heightened exposure post-flooding, while urban populations in cities like Lahore, Faisalabad, and Multan confront compounded risks from damaged infrastructure and pollution.

The interplay of climate disasters with persistent air, water, and soil pollution underscores human health as a critical environmental pressure point within Punjab.

Pressure Point	Causes in Punjab	Effects	Hotspots	Data Source
Air Quality	Industrial & vehicle emissions, crop residue burning, smog build-up	Smog episodes, respiratory illness risk, hazardous AQI peaks	Lahore, Faisalabad, Multan, Gujranwala, Bahawalpur	EPA, NDMA
Water Resources	Excessive groundwater extraction, untreated industrial and municipal discharge	Water scarcity, contamination, eutrophication	Ravi & Chenab basins, Faisalabad, Bahawalpur	PCRWR
Soil/Land	Intensive monoculture, chemical use, crop burning	Fertility loss, erosion, salinity, degradation	Central & southern Punjab	Agri. Punjab
Biodiversity	Habitat loss, wetland conversion, hunting	Species decline, ecosystem imbalance	Wetlands, Chashma region, protected areas	WWF-Pakistan Annual Report 2025

Climate Change	GHG emissions from energy/industry, changing rainfall patterns	Heatwaves, crop stress, erratic rainfall	Multan, Bahawalpur, Faisalabad & south Punjab	Federal Ministry of Climate Change
Waste/ Resources	Rapid urbanisation, industrial waste mismanagement, plastics	Landfill overflow, soil & water pollution	Lahore, Gujranwala, Faisalabad	Industrial Environmental Management (2025)

Table 4. 7: Summary of Environmental Pressure Points and Their Effects

4.5. Conclusion

The overall analysis underscores that Punjab is undergoing a profound and interconnected environmental transition, driven by rapid population growth, expanding urbanisation, concentrated industrial activity, and increasing climate variability. These factors no longer operate in isolation but act synergistically to amplify pressures on air quality, water resources, land productivity, and ecological systems, propelling the province towards a critical threshold.

The evidence indicates a shift from manageable environmental challenges to a systemic, multifaceted crisis characterised by rising temperatures, erratic rainfall, floods, heatwaves, groundwater depletion, pollution, and biodiversity loss—all of which are mutually reinforcing. Concurrently, the escalating impacts on human health, agriculture, and economic stability underscore the direct linkage between environmental degradation and development outcomes.

This evolving scenario signals that traditional approaches to environmental management are inadequate. There is an urgent need for integrated, data-driven, and climate-resilient strategies that harmonise urban planning, industrial regulation, and natural resource management. Ultimately, the current trajectory serves both as a warning and an opportunity, emphasising the imperative for immediate, coordinated action to secure long-term environmental sustainability, economic resilience, and an improved quality of life across the province.

CHAPTER 05

Air Quality of Punjab



Part I

5.1 Situational Analysis of Air Quality:

Air pollution is recognised by the World Health Organization (WHO) as a major public health hazard, responsible for nearly seven million premature deaths each year. It is defined as the alteration of the natural atmospheric composition by chemical, physical, or biological agents, impacting both indoor and outdoor environments. Current WHO data indicate that 99% of the global population is exposed to air quality levels that exceed recommended limits, with the greatest burden falling disproportionately on low and middle-income countries[1].

Air pollution and climate change share common drivers, notably the combustion of fossil fuels, which simultaneously releases greenhouse gases and deteriorates air quality. Among the principal pollutants, fine particulate matter (PM2.5) and coarse particulate matter (PM10) are considered particularly harmful due to their capacity to penetrate deep into the respiratory system and bloodstream, leading to serious health complications. Emissions originate from sources such as traffic, industry, and agriculture, while secondary particulates form from chemical precursors including volatile organic compounds (VOCs), sulphur dioxide (SO_2), nitrogen oxides (NO_x), and ammonia (NH_3), thereby adding complexity to the management of air quality[2]. Globally, trends in air pollution vary considerably across regions. While North America and Europe have experienced reductions in fine particulate matter (PM2.5), exposure levels in Central and South Asia have continued to increase[3].

Evidence from South Asian cities underscores the severity of air pollution challenges in the region. Long-term monitoring of PM10, nitrogen oxides (NO_x), sulphur dioxide (SO_2), and carbon monoxide (CO) has revealed that concentrations of PM10, CO, and NO_x frequently exceed Pakistan's National Environmental Quality Standards (NEQS). Concurrently, Air Quality Index (AQI) values have consistently fluctuated within the unhealthy to severe categories. Research further indicates that climatic variables—such as temperature fluctuations, fog events, and dust storms—alongside pollutants like nitrogen dioxide (NO_2), significantly contribute to the incidence of acute respiratory

illnesses. Spatial analyses employing Geographically Weighted Regression (GWR) have confirmed that these health impacts vary considerably across different locations, thereby highlighting the necessity for targeted, location-specific interventions.

Similarly, assessments utilising both AQI and the Multi Pollutant Index (MPI) have identified Lahore and Karachi as among the most polluted urban centres in Pakistan, especially in areas burdened by dense industrial activities and heavy traffic congestion[4].

The severity of urban air pollution is exacerbated by climatic and meteorological conditions. Phenomena such as the urban heat island effect, atmospheric stagnation, low wind speeds, and temperature inversions frequently trap pollutants close to the ground, resulting in localized pollution hotspots. Climate change is projected to further influence atmospheric chemistry and weather patterns, thereby altering pollutant dispersion and complicating air quality management efforts. In response to these growing challenges, the World Health Organization (WHO) has developed Air Quality Guidelines (AQGs), which prescribe permissible concentration limits for major pollutants to protect public health[5].

5.1 Situational Analysis of Air Quality:

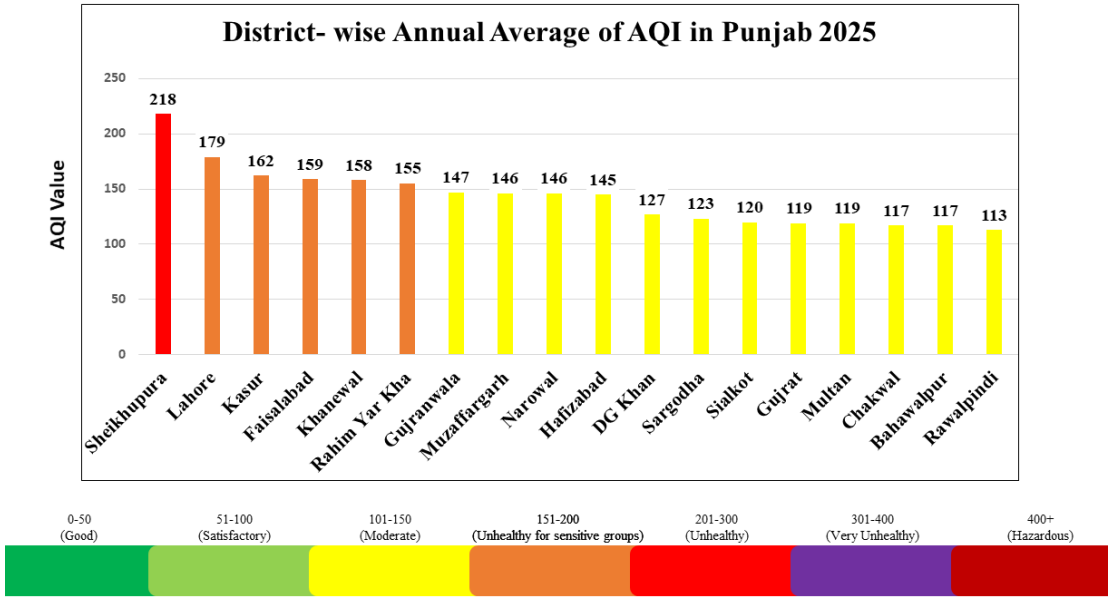
Punjab's smog crisis, which intensifies during late autumn and winter, has become a recurring environmental and public health emergency. As the monsoon season concludes and temperatures decline, atmospheric conditions stabilise with low wind speeds and frequent temperature inversions, trapping pollutants near the ground. This meteorological scenario coincides with peak emissions from human activities. The most significant contributor is crop residue burning, particularly of rice straw following the Kharif harvest in October and November, which releases dense smoke laden with particulate matter that disperses across cities such as Lahore, Faisalabad, and Multan. In addition, industrial emissions from factories and brick kilns, coupled with vehicular

pollution from ageing vehicles and substandard fuels, exacerbate the deterioration of air quality[6].

5.2 Pollution Index of Punjab

The Punjab Air Quality Index (AQI) Report for 2025, published by EPA Punjab, reveals a pronounced seasonal variation in pollution levels across the province. The year commenced with elevated pollution levels in January (AQI 276) and February (approximately 240), followed by a gradual improvement throughout the spring and monsoon months. During July and August, AQI values reached their lowest points of 77 and 87 respectively, largely due to increased precipitation and enhanced atmospheric dispersion. However, with the onset of the smog season in October (AQI 155), air quality sharply deteriorated, culminating in unhealthy average AQI readings of 212 and 226 in November and December, respectively.

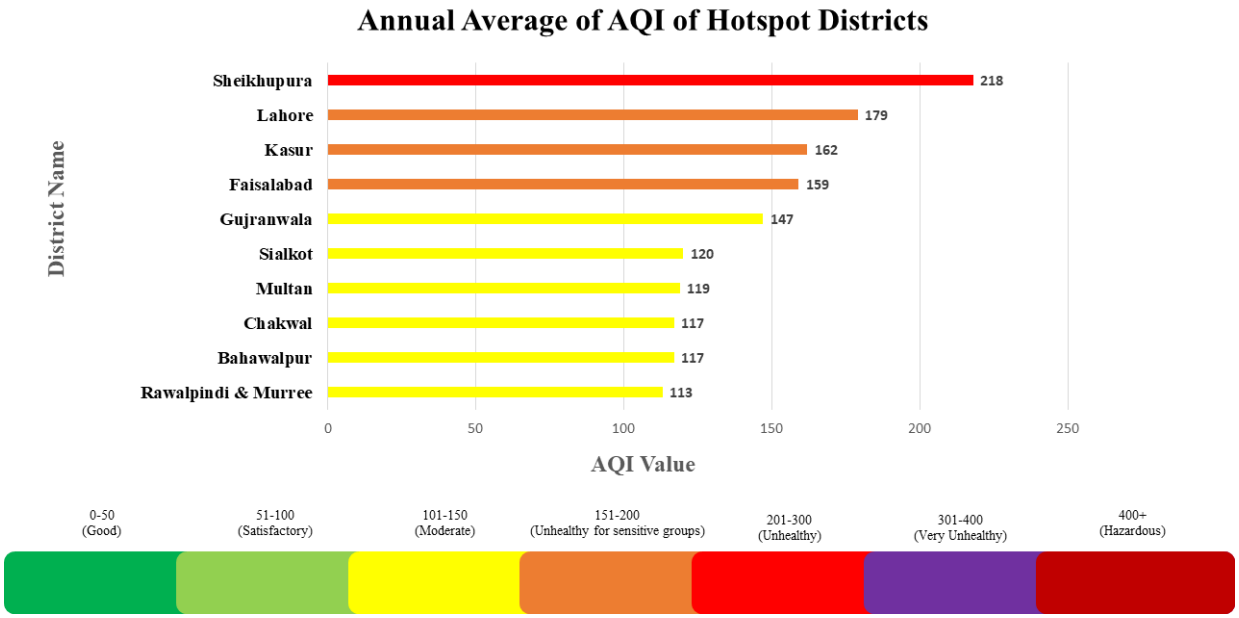
It is important to note that for several districts including Sheikhupura, Kasur, Khanewal, and Rahim Yar Khan. Comprehensive data for the first half of the year (January to June) is limited or unavailable. This data gap is attributable to delays in the installation of Air Quality Monitoring Systems (AQMS), many of which only became fully operational in late 2025.



Graph 5.1 District wise Annual average value of AQI in Punjab, 2025

5.2.1 Pollution Index of hotspot districts:

The annual average Air Quality Index (AQI) values for the selected hotspot districts exhibit notable variation, ranging from **113 to 218**. Overall, the data indicate that most districts fall within the **"Moderate" to "Unhealthy** categories. However, Sheikhupura district registers an **"Unhealthy"** level, underscoring a significant and widespread air pollution concern in the region.



Graph 5.2 Annual average AQI level of hotspot districts in Punjab in 2025

The pollution index is primarily influenced by the type, number, and emission potential of industries, alongside other anthropogenic sources such as vehicular traffic, agricultural burning, and energy generation. Districts such as Lahore, Sheikhupura, Faisalabad, and Gujranwala consistently exhibit higher Air Quality Index (AQI) levels due to their dense concentrations of high-emission industries, including steel re-rolling mills, textile processing units, chemical manufacturing plants, and thermal power stations. These sectors emit substantial quantities of particulate matter ($PM_{2.5}$ and PM_{10}), sulphur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs), significantly amplifying the overall pollution load.

In contrast, districts like Bahawalpur and Rawalpindi demonstrate relatively lower AQI levels, attributable to their limited industrial base and reduced emission intensity. These areas possess fewer and less diverse pollution sources, resulting in a diminished cumulative pollution index. Similarly, Sialkot and Multan fall within the moderate pollution category, where industrial activity exists but is either less intensive or more spatially dispersed, yielding comparatively moderate AQI values.

Meteorological factors constitute another critical determinant of AQI variation. During winter months, temperature inversions, low wind speeds, and a reduced atmospheric mixing height impede pollutant dispersion, leading to their accumulation at ground level. Districts in central Punjab, particularly in the vicinity of Lahore, are especially susceptible to these conditions, which they experience as severe smog episodes accompanied by elevated AQI readings. Furthermore, proximity to agricultural regions exacerbates pollution exposure through emissions from stubble burning, further increasing AQI levels in districts such as Sheikhupura, Kasur, and Faisalabad.

Conversely, districts in southern Punjab, including Bahawalpur and Multan, often benefit from improved dispersion conditions characterized by relatively higher wind speeds and open landscapes. These factors facilitate pollutant dilution, resulting in lower AQI levels despite the presence of emission sources.

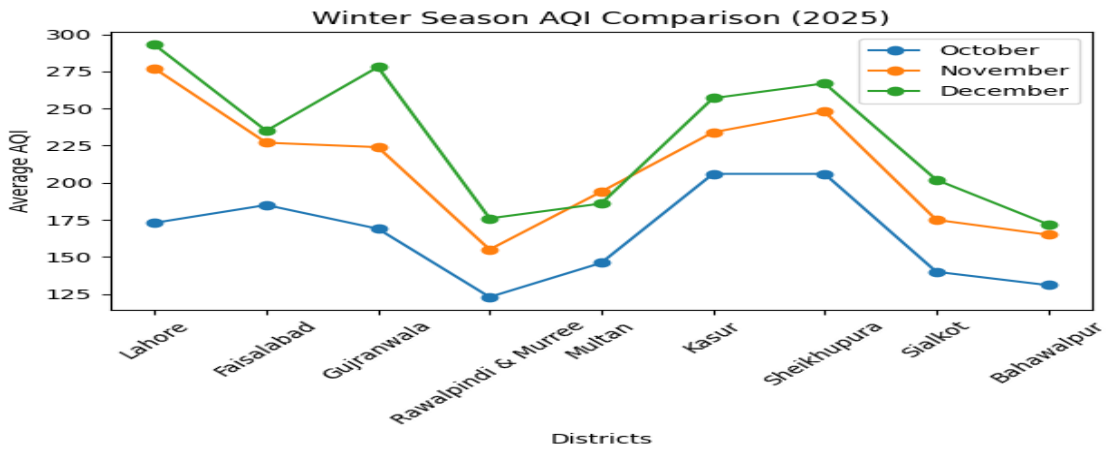
Urbanisation and traffic density also exert significant influence. Highly urbanised districts like Lahore endure intense vehicular emissions and construction activities, which further elevate their pollution indices. In contrast, less urbanised districts with lower traffic volumes tend to maintain superior air quality.

In summary, elevated AQI levels are observed in districts with high pollution indices, driven by concentrated industrial activity, dense traffic flows, energy generation, and unfavourable meteorological conditions. Conversely, districts with fewer emission sources, lower industrial density, and more favourable atmospheric dispersion tend to record lower AQI levels. This spatial variation highlights the imperative for district-specific air quality management strategies,

which focus on mitigating dominant pollution sources and addressing seasonal meteorological challenges.

5.2.2 Comparison of AQI level of hotspot districts during winter season:

The analysis of average Air Quality Index (AQI) values during the winter season (October–December 2025) across ten hotspot districts—Lahore, Faisalabad, Gujranwala, Rawalpindi, Murree, Multan, Kasur, Sheikhupura, Sialkot, and Bahawalpur—reveals a clear and consistent deterioration in air quality as the season advances. The graphical trend indicates a steady increase in AQI values from October through to December, underscoring the progressive intensification of air pollution during this period.

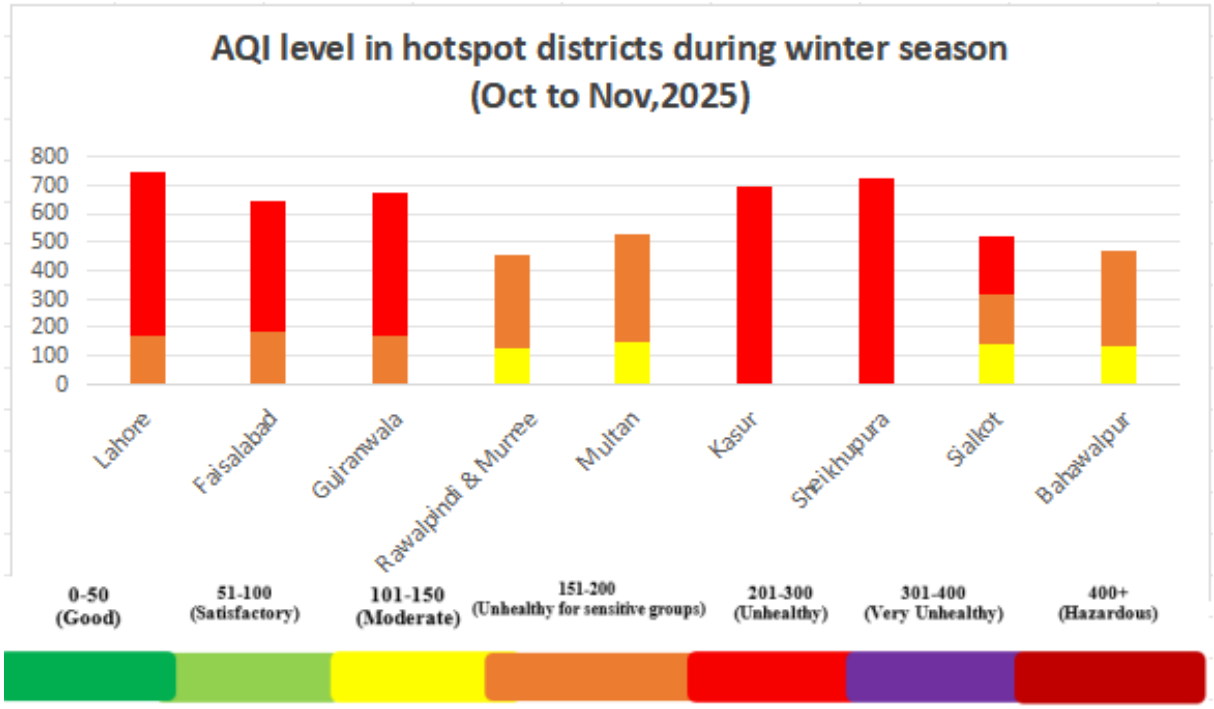


Graph 5.3 Comparison of AQI level among hotspot districts during winter season

This trend is observed in almost all districts, reflecting the intensification of smog conditions driven by unfavourable meteorological factors such as temperature inversions, low wind speeds, and reduced atmospheric mixing heights. The most severe pollution levels are concentrated in the Central Punjab industrial belt, particularly in Lahore, Gujranwala, Faisalabad, Sheikhupura, and Kasur. Among these, Lahore experiences the highest AQI values, escalating sharply from 173 in October to 293 in December, indicative of extreme pollution stress.

A significant contributor to the elevated AQI levels in Kasur and Sheikhupura is the widespread practice of crop residue (stubble) burning during the winter months, which substantially exacerbates air pollution in these districts. The pronounced upward trends in these areas highlight the combined effects of dense industrial activity, vehicular emissions, and poor atmospheric dispersion, rendering them the province's core smog hotspots.

Moderate yet consistently high AQI levels are recorded in Faisalabad, Multan, and Sialkot. Faisalabad exhibits a steady increase from 185 in October to 235 in December, primarily attributable to emissions originating from the textile sector and related industries. Multan's pattern differs slightly, with AQI rising from 146 in October to 194 in November, followed by a modest decline to 186 in December, potentially reflecting localised meteorological influences or improved dispersion conditions. Sialkot shows a gradual AQI increase, indicating moderate industrial emissions paired with relatively better air circulation compared to the central districts.



Graph 5.4 Range of AQI levels during winter season

In contrast, relatively lower AQI levels are observed in Rawalpindi, Murree, and Bahawalpur. Among the hotspot districts, Rawalpindi and Murree record the lowest AQI values, rising modestly from 123 in October to 176 in December, with Bahawalpur exhibiting a similar, albeit slightly higher, trend. These districts benefit from favourable geographical and meteorological conditions, including higher wind speeds, improved ventilation, and lower industrial density, which collectively contribute to better air quality and reduced pollutant accumulation.

Overall, the winter AQI trends clearly illustrate that air pollution in Punjab's hotspot districts is both seasonally influenced and spatially concentrated. The progressive rise in AQI values underscores the predominant role of meteorological factors in exacerbating pollution during winter, while the markedly elevated levels in central Punjab reflect the impact of densely concentrated emission sources. This pattern highlights the urgent need for targeted mitigation strategies focusing on high-risk districts, particularly within the central industrial corridor, alongside the integration of meteorological forecasting into comprehensive air quality management frameworks.

5.3 Major Sources of Air Pollution in Punjab:

Air pollution in Punjab is driven by a complex interplay of anthropogenic and natural sources. Rapid industrialisation, urban expansion, and increasing vehicular reliance have intensified emissions of fine particulate matter, toxic gases, and black carbon. Seasonal agricultural practices, such as crop residue burning, and domestic fuel usage further exacerbate the situation. Additionally, natural factors including dust storms and pollen dispersal contribute supplementary pollutant loads. Collectively, these sources generate persistent smog episodes, deteriorate air quality, and pose significant public health risks across the province.

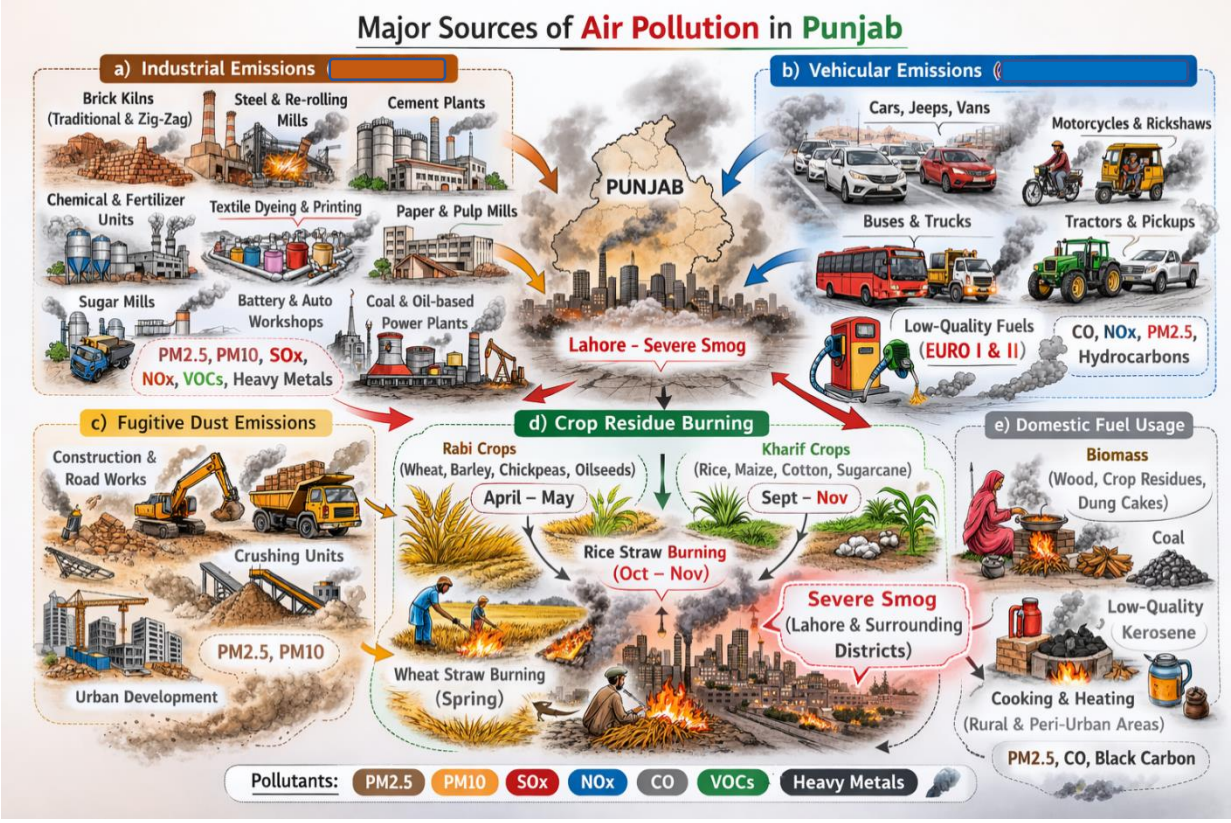


Figure 5. 1: Anthropogenic Sources of Air Pollution in Punjab

5.3.1 Anthropogenic Sources of air pollution in Punjab:

5.3.1.1 Industrial Emissions Punjab hosts a significant number of air-polluting industries that emit fine particulate matter ($PM_{2.5}$, PM_{10}), black carbon, sulfur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), acid fumes, and heavy metals. Major contributors include brick kilns (both traditional and zig-zag types), steel furnaces and re-rolling mills, cement plants, chemical and fertiliser units, textile dyeing and printing facilities, paper and pulp mills, sugar mills, battery manufacturing and recycling units, food processing industries (such as ghee, edible oils, and bakeries), coal and oil-based power plants, and automotive repair workshops. Many of these industries rely on low grade fuels such as coal, furnace oil, and biomass, which generate elevated emissions of SO_2, CO, and fine particulates. Industrial emissions from non-combustion processes account for approximately 9% of Punjab's total air

pollution load, while industrial activities as a whole contribute 24%, ranking second only to transport sources[10].

5.3.1.2 Vehicular Emissions According to the Punjab Bureau of Statistics (2024), the province of Punjab has approximately 22.2 million registered vehicles, including cars, jeeps, motorcycles, rickshaws, buses, tractors, vans, and pickups. Of these, around 7 million vehicles are concentrated in the Lahore division, the highest number within the province. A significant proportion of these vehicles operate using low quality fuels and lack modern emission control technologies. Diesel powered vehicles are particularly problematic, emitting large quantities of nitrogen oxides (NO_x) and particulate matter.

According to the Chief Minister of Punjab's Roadmap for Smog Mitigation report (2024), emissions from the transport sector contribute over 39% of Punjab's total air pollution, establishing transport as the single largest source of smog and degraded air quality in the province.

A major contributing factor is the continued use of outdated fuel and vehicle standards. Pakistan's transport sector largely relies on vehicles conforming to EURO I and EURO II emission standards, which permit substantially higher pollutant emissions compared to the more stringent EURO IV–VI standards adopted internationally. The prevalence of low quality fuels and the absence of catalytic converters lead to inefficient combustion and elevated emissions of carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons, and particulate matter. This outdated regulatory and fuel framework considerably exacerbates urban air pollution.

5.3.1.3 Fugitive Dust Emissions: Construction activities, road works, dredging, and crushing units generate significant fugitive dust, which constitutes a major source of particulate matter ($PM_{2.5}$ and PM_{10}), contributing approximately 1% of the total emissions in Punjab. With rapid urbanisation and ongoing development projects throughout the province, dust emissions remain a pervasive problem, particularly in expanding metropolitan areas such as Lahore, Faisalabad, Multan, Rawalpindi, and Gujranwala.

5.3.1.4 Crop Residue Burning: Punjab experiences two primary cropping cycles: Rabi (winter) and Kharif (summer). Crops such as wheat, barley, chickpeas, and oilseeds are harvested during April and May, whereas rice, maize, cotton, and sugarcane are harvested between September and November. To clear fields quickly, farmers frequently resort to burning crop residues. Although wheat straw burning takes place in spring, the most severe pollution period occurs from October to November, when rice straw burning coincides with stable atmospheric conditions that trap pollutants and exacerbate smog episodes in Lahore and surrounding districts. Historical estimates indicate that Punjab contributes the majority of Pakistan's biomass burning emissions, with wheat straw and bagasse collectively accounting for nearly 11% of the province's total emissions[10]. This practice remains a critical driver of seasonal smog.

5.3.1.5 Domestic Fuel Usage: In addition to industrial and vehicular sources, domestic fuel use significantly contributes to localised air pollution. Biomass fuels—including wood, crop residues, and dung cakes alongside coal and low quality kerosene, are commonly utilised for cooking and heating in rural and peri urban households. The combustion of these fuels releases particulate matter, carbon monoxide, and black carbon, thereby exacerbating the overall pollution burden. Domestic and commercial energy consumption together account for approximately 16% of total air emissions in the region[10].

5.3.2 Natural Sources of air pollution in Punjab:

5.3.2.1 Dust Storms and Windblown Soil Southern Punjab, particularly districts such as Bahawalpur, Rahim Yar Khan, Multan, and Dera Ghazi Khan, frequently experiences dust storms due to its proximity to the Cholistan Desert and surrounding semi-arid landscapes. Strong pre-monsoon winds mobilise vast quantities of coarse particulate matter (PM10), which can be transported over long distances, significantly degrading air quality in urban centres. Additionally, western Punjab, near the Suleiman Range, contributes localised dust emissions originating from dry soils and sparse vegetation cover[11].

5.3.2.2 Desert Dust Transport The Cholistan Desert serves as a major source of both fine and coarse dust, particularly during the summer months when wind speeds intensify. Dust particles generated in this region are frequently transported across multiple districts, impacting urban centres such as Multan and occasionally reaching as far as Lahore. This phenomenon is exacerbated during dry spells, when vegetation cover is sparse and soil erosion rates are elevated, thereby increasing the volume of airborne dust[12].

5.3.2.3 Pollen and Biological Particulates In northern Punjab, particularly in Rawalpindi and Murree, forested areas contribute spores and biological particulates to the atmosphere, with emissions becoming more pronounced under humid conditions. These seasonal biological emissions exacerbate respiratory problems and increase the concentration of organic particulates in the air [13].

5.3.2.4 Forest and Grassland Fires Occasional wildfires on the Potohar Plateau and in the Murree Hills during the dry summer months release smoke and fine particulate matter into the atmosphere. Similarly, riverine forests along the Indus and Ravi belts may experience grassland fires during periods of drought, contributing to localised emissions. Although less frequent than crop residue burning, these fires nonetheless play a role in episodic deterioration of air quality[14].

5.3.2.5 Natural Methane Emissions Wetlands such as Chashma Barrage, Taunsa Barrage, Head Balloki and Uchhali Lakes release methane through anaerobic decomposition[15]. These sources add to greenhouse gas concentrations, indirectly affecting air quality and atmospheric chemistry[41].

[41] [9n]Publications and Reports | Bureau of Statistics, Punjab

5.4 Pollution Hotspot Assessment through E-Maps

A pollutant-based hotspot assessment was conducted for selected air pollution hotspot districts using industrial emission inventory data integrated with GIS-based spatial visualisation. The analysis concentrated on nine major air pollution hotspots in Punjab, namely Lahore, Faisalabad, Gujranwala, Rawalpindi, Multan, Kasur, Sheikhupura, Sialkot, Bahawalpur, and Murree.

The primary dataset comprised sector-wise industrial distribution, including the total number of industrial units and those identified specifically as air pollution sources. This information was utilised as a proxy indicator to delineate spatial pollution hotspots within each district.

5.4.1 Industrial Contribution to Pollution

The comparative analysis of industrial distribution reveals significant variations in pollution levels across the hotspot districts (see Figure 31). Lahore exhibits the highest number of industrial units as well as the largest proportion of air pollution causing facilities, indicating a very high pollution intensity. Faisalabad and Sheikhupura also demonstrate substantial industrial activity, with a considerable share of units contributing to air emissions.

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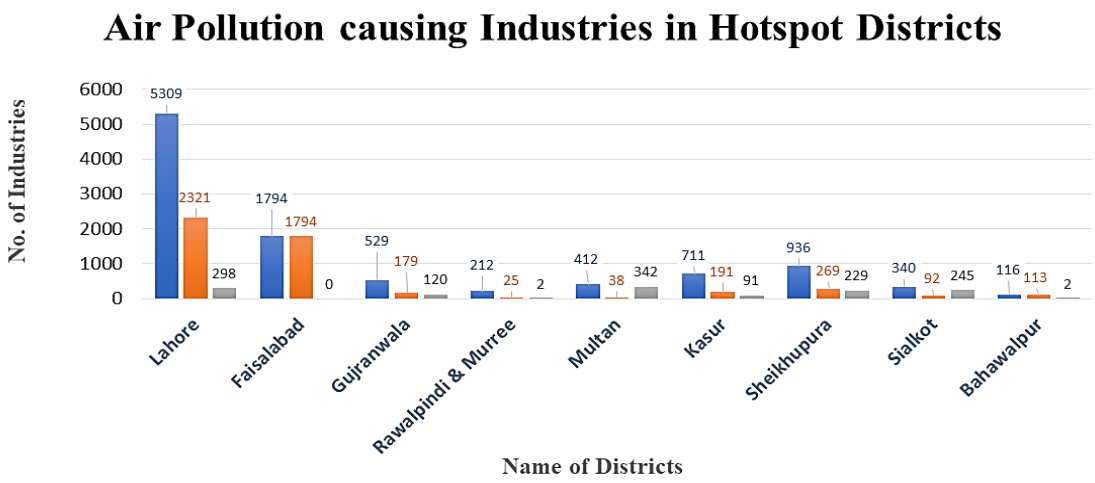
[10] Government of Punjab, Environmental Protection Department. (2024). *Chief Minister Punjab Smog Mitigation Plan 2024*. Lahore: Government of Punjab. Retrieved from https://epd.punjab.gov.pk/system/files/CM%20Punjab%20Smog%20Mitigation%20Plan%202024_FD_11102024.pdf

[11] [13] Yaqub, H., Younes, I., Mahmood, K., & Mahmood, S. (2015). A case study of dust storm events in Pakistan using normalized dust detection index. Arabian Journal of Geosciences, 8(12), 11067–11078. https://doi.org/10.1007/s12517-014-1687-7

[12] World Health Organization. (2025). Climate change, air pollution, pollen and health: Technical brief. Geneva: World Health Organization. Retrieved from https://www.who.int/publications/i/item/climate-change-air-pollution-pollen-and-health

[14] Nafees, M., Rashid, W., Sultan, H., Khan, N. H., Khurshid, M., Ali, W., & Bohnett, E. (2024). Occurrence, probable causes and management of forest wildfires in the Northern Highlands of Pakistan. *Environmental Challenges*, *15*, 100930. https://doi.org/10.1016/j.envc.2024.100930

[15] Latif, Z., Rasul, B., Ahmad, M., Fazil, M., Butt, S., Qureshi, R. M., Akram, W., Choudhry, M. A., & Pakistan Institute of Nuclear Science and Technology, Islamabad (Pakistan). Isotope Application Division. (2010). Assessment of ecological Process in Chashma wetland and its surroundings using isotopic techniques



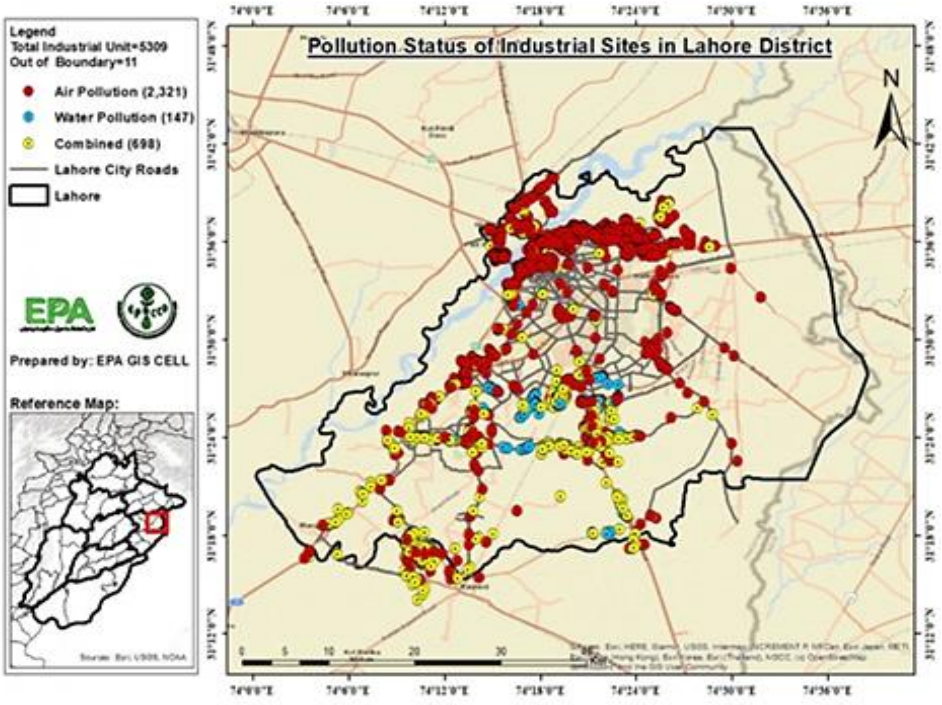
Graph 5.5 Air pollution among hotspot districts

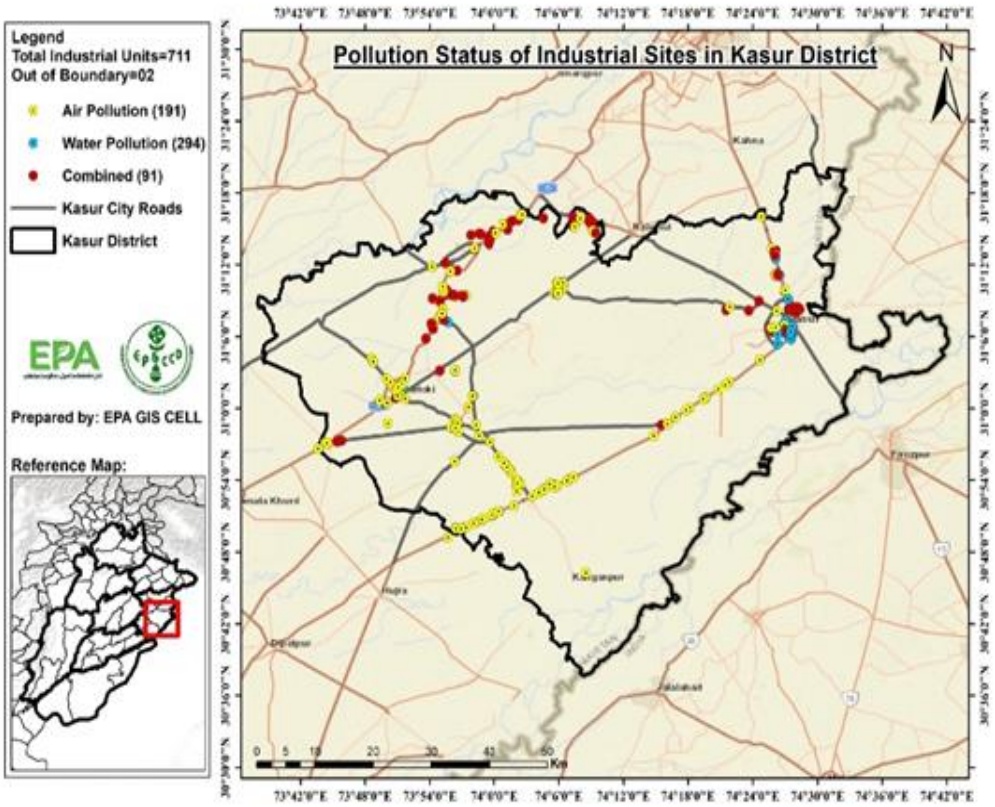
5.4.2 Air Pollution assessment in Central Punjab Districts:

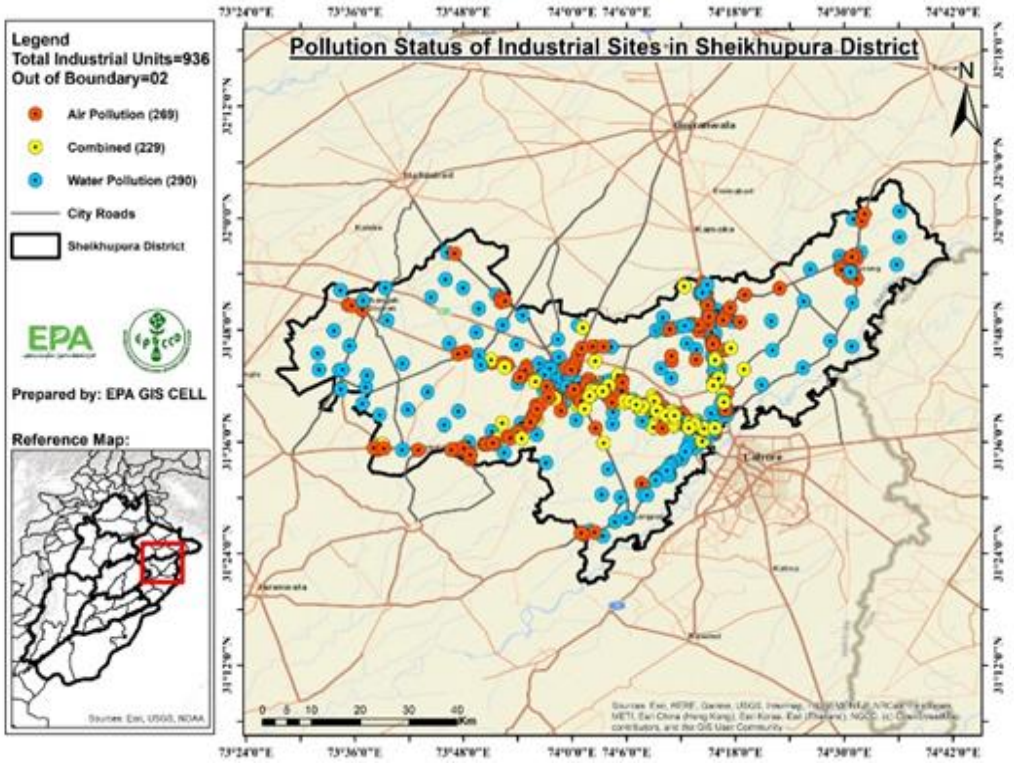
Central Punjab including districts such as Lahore, Faisalabad, Sheikhupura, Kasur, and Sialkot—represents the province's most industrialised region. Within this area, air polluting industries are either highly concentrated in major industrial estates and urban corridors (e.g., Lahore, Faisalabad, Sheikhupura, Kasur) or more widely dispersed amidst mixed landuse settings, as observed in Sialkot. This region exhibits the highest pollution intensity, with multiple hotspots formed by textile, leather, chemical, and manufacturing industries, alongside extensive brick kiln belts located in peri-urban zones.

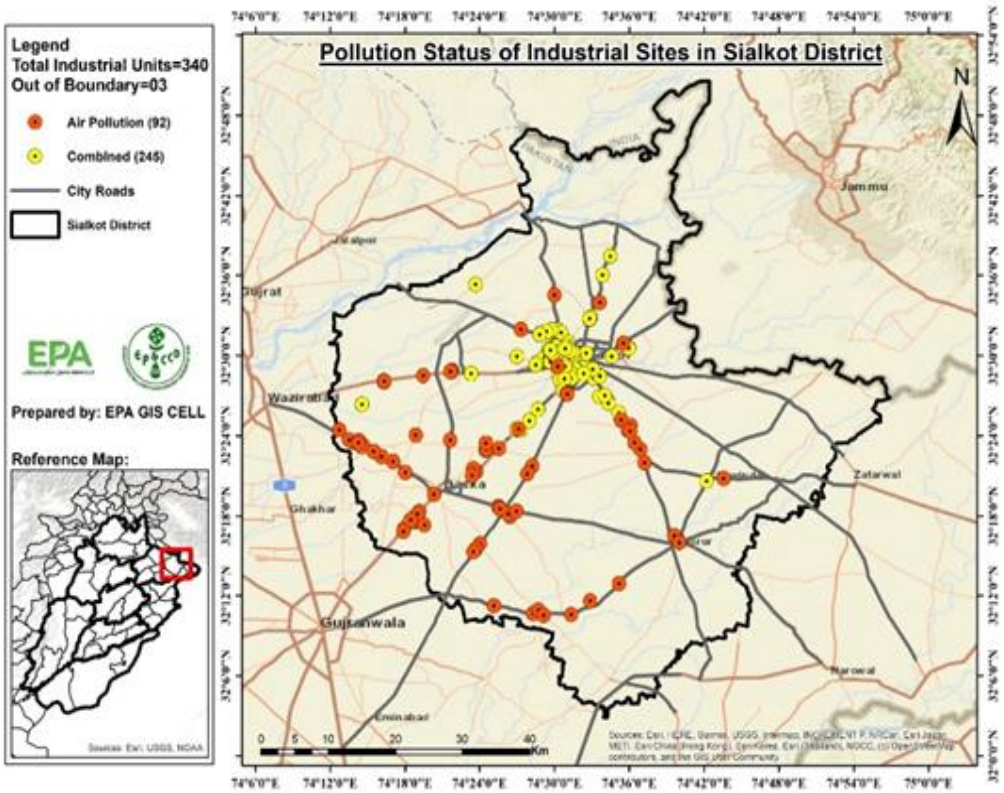
Lahore stands out as the most intensive and densely clustered industrial hub, with significant concentrations along the Kot Lakhpat area, the Quaid-e-Azam Industrial Estate corridor, and Raiwind Road. Additional clusters aligned with major transport routes and scattered inner-city industrial units create a complex mosaic of elevated pollution, particularly concentrated in the southern and south-western zones of the city.

Similarly, Faisalabad features strong industrial clustering, predominantly dominated by textile, dyeing, and manufacturing enterprises situated within urban industrial zones. Peripheral brick kilns form secondary belts of pollution, contributing further to the region's environmental burden. This spatial pattern is accentuated by linear industrial development along major roads and pollutant dispersion towards downwind areas.


Pollution Status of Industrial Sites in Lahore District
Legend
Total Industrial Unit=5309
Out of Boundary=11
Air Pollution (2,321)
Water Pollution (147)
Combined (698)
Lahore City Roads
Lahore
EPA
Prepared by: EPA GIS CELL
Reference Map:
N


Pollution Status of Industrial Sites in Kasur District
Legend
Total Industrial Units=711
Out of Boundary=02
Air Pollution (191)
Water Pollution (294)
Combined (91)
Kasur City Roads
Kasur District
EPA
Prepared by: EPA GIS CELL
Reference Map:
N


Pollution Status of Industrial Sites in Sheikhupura District
Legend
Total Industrial Units=936
Out of Boundary=02
Air Pollution (269)
Combined (229)
Water Pollution (290)
City Roads
Sheikhupura District
EPA
Prepared by: EPA GIS CELL
Reference Map:
N
0 5 10 20 30 40 Km


Pollution Status of Industrial Sites in Sialkot District
Legend
Total Industrial Units=340
Out of Boundary=03
Air Pollution (92)
Combined (245)
City Roads
Sialkot District
EPA
Prepared by: EPA GIS CELL
Reference Map:
N
Jammu
Gujrat
Wazirabad
Ghakhar
Gujranwala
Zafarwal
Narowal
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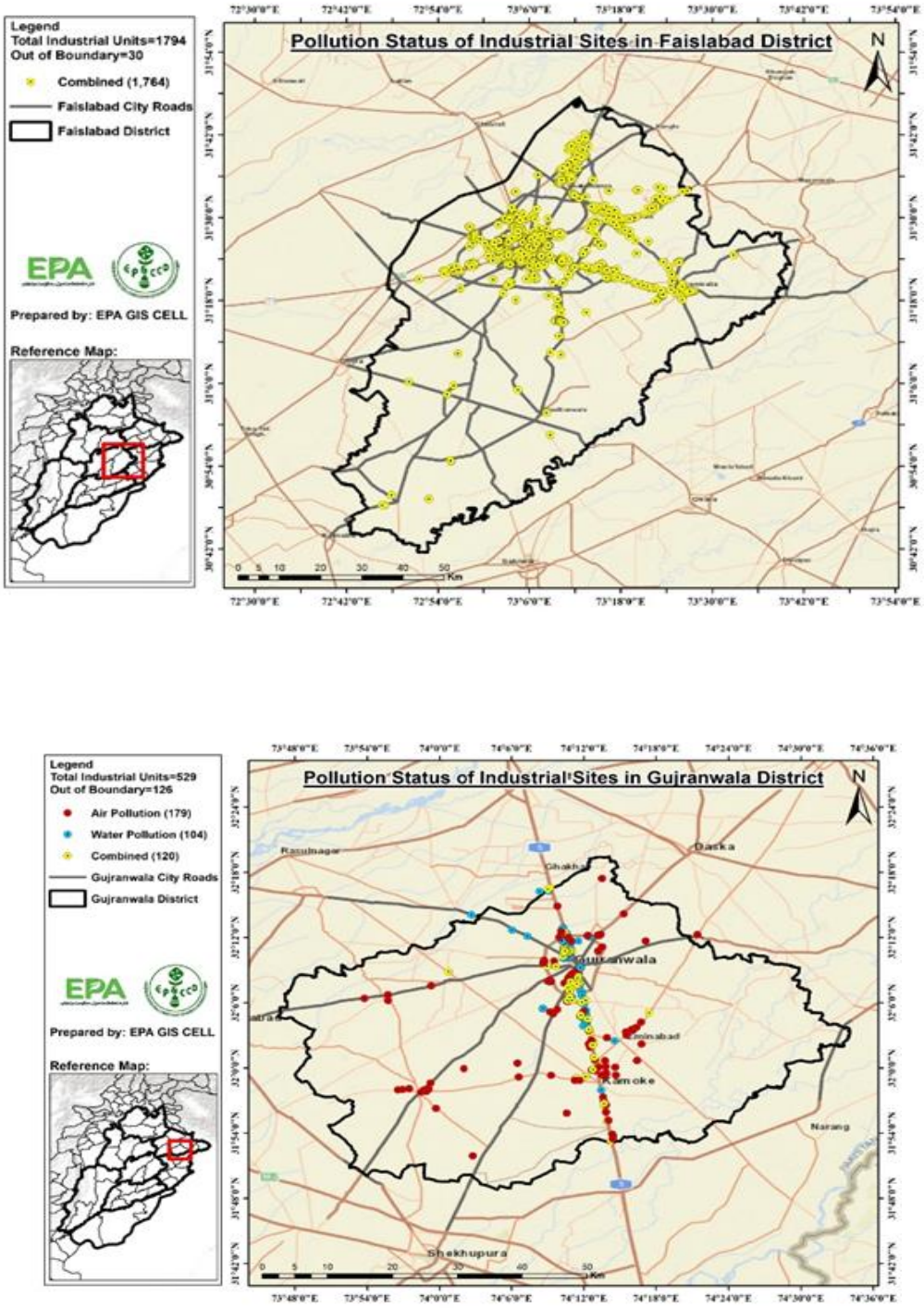


Figure 5.2: Pollution hotspot mapping of central Punjab districts

Sheikhupura displays a corridor-based and clustered industrial structure along the Lahore–Sheikhupura axis, with major industrial estates forming distinct

pollution hotspots. Additional emissions arise from brick kilns located in peri-urban fringe areas, further contributing to the air quality burden.

In contrast, Kasur's industrial landscape is characterised by a single prominent cluster comprising tanneries and leather processing units, which constitutes a concentrated pollution hotspot. This is supplemented by peripheral brick kilns and scattered smaller industrial enterprises.

Sialkot, meanwhile, exhibits a more dispersed and mixed land-use pattern, where small and medium scale export-oriented industries are interspersed within residential zones. This spatial arrangement results in diffuse pollution patterns rather than discrete, dominant clusters.

5.4.3 Air Pollution Assessment in Southern Punjab Districts:

Southern Punjab, encompassing districts such as Multan and Bahawalpur, is characterised by a mixed and comparatively low to moderate industrial density. Multan exhibits moderate industrial clustering along highways and within industrial estates, whereas Bahawalpur presents a highly dispersed industrial pattern dominated by small-scale industries and brick kilns. In both districts, peripheral brick kiln belts and scattered agro-based industries constitute the primary pollution sources, resulting in diffuse yet widespread air pollution rather than concentrated pollution hotspots.

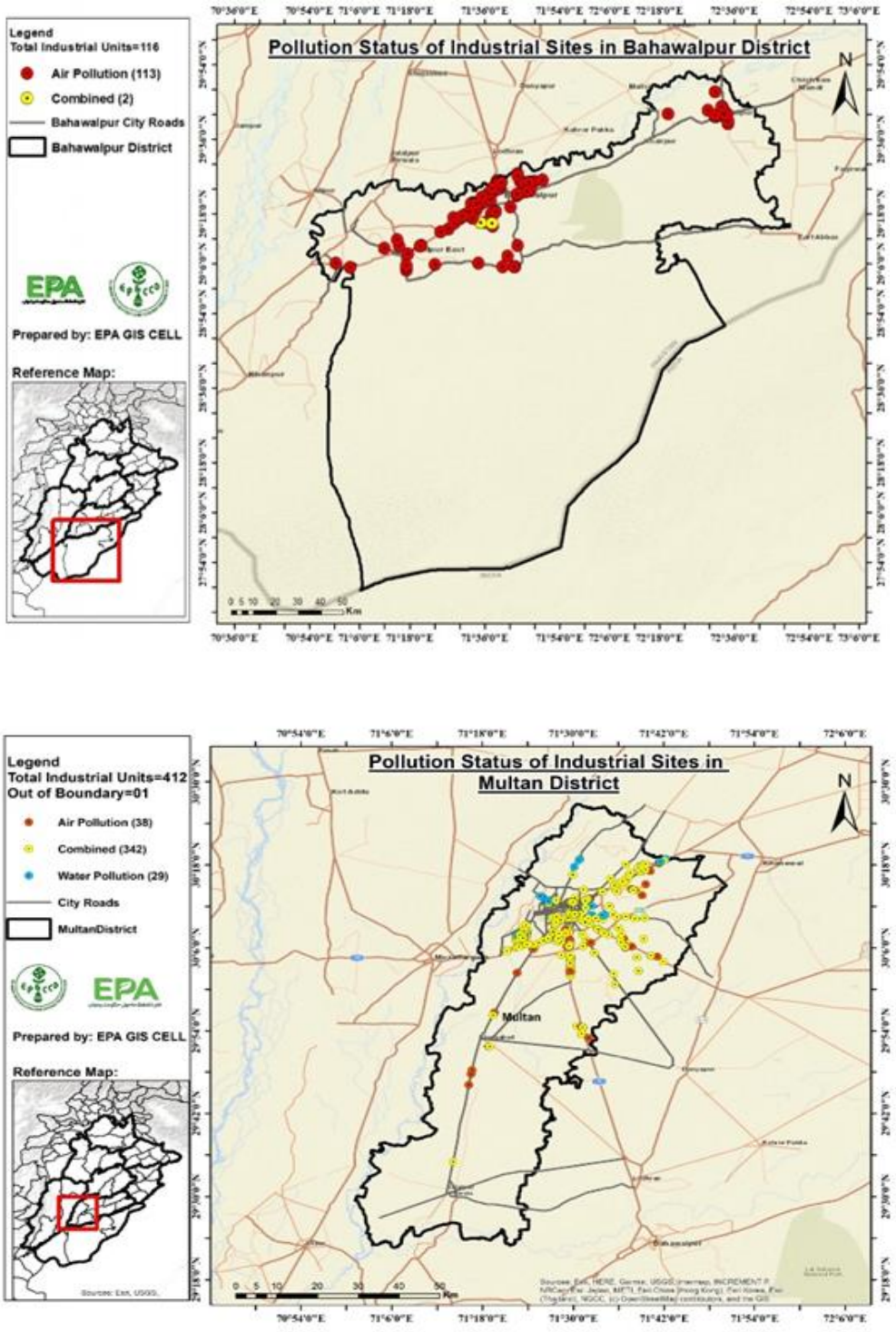


Figure 5.3: Pollution hotspot mapping of Southern Punjab Districts

Similarly, Multan displays moderate industrial clustering, with most industries located along highways and on the urban outskirts. Meanwhile, brick kilns and agro-based activities form an extensive peripheral pollution belt. In contrast, Bahawalpur exhibits the most dispersed and low-density industrial distribution, dominated by small-scale industries and brick kilns scattered across both urban and rural zones. This spatial configuration results in diffuse pollution sources rather than the formation of concentrated hotspots.

5.4.4 Air Pollution Assessment in Northern Punjab Districts:

Northern Punjab, exemplified by Rawalpindi, possesses a comparatively moderate and limited industrial base. Industrial facilities tend to be scattered rather than clustered, with a few significant point sources—such as cement and thermal power plants—contributing disproportionately to overall emissions. Consequently, pollution in this region is relatively localised and less spatially dense when compared with Central Punjab.

The city's industrial sector primarily comprises pharmaceutical units, flour mills, a thermal power plant, and a cement plant. These facilities are dispersed across designated industrial zones and peri-urban areas rather than forming dense clusters. Notably, the cement plant and thermal power station are the most substantial contributors to air pollution, given their elevated emissions of particulate matter and gaseous pollutants.

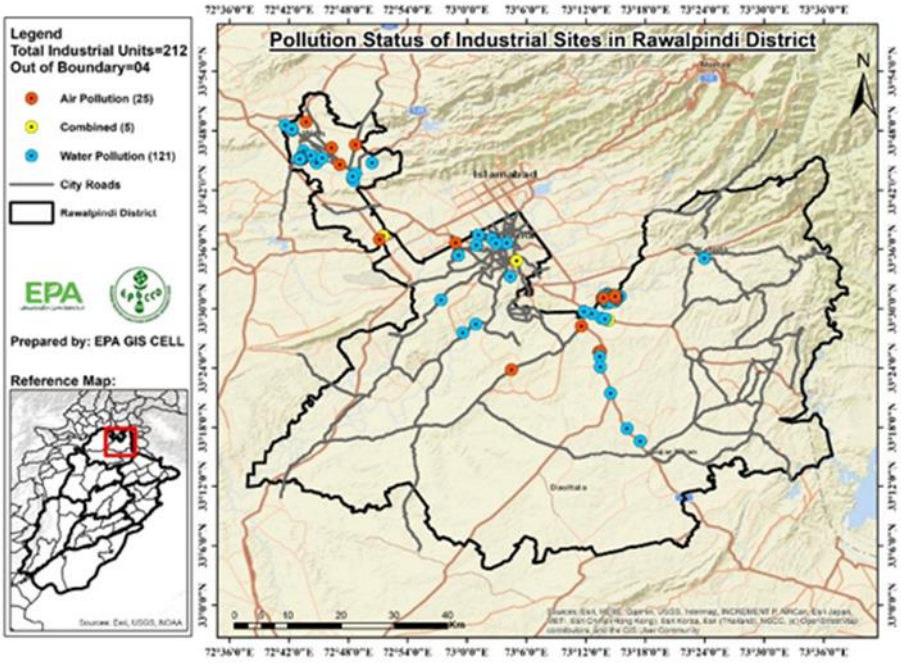


Figure 5.4: Pollution hotspot mapping of Northern Punjab districts

Unlike more heavily industrialised cities, Rawalpindi does not exhibit dense industrial clustering. Instead, it features a dispersed distribution of small to medium scale industries, frequently situated along major transport routes and on the city's outskirts, thereby alleviating congestion within the urban core.

Furthermore, limited brick kiln activity in the surrounding peri-urban areas contributes to a peripheral pollution belt. Local wind patterns and proximity to Islamabad also play a significant role in influencing pollutant dispersion throughout the region.

5.5 Assimilation Capacity of Punjab's Industrial Districts

Assimilation capacity refers to the natural environment's ability to absorb, disperse, and neutralise pollutants without surpassing prescribed air quality standards. It represents the maximum pollutant load that a region can sustain without causing long-term environmental degradation. This concept is widely employed to assess the pollution load-carrying capacity of an area under varying atmospheric and industrial conditions. The assimilative capacity of the atmosphere is primarily governed by meteorological parameters such as wind

speed, mixing height, atmospheric stability, and temperature inversions. Among these, mixing height plays a pivotal role in determining the vertical extent over which pollutants can disperse. Lower mixing heights—especially during winter—limit vertical dispersion and result in pollutant accumulation near ground level, whereas higher mixing heights facilitate dilution and dispersion.

In the literature, assimilative capacity is often approximated using proxy indicators such as the ventilation coefficient, defined as the product of wind speed and mixing height. Higher ventilation coefficients indicate greater dispersion potential and correspondingly improved air quality conditions, whereas lower values signify stagnant atmospheric conditions and elevated pollution concentrations.

Urban environments present a particularly complex scenario for assessing assimilative capacity due to the presence of diverse emission sources, including point sources (industries), line sources (vehicular emissions), and area sources (domestic and commercial activities). These sources emit a wide variety of pollutants in differing forms and quantities, at varying heights and over temporal intervals. Furthermore, meteorological variability influences pollutant dynamics through transport, dispersion, chemical transformation, deposition, and absorption processes, rendering urban air quality highly complex.

Assimilative capacity also exhibits considerable spatial and temporal variability. It is generally higher during daytime and in seasons characterised by strong winds and thermal mixing, while it diminishes during stable atmospheric conditions, notably in winter when temperature inversions frequently occur. Regions with flat or basin-like topography tend to have lower dispersion potential, predisposing them to frequent smog events, whereas hilly or elevated terrains typically support improved air circulation and pollutant dilution.

District-Wise Assimilation Capacity

District Category	Primary Districts	Assimilation Capacity	Key Natural Factors
Northern Uplands	Rawalpindi, Murree	High	Hilly terrain, higher wind speeds and better vertical air mixing[22].
Central Plains	Lahore, Sheikhupura, Gujranwala, Kasur	Very Low	Flat topography, low wind speeds and frequent "Temperature Inversions" in winter[23].
	Faisalabad, Sialkot	Low	Dense urban heat islands and stagnant air pockets during the dry season[24].
Southern Plains	Multan, Bahawalpur,	Moderate	Vast open spaces and higher average temperatures that aid thermal lifting of smoke[25].

The pronounced variation in assimilation capacity across Punjab is largely attributable to the “Bowl Effect” observed in the central regions. During the winter months (October–February), districts such as Lahore and Gujranwala experience a meteorological phenomenon whereby a layer of warm air overlays a cooler, stagnant air mass near the ground. This temperature inversion acts as a “lid,” inhibiting the vertical dispersion of industrial emissions. Given the flat topography of these districts and their distance from the sea, they lack the moderating influence of strong coastal breezes or mountain-induced winds that might otherwise cleanse the atmosphere. Consequently, even relatively small quantities of industrial smoke remain trapped at breathing level for extended periods, often persisting for several days[26].

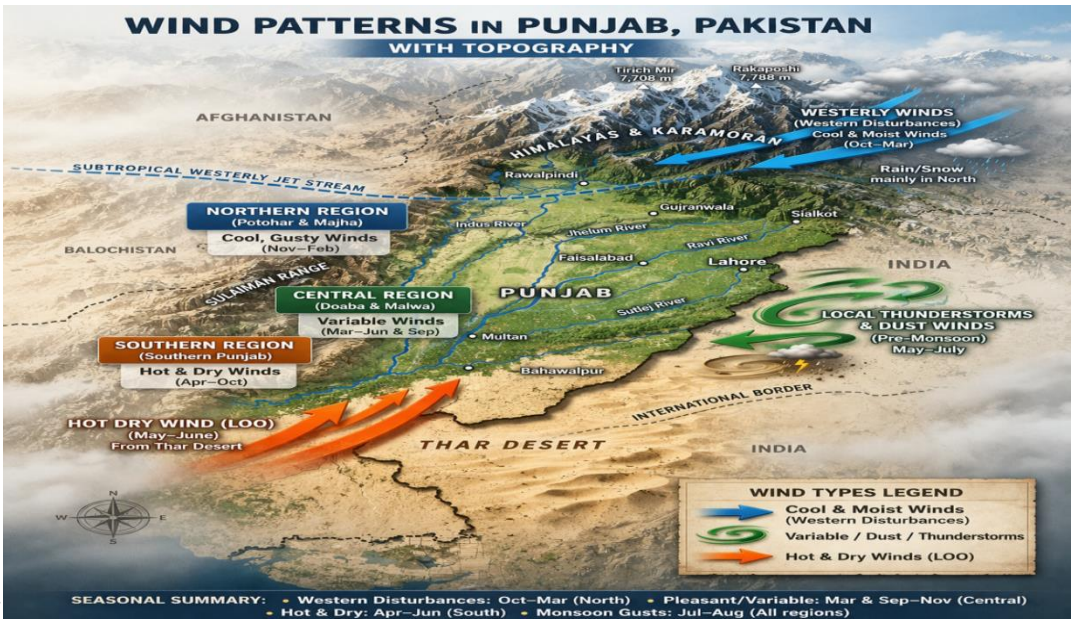


Figure 5.5: Wind Patterns in Punjab, Pakistan

In contrast, the Northern Uplands, encompassing Rawalpindi and Murree, benefit from a more rugged topography. The varied elevations generate natural atmospheric turbulence, which disperses concentrated plumes of smoke emitted by large sources such as cement plants. Similarly, the Southern Districts experience higher thermal energy; intensified ground heating compared to northern regions produces upward thermals that elevate pollutants into higher atmospheric layers, where stronger upper-level winds facilitate their dispersal away from population centres[27].

Ultimately, although the Central Districts possess comparatively advanced industrial technology, they have the least natural capacity to mitigate pollution. Consequently, a factory located in Lahore must implement significantly stricter emission controls than an equivalent facility in Mianwali, owing to Lahore's severely limited atmospheric ability to self-purify.

5.6 EPA Punjab's Air Quality Management Regime

The Environmental Protection Agency (EPA) Punjab has played a pivotal role in enforcing these reforms and ensuring compliance. Enforcement measures have included sealing noncompliant factories and brick kilns, imposing fines on

vehicles emitting excessive smoke, and penalising farmers for stubble burning. Additionally, EPA Punjab expanded its network of real time air quality monitoring stations, making pollution data publicly accessible. These initiatives have not only curtailed emissions but also enhanced transparency and accountability, thereby ensuring that reforms yield tangible improvements in air quality.

During critical smog episodes, Section 6(1)(t) of the Punjab Environmental Protection Act, 1997, was invoked to restrict outdoor activities and mandate the early closure of markets in Lahore, Faisalabad, Gujranwala, and Multan. As a result of these combined reforms and enforcement efforts, Punjab has experienced a reduction in the severity of smog episodes relative to 2021–22, a period when Lahore frequently ranked among the world's most polluted cities. Real-time monitoring stations now provide transparent Air Quality Index data, while public health advisories assist in minimising exposure risks.

Despite ongoing challenges such as seasonal crop residue burning and rapid urbanisation, the synergy between robust policy frameworks and EPA enforcement has positioned Punjab on a trajectory towards cleaner air and improved public health—marking a significant advance in environmental governance.

5.6.1 Air Quality Management Cycle

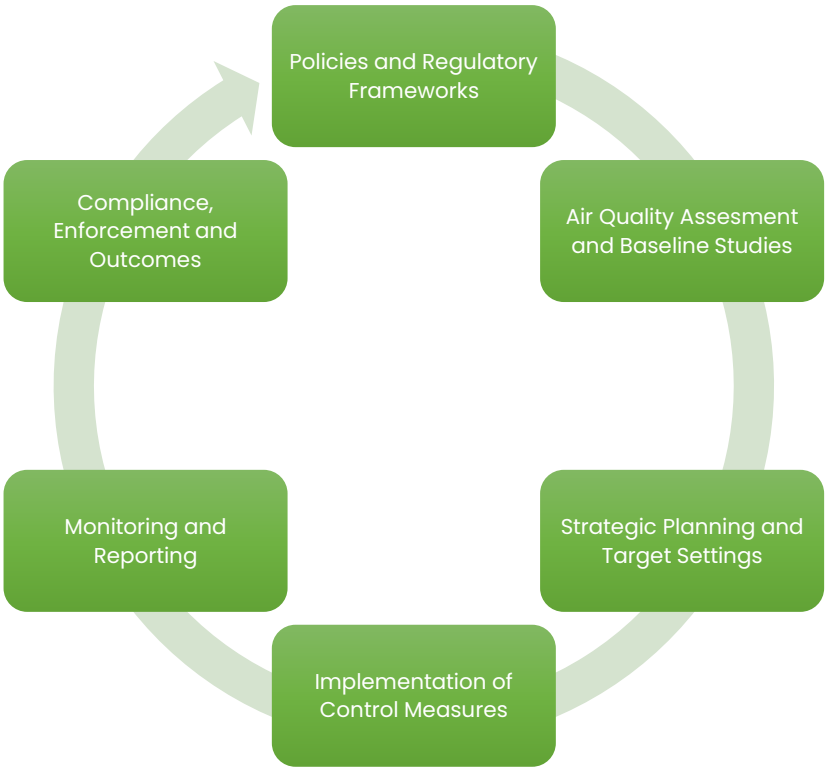


Figure 5. 6: Air Quality Management Cycle

EPA Punjab's air quality improvement strategy focuses on reducing emissions across key sectors, including transport, industry, agriculture, domestic fuel use, and fugitive dust sources, while simultaneously protecting public health from hazardous pollutants. Central to this approach is the expansion of continuous air quality monitoring stations, comprehensive emission inventories, and smog forecasting systems to provide real-time data and early warnings. Sector-specific emission reduction plans complement these efforts, alongside industrial compliance measures, vehicular emission control programmes, and targeted interventions aimed at reducing particulate matter concentrations and other primary pollutants. These initiatives are supported by regulatory frameworks such as ambient air quality standards and Environmental Quality Standards, as well as economic instruments including penalties and incentives designed to promote compliance.

Equally critical to the strategy is institutional coordination. EPA Punjab collaborates closely with departments of Transport, Industries, and Agriculture, the Punjab Safe City Authority, Punjab Highway Patrol, Lahore Waste Management Company, and local governments, as well as regional partners, to address cross-jurisdictional pollution challenges. The strategy further emphasises climate co-benefits by integrating air quality management with greenhouse gas mitigation efforts. Transparency and accountability are enhanced through active citizen engagement and the utilisation of open data platforms.

Collectively, these measures aim to achieve improved air quality, enhanced public health outcomes, strengthened institutional capacity, and heightened public awareness, thereby ensuring a resilient and sustainable environmental management framework for Punjab.

5.6.2 Integrated Air Quality Governance and Monitoring:

5.6.2.1 Extension of Air Quality Monitoring System (AQMS) in Punjab:

The Environmental Protection Agency (EPA) Punjab plays a vital role in monitoring and managing air quality across the province, addressing the severe air pollution challenges faced by the region. To this end, the EPA has established and significantly expanded an air quality monitoring network.

In 2025, the air quality monitoring infrastructure in Punjab underwent substantial enhancement. EPA Punjab successfully installed 41 additional Air Quality Monitoring Stations (AQMSs) across major cities and industrial zones, augmenting the existing network of 41 stations distributed over 18 districts, as illustrated in Figure 5.7. This expanded network provides comprehensive, continuous data on key pollutants, including particulate matter ($PM_{2.5}$ and PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone (O_3). The comprehensive monitoring infrastructure enables the EPA to track seasonal variations, identify primary pollution sources—such as industrial emissions, vehicular exhaust, and



Figure 5. 7: Air Quality Monitoring Station

transboundary smog—and evaluate the efficacy of environmental regulations and initiatives such as the "Clean Punjab" programme and enforcement actions against industrial violators. The continuous collection and analysis of this data are crucial for issuing public health advisories, conducting environmental impact assessments, and guiding policy efforts towards achieving cleaner and healthier air throughout Punjab.To complement this monitoring system, EPA Punjab has established a formal mechanism for calculating and disseminating the Air Quality Index (AQI) province-wide. The AQI is calculated based on hourly average concentrations of key criteria pollutants, consistent with the Punjab Clean Air Policy (2023). This index serves as an essential tool for identifying pollution hotspots, facilitating transparency, and informing targeted policy decisions aimed at mitigating air pollution and improving environmental quality.

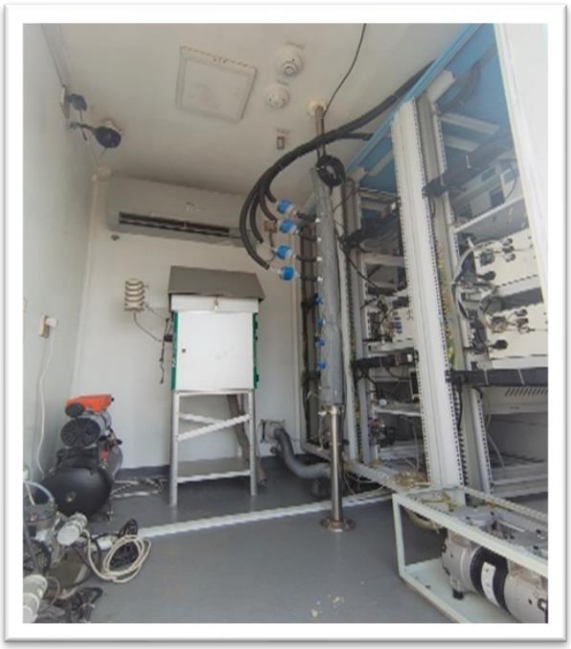


Figure 5. 8: Inside view of AQMS

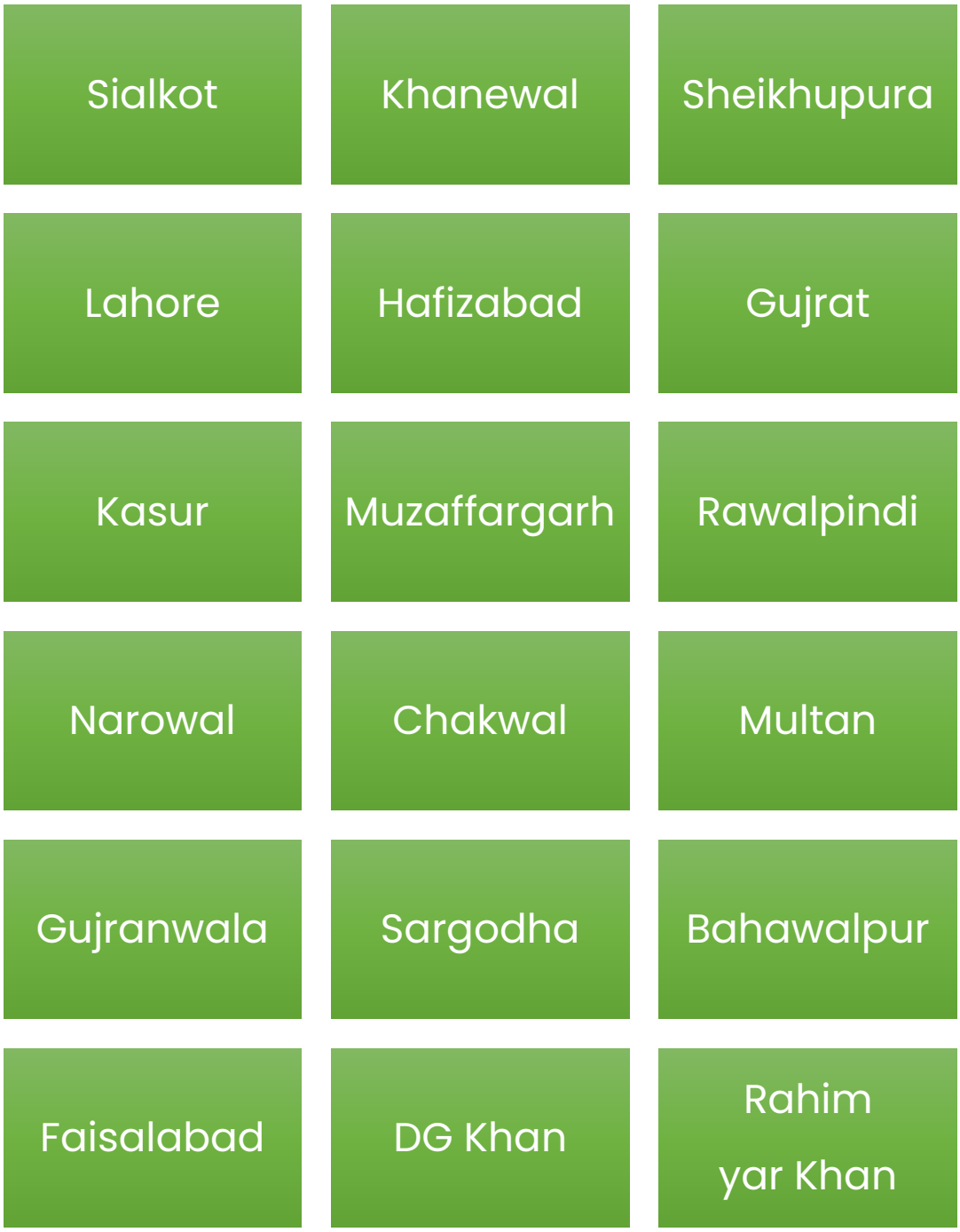
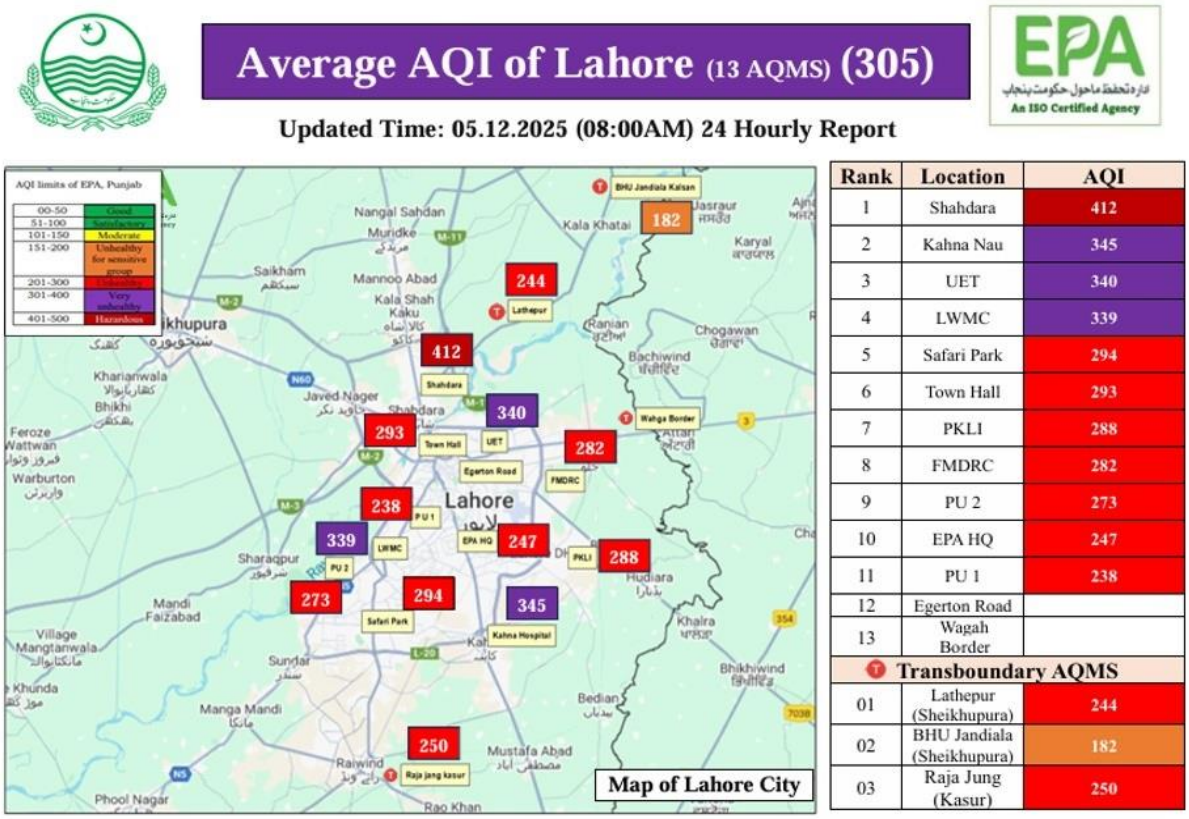


Figure 5. 9: Districts Selected for AQMS Installation to Monitor Regional Air Quality

5.6.3 AQMS in Lahore:

Lahore has experienced severe smog episodes over the past five years,



Rank	Location	AQI
1	Shahdara	412
2	Kahna Nau	345
3	UET	340
4	LWMC	339
5	Safari Park	294
6	Town Hall	293
7	PKLI	288
8	FMDRC	282
9	PU 2	273
10	EPA HQ	247
11	PU 1	238
12	Egerton Road	
13	Wagah Border	
Transboundary AQMS		
01	Lathepur (Sheikhupura)	244
02	BHU Jandiala (Sheikhupura)	182
03	Raja Jung (Kasur)	250

Figure 5.10: AQMS Station in Lahore

particularly during the winter months. In response to this critical issue, the Environmental Protection Agency (EPA) Punjab has strategically increased the number of Air Quality Monitoring Stations (AQMS) within the city. Presently, 13 local AQMS operate at key locations throughout Lahore, providing continuous ambient air quality data. This network facilitates real-time pollutant monitoring and supports the issuance of timely public health advisories.

Additionally, three transboundary AQMS have been installed around Lahore to monitor air pollution originating from neighbouring regions or cross-border sources. These stations enable differentiation between local emissions and externally transported pollutants, allowing for more accurate pollution assessments and the development of targeted mitigation strategies. The

locations of all monitoring stations are depicted in the figures below, illustrating Lahore's integrated approach to air quality management.

To ensure consistency and transparency, Air Quality Index (AQI) values are calculated based on the average concentrations of key pollutants and disseminated at regular intervals throughout the day. This structured reporting system facilitates timely communication of air quality conditions to government departments, stakeholders, and the public. By institutionalising AQI reporting, EPA Punjab has enhanced its capacity to deliver evidence-based advisories, raise public awareness, and support policy interventions directed at effective air quality management.

5.6.4 AQI Dissemination Dashboard

The Environmental Protection Agency (EPA) Punjab has operationalised the AQI Punjab Dashboard as a comprehensive real-time air quality dissemination platform designed to enhance public awareness, environmental monitoring, and evidence-based decision-making. This dashboard is supported by a network of regulatory-grade ambient air quality monitoring stations integrated with meteorological and weather observation systems throughout Punjab. The platform provides hourly updated Air Quality Index (AQI) values alongside pollutant-specific concentrations, including $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and O_3.

Beyond real-time monitoring, the dashboard offers city-wise trends, historical comparisons, monthly pollutant patterns, station-specific analyses, and area-wise AQI categorisation, facilitating a nuanced understanding of pollution dynamics. Serving as a centralised public information resource, the system enables citizens, researchers, and policymakers to access transparent and reliable air quality data, complemented by health advisories and environmental alerts.

5.6.5 AQI Forecasting and Early Warning System

To strengthen proactive environmental governance and enhance public awareness, EPA Punjab has developed Pakistan's first localised Air Quality Index (AQI) forecasting and early warning system, integrated within the AQI Punjab

platform. This forecasting framework employs machine learning techniques, meteorological observations, satellite-derived atmospheric datasets, and historical pollution trends to predict forthcoming air quality conditions with improved spatial and temporal accuracy. The system synthesises real-time emissions data, weather variables, wind patterns, humidity levels, temperature inversions, and regional atmospheric movements to generate forecast-based AQI outlooks and pollution advisories.

These advanced predictive capabilities facilitate timely decision-making, enable early dissemination of smog alerts, and support public health precautions—particularly during episodes of elevated pollution and seasonal smog events in Punjab.

5.7 Environmental Monitoring and Scientific Surveillance

Following the establishment of real-time Air Quality Index (AQI) monitoring and forecasting systems, EPA Punjab promptly enhanced its environmental monitoring framework to ensure effective ground-level implementation and regulatory oversight. The Agency adopted a dual-dimensional monitoring approach comprising both field monitoring and scientific monitoring mechanisms. Field monitoring encompasses physical inspections, compliance verification, emission source identification, and enforcement activities conducted by field teams across Punjab. Concurrently, scientific monitoring is performed through regulatory-grade air quality monitoring stations, meteorological observations, digital mapping platforms, satellite datasets, and data-driven analytical tools.

The integration of operational and scientific monitoring frameworks has significantly enhanced EPA Punjab's environmental surveillance capabilities, enabling more accurate identification of pollution hotspots and facilitating evidence-based interventions for air quality management throughout the province.

5.7.1 Industrial monitoring through Unique ID Allotment:

As part of efforts to strengthen its monitoring framework, the Environmental Protection Agency (EPA) Punjab has conducted comprehensive inventories of industrial units and brick kilns across the province. To ensure data integrity and facilitate effective monitoring and enforcement, inspectors are mandated to record both the Unique Identification Number (UID) and the corresponding name of each industrial unit or brick kiln during site inspections. During 2025, a total of 14,000 industrial units were assigned UIDs through a structured and transparent process, as detailed below.

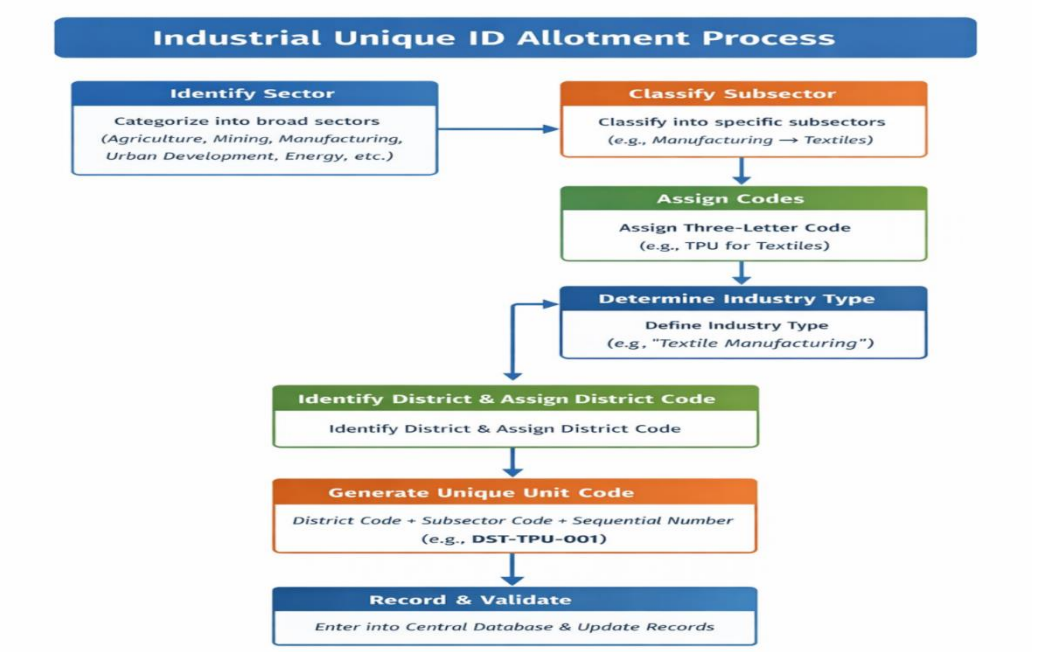


Figure 5. 11: Industrial Unique ID Allotment Process

5.7.2 GIS-Based E-Mapping for Strengthened Environmental Monitoring:

Punjab has successfully completed the e-mapping of industrial units across the province, facilitating spatial monitoring, pollution profiling, and enhanced planning of inspection activities. District-wise industrial cluster maps have been developed to identify pollution hotspots, evaluate sectoral concentrations, and

prioritise targeted environmental interventions. Additionally, updated digital industrial directories are maintained to monitor field inspections, track compliance status, and support evidence-based regulatory decision-making. The integration of spatial mapping with centralised environmental databases has markedly improved transparency, monitoring efficiency, and enforcement coordination, thereby strengthening the overall framework of environmental governance in Punjab. E-maps of selected districts are appended in Annexure II of this report.

5.7.3 Drone-Based Environmental Surveillance

The Punjab Environmental Protection Department has launched Punjab's first aerial surveillance initiative through the establishment of a dedicated drone-based monitoring system equipped with thermal technology and supported by a specialised GIS wing, these drones are being deployed to monitor environmental violations in real time.

The ASC conduct aerial surveillance visits to identify pollution hotspots throughout Punjab and gathered actionable information for the EPA to enforce environmental regulations and mitigate pollution.







Figure 5.12: Drones for Air Quality Monitoring

5.7.3.1 Formation of Drone Surveillance Squad: The Drone Surveillance Squad (DSS), constituted by the Director General, EPA, Punjab under the supervision of Additional Director General (Operations) EPA.

5.7.3.2 Field Operation of DSS:

The Drone Surveillance Squad (DSS) has monitored industrial sites and construction activities, conducted drone-based surveillance of Air Quality Monitoring Stations (AQMS) and performed GIS mapping of AQMS locations across eight districts in Punjab. The DSS has significantly enhanced the monitoring of industrial compliance, construction progress, and air quality management, thereby strengthening the capacity for environmental enforcement and surveillance throughout the province.

Operational Indicator	Key Findings
Mission Flights Conducted	67 mission flights
Operational Area Covered	7,978 acres
Industries Identified	1,081 industries
Facilities Inspected	2,491 facilities
Environmental Violations Detected	300 violations

Table 5. 1: DSS Operations Summary

5.7.4 Hawkeye Monitoring Vehicle:

Under the Hawkeye Initiative, the Environmental Protection Agency (EPA) Punjab has established a dedicated Patrolling Squad tasked with monitoring air pollution hotspots and curbing pollution sources. The squad conducts continuous surveillance within Lahore and undertakes special inspection visits across the province according to a structured weekly monitoring plan. Its mandate is to identify sources of pollution and promptly report violations to higher authorities to facilitate timely regulatory action.

5.7.4.1 Strategic task assigned to Hawkeye for Air Quality Monitoring

- Industrial hotspot monitoring
- Brick Kiln Monitoring
- Dust management monitoring
- Hotspots identification for fog Cannon Operations
- Stubble Burning monitoring

The Hawkeye monitoring vehicle is equipped with a camera-mounted surveillance system that provides live coverage of industrial monitoring activities. This real-time monitoring capability enhances transparency, improves enforcement efficiency, and ensures timely intervention against non-compliant units. Monitored violations are reported to the relevant district officers via the Inter-Accountability Dashboard, accompanied by documented evidence. Upon receipt of the report, the respective district office is responsible for taking action to address the complaint. The designated officer must ensure that appropriate measures are implemented and that the complaint is resolved and formally closed within 20 days.



Figure 5.14: Hawk Eye Operations in Field

5.7.4.2 Monitoring action of Hawkeye Squad:

In 2025 following numbers of air pollution sources have been monitored by Hawkeye Patrolling squad along with follow up actions.

Activity / Area	Progress / Findings
Industrial Hotspots Monitored (Lahore)	469 hotspots; black smoke emitting units identified; enforcement: 48 sealed, 27 fined, 9 notices
Under-Construction Sites Inspected	66 sites; verified mist sprinklers and dust suppression measures
Extended Monitoring	Kasur, Sheikhupura, Chiniot, Sargodha; focused on brick kilns, industrial emissions and dust management and stubble burning

Table 5.2: Monitoring Actions of Hawkeye Squad in Punjab

5.7.5 CCTV Monitoring of Industrial Emissions: A pathway towards inspector less Regime:

Rule 4 of the Punjab Environmental Protection (Smog Prevention & Control) Rules, 2023, mandates that all industrial units operating boilers, furnaces, or incinerators install CCTV cameras meeting specified technical standards. These cameras must be positioned to capture emissions at stack terminals and provide live online access to EPA Punjab for continuous monitoring. EPA officers observe these feeds, supported by an AI-integrated monitoring system that operates around the clock to enforce emission control standards. The system is trained to detect violations such as denial of access to monitoring feeds, obscured views of chimneys, offline or interrupted transmissions, and the presence of visible black smoke.



Figure 5.15: CCTV Monitoring of industries

A single automated notification of violation by the system is deemed insufficient on its own. In such instances, EPA officers file formal complaints via the EPA helpline (1373), notifying the industry owner and the relevant district officer. Repeated violations are logged on the Inter-Accountability Dashboard, prompting the district officer to take appropriate legal action against the offender, including more severe measures in extreme cases. This robust system enhances accountability and significantly strengthens EPA Punjab's capacity to enforce emission control standards across the province.

5.7.6 Scientific Surveillance

EPA Punjab has established a scientific surveillance framework predicated on real-time environmental intelligence, regulatory-grade monitoring infrastructure, and data-driven analytical systems. This mechanism integrates ambient air quality monitoring stations, meteorological sensors, satellite observations, AQI forecasting models, and digital mapping platforms to provide continuous assessment of environmental conditions throughout Punjab. By conducting pollutant-specific analyses, trend evaluations, and spatial monitoring, the system facilitates the identification of pollution hotspots, seasonal variations, and emerging environmental risks. This scientific surveillance framework not only enhances evidence-based policymaking and regulatory planning but also supports the timely issuance of advisories, forecasting, and targeted interventions necessary for effective air quality management.

5.7.7 Stack Emission Monitoring:

The monitoring of industrial stack emissions constitutes the backbone of environmental enforcement in Punjab. The Environmental Protection Agency (EPA) Punjab, through its accredited laboratory, employs high-precision, regulatory-grade

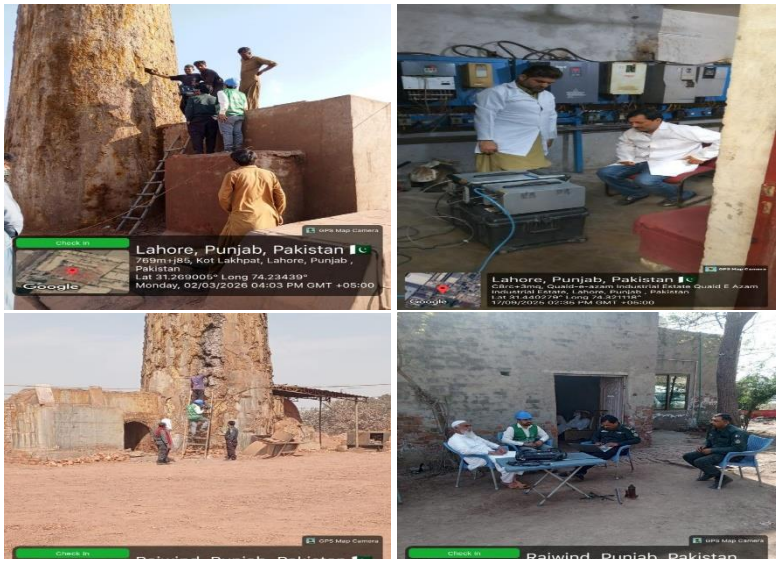


Figure 5.16: Stack Emission Monitoring of Industries in Punjab

instrumentation to verify that "point source" emissions comply with Punjab Environmental Quality Standards (PEQS).

5.7.7.1 Stack Emission Monitoring Process:

Regulatory stack testing begins with isokinetic sampling, a technical necessity for accurately measuring particulate matter (PM). Due to the mass and momentum of particles, the air must be drawn into the sampling probe at precisely the same velocity as the gas rising within the stack. If the sampling velocity is either too fast or too slow, the collected sample will not accurately represent the true dust concentration. EPA field teams utilise a probe inserted into a designated "sampling port," which is a hole drilled at a specific height—typically eight times the stack diameter above any bends—to extract representative samples.

For gaseous pollutants such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), and carbon monoxide (CO), EPA employs portable yet highly sophisticated analysers, such as the LANCOM 4, which offer real-time digital readouts of gas concentrations. A critical aspect of the methodology is oxygen correction. Since facilities could artificially "dilute" emissions by introducing excess fresh air to reduce pollutant concentration, EPA calculates the "corrected concentration" based on a standard oxygen percentage. This correction ensures reported values accurately reflect the true efficiency of fuel combustion and scrubber performance, regardless of variations in stack airflow.

5.8 Enforcement Actions:

The Punjab Environmental Protection Agency has implemented rigorous enforcement actions under the Punjab Environmental Protection Act (amended 2017) and the Punjab Smog Prevention and Control Rules, 2023, to mitigate air pollution and smog. The Agency conducts regular inspections, issues Environmental Protection Orders (EPOs), levies fines, seals non-compliant industrial facilities, and prosecutes offenders. The Smog Prevention and Control Rules of 2023 place particular emphasis on managing construction dust, industrial emissions, brick kiln operations, and vehicular pollution, especially during the smog season. These concerted efforts aim to reduce particulate matter concentrations and safeguard public health across Punjab.

5.8.1 Brick Kiln Inspections:

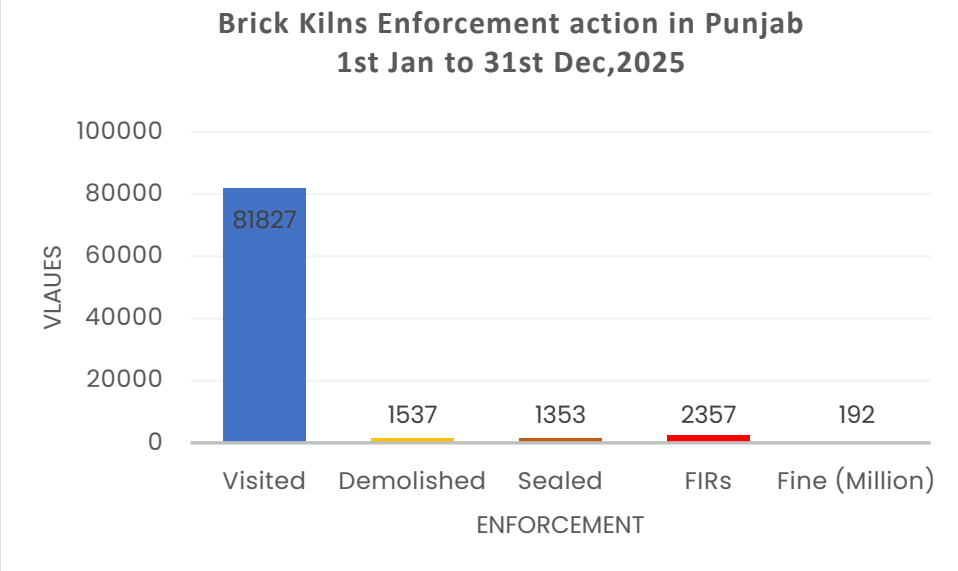
EPA Punjab maintains a zero-tolerance policy towards brick kilns operating with conventional technology or using substandard fuels such as hard coke, tyres, plastics, rubber, latex, leather, Rexene, pyro oil, tyre carbon, plastic waste lumps, hospital waste, or any other fuels prohibited by the Agency. In 2025, enforcement teams conducted inspections of a total of 81,827 kilns, demonstrating extensive



Figure 5.17: Enforcement actions at Brick Kilns in Punjab

monitoring coverage throughout the province.

As a consequence of non-compliance with environmental standards, 1,537 brick kilns were demolished and 1,353 were sealed, reflecting stringent punitive



measures by the authorities. Additionally, 2,357 First Information Reports (FIRs) were registered against violators, initiating legal proceedings under relevant environmental legislation. Financial accountability was further reinforced through the imposition of fines totaling 192 million rupees.

Graph 5.6: Brick Kilns Enforcement Actions in Punjab

5.8.2 Industrial Inspections:

The Environmental Protection Agency (EPA) Punjab enforces industrial emission standards through systematic inspections and air quality monitoring in proximity

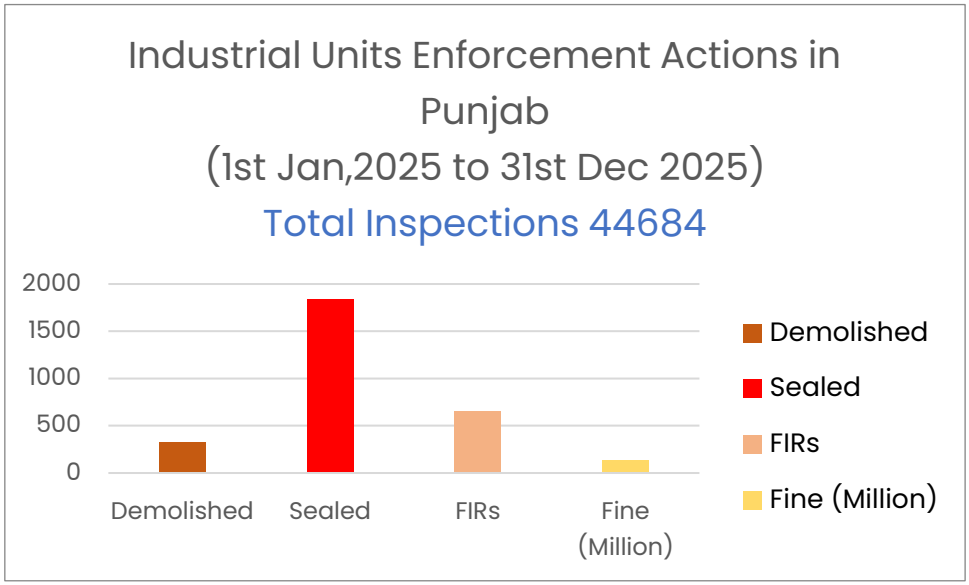


Figure 5. 18: Enforcement Actions at Industrial Units in Punjab

to industrial zones. Upon detection of violations, the Agency pursues legal actions including fines and facility closures. Beyond enforcement, EPA Punjab encourages the adoption of cleaner technologies by providing technical assistance and incentives promoting best practices. Industrial sectors such as steel mills and boiler operations are mandated to install and maintain emission control systems, including baghouse filters to capture particulate matter, scrubbers for the removal of sulphur oxides and other gaseous pollutants,

electrostatic precipitators to further reduce particulate emissions, and catalytic converters aimed at lowering nitrogen oxide (NO_x) emissions. Through these interventions, the EPA ensures regulatory compliance, mitigates pollution, and advances environmentally sustainable industrial processes.

In accordance with the Punjab Smog Prevention and Control Rules, 2023, enforcement data for industrial units during the period 1 January to 31 December 2025 demonstrates extensive regulatory activity. Inspection teams conducted 44,684 visits, underscoring robust monitoring efforts. As part of strict enforcement measures, 319 industrial units were demolished, and 1,834 units were sealed for non-compliance with environmental regulations. Furthermore, 649 First Information Reports (FIRs) were registered against violators, initiating legal proceedings under applicable environmental laws. Financial penalties imposed during this period totalled 128 million rupees.



Graph 5. 7: Industrial Units Enforcement Actions in Punjab

5.8.3 Anti - Stubble Burning Enforcement:

The Environmental Protection Agency (EPA) Punjab has successfully implemented the Action Plan for the Prevention and Control of Stubble Burning in hotspot areas along motorways and surrounding Lahore. Ten dedicated surveillance beats were deployed to provide round-the-clock monitoring, supplemented by 67 Quick Response Centres (QRCs) strategically activated to

ensure rapid firefighting capabilities across 538 villages encompassing approximately 211,000 acres of rice cultivation.

A robust Incident Reporting and Response Mechanism was operationalised to facilitate immediate communication of stubble burning incidents via EPA Surveillance Squads, the EPD Helpline (1373), automated Robo Calls, District Administrations, and other credible sources. Verified reports were swiftly relayed to the nearest QRCs, which promptly mobilised water bowsers and firefighting personnel to extinguish fires and prevent their spread. This coordinated system enabled timely detection, rapid response, and effective mitigation of stubble burning events.

The Agriculture Department supported these efforts by facilitating water refilling and operational logistics, ensuring the uninterrupted functioning of QRCs. Consequently, stubble burning was significantly reduced, environmental degradation mitigated, and public health protected. The successful execution of this plan exemplifies proactive environmental management, strong inter-agency coordination, and measurable progress towards sustainable agricultural practices.



Figure 5.19: Quick Response against Stubble Burning by using Water Bowsers

5.8.4 Fugitive Dust Management:

Fugitive dust emissions represent a significant source of $PM_{2.5}$ and PM_{10} pollution. In response, EPA Punjab introduced strategic measures in 2025, including a mandatory requirement that all sand trolleys transporting construction materials be securely covered with tarpaulin sheets or analogous durable coverings to prevent dust emissions on public roads. During the smog season, the entry of any uncovered trolley into Lahore was strictly prohibited.

Enforcement efforts were intensified, with twelve squads deployed in three shifts across six key excavation sites—Manga Mandi, Kartar Band, Nonarian, Bahadru/Charmro, Saggian, and Ganja Kalan—to monitor adherence to these regulations. These squads conducted continuous, round-the-clock inspections of sand and clay loading trolleys to ensure compliance with environmental guidelines.

The sand trolley inspections were conducted to ensure rigorous

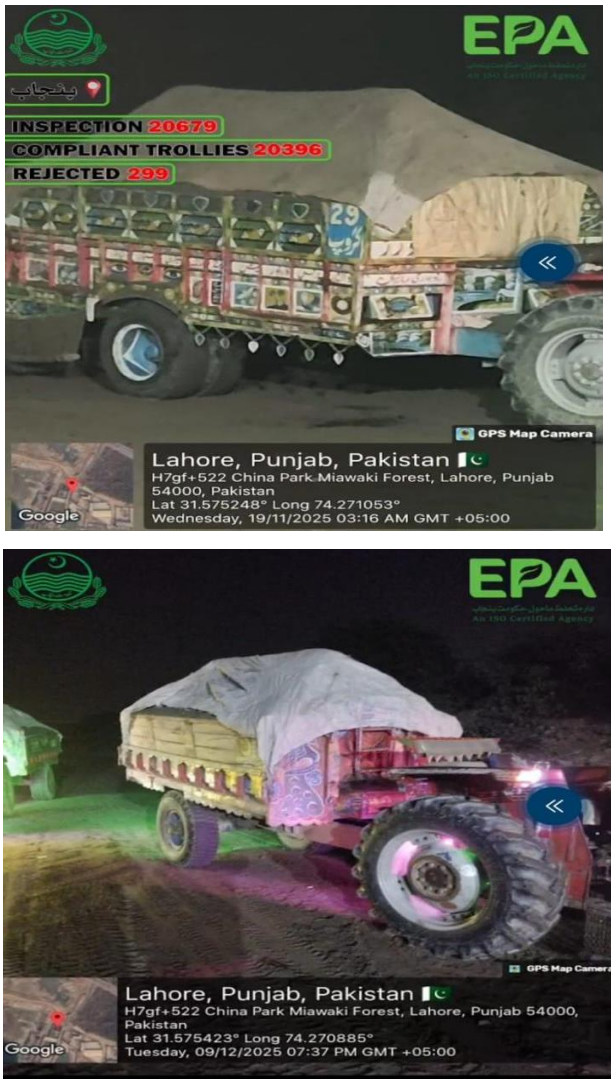
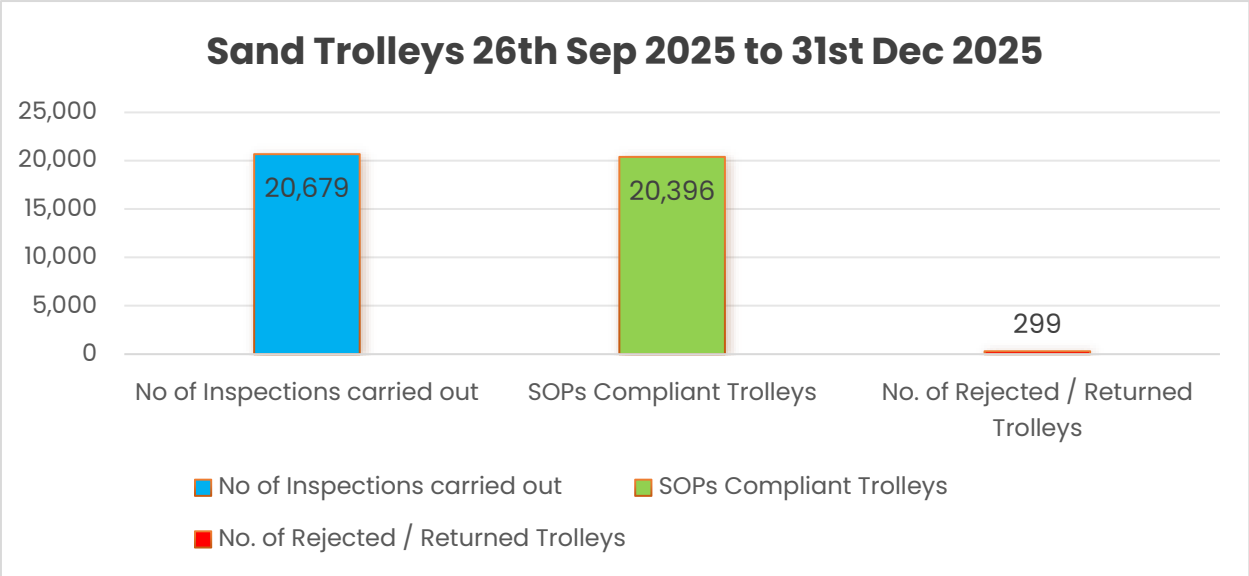


Figure 5.20: Covered Sand Trolleys in Punjab

enforcement of environmental standards and Standard Operating Procedures (SOPs) governing the transportation of construction materials. These inspections aimed to minimise dust emissions, guarantee the proper covering of loads, and prevent violations that exacerbate air pollution and pose public health risks.

A total of 20,679 inspections were conducted to monitor transportation activities. Of these, 20,396 trolleys were found to be compliant with the established Standard Operating Procedures (SOPs), reflecting an exceptionally high compliance rate. However, 299 trolleys were rejected or sent back due to violations including improper covering of loads or failure to adhere to environmental guidelines.



Graph 5.8: Sand Trolleys Enforcement Actions in Punjab

This high compliance rate demonstrates the efficacy of regulatory oversight and reflects the increasing commitment of transporters to adhere to environmental safeguards. Simultaneously, the rejection of non-compliant trolleys underscores

the necessity for sustained vigilance and rigorous enforcement measures to deter future violations.

5.8.5 Emission Testing of Vehicles:

A study conducted by the Urban Unit identified vehicular emissions as a major anthropogenic contributor to urban air pollution and smog in Punjab. In response, the Honourable Chief Minister of Punjab personally initiated and directed focused interventions under the Clean Air Campaign 2025 to control vehicular emissions. As part of this initiative, EPA Punjab launched an Emission Testing System (ETS) targeting light transport vehicles (LTVs).

The campaign employs KANE EGAS Emission Analysers to monitor carbon monoxide (CO) and other vehicular emission parameters, ensuring compliance with Rule 3 of the Punjab Environmental Protection (Motor Vehicles) Rules, 2013. These rules prohibit the operation of motor vehicles emitting pollutants beyond prescribed Environmental Quality Standards, as set forth under clause (g) of subsection (1) of section 6 of the Act. To facilitate this, authorised test centres have been established at multiple locations across Lahore.

This initiative underscores Punjab's commitment to reducing transport-related emissions, improving urban air quality, and strengthening scientific environmental enforcement mechanisms throughout the province.



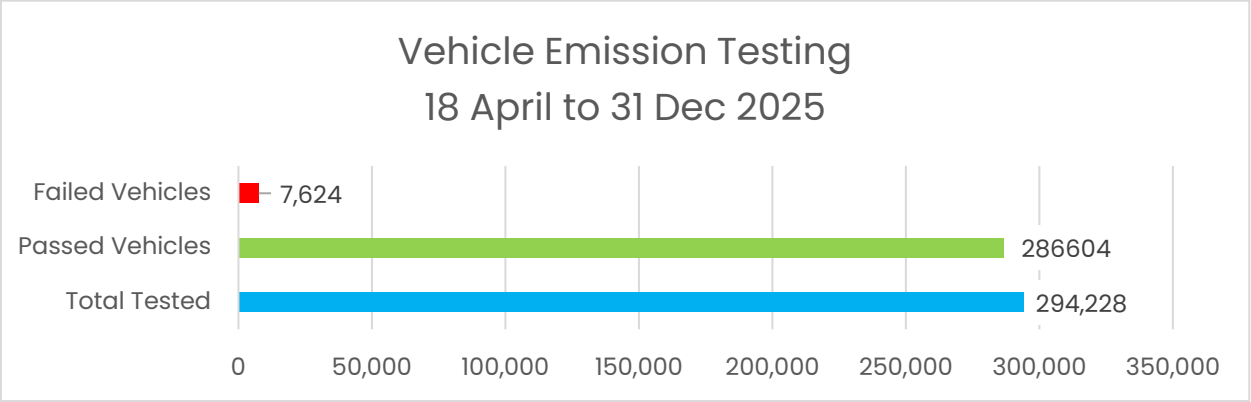
Figure 5.21: Emission Testing Squads (ETS) Monitoring

5.8.5.1 Formation of ETS Squads:

A total of 70 Emission Testing System (ETS) squads were deployed across Lahore to conduct on-ground emission testing and compliance inspections. To enhance operational effectiveness, special night shifts and weekend operations were introduced, ensuring continuous monitoring during peak traffic periods and commercial activity hours. Additionally, an appointment-based emission testing system was implemented to facilitate public access, reduce operational congestion, and improve the overall efficiency of emission testing services.

5.8.5.2 Test Validation:

All Light Transport Vehicles (LTVs) and motor cars operating on the roads of Lahore are mandated to undergo the Emission Testing System (ETS) administered by the Punjab Environmental Protection Agency (EPA). Only vehicles that comply with the prescribed Punjab Environmental Quality Standards (PEQS) for exhaust emissions and noise levels are authorised for road use. Successful vehicles are issued a green EPA sticker as official proof of conformity.



Graph 5.9: Vehicle Emission Testing Statistics in Lahore



Figure 5.22: Emission Testing and Green Sticker Affixation

The Punjab Environmental Protection Agency (EPA) conducted emission testing on 294,228 light transport vehicles (LTVs) across major districts. Of these, 7,624 vehicles failed to comply with Punjab Environmental Quality Standards (PEQS) and were consequently subject to fines or possible impoundment. Vehicles meeting the standards were issued the green EPA compliance sticker as proof of conformity.

5.8.6 Fuel Quality Inspections:

In pursuance of Rule 2(n) of the Punjab Environmental Protection (Smog Prevention and Control) Rules, 2023, and directives issued under Section 6(1)(t) of the Punjab Environmental Protection Act, 1997, the Environmental Protection Agency (EPA) Punjab has initiated stringent enforcement measures to ensure compliance with fuel specifications mandated by the Oil and Gas Regulatory

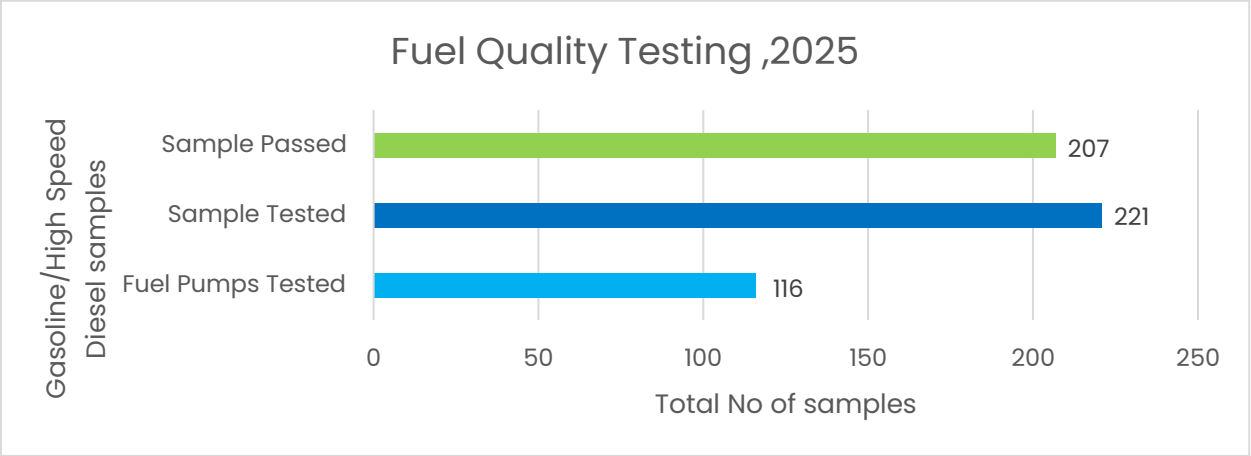


Figure 5.23: Fuel Quality Testing Enforcement Actions in Punjab

Authority (OGRA). These actions aim to curb vehicular emissions, mitigate smog formation, and protect public health.

To combat fuel-related pollution, three mobile fuel testing laboratories have been deployed to regularly inspect fuel quality at points of sale, aiding in the prevention of fuel adulteration that contributes to elevated emissions. This initiative promotes the use of cleaner-burning fuels, enhances engine performance, and ultimately supports improved air quality for all citizens.

During the enforcement campaign, EPA Punjab inspected 116 fuel pumps to verify compliance with the Oil and Gas Regulatory Authority's (OGRA) approved specifications for gasoline and high-speed diesel.



Graph 5.10: Fuel Quality Testing Enforcement Actions in Punjab

The results depicted in the graph indicate that the majority of retail outlets supply fuel of acceptable quality; however, the detection of non-compliant samples underscores the necessity for continuous monitoring and rigorous enforcement to ensure that only standard-quality fuel is available in the market.

5.8.7 Installation of Suction Hood at commercial restaurants:

Under the Punjab Environmental Protection Act, 1997, the Environmental Protection Agency (EPA) Punjab has mandated the installation of Type-I suction hoods in commercial restaurants and outdoor cooking stations that utilise coal, wood, or charcoal to mitigate air pollution. These hoods are designed to capture smoke, grease vapours, particulate matter, volatile organic compounds (VOCs), and other pollutants generated during grilling, thereby preventing their release into the atmosphere. Such emissions—including carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs), and trace metals—significantly contribute to



Figure 5.24: Installation of Suction Hoods at Restaurant

both indoor and outdoor air pollution and exacerbate smog formation, particularly during winter temperature inversion events.

Proper installation, maintenance, and use of filters or scrubbers are essential to substantially reduce these harmful emissions, improve ambient air quality, and protect public health. EPA Punjab has issued technical designs and Standard Operating Procedures (SOPs) for the installation of suction hoods, detailed in Annexure 2 of this chapter. Between 27 November and 31 December 2025, Punjab EPA conducted inspections of 887 commercial units. Among these, 313 units were found to comply with environmental regulations, while 450 non-compliant units were sealed.



Graph 5.11: Suction Hood Enforcement at BBQ Shops

5.8.8 Fog Cannons Deployment:

As part of its targeted response to recurring smog episodes, the Environmental Protection Agency (EPA) Punjab has initiated the strategic deployment of fog cannons across critically polluted zones to mitigate elevated concentrations of airborne particulate matter. This intervention serves as an immediate, localised air quality control measure. Fog cannons, mechanical dust suppression devices, are designed to reduce local dust generated from the following sources:

- Construction and demolition sites
- Roadside and industrial dust resuspension
- Dry soil areas and brick kiln corridors

The project aimed to enhance air quality and reduce environmental impacts through the deployment of 15 fog cannons in Lahore. These units are mounted on vehicles covering a total distance of 47,000 kilometres across designated operational zones. EPA Punjab anticipates significant improvements in service delivery and sustainability as a result of this initiative.

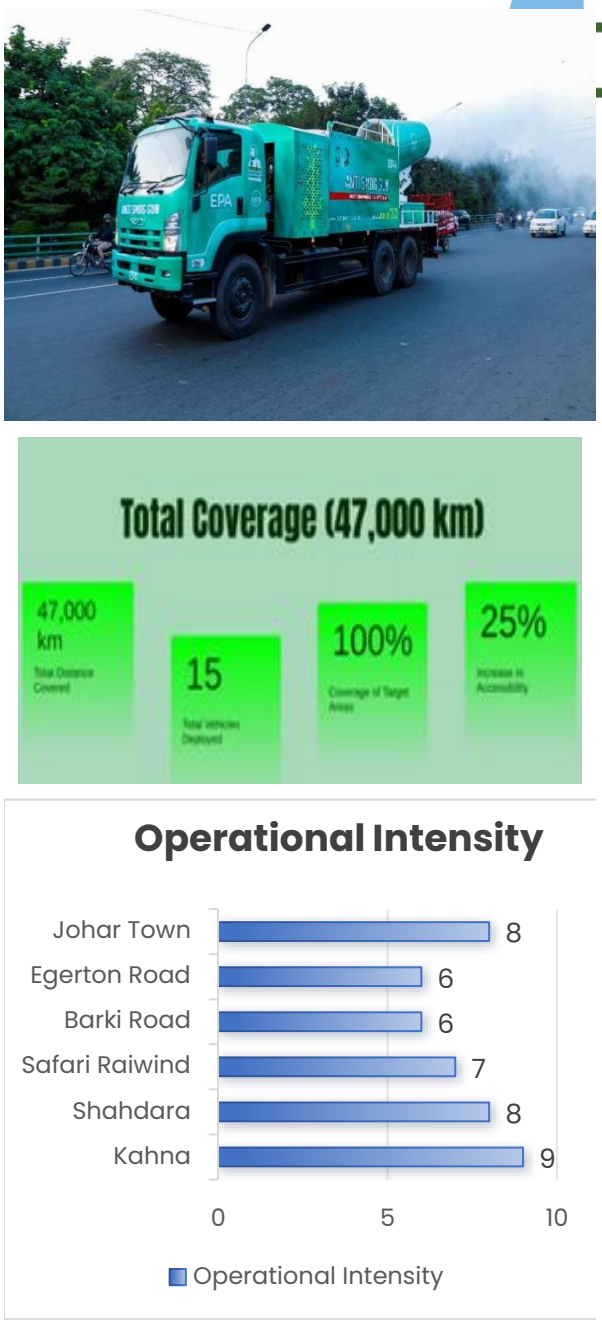


Figure 5.25: Fog cannon operations and coverage

5.8.8.1 Environmental Impacts:

The fleet operations have had a notable positive impact on the environment, contributing to reductions in carbon emissions and improvements in air quality. When employed correctly and selectively, fog cannons can temporarily reduce ambient PM_{10} concentrations within a radius of 50 to 100 metres, particularly under calm or stagnant meteorological conditions. Their deployment is

prioritised during severe smog episodes, with a focus on traffic corridors and identified pollution hotspots.

5.8.8.2 Evidence of PM 10 reduction at AQI hotspots sites across Lahore:

Fog cannon operations at multiple sites demonstrated significant reductions in PM_{10} concentrations, with observed decreases ranging from approximately 20% to 48%. These findings underscore the effectiveness of fog cannons in suppressing fine dust within localised, high-exposure areas such as unpaved roads and industrial zones. The deployments analysed in this study were conducted as operational field demonstrations, designed to evaluate the practical dust-suppression capabilities of fog cannons under real-world conditions, rather than as controlled scientific experiments aimed at establishing statistically rigorous emission reduction factors.

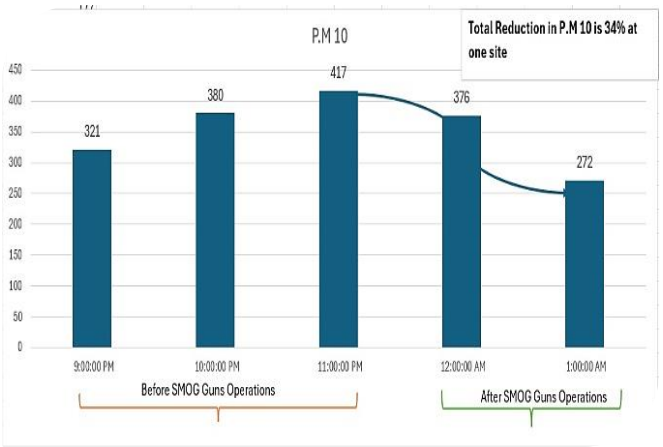
For the Kahna and Thokar deployments, fog cannons operated within an approximate one-kilometre radius of fixed ambient air quality monitoring stations located at DHQ Hospital Kahna and the Lahore Waste Management Company (LWMC) office near Thokar, respectively. At the Quaid-e-Azam Industrial Estate (QIE), a mobile monitoring unit was deployed alongside the fog cannon operations to assess changes in particulate matter concentrations before and after deployment. Reported reductions in $PM_{2.5}$ and PM_{10} were derived from actual field measurements taken immediately before and after fog cannon use at these locations.

It is important to note that meteorological variables were not incorporated in this study, and the deployment methodology was aligned with the intended operational use of fog cannons as localised dust-control devices. Prior to deployment, EPA field teams identified dust-prone areas based on elevated PM concentrations, visible dust generation, traffic volumes, construction activities, and industrial emissions. Fog cannons were strategically positioned to maximise coverage of these dust sources and operated under meteorological conditions favourable for effective droplet capture—particularly during periods of low to moderate wind speeds.

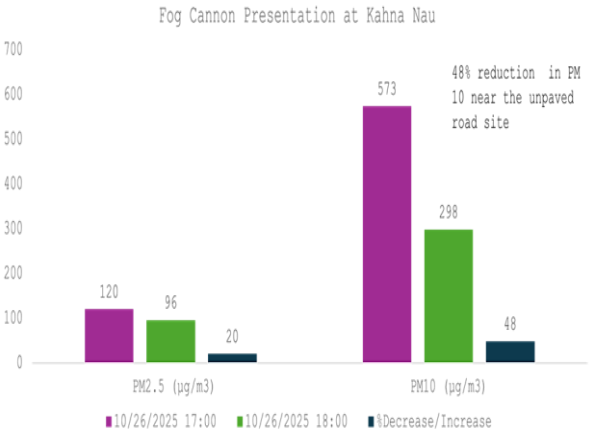
Monitoring data were collected both prior to and following sustained operation to assess immediate localised impacts. While reductions were temporary, these

results highlight fog cannons as effective rapid-response tools for mitigating acute pollution episodes. They serve as valuable complements to long-term emission control strategies and provide immediate public health benefits.

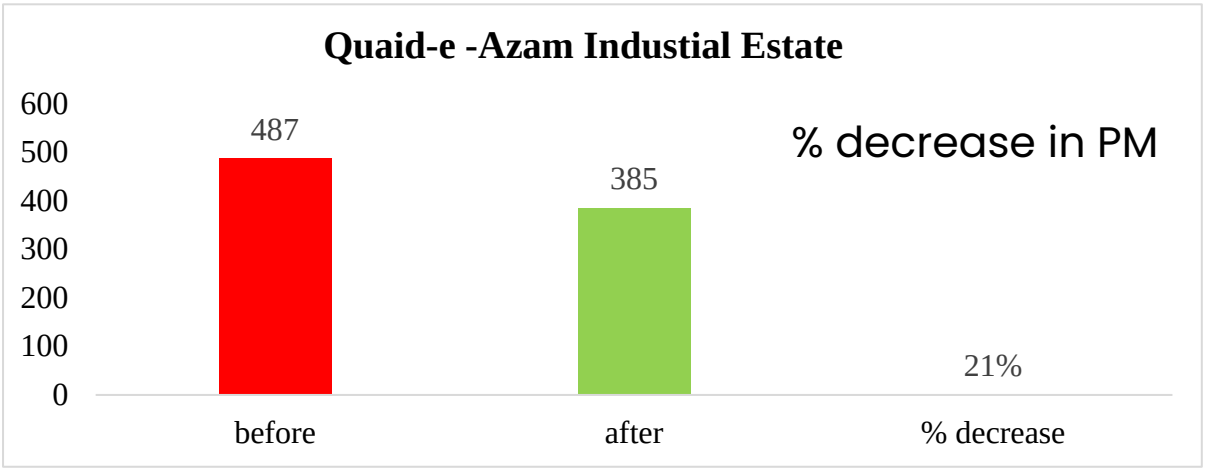
Area-wise studies on the effectiveness of fog cannon operations are illustrated below:



Fog cannon Deployment at Thokar



Fog cannon Deployment at Kahna



Fog Cannon deployment at Quaid- e- Azam Industrial Estate

Fig 5.12: Reduction in Particulate Matter due to fog cannon operations in Lahore

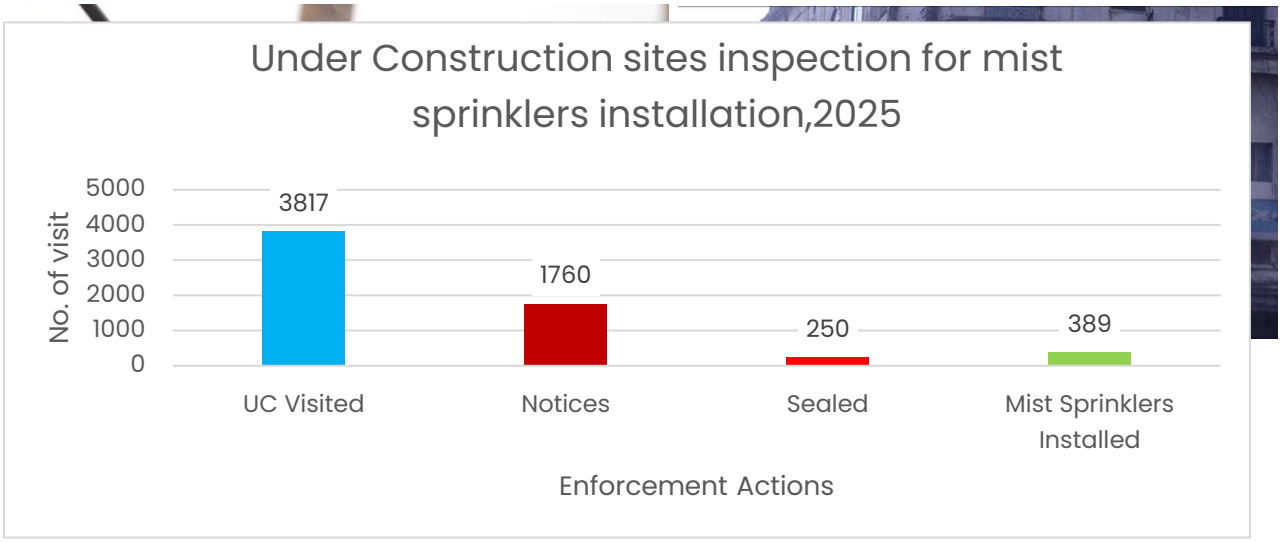
India (Delhi, 2020): Trials conducted by the Central Pollution Control Board (CPCB) demonstrated that fog cannons reduced $PM_{2.5}$ concentrations by only 10–15% within a 50–100 metre radius of the spray zone. No measurable impact was observed on the overall city-wide Air Quality Index (AQI). The fog cannons were primarily deployed near coal yards and highways to suppress coarse dust (PM_{10}). While effective in reducing visible dust, they were largely ineffective against $PM_{2.5}$, which constitutes the dominant pollutant in urban smog. In controlled industrial environments, fog cannons achieved dust reductions of up to 90%, thereby significantly improving air quality for workers. Nonetheless, such results are not directly transferable to open urban settings characterised by complex and multiple pollution sources[30].

5.8.9 Mist Sprinkles Installation at Under Construction Sites:

The Environmental Protection Agency (EPA) Punjab, under the authority of the Punjab Environmental Protection Act 1997, has mandated stringent dust control measures at all building construction sites to mitigate air pollution resulting from fugitive dust generated by excavation, demolition, and material handling.

Key measures include:

- Installation of mist sprinkler systems around construction sites prior to commencement of work, with nozzles properly spaced and system capacity calibrated to site-specific conditions.
- Implementation of operational controls such as appropriate storage and covering of construction materials, controlled demolition and excavation practices, reduced vehicle speeds on-site, routine site cleaning, and water sprinkling during ground levelling.
- Enforcement of site safety protocols aimed at preventing water accumulation and mosquito breeding.
- Display of regulatory guidelines prominently on banners at construction sites to ensure awareness and compliance.



Graph 5. 13: Status of Mist Sprinklers installation at under construction sites in Punjab

5.9 Nature Based Solution

Nature-Based Solutions (NbS) are sustainable approaches that harness natural processes and ecosystems to address environmental and social challenges. These solutions encompass practices such as wetland restoration, urban forestry, green roofs, rain gardens, and floodplain management, which collectively contribute to mitigating climate change impacts, reducing flooding, controlling pollution, and conserving biodiversity.

The Environmental Protection Agency (EPA) Punjab has shifted its focus towards Nature-Based Solutions, recognising that traditional "grey infrastructure" — such as concrete drainage systems and treatment facilities — can be costly and less adaptable to the evolving challenges posed by climate change. NbS are acknowledged by the EPA as more sustainable, cost-effective, and resilient alternatives that enhance water quality, support biodiversity, alleviate urban heat island effects, and promote public health.

Consequently, EPA Punjab has progressively integrated green infrastructure and ecosystem-based approaches into its environmental policies and water management frameworks.

5.9.1 Miyawaki Forest Initiative

The Miyawaki forest method is a nature-based solution that entails planting dense clusters of native trees and vegetation to establish fast-growing, self-sustaining forests in urban and degraded environments. This approach contributes to improved air quality, enhanced biodiversity, mitigation of urban heat, carbon dioxide absorption, and natural stormwater management. A Miyawaki forest was established at Hiran Minar as part of efforts to promote ecological sustainability, biodiversity conservation, and urban greening.

Recognising these environmental benefits, the Environmental Protection Agency (EPA) Punjab has supported similar urban forestry and green infrastructure initiatives as integral components of its broader commitment to climate resilience and sustainable urban development. Through the provision of grants, fostering community partnerships, and facilitating environmental restoration programmes, the EPA encourages the creation of compact urban forests and tree-planting projects that align with Nature-Based Solutions. These efforts aim to restore ecosystems and enhance the quality of life within local communities.

5.9.2 Tree Plantation

In the spring of 2025, the Environmental Protection Agency (EPA) Punjab launched a targeted tree plantation campaign at brick kiln sites under the flagship "Plant for Pakistan" initiative, which forms part of the Chief Minister's broader vision to enhance green cover and improve environmental quality across the province.

Trees serve as natural sinks for air pollutants and play a crucial role in enhancing environmental quality. Through photosynthesis, they absorb carbon dioxide (CO_2) and release oxygen, while their leaves and bark capture particulate matter (PM_{10} and $PM_{2.5}$) and absorb harmful gases such as sulphur dioxide (SO_2) and nitrogen oxides (NO_x). This source–sink relationship is fundamental to regulating atmospheric pollution levels. Recognising brick kilns as major emission sources,

EPA Punjab strategically targeted these sites within its plantation campaign to mitigate emissions and improve air quality.

The initiative sets a target of planting 60 trees per kiln, with an overarching goal of establishing 513,060 trees across key divisions of Punjab—including Lahore, Gujranwala, Multan, Faisalabad, Bahawalpur, Sahiwal, Sargodha, Rawalpindi, and Dera Ghazi Khan—where brick kiln clusters are densely concentrated. Implemented in phases and supported by a monitoring mechanism to ensure









tree survival and assess environmental impact, the campaign has made significant progress in its initial phase by targeting 4,167 brick kilns and planting 270,679 trees, thereby contributing substantially to afforestation and pollution reduction objectives.

In addition to the targeted plantation programme around brick kilns, the Environmental Protection Agency (EPA) Punjab expanded the initiative to encompass industrial areas, public spaces, and educational institutions, planting a total of 177,735 trees. This broader afforestation effort contributes to the development of green belts that serve as natural barriers, intercepting pollutants at their source and curbing their dispersion into adjacent residential neighbourhoods. Along roadways, these trees act as effective sinks for vehicular emissions and simultaneously reduce dust resuspension caused by traffic movement.



Tree plantation at industrial units



Tree plantation at educational institutes



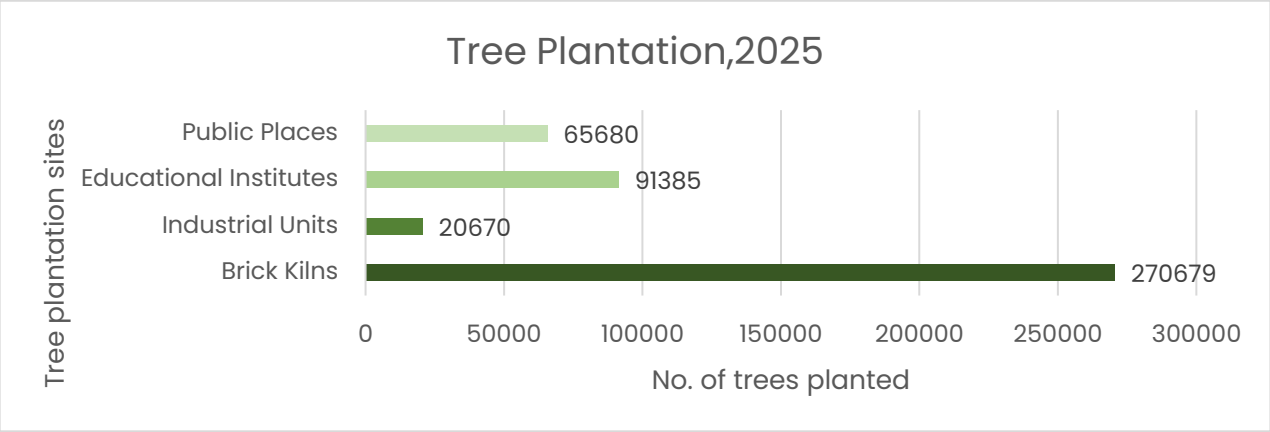
Tree plantation at public places



Tree plantation by students at school

Figure 5.27 Tree plantation activities by EPA Punjab

This green initiative not only tackles environmental degradation at its source but also aligns with national climate objectives aimed at increasing forest cover, reducing carbon emissions, and enhancing climate resilience. By focusing on high-emission industrial sectors, the Environmental Protection Agency (EPA) Punjab is establishing a robust precedent for harmonising industrial development with environmental stewardship, thereby fostering healthier and more sustainable communities throughout the province.



Graph 5.14: Tree Plantation in Punjab

5.10 Policy Reforms:

5.10.1 Punjab Clean Air Program (P-CAP)

The Punjab Clean Air Program (P-CAP) is a World Bank–supported initiative designed to enhance air quality management governance and reduce harmful $PM_{2.5}$ exposure in Lahore Division. Approved in March 2025 with a US$300 million International Development Association (IDA) credit, the programme is scheduled to run until June 2030 and involves multiple Punjab government departments, including Environment Protection & Climate Change, Agriculture, Industries, Transport, and Planning & Development.

P-CAP's structure focuses on three principal areas: improving governance and public awareness relating to air quality; reducing emissions from the transport sector through modernisation and the promotion of e-mobility; and addressing agricultural pollution by encouraging alternatives to crop residue burning. With a total financing package of US$510 million, inclusive of borrower contributions,

the programme emphasises climate change mitigation, low-carbon urban development, and citizen engagement.

As of late 2025, implementation progress and monitoring have been rated satisfactory, reflecting strong institutional commitment. Overall, P-CAP represents a comprehensive endeavour to tackle Lahore's severe smog problem through a combination of policy reform, institutional strengthening, and sector-specific interventions[16].

5.10.2 Punjab Green Credit Program and Air Quality Initiative:

The Government of Punjab has launched the Punjab Green Credit Program (PGCP) as a flagship initiative aimed at combating air pollution and enhancing environmental quality. This innovative, performance-based scheme provides direct financial rewards to citizens who adopt sustainable practices, such as installing solar appliances, utilising bicycles and electric vehicles, reporting pollution sources, and implementing energy efficiency measures.

By linking economic incentives to tangible environmental actions, PGCP not only contributes to the reduction of smog, greenhouse gas emissions, and particulate pollution but also promotes public health through the provision of cleaner air and healthier living conditions. The programme represents a transformative approach to making environmental responsibility economically beneficial, fostering active community participation, and advancing Pakistan's commitments to climate resilience and sustainable development.

5.10.3 Driving Clean Futures: Electric Vehicles as Catalysts for Smog Reduction and Climate Resilience:

The adoption of electric vehicles (EVs) has emerged as a highly effective strategy for reducing air pollution and greenhouse gas emissions. EPA Punjab has demonstrated commitment to this approach by procuring 250 electric bikes and



Figure 5. 28: Purchase of E-Vehicles for field operations by EPA Punjab

50 hybrid vehicles to bolster its field operations.

Empirical evidence indicates that a 1% increase in EV sales within a city can reduce local CO_2 emissions by 0.096%, while also decreasing emissions in neighbouring cities by 0.087%, highlighting both direct and regional benefits. Moreover, EV adoption contributes to the improvement of air quality, as each additional EV unit sold is associated with a reduction in $PM_{2.5}$ concentrations by approximately 1.75×10^{-5} $\mu g/m^3$. Given that $PM_{2.5}$ is a major contributor to smog and respiratory illnesses, such reductions directly support public health outcomes.

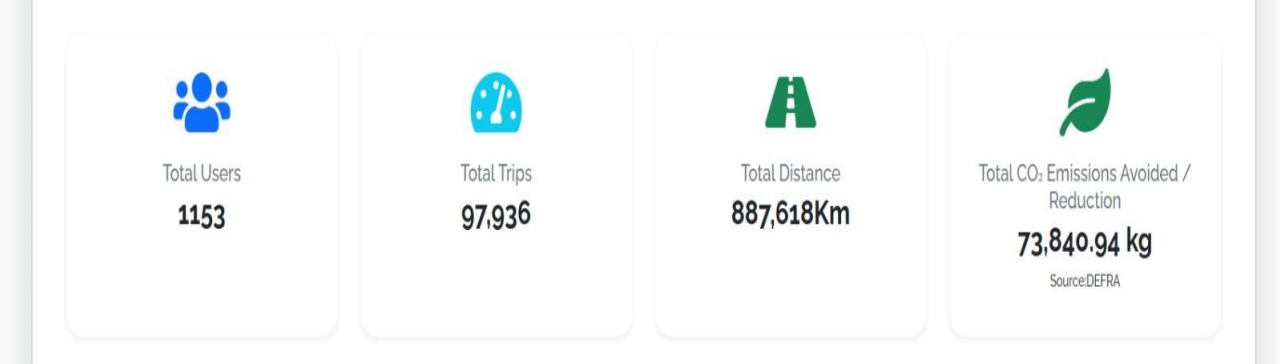
Collectively, these findings underscore that EVs not only play a critical role in climate change mitigation but also contribute significantly to alleviating smog, improving urban air quality, and safeguarding community health.

5.10.3.1 Pedaling toward Cleaner airs: Public Embrace of E-Bikes in Punjab

Under the Punjab Green Credit Program, a total of 1,153 individuals have purchased electric bikes, marking a significant advancement towards sustainable mobility. Collectively, these users have completed 97,936 trips and covered a total distance of 887,618 kilometres. This transition to clean transportation has yielded substantial environmental benefits, with an estimated reduction of 73,840.94 kilograms of greenhouse gas emissions. The initiative exemplifies the program's effectiveness in promoting eco-friendly transport solutions while contributing to climate resilience and improved air quality in Lahore.



Figure 5.29: Monitoring, Reporting and Verification of E-Bikes by Green Credit Team



5.11 Outcomes of Air Pollution Abatement Measures EPA Punjab (2025)

5.11.1 Net pollution shift in 2025

The expansion of the Air Quality Monitoring System (AQMS) across 18 districts of Punjab, operational since June 2025, represents a significant institutional advancement in enhancing air quality management and surveillance. While a comprehensive and validated assessment of pollution trends will be formally presented in the Environmental Protection Agency (EPA) Punjab's 2026 report, preliminary insights can be gleaned from the IQAir Annual Report 2025. Lahore, as the most severely smog-affected region, has been a central focus of air quality monitoring efforts. In this regard, the Environmental Protection and Climate Change Department (EPCCD) has maintained AQMS installations in Lahore over recent years, generating indigenous, continuous data that provides valuable baseline information on long-term air quality trends and elucidates key pollution patterns within the region.[42]

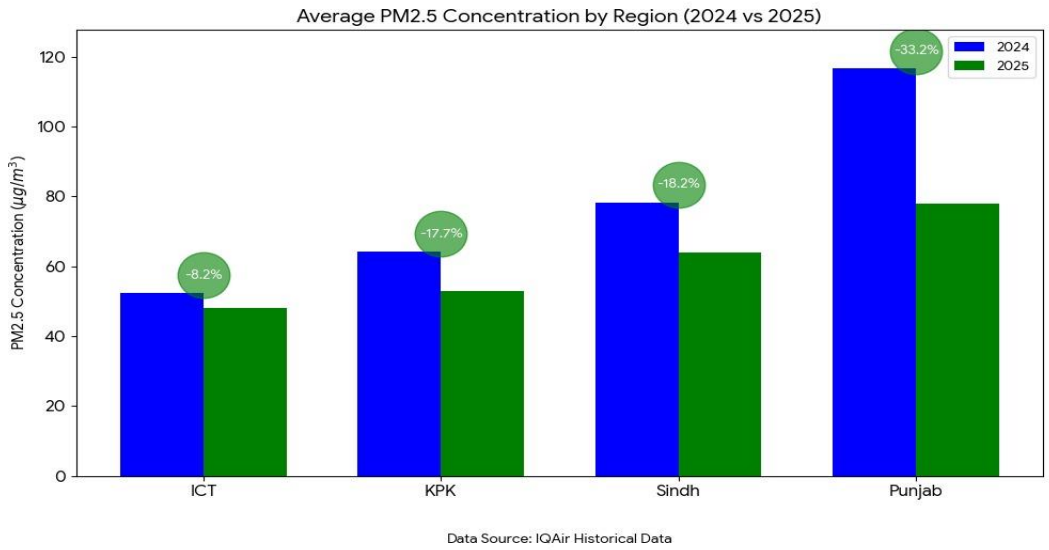
28Central Pollution Control Board (CPCB, India), "Guidelines for the Use of Anti-Smog Guns for Dust Suppression" (2021)

29https://www.pakwheels.com/forums/t/meet-chinas-mist-cannons-a-unique-approach-to-shoot-down-smog-from-sky/605787

30 https://www.australianmining.com.au/news/dust-control-solutions-in-mining/

5.11.2 Air Quality Improvement in Punjab:

In Punjab, a substantial reduction in $PM_{2.5}$ concentrations was observed between 2024 and 2025, as reported in the IQAir Annual Report 2025. The province recorded the highest $PM_{2.5}$ level among all regions in 2024, at approximately 118 µg/m³, which declined significantly to around 78 µg/m³ in 2025. This represents an impressive reduction of approximately 33%.



Graph 5.15 Substantial Reduction in PM 2.5 levels in Punjab

5.11.3 Particulate Matter reduction in Hot spot districts:

The IQAir 2025 report reveals that $PM_{2.5}$ levels in major Pakistani cities—including Lahore, Bahawalpur, Rawalpindi, and Faisalabad—have exhibited significant

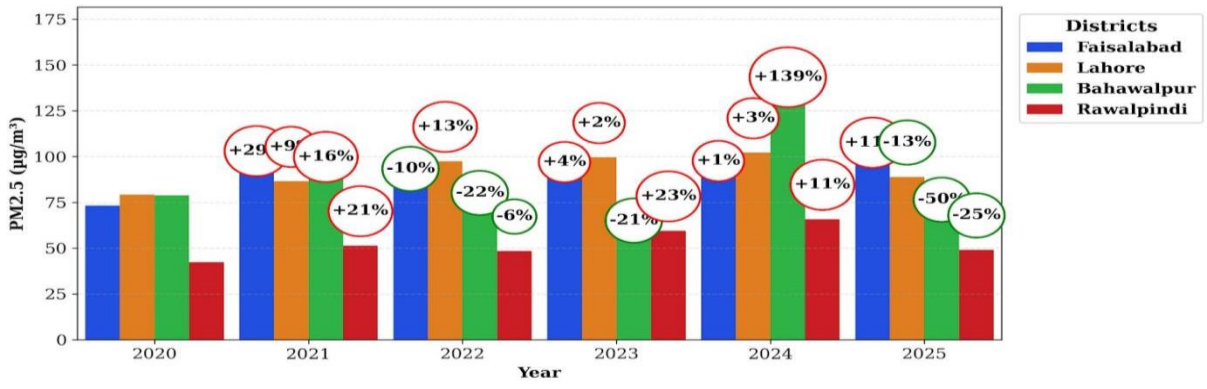
31 Zhao, X., Hu, H., Yuan, H., & Chu, X. (2023). How does adoption of electric vehicles reduce carbon emissions? Evidence from China. Heliyon, 9(9), e20296. https://doi.org/10.1016/j.heliyon.2023.e20296

32 Wu, Y., Gu, F., Ji, Y., Ma, S., & Guo, J. (2023). Electric vehicle adoption and local PM2.5 reduction: Evidence from China. Journal of Cleaner Production, 396, 136508. https://doi.org/10.1016/j.jclepro.2023.136508

fluctuations between 2020 and 2025. Air pollution increased markedly across all cities in 2021. During 2022–2023, trends varied, with some cities showing improvement while others experienced further deterioration. A pronounced spike occurred in 2024, particularly in Bahawalpur, indicative of severe pollution episodes. By 2025, a general decline in $PM_{2.5}$ concentrations is evident across most cities, suggesting a positive trend towards improved air quality.

In summary, Pakistani cities demonstrate pronounced inter-annual variability in air pollution, with recurring spikes notably in 2021 and 2024. While some improvements are observable by 2025, the overall pattern reflects inconsistent control measures alongside the persistent influences of industrial emissions, urbanisation, and seasonal smog conditions.

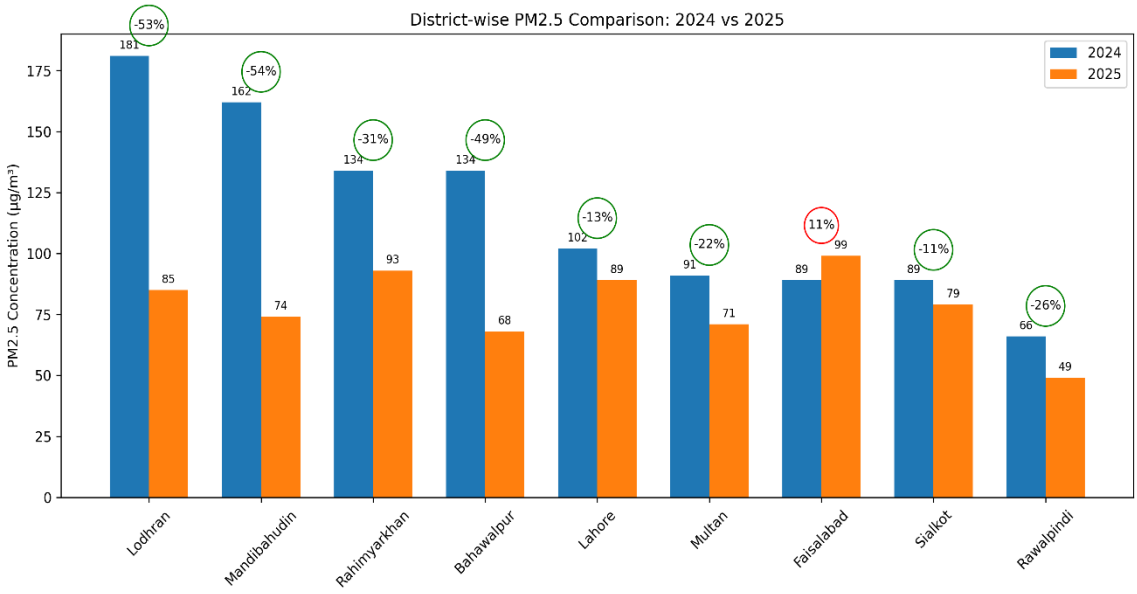
Graph 5.17, presented below, illustrates a significant reduction in $PM_{2.5}$ concentrations across most districts in 2025 compared to 2024, based on IQAir historical data. Major districts such as Lodhran (-53%), Mandi Bahauddin (-54%), Rahim Yar Khan (-31%), and Bahawalpur (-49%) witnessed substantial decreases in $PM_{2.5}$ levels, indicating a strong positive trend in air quality. Similarly, urban centres including Lahore (–13%), Faisalabad (+11%), Multan (–22%), and Rawalpindi (-26%) exhibited notable improvements, though the extent of reduction varied. Faisalabad remains an exception, showing a slight increase



(+11%), suggestive of localised factors adversely affecting air quality.

Graph 5.16 Comparison of $PM_{2.5}$ levels across hotspot districts (2024 Vs 2025)

This overall improvement is attributable to enhanced regulatory and enforcement efforts by the Environmental Protection Agency Punjab, which include stricter controls on industrial emissions, the adoption of zigzag technology in brick kilns, improved vehicular emissions monitoring, and coordinated smog mitigation campaigns during peak seasons. Additionally, favourable meteorological conditions in 2025—such as increased rainfall, improved wind dispersion, and fewer temperature inversion events—played a pivotal role in reducing pollutant concentrations. The synergistic effect of policy interventions and supportive climatic factors has thus contributed to measurable advancements in air quality across Punjab during 2025.



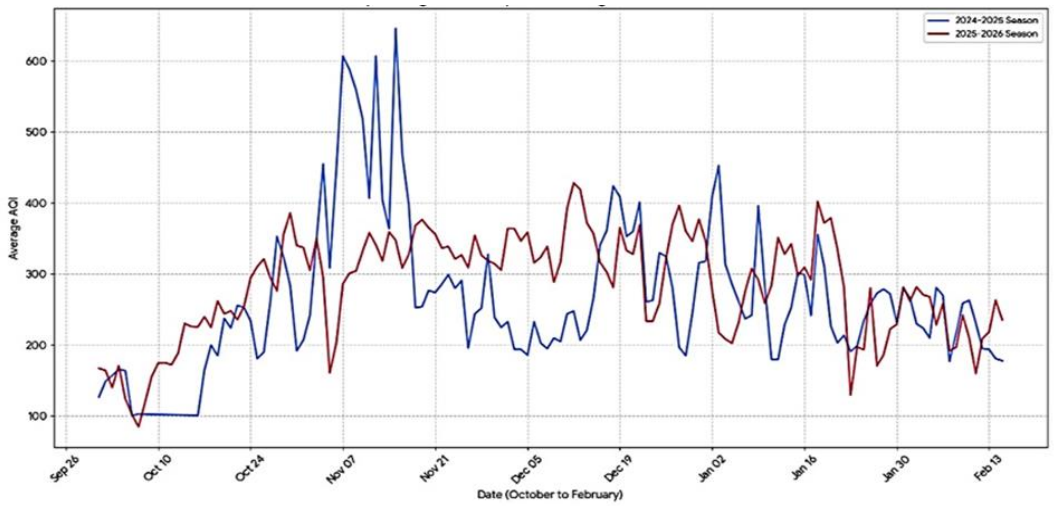
Graph 5.17 Trends in PM2.5 reductions in Punjab districts

5.11.4 Lahore air quality improvement:

The comparison of Lahore's air quality during the 2024 and 2025 smog seasons highlights the persistent challenge of atmospheric pollution, even as regulatory interventions intensify. While the overall annual average for 2025 showed a slight improvement over 2024. More notable progress is observed during the peak smog period (October–December), where a substantial reduction of approximately 19% was recorded in 2025 compared to the previous year.

A key element of EPA Punjab's strategy to mitigate pollution peaks has been the mandatory installation of Emission Control Systems (ECS) across the industrial sector. Moving beyond passive monitoring, the EPA has enforced the deployment of technologies such as wet scrubbers, baghouse filters, and electrostatic precipitators in high-emission facilities including steel re-rolling mills and food processing plants. Targeted dust emission controls have been implemented through mist sprinkler systems installed at construction sites, suction hood installations at restaurants, and the timely deployment of fog cannons at pollution hotspots. Complementing these efforts, the successful conversion of brick kilns to Zig-Zag technology has significantly reduced black carbon emissions.

These technical interventions aim to reduce the overall "pollution load" at the source, ensuring that even under unfavourable meteorological conditions, the total particulate matter introduced into the atmosphere remains substantially lower than the unregulated levels observed in early 2024.



Graph 5.18 Net Pollution shift in Lahore, 2025

The graph depicts Air Quality Index (AQI) trends specifically for the smog season (October–December), comparing peak pollution periods across consecutive years to illustrate how pollutant concentrations responded to industrial activity and regulatory interventions. Despite notable improvements in industrial

emissions, the report underscores that meteorological conditions continue to be the primary determinant of daily air quality.

5.11.5 Improvement in Air Quality and Reduction in Pollutants

The implementation of targeted emission control measures across the industrial, transport, and construction sectors has led to a gradual improvement in ambient air quality throughout Punjab. Key pollutants, including particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen oxides (NO_x), and carbon monoxide (CO), have exhibited declining trends as a result of sustained regulatory oversight and mitigation efforts.

Emissions from industrial boilers decreased by 25% following the installation of advanced emission control systems such as wet scrubbers. Within the brick kiln sector, the conversion of 4,073 units to Zig-Zag technology has enhanced combustion efficiency, contributing to a 16.08% reduction in greenhouse gas emissions and a 29.32% decline in particulate matter levels.

In the steel industry, substantial emission reductions were achieved through widespread adoption of emission control technologies and the near-complete elimination of non-compliant facilities. Consequently, particulate emissions within this sector declined by 49.34% between 2021 and 2025.

Collectively, these sectoral interventions, underpinned by robust regulatory enforcement and technological advancements, have contributed significantly to the improvement of air quality in Punjab.

5.12 Conclusion

Province-wide $PM_{2.5}$ concentrations declined in 2025 compared to 2024, with notable reductions observed in several hotspot districts. This positive trend reflects the combined effects of regulatory measures, enhanced industrial emission controls, and favourable meteorological conditions. Lahore, the city most affected by smog, recorded substantial annual improvements, particularly during the peak smog season from October to December. This progress is attributed to coordinated interventions by the Environmental Protection Agency Punjab and the Environmental Protection and Climate Change Department

Punjab, including the enforcement of stricter emission standards, installation of industrial pollution control technologies, widespread adoption of zig-zag technology in brick kilns, and intensified dust mitigation efforts.

Regionally, Central Punjab remains the most industrially concentrated and pollution-intensive area, while Northern Punjab exhibits moderate, more dispersed industrial activity. Southern Punjab is characterised by a scattered industrial landscape dominated primarily by small-scale industries and brick kilns. Overall, the year 2025 marks incremental yet meaningful advancements in air quality management across Punjab, underscoring the ongoing necessity for sustained enforcement, technological upgrades, and expanded monitoring to secure long-term and stable environmental improvements.

PART 02

Environmental Quality Assessment & Pollution Management

Chapter 5

Part II : Emission Inventory of Major Industrial Sectors of Punjab

5.13 Sector wise emission load of Punjab

A fundamental prerequisite for effective air quality management and emission control is the development of accurate emission inventories, which depend critically on reliable emission factors. Traditionally, emission inventories in developing regions have relied on default emission factors provided by international organisations such as the Intergovernmental Panel on Climate Change (IPCC) and the United States Environmental Protection Agency (USEPA). However, these default values—often derived under controlled laboratory conditions—may not adequately represent the local fuel characteristics, combustion technologies, and operational practices encountered in real-world settings. In Punjab, for instance, factors such as the widespread adoption of zig-zag brick kiln technology, variability in coal quality, and inconsistent combustion conditions significantly influence emission profiles.

Against this backdrop, the present study seeks to develop locally representative emission factors using a Bottom-Up Approach based on field measurements and practical estimation techniques. Given the challenges associated with direct measurement of flue gas volume—such as high cost, technical complexity, and operational constraints—a novel CO_2-based flue gas volume estimation method has been adopted. This approach utilises measured CO_2 concentrations, known stoichiometric CO_2 generation from fuel combustion, and stack temperature data to estimate total exhaust gas volume, which is then employed to calculate emission factors for key pollutants.

This work not only provides emission factors tailored to local conditions but also enhances the accuracy of emission inventories, thereby supporting evidence-based policymaking and reinforcing regulatory frameworks for air quality management in Punjab.

The comprehensive industrial emission inventory compiled for Punjab's ten divisions reveals a significant environmental challenge driven by a densely

concentrated industrial base. Across the province, industrial activities annually emit approximately 57.8 million tonnes (Mt) of CO_2, alongside substantial quantities of gaseous pollutants including 79.20 kilotonnes (kt) of nitrogen oxides (NO_x), 69.76 kt of carbon monoxide (CO), and 30.66 kt of sulphur dioxide (SO_2). Particulate matter (PM), the principal contributor to seasonal smog episodes, totals 35.21 kt annually. Although industrial growth is broadly distributed, pollution "hotspots" are heavily concentrated within the Lahore, Gujranwala, and Faisalabad divisions, which collectively account for nearly half of the province's total industrial units.

Table 5.3 Industrial emission inventory of Punjab's 10 divisions

			Fuel Usage				Emissions				
Sr. No.	**Total**	**Industry**	**Coal (Mt)**	**Gas (BCM)**	**Diesel (Mt)**	**Biomass (Mt)**	**CO_2 (Mt)**	**CO (kt)**	**NO_x (kt)**	**SO_2 (kt)**	**PM (kt)**
1.	Brick Kilns	9041	1.8805	0.0000	0.1175	0.4521	4.7141	29.1605	2.7631	20.8417	12.3057
2.	Cement Plants	16	4.5273	0.3200	0.0800	0.0000	12.4518	13.4657	60.6495	2.0653	16.6645
3.	Cement Blocks Mfg	69	0.0055	0.0021	0.0021	0.0000	0.0227	0.0677	0.0750	0.0620	0.0320
4.	Textile Dyeing & Printing	893	0.0447	0.2679	0.0268	0.0893	1.0583	5.3536	3.4697	1.7142	0.7455
5.	Iron & Steel Re-rolling	292	0.0292	0.0058	0.0058	0.0000	0.0901	0.2256	0.2808	0.3013	0.1399

6.	Sugar Mills	51	0.0357	0.1020	0.0255	0.5712	1.4002	4.4485	1.7689	0.8637	1.5477
7.	Beverages / Food Processing	72	0.0043	0.0144	0.0043	0.0000	0.0615	0.2976	0.2288	0.1109	0.0507
8.	Bakeries / Sweets	254	0.0000	0.0152	0.0051	0.0000	0.0580	0.3078	0.2249	0.0751	0.0395
9.	Milk & Dairy	78	0.0000	0.0078	0.0016	0.0000	0.0264	0.1485	0.1028	0.0380	0.0153
10.	Chemical Formulation	126	0.0088	0.0315	0.0050	0.0000	0.1194	0.6113	0.4452	0.2348	0.0877
11.	Chemical Manufacturing	79	0.0158	0.0316	0.0040	0.0000	0.1294	0.6212	0.4688	0.2996	0.1080
12.	Gelatin Units	8	0.0012	0.0024	0.0002	0.0016	0.0124	0.0533	0.0354	0.0228	0.0113
13.	Leather Tanneries	579	0.0347	0.1448	0.0116	0.0000	0.5008	2.6941	1.8791	1.0207	0.3268
14.	Distilleries	8	0.0008	0.0024	0.0002	0.0080	0.0225	0.0789	0.0354	0.0195	0.0232
15.	Flour Mills	515	0.0000	0.0515	0.0155	0.0000	0.1906	1.0254	0.7398	0.2532	0.1253
16.	Rice Mills	1399	0.0000	0.0000	0.0280	0.8394	1.5157	3.7273	0.5993	0.0603	1.8880

17.	Glass Industry	16	0.0064	0.0016	0.0003	0.0000	0.0176	0.0467	0.0536	0.0672	0.0264
18.	Paper Board	123	0.0148	0.0246	0.0062	0.0049	0.1236	0.5369	0.4155	0.2576	0.1180
19.	Paper & Pulp	120	0.0240	0.0360	0.0072	0.0096	0.1837	0.7862	0.5997	0.3987	0.1778
20.	Fertilizer Units	20	0.0000	0.2000	0.0200	0.0000	0.6134	3.6356	2.3995	0.9667	0.2960
21.	Ghee/Oil Units	54	0.0043	0.0108	0.0016	0.0000	0.0430	0.2119	0.1579	0.0925	0.0343
22.	Edible Oil Mills	134	0.0134	0.0335	0.0054	0.0000	0.1346	0.6603	0.4939	0.2871	0.1079
23.	Engineering / Metal Works	702	0.0281	0.0702	0.0351	0.0000	0.3577	1.5904	1.3175	0.6114	0.3398
24.	Cement Based CO2	0	0.0000	0.0000	0.0000	0.0000	33.9570	0.0000	0.0000	0.0000	0.0000
	Total	**14649**	**6.6795**	**1.3761**	**0.4089**	**1.9761**	**57.8043**	**69.7551**	**79.2041**	**30.6642**	**35.2112**

5.13.1 Sectoral Contributors and Key Pollutants

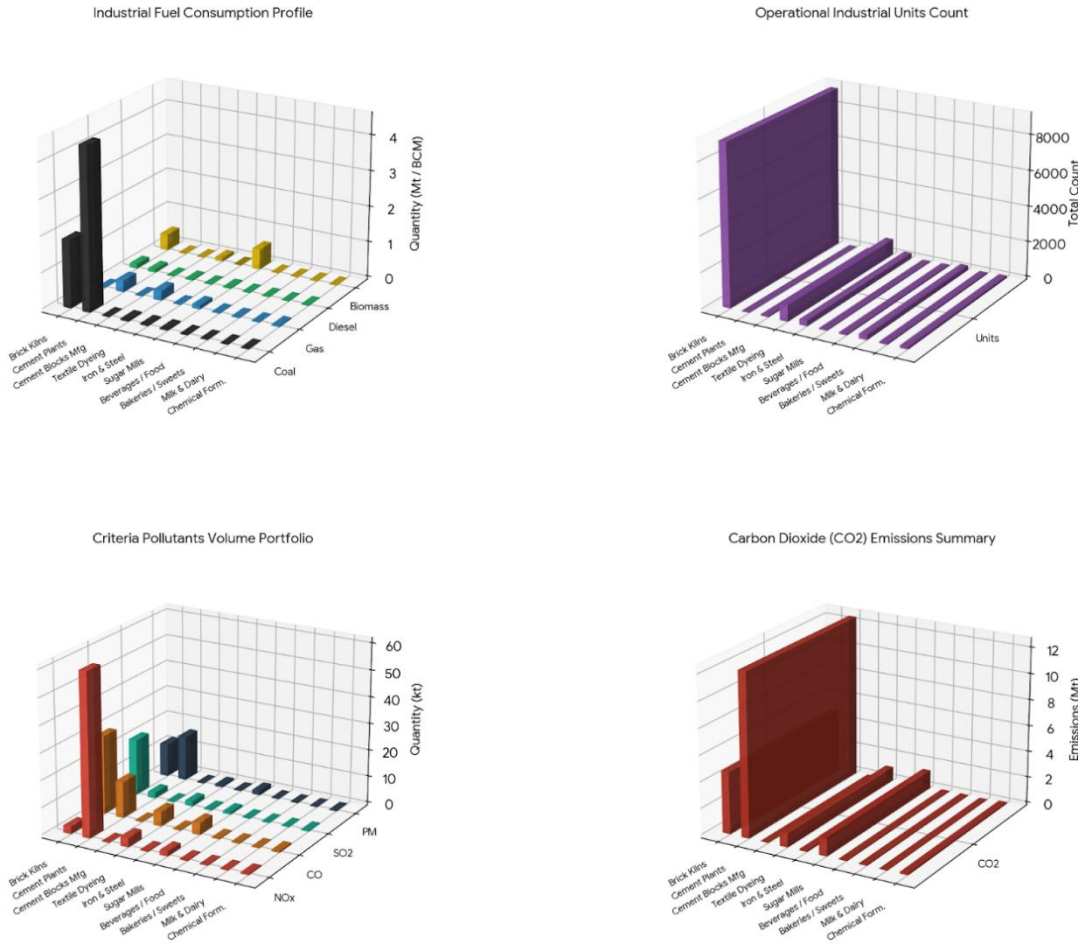
Among the major industrial sectors, three "Critical Sectors" predominantly contribute to the Air Quality Index (AQI) across Punjab:

Cement Plants: This sector is the largest contributor to nitrogen oxides (NO_x), emitting approximately 60.64 kilotonnes (kt), and particulate matter (PM), contributing 16.72 kt. Cement-related CO_2 emissions are estimated at around 33.96 million tonnes (Mt). Despite EPA Punjab's successful implementation of

modern Emission Control Systems (ECS), including electrostatic precipitators, the substantial scale of production renders cement plants a top-tier regulatory priority.

Brick Kilns: Brick kilns are a major source of carbon monoxide (CO), emitting approximately 29.16 kt, and sulphur dioxide (SO_2), contributing 20.84 kt. The transition to more efficient Zig-Zag kiln technology has significantly reduced black carbon emissions; however, the continued use of sulfur-rich coal poses ongoing challenges in mitigating regional haze.

Rice Mills and Textile Units: Rice mills contribute notably to localised emissions of PM (1.89 kt), CO (3.73 kt), and NO_x (0.60 kt). Textile units similarly emit substantial quantities of CO (5.35 kt) and NO_x (3.47 kt), predominantly due to the utilisation of biomass fuels and high-temperature boiler operations.

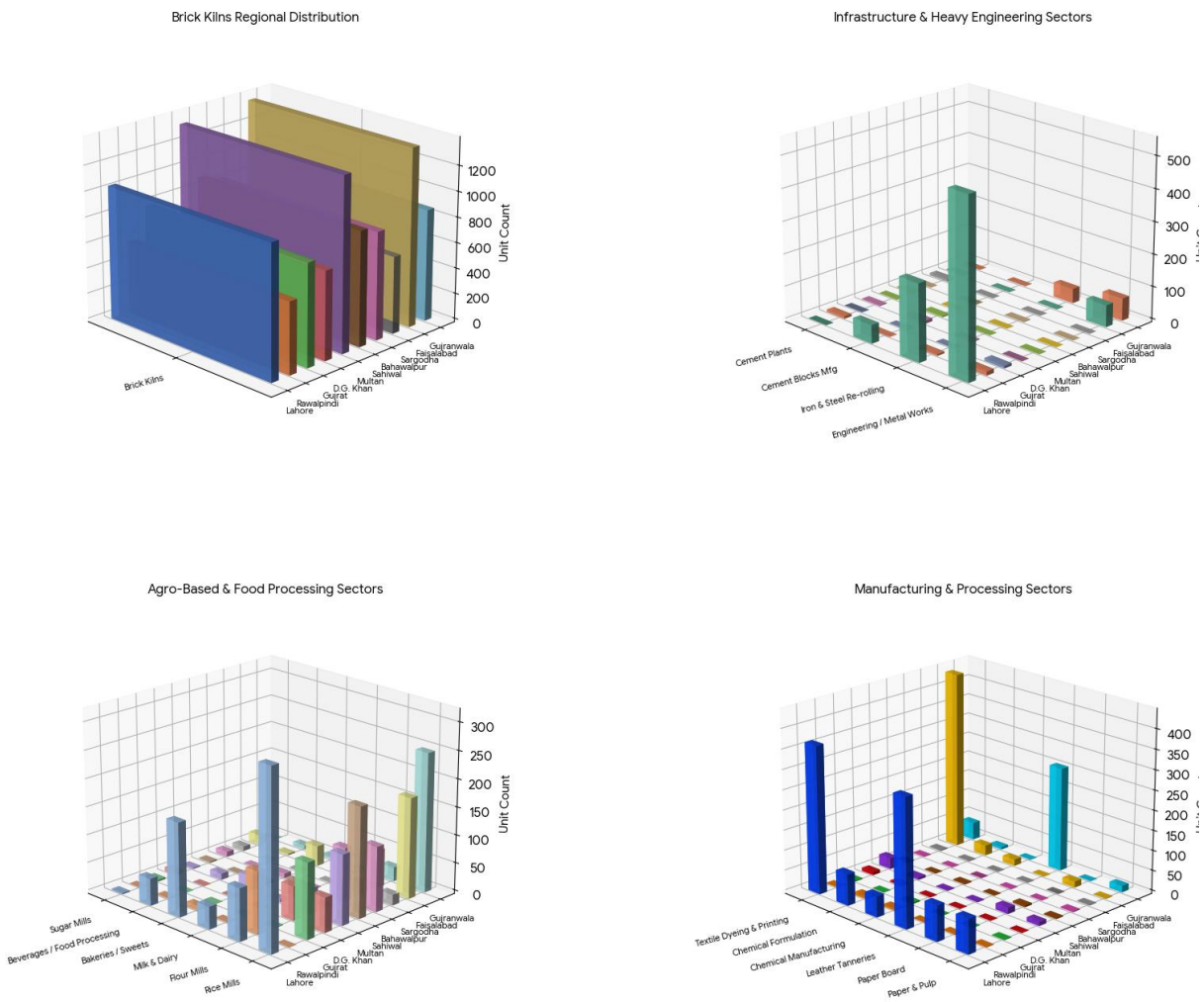


Graph 5.19 Industrial emission and resource consumption analysis

Table 5.4 Division wise total number of industrial sectors in Punjab

Industry Type	Lahore Division	Rawalpindi Division	Gujrat Division	D.G. Khan Division	Multan Division	Sahiwal Division	Bahawalpur Division	Sargodha Division	Faisalabad Division	Gujranwala Division	Total
Brick Kilns	1042	560	798	690	1355	894	840	601	1391	870	9041
Cement Plants	0	7	0	2	0	0	0	7	0	0	16
Cement Blocks Mfg	57	0	0	9	3	0	0	0	0	0	69
Textile Dyeing & Printing	367	2	2	8	27	1	1	2	440	43	893
Iron & Steel Re-rolling	238	5	0	2	0	0	1	0	1	45	292
Sugar Mills	2	0	3	7	2	2	9	8	18	0	51
Beverages / Food Processing	48	2	0	0	11	0	1	0	3	7	72
Bakeries / Sweets	167	8	0	0	26	4	8	1	36	4	254
Milk & Dairy	40	1	0	0	5	24	1	0	7	0	78
Chemical Formulation	78	7	0	3	6	0	0	1	25	6	126
Chemical Manufacturing	52	5	3	0	1	2	0	0	16	0	79

Gelatin Units	6	0	1	0	0	0	0	0	1	0	8
Leather Tanneries	319	0	0	0	1	0	0	0	0	259	579
Distilleries	2	0	1	1	0	0	2	0	2	0	8
Flour Mills	93	110	1	61	45	0	94	19	67	25	515
Rice Mills	317	0	134	62	125	197	116	19	180	249	1399
Glass Industry	12	1	0	0	1	0	0	1	1	0	16
Paper Board	88	1	0	0	15	4	0	0	15	0	123
Paper & Pulp	86	1	1	0	10	2	2	1	1	16	120
Fertilizer Units	5	0	0	0	2	2	5	1	5	0	20
Ghee/Oil Units	17	0	1	5	7	3	5	0	11	5	54
Edible Oil Mills	24	0	0	6	49	2	49	0	4	0	134
Engineering / Metal Works	545	12	8	0	0	0	0	0	68	69	702
	3605	**722**	**953**	**856**	**1691**	**1137**	**1134**	**661**	**2292**	**1598**	**14649**



Graph 5.20 Punjab industrial inventory analysis (2025)

5.13.2 Dominant Sources of Industrial Air Pollution in Punjab

The study provides emission factors specific to local conditions using a bottom-up approach. It enhances the accuracy of emission inventories, supports evidence-based policymaking, and strengthens regulatory frameworks for air quality management in Punjab.

The compiled emission inventory for Punjab, encompassing approximately 14,649 industrial units across 23 sectors, offers a comprehensive assessment of fuel consumption and pollutant emissions. The analysis reveals that total annual fuel consumption comprises 6.68 million tonnes (Mt) of coal, 1.38 billion cubic

metres (BCM) of natural gas, 0.42 Mt of diesel, and 1.98 Mt of biomass, resulting in total emissions of approximately 57.80 Mt of CO_2, 69.76 kilotonnes (kt) of CO, 79.20 kt of NO_x, 30.66 kt of SO_2, and 35.21 kt of particulate matter (PM).

A key finding of this inventory is the dominance of a few high-impact sectors in determining the overall air pollution burden:

Cement Plants: Despite comprising only 16 units, cement plants emerge as the largest contributors to NO_x (60.65 kt) and significant sources of particulate matter (16.66 kt). Process emissions from cement production alone account for 33.96 Mt of CO_2, underscoring the sector's critical role in both air pollution and climate change. Controlling emissions from cement plants offers a high-impact pathway for improving regional and provincial air quality, as these facilities are major point sources of nitrogen oxides and particulate matter. Located predominantly in hilly areas, particulate emissions are often dispersed or washed out by meteorological factors, limiting their impact on local AQI. However, reducing CO_2 emissions remains challenging, as it is an inherent byproduct of cement chemistry. Significant carbon reduction would require emerging and costly carbon capture and storage (CCS) technologies or the development of novel low-carbon binding materials, making this the sector's most formidable environmental challenge.

Brick Kilns: With 9,041 units, brick kilns represent the most widespread combustion source and are the largest contributors to carbon monoxide (29.16 kt) and sulphur dioxide (20.84 kt) emissions. Their reliance on coal and relatively low combustion efficiencies make them key drivers of regional air pollution, especially during winter smog episodes.

Rice Mills and Biomass-Based Industries: These sectors contribute significantly to particulate matter emissions (1.89 kt) due to the combustion of agricultural residues, such as rice husks, leading to localized particulate pollution.

Textile Dyeing and Printing Units: Numbering 893, these units are notable contributors to nitrogen oxides (3.47 kt), attributed largely to the extensive use of high-temperature gas-fired boilers.

The sectoral distribution reveals a markedly skewed emission profile, with a small number of sectors disproportionately responsible for total pollution loads. This underscores the importance of targeted regulatory interventions over blanket control strategies.

From a spatial perspective, industrial activity is concentrated within divisions such as Lahore, Faisalabad, Gujranwala, and Multan, which collectively account for a significant share of total units and emissions. This clustering intensifies regional air quality challenges and necessitates focused monitoring and enforcement efforts in these hotspots.

The inventory also illustrates the influence of fuel type on emissions:

- Coal-based sectors (brick kilns, cement, steel) dominate emissions of CO, SO_2, and particulate matter.
- Gas-based sectors contribute predominantly to NO_x emissions.
- Biomass combustion is a substantial source of particulate matter emissions.

Overall, while progress has been made in specific areas—such as the adoption of zig-zag kiln technology and emission control systems in cement plants—the scale of industrial activity continues to exert substantial pressure on Punjab's air quality.

5.14. Actions and Policy Reforms

5.14.1 Actions & Reforms by EPA Punjab (Already Implemented)

The report acknowledges EPA Punjab's implementation of various regulatory and enforcement measures as key contributors to the observed reduction in $PM_{2.5}$ levels in 2025.

1. Industrial Emission Controls (Point Sources)

Sector	Action / Reform	Target Pollutant

Cement Plants	Mandatory installation of **Emission Control Systems (ECS)** including Electrostatic Precipitators (ESPs) and baghouse filters.	PM
Steel Re-rolling Mills/ Textile & Food Processing	Enforcement of **wet scrubbers** and baghouse filters to capture fine particulate matter.	PM
Brick Kilns (9,041 units)	Successful province-wide conversion from traditional Fixed Chimney Bull's Trench Kilns (FCBTK) to **Zig-Zag technology**.	PM/Black Carbon

2. Vehicular & Mobile Source Controls

Action / Reform	**Target Pollutant**
Enhanced Vehicular Emission Monitoring at major transport hubs and check posts in Lahore, Faisalabad and Gujranwala.	CO, NO_x, PM
Promotion of cleaner fuel standards in collaboration with the Oil and Gas Regulatory Authority (OGRA).	SO_2, PM

3. Construction & Fugitive Dust Management

Action / Reform	Target Pollutant
Mandatory installation of mist sprinklers at all large construction sites (especially in Lahore, Rawalpindi, Faisalabad).	PM_{10}, $PM_{2.5}$
Timely deployment of fog cannons at pollution hotspots and high-traffic corridors.	PM

4. Agricultural Burning Control (Stubble Burning)

Action / Reform	Target Pollutant
Coordinated smog mitigation actions during post-harvest season (October–November) in Sheikhupura, Kasur, Sialkot.	PM, Black Carbon, VOCs

Strict enforcement of burning bans with rapid response teams in peri-urban areas.	PM

5. Commercial & Household Sources

Action / Reform	Target Pollutant
Suction hood fixation at major restaurants and commercial kitchens (Lahore, Rawalpindi).	PM, VOCs
Promotion of centralised steam supply for *dhobi ghats* (laundries) and small industries in urban centers.	PM, SO_2

5.14.2 Policy & Regulatory Reforms (Institutional)

Policy Reform	Implementing Body	Objective
Expansion of Air Quality Monitoring System (AQMS) to 18 districts (operational since June 2025).	EPA Punjab / EPCCD	Real-time data collection for evidence-based decision-making.
District-specific emission reduction targets based on pollution load mapping (Lahore, Sheikhupura, Faisalabad given higher priority).	EPA Punjab	Targeted interventions where pollution intensity is highest.
Integration of meteorological forecasting into smog action plans (winter season).	EPA Punjab + Met Department	Early warning systems and pre-emptive restrictions during temperature inversion events.
Development of locally representative emission factors (Bottom-Up Approach) for accurate emission inventories.	EPA Punjab (Research Wing)	Replaces default IPCC/USEPA factors with Punjab-specific values for brick kilns, cement and textiles.
Strengthened regulatory framework requiring ECS for all high-emission industries.	EPA Punjab	Legal mandate for continuous emission reduction.

5.14.3 Recommended Reforms

The report also highlights gaps where further reforms are needed:

Recommended Reform	Rationale (from data)	Target Divisions
Carbon Capture & Storage (CCS) feasibility study for cement plants.	Cement-related CO_2 = 42 Mt (inherent process emission).	Rawalpindi, Sargodha
Real-time stack monitoring.	All boilers, energy generators and Cement Plants.	Lahore, Faisalabad, Gujranwala
Low-sulfur coal mandate for brick kilns.	Brick kilns contribute 20.81 kt SO_2 annually.	All 9,041 kilns, especially in central Punjab
Expanded biomass combustion controls for rice mills.	Rice mills emit 2.05 kt PM annually (from rice husk burning).	Sheikhupura, Kasur, Gujranwala
Low Emission Zones (LEZs) in high-pollution industrial clusters.	Clustering of textile, leather and steel units creates extreme local hotspots.	Kot Lakhpat (Lahore), Raiwind Road, Faisalabad Industrial Estate
Enhanced dispersion modeling for winter inversion periods.	Central Punjab has "Very Low" assimilation capacity in winter.	Lahore, Gujranwala, Sheikhupura, Kasur
Incentives for Zig-Zag kilns + penalties for non-compliance.	9,041 kilns still dominate CO and SO_2 emissions.	Province-wide
District-level AQI action triggers (e.g., mandatory restrictions when AQI > 300).	December AQI reached 293 in Lahore, 281 in Kasur.	All hotspot districts

5.14.4 Multi-Departmental Coordination Required

Based on the sector-wise emission load, the following departments must collaborate with EPA Punjab:

Department	Role in Air Pollution Control
Industries Department	Enforce ECS in textile, steel and chemical units; promote cleaner production technologies.
Transport Department	Vehicular emission testing, promotion of Euro-V fuels and electric vehicle (EV) policy.
Agriculture Department	Stubble burning prevention, crop residue management (e.g., Happy Seeder subsidy).
Housing & Urban Development	Construction dust control, green building codes.
Local Government	Restaurant emission controls, waste burning bans, street sweeping mechanization.
Energy Department	Coal quality regulation, shift to cleaner fuels in power plants.
Met Department	Winter inversion forecasting, smog early warnings.

5.15 Limitations of the Report

- Brick kiln coal consumption was not directly measured but inferred from the Economic Survey of Pakistan, employing a default factor of 42 grams of coal per brick.
- Calculations were restricted to operational industrial units only.
- The CO_2-based flue gas volume estimation method introduces compounded limitations to the accuracy of emission factors and inventories.
- Small-scale, informal, and unregistered industrial units were excluded from the inventory, which currently encompasses 14,649 registered industrial units across 23 sectors.
- Variability in fuel quality is inadequately captured; coal, diesel, and biomass fuel quality vary considerably across suppliers and seasons, yet the inventory relies on average default values.
- Biomass fuel consumption estimates were derived indirectly based on production capacity rather than through direct measurement. Actual

biomass usage fluctuates with factors such as moisture content, seasonal availability, and operator practices.

- Trans-boundary pollution from India is recognised as a significant factor, particularly during the winter months, affecting Air Quality Index (AQI) levels in central Punjab districts; however, the report does not provide quantitative estimates of its contribution to pollution loads in individual districts.
- Assimilation capacity assessment was qualitative rather than quantitative. The report classifies assimilation capacity into categorical levels such as "Very Low," "Low," "Moderate," and "High" based on general meteorological patterns but does not employ quantitative ventilation coefficient modelling for each district.

CHAPTER 06

Water Resources and Wastewater Management in Punjab



6.1 Introduction

Punjab, historically known as the "Land of Five Rivers," possesses one of the world's largest and most intricate water management systems. The province relies on an interconnected network of rivers, canals, barrages, reservoirs, and groundwater aquifers that collectively support agriculture, domestic consumption, industrial production, and urban development. Surface water resources derived from the Indus Basin system—including the Ravi, Chenab, Jhelum, Sutlej, and Indus rivers—sustain one of the largest irrigation networks globally, while groundwater serves as a critical supplementary source for domestic, agricultural, and industrial needs. As Punjab continues to experience rapid population growth, urban expansion, and industrialisation, demand for clean and reliable freshwater resources has escalated dramatically, rendering water security a paramount environmental and economic concern for the province.

Concurrent with rising water consumption, wastewater generation has expanded substantially across Punjab. Wastewater produced from municipal settlements, industrial operations, commercial activities, hospitals, and agricultural runoff has emerged as a significant environmental challenge. Large volumes of untreated municipal sewage and industrial effluents are discharged into rivers, drains, and canals. Further degradation of water quality arises from agricultural runoff containing fertilisers and pesticides. In numerous urban areas, drains have increasingly become conduits for untreated wastewater, posing grave risks to aquatic ecosystems, groundwater quality, and public health. Excessive groundwater extraction combined with contamination from pollutants has exacerbated pressure on Punjab's freshwater resources, diminishing the natural regenerative capacity of underground aquifers.

Punjab's industrial sector remains a major contributor to wastewater pollution, particularly in clusters associated with textile processing, tanneries, chemicals, pharmaceuticals, food processing, and various manufacturing activities. Industrial wastewater frequently contains hazardous contaminants, heavy metals, and untreated chemical discharges, imposing substantial stress on

aquatic environments and neighbouring communities. Recognising the environmental and public health implications of deteriorating water quality and mounting wastewater generation, the Government of Punjab has initiated multiple regulatory, technological, and enforcement-based interventions aimed at reinforcing water resource management and improving wastewater governance.

6.2 Punjab's Water Resources Profile: Overview

Punjab's water system is sustained through a complex integration of surface water and groundwater resources that collectively underpin agriculture, industry, domestic consumption, and urban development across the province. The primary surface water sources include the Chenab, Jhelum, Ravi, and Sutlej rivers, which are supplemented by an extensive canal network operating within the Indus Basin Irrigation System. In addition to surface water, more than 1.3 million tube wells extract groundwater from alluvial aquifers to satisfy rising agricultural and municipal demands.

Despite possessing one of the most developed irrigation infrastructures in the region, Punjab faces increasing challenges related to water quality degradation, resource depletion, and long-term sustainability. Monitoring data from the Pakistan Council of Research in Water Resources (PCRWR) and the Water and Power Development Authority (WAPDA) indicate that while upstream and western water sources generally remain relatively clean, significant deterioration has been observed in eastern rivers, urban water supplies, and groundwater reserves. This decline is primarily attributable to untreated sewage, industrial discharges, agricultural runoff, and naturally occurring contaminants such as arsenic.

Population growth, rapid urbanisation, and escalating water demand have further intensified pressures on freshwater resources, rendering water security and access to safe drinking water among the most critical environmental challenges confronting Punjab today. As of 2024, 47% of Pakistan's population has access to safe drinking water, marking progress from 39% in 2022 (PCRWR, 2025), though this remains substantially short of the Sustainable Development Goal

(SDG) 6.1 universal access target. As the country's most populous province, Punjab stands at the forefront of addressing this challenge.

A comprehensive water resources profile of Punjab is provided in Table 6.1.

Table 6.1. Water Resources Profile of Punjab: Sources, Scale and Quality Assessment

Source / Body	Length / Scale	Quality Summary	References
Freshwater (Rivers)			
Chenab River	~974 km total; ~960 km (in Pakistan)	Clean in upper reaches; pollution from industry and agriculture increases downstream through central Punjab.	Britannica — Chenab River (length ~974 km) PCRWR — Surface Water Quality Profile 2022 IWA Journal of Water & Climate Change, 2024
Jhelum River	~725 km total	Best quality among Punjab's rivers; feeds Mangla Dam reservoir for irrigation and drinking supply.	Wikipedia — Jhelum River (length 725 km) WAPDA — Mangla Dam Project Profile IWA Water Policy — Water Politics in Pakistan, 2025
Ravi River	~720 km total	Heavily polluted by Lahore's untreated sewage and industrial effluent. Flow drastically reduced post 1960 Indus Waters Treaty.	PCRWR — Surface Water Quality Profile 2022 Business Recorder — PCRWR DG statement, Oct 2025 PMC — Drinking Water Quality in Pakistan, 2017
Sutlej River	~1,450 km total	Trans-boundary industrial discharge from India and unchecked effluents have severely degraded quality in lower Punjab.	PCRWR — Surface Water Quality Profile 2022 IWA Water Policy — Water Politics in Pakistan, 2025 PMF IAS — Indus River System (length data)
Surface Water (Irrigation Infrastructure)			
Indus Basin Irrigation System (IBIS) — Punjab canals	Thousands of km of canals	World's largest contiguous irrigation system. Canal water contaminated by agricultural runoff, pesticides and seepage. Irrigation efficiency below 40%.	World Bank — Managing Groundwater in Indus Basin, 2021 Express Tribune — PCRWR DG report, Dec 2025 Frontiers in Environmental Science, 2023
Mangla Dam Reservoir (Jhelum)	Dam: 138 m high; 1,000 MW capacity	Relatively clean reservoir; principal source of irrigation and hydroelectric power for Punjab; managed by WAPDA.	WAPDA — Mangla Dam Project Profile Rivers of Pakistan — Alvipedia (WAPDA-cited data), 2026
Groundwater			
Alluvial Aquifer (Tube Wells)	>1.3 million tube wells; ~50 MAF/yr extracted	Fresh water (TDS <500 ppm) near rivers; saline farther away. Arsenic 10–200 µg/L in southern Punjab — above WHO limit of 10 µg/L. Over-extraction causing depletion.	USGS — Fresh & Saline Groundwater Zones, Punjab (WAPDA/WASID data) World Bank — Indus Basin Groundwater, 2021 Business Recorder — PCRWR (tube well count & extraction), Oct 2025 MDPI Sustainability — Water Quality Assessment Pakistan, 2023 (arsenic range)
Rechna Doab Aquifer (Gujranwala belt)	Freshwater depth up to 1,700 ft	Most extensive fresh groundwater zone in Punjab; relatively low TDS due to high recharge from rainfall (>30 in/yr) in upper Rechna Doab.	USGS — Fresh & Saline Groundwater, Punjab (WAPDA/WASID field data) USGS Water Supply Paper 1608-H — Punjab Groundwater Hydrology
Drinking Water			
Piped municipal supply (urban Punjab)	Covers major cities; 7% rural areas still use open sources	Arsenic detected in Lahore, Gujranwala, Sheikhupura, Multan and Bahawalpur supply lines. Microbial (E. coli) contamination at household taps widespread.	PMC — Drinking Water Quality Status, Pakistan, 2017 (city-level data) PCRWR — National Water Quality Monitoring Programme (NWQMP) 2020 PCRWR — Drinking Water Quality in Pakistan, 2021
Tube well / hand pump (rural Punjab)	~1.02 million rural units in Punjab	Frequently contaminated with arsenic, nitrates, fluoride and fecal coliforms. Heavy metals (Fe, Mn, Pb) above permissible limits in rural groundwater samples.	PMC — Drinking Water Quality, Pakistan, 2017 (rural Punjab chemical analysis) PCRWR — NWQMP Water Quality Data 2020 IWA Water Policy — Water Politics in Pakistan, 2025 (tube well count)
Safe drinking water access (national benchmark)	Pakistan-wide; Punjab performs best provincially	Up from 39% in 2022. Unsafe water linked to ~53,000 child deaths/yr nationally. Punjab is the best-performing province but still far from SDG 6.1 universal access target (2030).	Express Tribune — PCRWR DG Dr. Hifza Rasheed, Dec 2025 Business Recorder — PCRWR data, Oct 2025 PCRWR — Official Water Quality Status Page

			PMC — Drinking Water Quality Monitoring Review, 2023

6.3 Freshwater Resources: Current Condition, Stressors and Future Projections

6.3.1 Current Freshwater Condition in Punjab

Punjab's freshwater resources are increasingly subjected to environmental and hydrological stress driven by rapid urbanisation, population growth, industrial expansion, and unsustainable groundwater extraction. The province predominantly relies on the Indus River System, which includes the Ravi, Chenab, Jhelum, and Sutlej rivers, supported by one of the world's largest canal irrigation networks. Despite this extensive infrastructure, Punjab's overall freshwater balance is becoming increasingly fragile, as water demand steadily exceeds the sustainable recharge capacity.

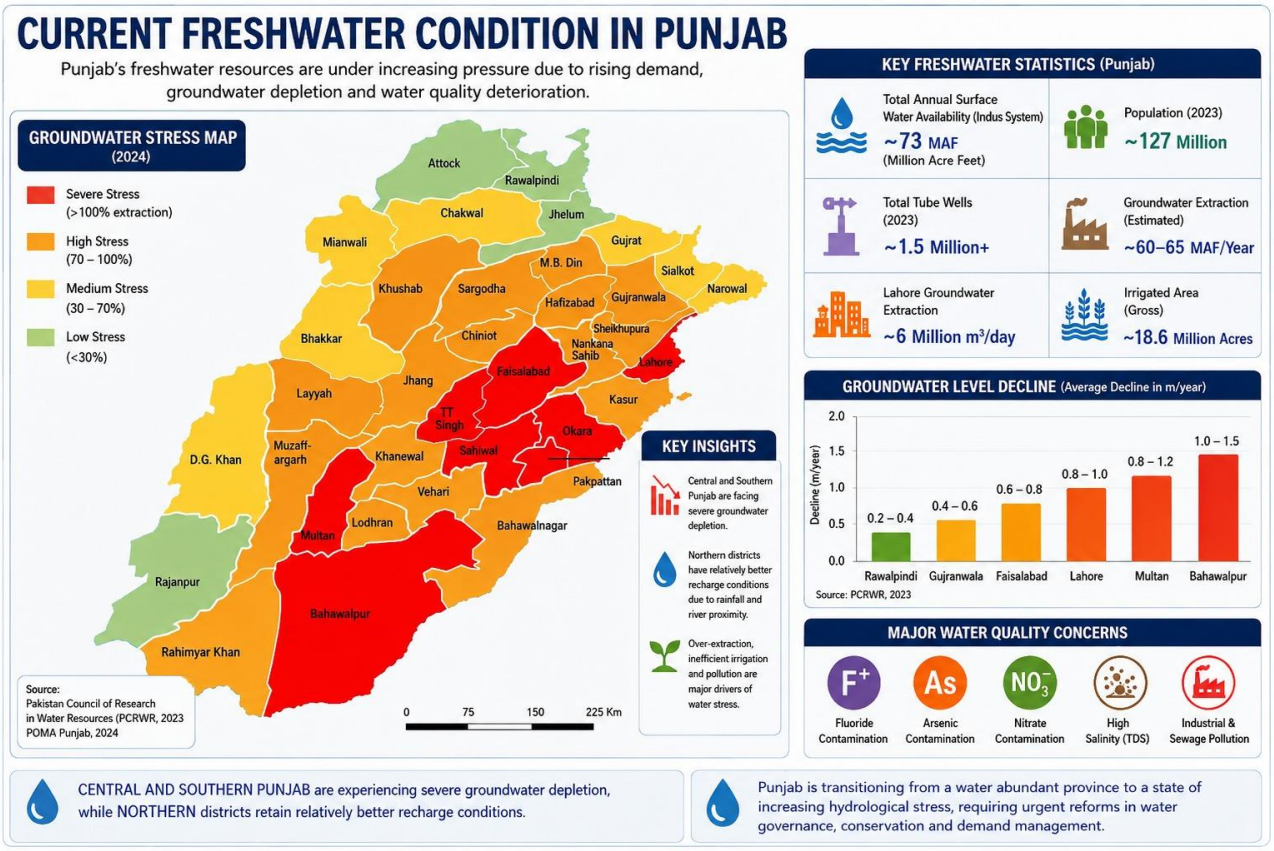
Groundwater has emerged as the dominant source of water for domestic, agricultural, and industrial consumption, particularly in major urban and peri-urban areas. Over recent decades, intensive reliance on tube wells and uncontrolled groundwater abstraction has precipitated continuous declines in aquifer levels across central and southern Punjab. According to the Pakistan Council of Research in Water Resources' (PCRWR) 2022 assessment, groundwater levels are declining at alarming rates in several districts, including Bahawalpur (1.5–1.9 m/year), Multan (1.0–1.2 m/year), Rawalpindi (0.8–1.2 m/year), Lahore (0.8–0.9 m/year), and Faisalabad (0.6–0.8 m/year).

Punjab currently operates over 1.5 million tube wells, a stark increase from just a few thousand in the 1960s, underscoring the province's growing dependence on underground water reserves. Groundwater extraction in Lahore alone has reached critical levels, with the city reportedly withdrawing over 6 million cubic metres daily to meet municipal, industrial, and commercial demands. To address this challenge, the Water and Sanitation Agency (WASA) Lahore has implemented multiple groundwater management strategies incorporating both technical and administrative measures. These include (i) rationalisation of tube well operating hours—from 24 hours a day to 10 hours a day—to curtail unnecessary pumping; (ii) installation of groundwater recharge wells to enhance aquifer replenishment; and (iii) collection and storage of rainwater for reuse in

horticultural and landscaping applications, thereby reducing dependence on groundwater.

Several additional factors exacerbate the situation, such as declining groundwater recharge, inefficient irrigation methods, water-intensive cropping patterns, and contamination from untreated industrial effluents, municipal wastewater, and agricultural runoff. Consequently, numerous regions within Punjab are experiencing deteriorating groundwater quality, characterised by increasing salinity and elevated concentrations of fluoride, arsenic, and nitrates. According to WASA Lahore, water supplied via its tube well network undergoes routine monitoring at its ISO 17025-certified Water Quality Laboratory, where regular surveillance and quality testing are conducted. Upon detection of contamination, corrective actions are promptly implemented to ensure compliance with drinking water standards. Additionally, filtration plants have been established across the city to enhance access to safe drinking water for the urban population.

Spatially, northern Punjab continues to retain relatively favourable groundwater recharge conditions owing to higher rainfall and proximity to rivers. In contrast, central and southern districts—including Lahore, Faisalabad, Multan, Pakpattan, Okara, and Vehari—are experiencing severe aquifer depletion. This hydrological status reflects a transition from historically water-abundant conditions towards increasing stress, necessitating urgent reforms in groundwater governance, urban water management, industrial regulation, and climate-resilient water conservation strategies.



6.3.2 Major Freshwater Stressors in Punjab

Groundwater Over-Abstraction

Punjab's freshwater system is increasingly reliant on groundwater abstraction to meet agricultural, domestic, and industrial demand. The rapid proliferation of tube well installations over recent decades has exerted unsustainable pressure on underground aquifers. In multiple districts, groundwater withdrawal rates now exceed natural recharge capacities, leading to a continuous decline in water table levels. This depletion is particularly pronounced in major urban and agricultural areas, where freshwater demand remains persistently high throughout the year. Excessive abstraction not only diminishes groundwater availability but also heightens aquifer susceptibility to saline intrusion and increased contaminant concentrations.

Wastewater Intrusion into Freshwater Systems

Untreated municipal sewage and industrial wastewater have become significant sources of freshwater quality degradation across Punjab. In numerous urban areas, drains conveying untreated effluents directly interface with irrigation channels and groundwater recharge zones. Continuous seepage from these polluted drains introduces biological contaminants, heavy metals, and toxic compounds into freshwater aquifers. Over time, this contamination diminishes groundwater suitability for potable use and exacerbates environmental stress on adjacent aquatic ecosystems.

Industrial Chemical Contamination

Industrial zones throughout Punjab generate wastewater containing hazardous pollutants such as chromium, lead, cadmium, sulfides, dyes, oils, and various other contaminants. Due to inadequate treatment infrastructure, substantial quantities of these pollutants enter freshwater systems via drains and seepage pathways. Persistent industrial contamination alters the chemical composition of both surface water and groundwater, thereby escalating long-term ecological degradation and public health risks. Industrial clusters situated adjacent to rivers and irrigation networks impose additional pressures on the quality of downstream freshwater resources.

Agricultural Intensification

Punjab's agricultural economy heavily relies on intensive irrigation and chemical-dependent farming practices. Excessive application of fertilisers, pesticides, and herbicides contributes to nutrient loading and chemical contamination of freshwater resources. Irrigation return flows transport dissolved salts and agrochemicals into canals, ponds, and underground aquifers, progressively degrading freshwater quality. Continuous agricultural extraction further increases dependence on groundwater resources, especially during periods of canal water shortages.

Urbanisation and Surface Sealing

Rapid urban development has substantially altered natural hydrological processes across major cities in Punjab. The expansion of roads, residential

housing, and commercial infrastructure has reduced permeable land surfaces, thereby limiting natural rainwater infiltration into underground aquifers. This decline in groundwater recharge, coupled with rising urban water demand, has exacerbated freshwater stress, particularly in densely populated urban centres.

Climate Variability and Hydrological Stress

Changing climatic patterns are increasingly impacting freshwater sustainability in Punjab. Irregular rainfall distribution, rising temperatures, and prolonged dry spells diminish groundwater recharge capacity while simultaneously elevating freshwater demand. Elevated temperatures further intensify evaporation losses from reservoirs, canals, and agricultural lands, thereby reducing overall water availability within the freshwater system.

Inefficient Water Management Practices

Outdated irrigation techniques, ageing municipal infrastructure, and inefficient water distribution systems contribute significantly to freshwater loss throughout Punjab. Considerable volumes of water are lost through seepage, leakage, evaporation, and unauthorised consumption before reaching end users. The limited adoption of water recycling, reuse technologies, and conservation practices further accelerates unsustainable freshwater consumption patterns.

6.3.3 Stressor Projections and Emerging Freshwater Risks

Scientific assessments and national water resource studies indicate that Punjab is increasingly experiencing freshwater stress due to ongoing groundwater depletion, reduced recharge capacity, and deteriorating water quality. According to projections by the Pakistan Council of Research in Water Resources (PCRWR), Pakistan has entered a state of water stress, with per capita renewable freshwater availability estimated at approximately 860–900 m^3 per capita per year below the internationally recognised water stress threshold of 1,000 m^3 per capita per year (as defined by the Falkenmark Index) and approaching the absolute scarcity threshold of 500 m^3 per capita per year. As the country's largest agricultural province and most densely populated region, Punjab remains at the epicentre of this emerging water crisis.

Continued over-extraction of groundwater, particularly in urban and agricultural areas, is expected to further lower aquifer levels, increase pumping depths, and undermine the long-term sustainability of freshwater reserves. Climate change projections compound this uncertainty, with rising temperatures, irregular monsoon patterns, prolonged dry spells, and altered river flow regimes predicted to diminish natural groundwater recharge while simultaneously escalating freshwater demand for agriculture, domestic consumption, and industrial activities. Urban expansion and increasing concretisation are also anticipated to diminish infiltration zones and natural recharge areas across Punjab's major cities.

If the current scale of untreated wastewater discharge, industrial pollution, and inefficient water consumption persists, the province is likely to confront intensified risks related to freshwater scarcity, declining drinking water quality, agricultural productivity challenges, and ecosystem degradation over the coming decades.

6.4. Conservation Approach by EPA Punjab

Recognising the long-term ramifications of emerging freshwater risks, EPA Punjab has adopted a conservation-focused regulatory framework designed to curtail freshwater wastage and promote sustainable water management practices throughout the province. This conservation mandate emphasises the reuse of water, enhancement of groundwater recharge, and integration of resource efficiency measures within commercial and urban development projects.

As part of this strategy, EPA Punjab has mandated the installation of water recycling plants at service stations to reduce the excessive freshwater consumption associated with vehicle washing activities and to minimise wastewater discharge into drainage systems. Concurrently, rainwater harvesting systems have been incorporated as a requirement within the environmental approval process for new development projects where applicable. Collectively, these initiatives signify a strategic transition towards preventive, sustainability-oriented freshwater governance, aimed at alleviating pressure on underground aquifers and securing long-term water availability across Punjab.

6.4.1 Installation of Recycling Plants at Service Stations

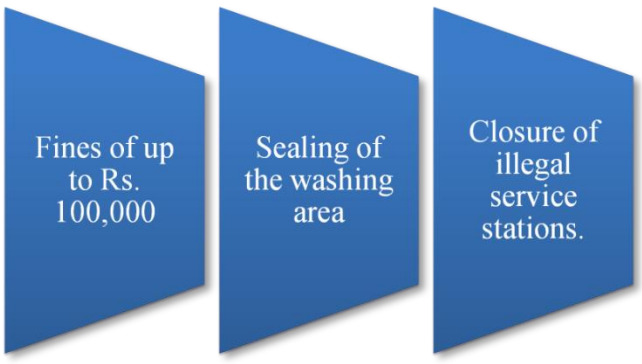
Under the authority granted by the Punjab Environmental Protection Act, 1997, EPA Punjab introduced stringent regulations targeting water conservation and pollution control. The Agency mandated that all service stations within the province install water recycling systems at their car wash facilities by a specified deadline. This regulatory measure aims to minimise water wastage and prevent the discharge of untreated wastewater into drainage systems.

Traditional car washing methods are known to consume substantial volumes of water. According to Earth911, conventional car washes without water-saving equipment typically use between 15 and 85 gallons (approximately 57 to 322 litres) per vehicle. Addressing this inefficiency, EPA Punjab made the installation of water recycling plants compulsory for all service stations.

Key enforcement actions included:

- Issuance of directives requiring car wash stations to install recycling systems;
- Issuance of formal notices to non-compliant operators;
- Sealing of and fines imposed on numerous stations failing to comply.

Non-compliant service stations may face the following consequences:



These enforcement measures ensure that service stations adhere to environmentally responsible practices. A recycling plant at a service station functions as a compact wastewater treatment system, designed to treat and

recycle water used for vehicle washing. Such systems enable the reuse of 70–90% of water, significantly reducing overall water consumption. The accompanying figure illustrates the general operation of a typical recycling plant.

A recycling plant typically consists of three primary components that sequentially treat and reuse wastewater with high efficiency. The first component is the sedimentation and grease trap system, which includes collection galleries installed around the washing area to channel all wastewater into a sedimentation tank, where heavier particulate matter settles. Following this, an underground grease trap separates oil and grease from the water, providing preliminary treatment.

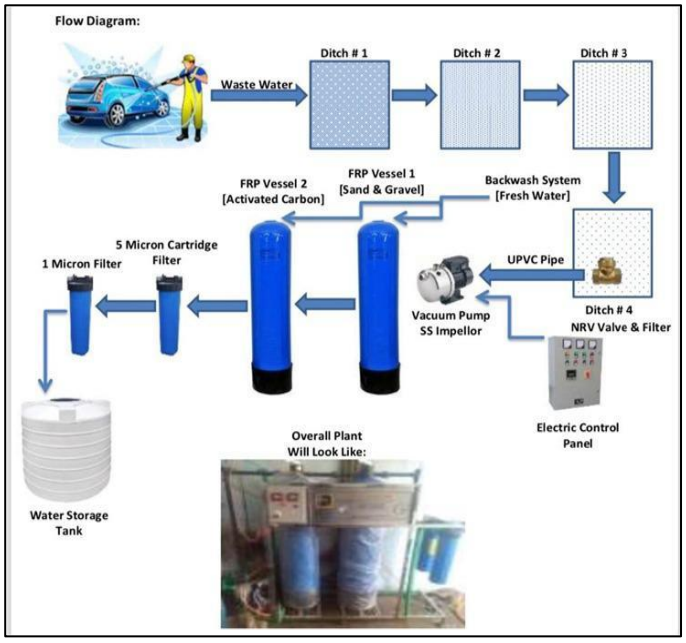
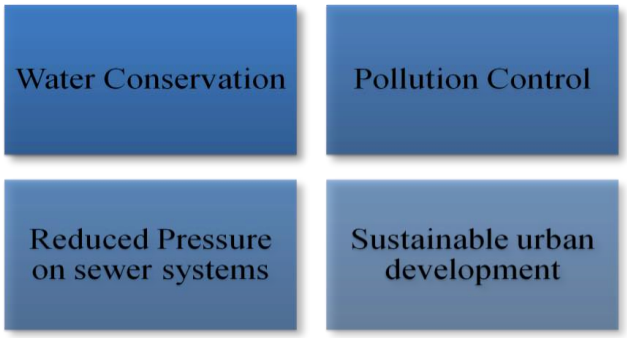


Figure 6.1: Working Mechanism of Recycling Plant

The second component is the prefabricated treatment plant, comprising several key units: a vacuum pump that draws the pre-treated wastewater and transfers it into treatment vessels; a skimmer or chemical dosing system that removes soap residues and disinfects the water through bacterial elimination; a sand filter (Vessel 1) that effectively removes suspended solids and reduces turbidity; and a carbon filter (Vessel 2) that further purifies the water by eliminating odours, colour, and low molecular weight organic compounds.

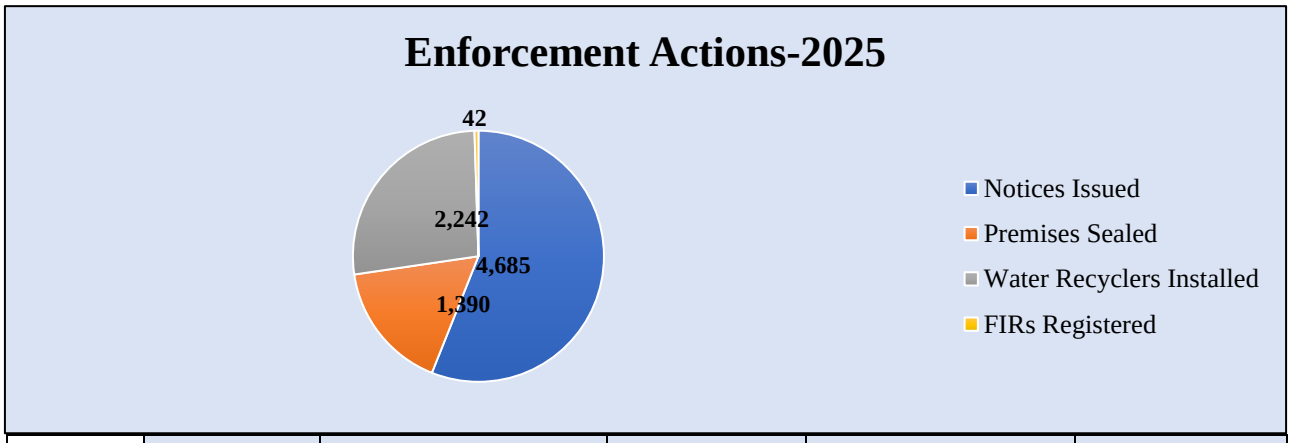
The final component is the clean water storage tank, typically designed as a ditch or reservoir, where the treated water is safely stored for reuse or discharge. Collectively, these components facilitate a systematic and effective wastewater recycling process.

The installation of recycling plants at service stations provides several environmental advantages.



EPA Punjab conducts regular inspections of service stations to ensure compliance with environmental regulations. In several cities, these inspections have led to the closure of stations that failed to install mandatory water recycling plants, exemplifying the Agency's commitment to strict enforcement. The overall enforcement statistics for 2025 are presented in the table below.

Table 6.2: Water Recycler Enforcement Data-2025 (Source: EPA Punjab)



	Notices Issued	Fine Collected (SS + Houses)	Premises Sealed	Water Recyclers Installed	FIRs Registered
Total 2025	**4,685**	**1,655,005**	**1,390**	**2,242**	**42**



Figure 6.2: Breakdown of enforcement actions for water recyclers at service stations in 2025

6.4.2 Mandating Rainwater Harvesting in Urban Development (2025)

In a landmark step towards sustainable water governance, the Environmental Protection Agency (EPA) Punjab institutionalised rainwater harvesting (RWH) as a mandatory requirement for environmental clearance in 2025, where applicable. This initiative was implemented under the stringent provisions of Section 12 of the Punjab Environmental Protection Act (PEPA) 1997, which regulates the issuance of Environmental Approvals.

By integrating RWH mandates into the Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) processes, the Agency has established water conservation not merely as a discretionary feature but as an essential prerequisite for new construction projects across residential, commercial, and institutional sectors.

The implementation of this policy seeks to address the escalating water crisis in Punjab's urban centers through four primary vectors:

1. By mandating specialised recharge pits and injection wells the policy, facilitates the direct replenishment of depleting water tables, countering decades of over-extraction.
2. Capturing precipitation at the source significantly reduces surface runoff thereby, alleviating the burden on municipal drainage systems and preventing localized flooding during monsoon peaks.
3. The utilisation of harvested water for non-potable purposes such as landscaping, cooling towers and floor cleansing directly lowers the dependency on high quality groundwater.
4. This initiative aligns Punjab's urban development with global climate adaptation goals building "Sponge City" characteristics into the provincial infrastructure to withstand extreme weather events.

To ensure the efficacy of this mandate, EPA Punjab has revamped its regulatory workflow as follows:

Project proponents are now required to submit detailed hydrological designs and site-specific rainwater harvesting (RWH) plans as integral components of their Environmental Management Plans (EMPs).

Compliance is verified via a two-stage process involving rigorous desk audits of project blueprints, followed by on-site technical inspections during both the construction and operational phases.

The Agency has partnered with technical experts to develop standardised guidelines for recharge mechanisms, ensuring that RWH systems are geologically appropriate and maintain water quality.

This transition from reactive water management to a preventive regulatory framework represents a paradigm shift in the province's environmental stewardship. Beyond the technical benefits of mitigating groundwater depletion, the policy has catalysed a cultural change within the real estate and construction sectors. Developers increasingly recognise "water-neutral" development as a defining feature of responsible, modern project management.

As these systems become ubiquitous across the provincial landscape, EPA Punjab anticipates measurable improvements in water security, reductions in urban environmental footprints, and a strengthened resilience against the hydrological uncertainties posed by climate change.

6.5. Freshwater Contamination and Wastewater Challenges

Despite water conservation efforts by EPA Punjab including the mandatory installation of water recycling plants at service stations and the integration of rainwater harvesting systems into development projects freshwater contamination remains a pressing environmental challenge throughout the province. Rapid urbanisation, industrial growth, and population increases have markedly escalated municipal sewage and industrial wastewater generation, surpassing the existing treatment and management capacity. Consequently, substantial volumes of untreated wastewater continue to be discharged into rivers, canals, drains, and open land, causing ongoing deterioration of both surface water and groundwater quality.

Punjab's water crisis is increasingly defined not only by declining freshwater availability but also by the transformation of natural water bodies into conduits for wastewater. Rivers, urban drains, and canals that historically provided freshwater are now subject to continuous pollution from municipal sewage, industrial effluents, and mixed urban runoff. This shift has severely diminished the environmental carrying capacity of freshwater systems and intensified reliance on already stressed groundwater reserves. With wastewater volumes escalating across urban and industrial centres, Punjab faces the dual challenge of conserving freshwater resources while preventing existing water bodies from becoming progressively unusable due to contamination and unmanaged wastewater flows.

6.5.1. Wastewater Profile of Punjab

Wastewater typically refers to water that has been utilised in domestic, municipal, commercial, agricultural, or industrial activities and is consequently unsuitable for direct reuse or discharge without treatment. Within the regulatory framework of Punjab, wastewater is assessed in accordance with the Punjab

Environmental Quality Standards (PEQS) for Municipal and Liquid Industrial Effluents. These standards stipulate permissible discharge limits for treated effluent prior to release into inland waters, sewage treatment systems, or land. Wastewater quality is evaluated against key parameters, including pH, temperature, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), oil and grease, sulphides, chlorides, sulphates, heavy metals, and other pollutants. Therefore, wastewater management in Punjab extends beyond the mere presence of water discharge to encompass conformity with prescribed environmental quality limits established by PEQS.

Punjab's wastewater profile is shaped by its large population, expanding urban settlements, intensive agricultural practices, and concentrated industrial activity. The province generates wastewater from major cities, industrial estates, housing societies, commercial zones, hospitals, service stations, livestock operations, and agricultural fields. Urban centres such as Lahore, Faisalabad, Multan, Gujranwala, and Rawalpindi produce substantial volumes of municipal sewage, while industrial districts including Lahore, Faisalabad, Kasur, Sialkot, Sheikhupura, Gujranwala, and Multan contribute significant industrial effluent loads. In numerous localities, drainage channels originally designed for stormwater conveyance have progressively become permanent conduits for mixed wastewater, receiving municipal sewage, industrial discharges, and urban runoff before ultimately impacting rivers, canals, soils, and groundwater systems.

The primary sources of wastewater in Punjab may therefore be categorised as municipal wastewater, industrial wastewater, agricultural runoff, and commercial wastewater. Municipal wastewater represents the largest volume, emanating daily from households, markets, offices, and urban settlements. Although industrial wastewater is comparatively more spatially confined, it poses the greatest environmental risk due to the presence of hazardous substances such as heavy metals, chromium, dyes, chemicals, oils, acids, alkalis, and elevated organic loads. Agricultural runoff introduces fertilisers, pesticides, salts, and irrigation return flows into receiving water bodies, while commercial activities—including service stations, hospitals, laboratories, workshops, and

residential communities—generate additional localized wastewater streams. This complex mixture of wastewater challenges Punjab both quantitatively and qualitatively, requiring management strategies that address rising volumes alongside strict control of toxic and persistent pollutants threatening freshwater resources and public health.

This comprehensive profile provides the foundation for an in-depth examination of Punjab's industrial wastewater situation, focusing particularly on pollution sources, contaminant characteristics, affected districts, and necessary regulatory interventions to control wastewater pollution across the province.

6.5.2. Punjab's Industrial Wastewater: Overview

Punjab, Pakistan's most populous and industrially active province, faces a severe industrial wastewater crisis precipitated by decades of unplanned growth and weak environmental enforcement. Key industries—such as textiles, tanneries, steel, chemicals, and pharmaceuticals—discharge vast quantities of effluent, much of it untreated, into open drains that flow directly into major rivers, including the Ravi and Chenab.[45] Lahore alone generates an estimated 1,350 million litres of wastewater per day from approximately 1,120 unplanned industrial units, the majority of which is discharged untreated into the Ravi River.[46] Faisalabad, the province's industrial heartland, channels effluent through the Madhuana and Paharang drains into the same river system, with an average daily wastewater discharge of 630 million litres, including that from surrounding towns.[47] In Kasur, tannery activities have contaminated local groundwater with chromium concentrations exceeding the World Health Organization's (WHO) safe limit of 0.05 mg/L, exposing residents to elevated risks of cancer, kidney failure, and skin diseases for multiple generations.[48]

The contaminant profile of Punjab's industrial wastewater is dominated by heavy metals including chromium, lead, cadmium, arsenic, nickel, zinc, and copper together with elevated concentrations of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), and suspended solids (SS), all of which frequently exceed the Punjab Environmental Quality Standards (PEQS).[49] Textile effluents from Faisalabad and Lahore are especially

laden with dyes, sulphates, and metals.[50] Tannery waste from Kasur and Sialkot releases hexavalent chromium—one of the most carcinogenic heavy metals known—while 100% of lead samples tested in Sialkot surpass the critical drinking water limit of 0.01 mg/L.[51]

Studies indicate that 80% of cities in Pakistan utilise untreated industrial and municipal wastewater for irrigation, thereby introducing heavy metals directly into the food chain via crops and vegetables.[52] A comprehensive industrial wastewater profile of major cities in Punjab is detailed in Table 6.3.

Table 6.3. Industrial Wastewater Pollution Profile of Major Cities in Punjab Pakistan: Sources, Contaminants and Health Impacts

City	Key Industries	Main Contaminants	Water Body Affected	Health / Environmental Impact	Sources
Lahore	Textiles, steel rolling, tanneries, electroplating, pigment factories (~1,120 unplanned units)	Cr, Pb, Ni High BOD/COD TDS, SS	River Ravi (Farukhabad & Hudiara drains)	Groundwater contamination; arsenic in 100% of drinking water samples above limit; waterborne disease	[5] ScienceDirect [43] PMC 2017 [44] Tandfonline
Faisalabad	Textiles, paints, glass, rubber, pigments, ceramics, pharmaceutics	Cd, Zn, Cu, Fe Sulfate BOD, COD, TDS	River Chenab & Ravi (Madhuana & Paharang drains)	Agricultural land contamination; irrigation water unfit for use; all parameters exceed PEQS	[9] MDPI 2022 [8] ScienceDirect 2024 [6] ResearchGate
Kasur	Leather tanneries (306 units in Dingarh, Niaz Nagar, Iqbal Nagar according to assessment of EPA Punjab in 2025)	Hexavalent Cr Nitrates High TDS	Local groundwater & shallow wells	Cancer, kidney failure, liver damage, skin lesions, bone deformities; Cr > WHO limit of 0.05 mg/L	[7] Minute Mirror [45] Lok Sujag
Sialkot	Leather tanneries, surgical instruments manufacturing	Cr, Pb, Fe, Ni Cd, Mn	Local groundwater & surface drains	100% of Pb samples exceed critical limit (0.01 mg/L) in drinking water	[10] PMC 2014 [46] IWA 2024
Gujranwala	Electrical goods, light engineering, food processing	Heavy metals Organic waste	River Ravi & drainage channels	Metal adulteration of water; arsenic above permissible limits in 73% of Sheikhupura-area samples	[12] PMC 2017 [13] Tandfonline
Multan	Tanneries, fertilizer manufacturing, ceramics	Cr, As Fertilizer runoff Nitrates	Local drainage; agricultural land	Fertilizer waste kills livestock; arsenic above limits in 94% of drinking water samples	[12] PMC 2017 [13] Tandfonline
Sheikhupura	Textiles, chemicals, mixed light industry	Cr, Cu, Zn BOD, COD	River Ravi (Farukhabad drain)	Arsenic above limits in 73% of drinking water samples; groundwater degradation	[4] MDPI Water [12] PMC 2017

43 PMC (2017) — Drinking water quality status and contamination in Pakistan.

44 Tandfonline (2023) — Legal responses to water pollution in Pakistan.

45 Lok Sujag — Kasur tanneries waste management & KTWMA.

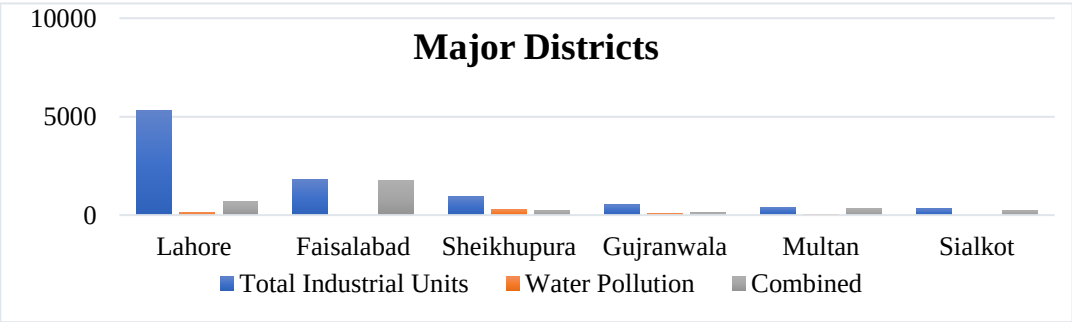
46 IWA Publishing (2024) — Groundwater pollution vulnerability, Kala Shah Kaku industrial complex.

6.6. Pollution Status of Industrial Sites of Province: GIS Analysis

Punjab continues to confront escalating environmental challenges fueled by rapid industrialisation. Among the most urgent issues is the effective management of industrial wastewater and the cumulative pollution burden. Addressing these concerns necessitates systematic profiling, spatial analysis, and data-driven regulatory interventions.

The **Pollution Status Mapping System** developed by the EPA GIS Cell provides precisely this form of comprehensive assessment. This data-driven approach enables regulators to identify pollution hotspots and prioritise targeted interventions. By integrating industrial inventory data with spatial pollution mapping, policymakers are better equipped to formulate informed regulatory frameworks. Collectively, this data-driven system empowers environmental regulators to **prioritise inspections strategically**, develop evidence-based policies, and allocate resources efficiently to areas bearing the greatest pollution burden, rather than dispersing enforcement efforts uniformly across all industrial sites. As Punjab expands the application of this approach across its districts, the Pollution Status Mapping System will become an indispensable tool for evidence-based environmental governance.

The following graphs illustrate the district-wise distribution of industrial wastewater hotspots across Punjab. The accompanying bar chart compares districts based on the total number of industrial units and the subset of those contributing to water pollution and combined pollution. While there is a general trend indicating that districts with a greater number of industrial units tend to experience higher levels of water pollution, the intensity of pollution varies across regions. Detailed pollution status maps are provided in Annex I for reference.



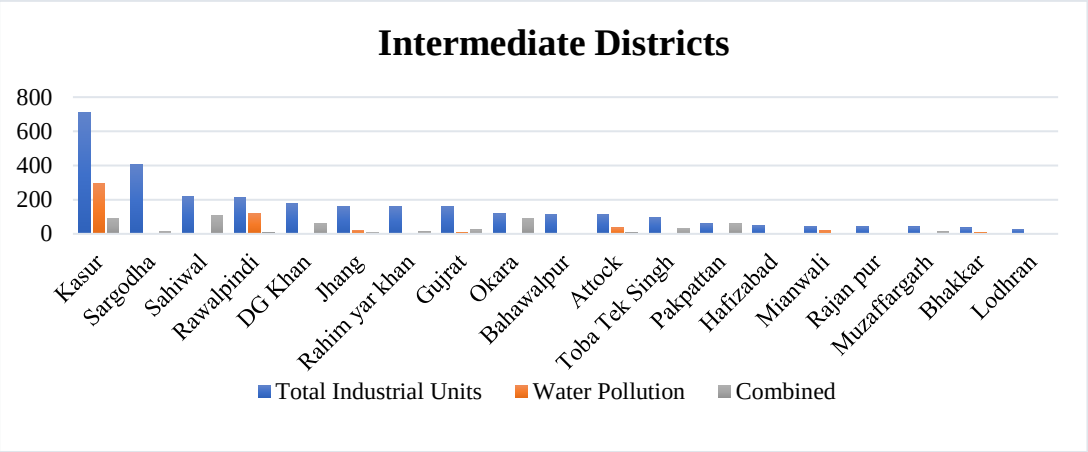


Figure 6.4: Water Pollution Status of industries in Intermediate Districts

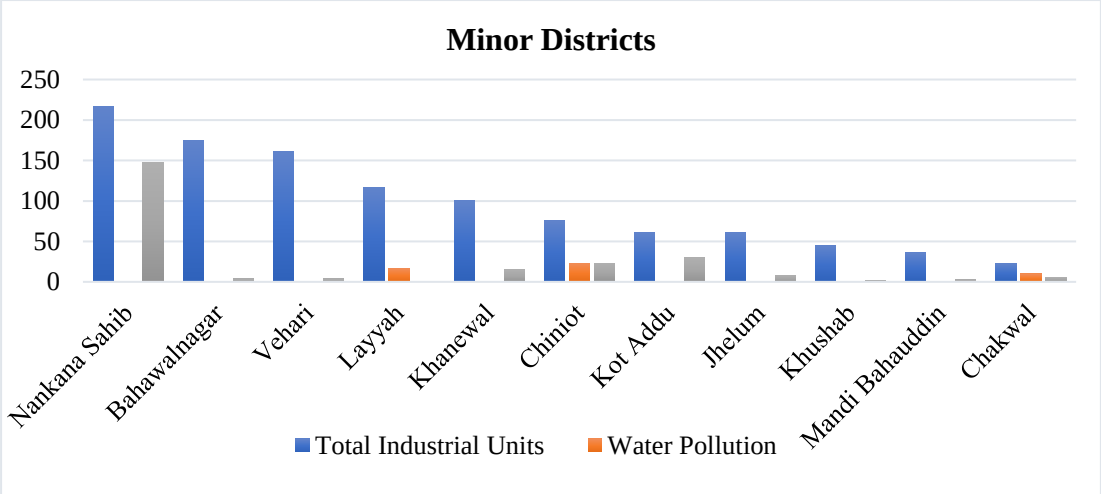


Figure 6.5: Water Pollution Status of industries in Minor Districts

6.7. Stressors Associated with Wastewater Pollution

Wastewater pollution in Punjab extends beyond mere drainage or treatment concerns; it generates multiple environmental stressors that adversely affect soil quality, groundwater safety, agricultural productivity, ecosystem stability, and public health. Untreated municipal sewage, industrial effluents, and agricultural runoff introduce organic matter, toxic chemicals, pathogens, heavy metals, and salts into the environment. These pollutants progressively permeate drains, rivers, agricultural lands, and underground aquifers, posing long-term risks to environmental sustainability and human well-being.

6.7.1 Degradation of Freshwater Quality

Untreated wastewater adversely impacts rivers, canals, drains, and groundwater reserves by elevating levels of organic pollution, chemical contaminants, suspended solids, and toxic substances. Continuous discharge of wastewater into freshwater sources diminishes their natural self-purification capacity, thereby reducing the availability of safe water for drinking, irrigation, livestock, and domestic purposes.

6.7.2 Soil Fertility and Land Degradation

Wastewater utilised for irrigation or discharged onto open land can progressively alter soil chemistry. Elevated levels of total dissolved solids (TDS), salts, heavy metals, oils, chemicals, and untreated organic matter reduce soil fertility and degrade soil structure. Prolonged exposure to such contaminants can diminish agricultural productivity, increase soil salinity, and disrupt the natural nutrient balance essential for healthy crop growth.

6.7.3 Food Security Risks

When contaminated wastewater is applied to agricultural fields, pollutants may accumulate in crops, vegetables, and fodder, posing risks to crop quality, livestock health, and overall food safety. Over the long term, diminished soil fertility, polluted irrigation water, and the buildup of heavy metals can adversely affect agricultural productivity, raising significant food security concerns for Punjab, Pakistan's principal agricultural province.

6.7.4 Groundwater Contamination

Punjab's heavy reliance on groundwater renders wastewater seepage a significant environmental risk. Polluted drains, lagoons, open wastewater ponds, and unlined disposal channels may facilitate the infiltration of contaminants into aquifers. Once groundwater becomes tainted with pathogens, nitrates, heavy metals, or industrial chemicals, remediation becomes exceedingly challenging and costly.

6.7.5 Public Health Burden

Wastewater pollution elevates the risk of waterborne and chemically induced diseases. Exposure to contaminated water can lead to ailments such as diarrhoea, gastroenteritis, skin infections, hepatitis, typhoid, and other health complications. In industrial zones, prolonged exposure to heavy metals and toxic chemicals heightens the likelihood of chronic illnesses, particularly for communities residing near polluted drains and industrial clusters.

6.7.6 Aquatic Ecosystem Degradation

Elevated levels of biochemical oxygen demand (BOD), chemical oxygen demand (COD), toxic chemicals, and suspended pollutants reduce dissolved oxygen concentrations in aquatic ecosystems, disrupting aquatic life. Common consequences of untreated wastewater discharge include fish mortality, offensive odours, blackened water, biodiversity loss, and degradation of riverine habitats. These impacts collectively undermine the ecological balance of rivers, drains, and wetlands.

6.7.7 Livestock and Rural Livelihood Impacts

In rural and peri-urban areas, the use of contaminated water for livestock adversely affects animal health and productivity. Furthermore, polluted irrigation water and degraded soils diminish crop yields, directly impacting farmers' incomes and rural livelihoods. Consequently, wastewater pollution emerges as both an environmental and socio-economic stressor.

6.7.8 Urban Environmental Stress

In urban areas, open drains transporting untreated wastewater generate foul odours, facilitate mosquito breeding, contribute to localized flooding, and degrade sanitation and visual aesthetics. These conditions diminish urban environmental quality and exacerbate the disease burden in densely populated communities.

6.7.9 Industrial and Regulatory Pressure

Wastewater pollution also imposes significant demands on regulatory institutions, as untreated discharges necessitate continuous monitoring, sampling, enforcement, prosecution, and compliance verification. In contexts where treatment infrastructure is inadequate or industrial facilities are dispersed, environmental governance becomes increasingly complex and resource-intensive.

6.7.10 Climate and Resilience Concerns

Climate variability exacerbates the stress caused by wastewater pollution. During dry periods, diminished river flows reduce the natural dilution capacity, leading to higher concentrations of pollutants. Conversely, heavy rainfall events can cause drains to overflow, dispersing contaminated wastewater into streets, agricultural fields, and low-lying residential areas. These phenomena heighten both environmental degradation and vulnerability to disaster risks.

6.8. Priority Sector Intervention by EPA Punjab

Tannery Wastewater Management

The tannery sector in Kasur constitutes a crucial component of Punjab's leather industry and export economy. However, it has historically been a significant contributor to industrial wastewater pollution, primarily through the discharge of untreated or partially treated effluents containing hazardous substances such as chromium, sulphides, and organic waste. In response to mounting regulatory scrutiny, evolving environmental standards, and increased awareness of public health implications, the sector is undergoing a pivotal transition towards sustainability.

This transformation centres on enhanced wastewater management, the adoption of cleaner production technologies, and the installation and effective operation of Wastewater Treatment Plants (WWTPs). Additionally, the sector is witnessing the relocation and consolidation of tanneries into specialised industrial zones, notably in Sialkot. Key milestones in this transition include the restructuring of tannery clusters in Sialkot and operational improvements at the Common Effluent Treatment Plant (CETP) in Kasur. These developments reflect Punjab's progressive regulatory and technological strategies aimed at curtailing untreated discharge, amplifying effluent treatment capacity, and securing the leather industry's long-term environmental sustainability and global competitiveness.

6.8.1 Transforming the Kasur Tannery Cluster toward Environmental Sustainability

The Kasur tannery cluster is a vital industrial hub in Punjab but has long been characterised by severe environmental degradation, primarily due to the discharge of hazardous wastewater containing high concentrations of chromium and other toxic chemicals. In response to this crisis, the Environmental Protection Agency (EPA) Punjab commissioned a specialised unit to conduct a comprehensive situational and technical analysis aimed at identifying the root causes of pollution and developing an actionable roadmap to ensure regulatory compliance.

To achieve a thorough understanding of the situation, the specialised unit employed a multi-faceted methodology:

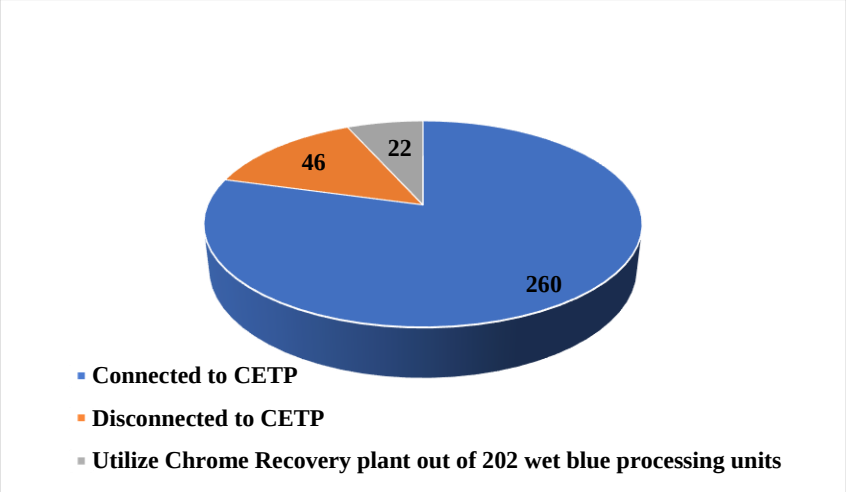
Extensive mapping of tannery distribution, operational scales, and industrial practices across key clusters, including Niaz Nagar, Younas Nagar, Din Garh, and Kot Molvi Abdul Qadir.

- Collection of samples from critical points such as tannery clusters, main drains, supply channels, and at inlets and outlets of treatment plants. These samples were analysed by both a private laboratory (M/S Pak Green

Enviro-Engineering) and the EPA laboratory in Lahore, assessing pollutant levels against Punjab Environmental Quality Standards (PEQS).

- Examination of official disease reports from the District Headquarters (DHQ) Hospital Kasur alongside community surveys to evaluate perceived environmental and health impacts on local residents.
- Physical inspections of treatment facilities, tannery zones, and open wastewater ponds and lagoons to document on-site conditions.

The assessment identified 306 tanneries within Kasur, with a significant majority (202 units) engaged in "wet blue" processing, which involves chrome tanning. Approximately 60% of these tanneries are classified as small to medium-sized (less than 60 Marla), and 70% operate using five or fewer tanning drums. The accompanying pie chart illustrates the proportion of units connected to the Common Effluent Treatment Plant (CETP) against those that are not. Notably, 22 of the 202 wet blue processing units utilise chrome recovery plants.



The study highlights systemic failures in pollution management, particularly concerning chromium waste treatment and regulatory compliance. Key observations include:

- Approximately 89% of wet blue tanneries (180 units) discharge wastewater without implementing any form of chromium recovery.

- The existing Chromium Recovery Plant (CRP) has a nominal capacity of 20,000 litres per day but is currently operating at only 1,500 litres per day, treating less than 1% of the estimated 180,000 litres of chromium-laden wastewater generated daily.
- The effectiveness of the CRP is severely hampered by chemical shortages, delays in transportation payments, insufficient staffing for second shifts, and the illegal sale of untreated wastewater.

The following tables summarise the technical assessments and health findings from the specialised unit's report on the Kasur tannery cluster. These results reveal significant discrepancies between measured pollutant concentrations at critical sampling points and the legal limits prescribed by the Punjab Environmental Quality Standards (PEQS).

This table presents contaminant levels of major pollutants recorded at key sampling locations compared to the permissible thresholds established by PEQS.

Table 6.4: Wastewater Analysis vs. PEQS (Technical Results)

Parameter	PEQS Limit	KTWMA Inlet Channel supply (Untreated)	KTWMA Outlet (Post-Treatment)	Inlet Red Channel	Main Drain Mixed (Treated and Red Channel)	CRP Inlet	CRP Outlet (Post-Treatment)
BOD_5 (mg/L)	80	2,620	975	2,100	1,455	4,650	2,850
COD (mg/L)	150	4,930	1,756	3,896	2,896	8,448	4,880
TDS (mg/L)	3,500	15,175	8,120	5,375	7,640	68,615	55,250
TSS (mg/L)	200	3,640	1,340	615	600	8,290	2,275
Chromium (mg/L)	1.0	5.967	2.0151	11.68	9.758	967.4	13.54
Sulfide (mg/L)	1.0	172	92	144	136	116	44
Sulphate (mg/L)	600	2,170	1,354	1,458	1,655	2,155	1,452
Chloride (mg/L)	1000	4,805	3,125	2,115	2,890	3,240	2,455

The following results from the health data analysis conducted between January and June 2025 provide conclusive evidence of the human cost associated with this pollution:

Table 6.5: Public Health Burden (DHQ Hospital Kasur Data)

Disease/Ailment Category	Reported Cases / Prevalence Rate	Key Observation Period (2025)
Acute Diarrhea/Gastroenteritis	1,587 Cases	May 2025
Acute Water Diarrhea (Susp.)	1,266 Cases	April 2025
Enteric/Typhoid Fever (Susp.)	214 Cases	April 2025
Suspected Hepatitis	42 – 45 Cases	April & May 2025
Itching and Skin Irritation	90% of Surveyed Community	Cumulative
Hypertension	83% of Surveyed Community	Cumulative
Occupational Fatigue (Workers)	74% of Tannery Workers	Cumulative



Open Ponds in Tannery Zone



Aeration Pond



Lagoons



Agriculture Area near the Treatment Plant



Tannery Water Inlet



Initial Manual Screening





Chrome Recovery Plant

6.8.2 Environmental Management Plan for Decontamination of Tannery Sites in Sialkot

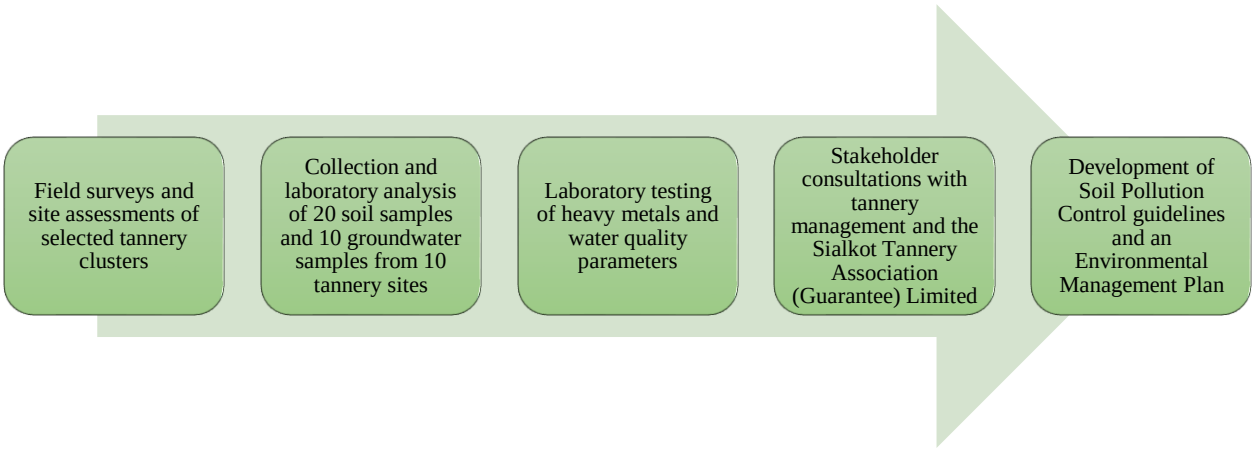
Sialkot is home to approximately 260 active tanneries distributed across 10 clusters, employing an estimated 6,500 to 7,000 workers. These tanneries are dispersed throughout urban and peri-urban areas, presenting considerable challenges for environmental compliance in line with international market

requirements. In response to governmental concerns regarding potential water pollution from tannery operations, an analytical study was undertaken.

An Environmental Management Plan (EMP) was developed to mitigate potential environmental contamination at existing tannery sites in Sialkot under the International Labour and Environmental Standards (ILES) Application in Pakistan's SMEs Project, funded by the European Union and implemented by WWF Pakistan. The initiative seeks to facilitate the relocation of scattered tanneries to the newly designated Sialkot Tannery Zone while ensuring environmentally responsible site management.

The primary objective of this assignment was to assess soil and groundwater contamination risks at current tannery locations and to develop an EMP that guides the safe management of sites during and after the relocation process.

The study encompassed the following key activities:



The investigation assessed potential contamination from tannery operations, focusing particularly on heavy metals such as chromium, lead, nickel, cadmium, and arsenic. Key findings include:

- Heavy metal concentrations were generally within internationally acceptable limits. Chromium levels ranged from 9 to 49 mg/kg, with one isolated sample recording 105 mg/kg, still within acceptable standards.

- Most physical, chemical, and bacteriological parameters complied with national and international standards, with no significant heavy metal contamination detected.
- Some groundwater samples revealed the presence of pathogens, including Escherichia coli and coliform bacteria, as well as slightly elevated fluoride levels, indicating a need for water treatment prior to consumption.

Overall, the study concluded that existing tannery sites were not significantly contaminated and did not require extensive decontamination measures. Given the absence of major contamination, the Environmental Management Plan (EMP) shifted its focus towards preventive environmental management during the tannery relocation process. The plan recommends the following measures:

- Proper drainage and disposal of processed water and chemicals prior to equipment dismantling.
- Safe storage and transportation of chemical containers and machinery.
- Collection and appropriate disposal of solid waste and sludge.
- Removal of stagnant wastewater and hazardous materials from the sites.
- Placement of safety signage at potential risk areas.
- Ensuring that no machinery, chemicals, or waste remain onsite following relocation.

Furthermore, the Sialkot Tannery Association (Guarantee) Limited undertakes to:

- Issue Soil Pollution Control guidelines to all relocating tanneries.
- Conduct on-site monitoring throughout the relocation process.
- Verify proper site remediation after relocation.
- Ensure environmentally compliant operations within the new Sialkot Tannery Zone.

This initiative supports:

- Environmentally responsible industrial relocation
- Enhanced compliance with international environmental standards
- Sustainable development of the leather sector in Sialkot
- Mitigation of environmental risks to soil, groundwater, and public health

The Environmental Management Plan offers a pragmatic framework for preventing environmental contamination during the transition of tanneries to the Sialkot Tannery Zone. By enforcing preventive guidelines and establishing rigorous monitoring mechanisms, the project contributes to strengthening environmental compliance and fostering sustainable industrial practices within Pakistan's leather sector. The overall progress of the tannery relocation programme is summarised below.

As per information received from STAGL, the current status / progress of shifting

of tanneries to Sialkot Tannery Zone (STZ)

208	• Total no. of tanneries in district Sialkot
540	• Total no. of plots at STZ
195	• No. of plots on which construction of building has started.
255	• No. of plots which are at construction of boundary wall stage
15	• No. of plots which are at earth filling stage
32	• No. of tanneries which are shifted with machinery equipment and have started with trial production



Shifting of Tanneries



Tanneries under construction at Sialkot Tannery Zone



Chrome Recovery Plant



Establishment of Common Effluent Treatment Plant



132 KV STZ Grid Station

6.9. Site-Specific Assessment of Polluted Drains

The tannery sector exemplifies how a specific industrial activity can generate concentrated wastewater pollution necessitating targeted regulatory intervention. However, wastewater pollution in Punjab is not confined to individual sectors. In many areas, untreated municipal sewage, industrial effluents, and urban runoff from multiple sources coalesce into major drains and watercourses, resulting in cumulative pollution loads that adversely affect rivers, groundwater, and adjacent communities.

Accordingly, alongside sector-specific interventions such as tannery wastewater management, EPA Punjab has implemented site-specific assessments of polluted drains to investigate the behaviour of mixed wastewater flows within the broader drainage network. This approach facilitates the identification of pollution hotspots, principal discharge points, affected industrial clusters, and compliance status relative to Punjab Environmental Quality Standards (PEQS).

Within this framework, the Hudiara Drain was selected as a critical case for comprehensive water quality assessment, given its transboundary character, substantial industrial footprint, and direct discharge into the River Ravi.

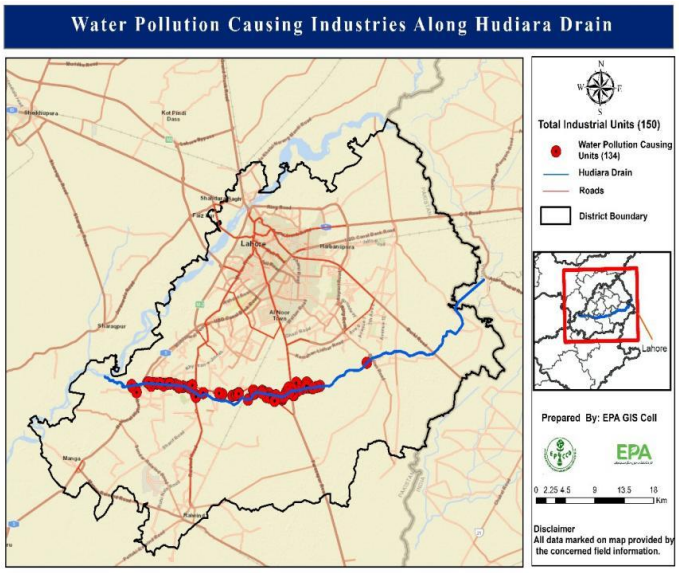
6.9.1. Water Quality Assessment of Hudiara Drain

The Hudiara Drain is a prominent natural stormwater channel that has transformed into a perennial wastewater conduit. It holds considerable environmental and geopolitical significance as a transboundary water pollution channel between India and Pakistan. Originally engineered to convey excess rainwater and mitigate seasonal flooding, it has evolved into a major environmental hazard due to the heavy discharge of untreated municipal sewage and industrial effluents along its course.[58]

The drain originates near Batala City in the Gurdaspur District of Punjab, India, extending approximately 98.6 kilometres in total length.[59] It flows for roughly 44.2 kilometres within Indian territory before crossing the international border into

Pakistan at Laloo village. Thereafter, it traverses around 54.4 kilometres through the outskirts of Lahore before discharging directly into the River Ravi. The drain contributes an average annual discharge of approximately 178 to 180 cubic feet per second (cusecs) into the River Ravi, rendering it one of the largest single sources of contamination for the river.[60]

In response to escalating concerns regarding industrial effluent discharge and its transboundary environmental impacts, the Environmental Protection Agency (EPA) Punjab initiated a comprehensive water quality monitoring programme for the Hudiara Drain. This drain, which conveys wastewater across the international border into Punjab, has long been subjected to pollution from industrial, municipal, and agricultural sources, posing significant risks to aquatic ecosystems, irrigation water quality, and public health.

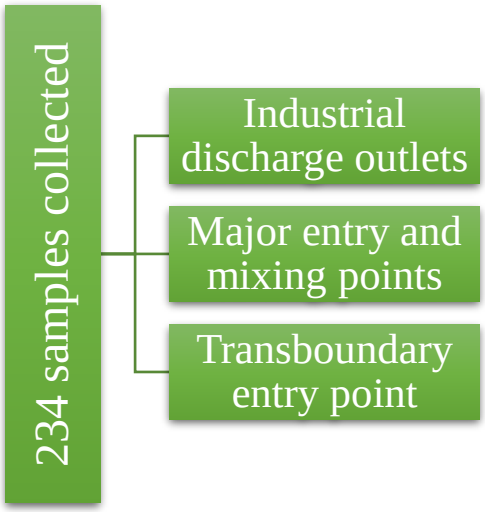


This GIS map, prepared by the Environmental Protection Agency (EPA) Punjab, illustrates the extensive industrial footprint along the Hudiara Drain within Lahore District. It underscores a critical environmental concern: of the 150 industrial units identified along the drain, 134 are classified as "Water Pollution Causing Units." These polluting facilities, represented by a dense string of red dots, are heavily clustered along the southwestern segment of the drain. The map serves as a

pH	BOD_5	COD	TDS
TSS	Chlorides	Sulphates	Sulphides

stark visual testament to the primary sources of toxic discharge that have transformed this once predominantly stormwater channel into a major, perennial contributor to pollution in the River Ravi.

To systematically assess the extent and sources of contamination, an extensive monitoring exercise was conducted from March to August 2025, focusing on key industrial discharge points as well as strategically selected sites along the Hudiara Drain, including its transboundary entry point. A total of 234 water samples were collected. Samples were sealed on-site and transported to a certified laboratory for comprehensive analysis of:



All results were evaluated against the Punjab Environmental Quality Standards (PEQS). The data confirmed that the Hudiara Drain is experiencing severe environmental stress, primarily due to excessive organic loading and the discharge of untreated industrial effluents. The findings reveal widespread and persistent non-compliance with PEQS across multiple sampling locations. The analytical results of the water samples are presented in the table below.

Table 6.6. Sample Analysis vs PEQS (Technical Results)

Parameters	PEQS Limits	Hudiara Drain – Entry Point (India)	M/S Bata Pakistan Limited	Compliance
BOD_5 (mg/L)	80	234	240	Non-Compliant
COD (mg/L)	150	660	544	Non-Compliant
TSS (mg/L)	200	245	250	Non-Compliant
Sulphides (mg/L)	1.0	—	3.2	Non-Compliant

Based on review of the 234 samples:

Parameter	% Samples Exceeding PEQS	Severity Level
BOD_5	>80%	Severe
COD	>85%	Severe
TSS	>70%	High
Sulphides	>60%	High

(Percentages based on compiled monitoring dataset)

Analysis of the 234 collected samples indicates:

- Widespread non-compliance with Punjab Environmental Quality Standards (PEQS) across the majority of industrial discharge points.
- A significant pre-existing pollutant load observed at the transboundary entry point.
- Compounding pollution effects arising from local industrial effluents.
- Persistent exceedances of standards related to organic load and suspended solids.

In response, WASA Lahore has planned the installation of four Wastewater Treatment Plants (VWWTPS) along the Hudiara Drain, located at Mohlanwal, Ferozpur Road, Barki Road, and near the Indian border. The feasibility studies for these treatment plants have been completed, and the Government of Punjab, in collaboration with WASA Lahore, is actively exploring financing options to facilitate their execution.














6.10. Institutional Response: Dedicated Wastewater Governance Framework

In recognition of the escalating environmental pressures caused by untreated wastewater, EPA Punjab adopted a focused and structured strategy specifically targeting the water sector. For the first time, a dedicated institutional mechanism was established to address wastewater pollution as a specialised issue rather than a routine inspection matter. Under this approach, specialised wastewater units were formed to identify, monitor, and regulate major wastewater-

generating sources throughout Punjab, with particular emphasis on industrial hotspots.

These units are charged with conducting field inspections, collecting effluent samples, preparing Site Monitoring Reports, initiating enforcement actions, verifying compliance, and ensuring the installation or enhancement of wastewater treatment systems. This dedicated framework marks a paradigm shift in EPA Punjab's approach—from general environmental enforcement towards sector-specific governance—addressing wastewater pollution through comprehensive profiling, continuous surveillance, laboratory analysis, legal proceedings, and ongoing compliance monitoring.

6.10.1. District-Level Enforcement: Specialised Water Unit & Surveillance Network

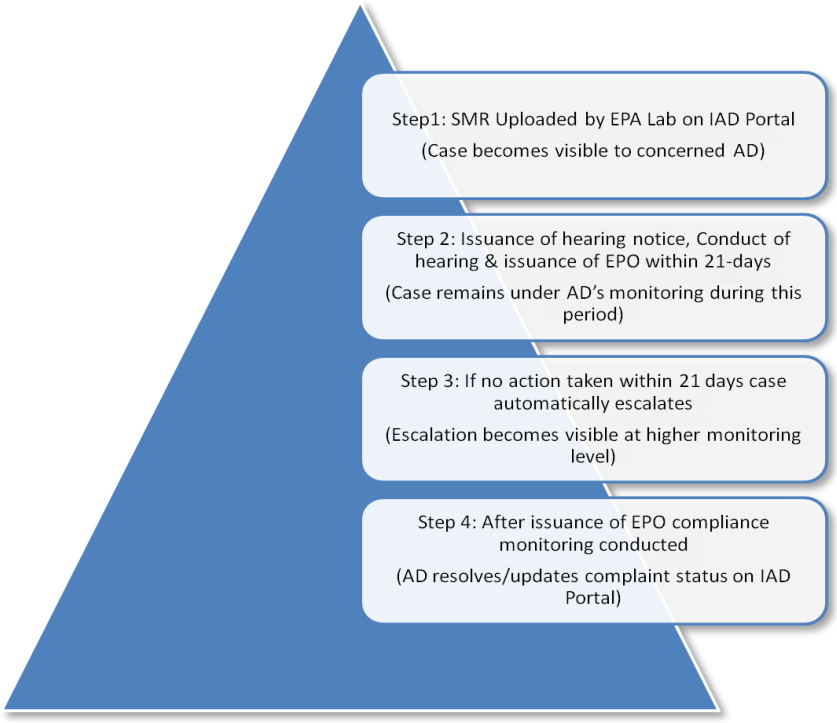
Rapid industrialisation across Punjab has significantly contributed to economic growth but has simultaneously intensified environmental challenges, particularly concerning the discharge of untreated industrial effluents into water bodies and drainage systems. The absence or inadequate operation of wastewater treatment infrastructure in numerous industrial units has led to the degradation of surface water quality and contamination of groundwater, posing substantial threats to ecosystems and public health. In response to these escalating concerns, and aligned with its regulatory mandate, EPA Punjab has reinforced its institutional framework to ensure systematic monitoring, enforcement, and compliance in the management of industrial wastewater under the Punjab Environmental Protection Act 1997.

EPA Punjab has established a Specialised Unit for Wastewater, tasked with developing a detailed profile of industrial wastewater across the province, with a focus on ten high-priority "hotspot" districts. The process commences with field inspections and sample collection, which are analysed by the EPA laboratory to produce Site Monitoring Reports (SMRs). In instances where these reports indicate non-compliance, the Unit initiates formal enforcement proceedings under Section 16 of the Punjab Environmental Protection Act 1997, including legal

hearings and the issuance of Environmental Protection Orders (EPOs) mandating specific corrective actions.

To verify pollution control, the Unit monitors progress through Compliance Status Reports (CSRs). Facilities that fail to rectify violations are subject to prosecution before the Punjab Environmental Tribunal. A principal objective of the Unit is to ensure the installation and effective operation of Wastewater Treatment Plants (WWTPs) at all significant effluent-generating sites. The following is a step-by-step illustration of the operations of the Specialised Unit for Wastewater:

Hearing proceedings are conducted by following steps:



The official attendance record of the owner or authorised representative is maintained, followed by verification of the requisite documentation. A concise presentation of the Sampling and Monitoring Report (SMR) findings is then delivered. Subsequently, the industry owner is afforded the opportunity to present their defence, supported by relevant evidence. Clarification questions posed by EPA Punjab are addressed accordingly. After considering all information, EPA

Punjab may decide to issue an Environmental Protection Order (EPO), mandate resampling, or grant an opportunity for compliance if justified.



The Specialised Unit for Wastewater operates under the relevant Directorate at EPA Headquarters, staffed by two Deputy Directors overseeing field units. Each field unit comprises one Assistant Director (Unit Head), one Inspector, and one Field Assistant. Due to the higher concentration of effluent-generating industries, Faisalabad (textile sector) and Kasur (tanneries) each have two units, while the remaining eight hotspot districts are served by one unit each, resulting in an initial total deployment of twelve units.

Given the interconnected nature of industrial wastewater drains and the associated risks of groundwater contamination, the Unit's operational jurisdiction is not limited to the ten designated hotspots. Field teams may be deployed to any district within Punjab where effluent discharge poses a significant environmental or public health threat. The table below delineates the designation and reporting hierarchy of the Specialised Unit for Wastewater:

Designation	Reporting Officer	Countersigning Officer
Assistant Director (Specialised Unit for Waste water)	Deputy Director (R&I) or Deputy Director (RC) or as assigned by relevant Directorate of EPA	Relevant Directorate of EPA
Inspector (Specialised Unit for Wastewater)	Assistant Director concerned	Deputy Director Concerned

Field Assistant (Specialised Unit for Wastewater)	Inspector concerned	Assistant Director concerned

The process of Environmental Protection Order (EPO) compliance monitoring and field verification commences upon the expiry of the EPO, at which point a field inspection is scheduled. During the site visit, the inspection team comprising the Inspector or Field Assistant (FA) conducts a thorough verification of environmental compliance. This includes assessing the installation and operational status of the Wastewater Treatment Plant (WWTP), evaluating any improvements made to existing systems, identifying effluent discharge points, and ensuring adherence to prescribed environmental standards. The team also inspects for potential bypass mechanisms or risks of non-compliance.

Following the inspection, the Inspector or FA prepares a Compliance Status Report (CSR), categorising the findings as full compliance, partial compliance, or non-compliance, which is then submitted to the Assistant Director (AD) for review. If full compliance is confirmed—substantiated by mandatory laboratory verification—the case is formally closed. In instances of partial or non-compliance, appropriate follow-up actions are initiated, including possible re-inspections, re-sampling, or the commencement of legal proceedings.

The Unit shall also take enforcement action against other sources of wastewater generation, such as housing societies, pursuant to directives from the competent authority. Its core objective is to compile comprehensive profiles of wastewater-generating industries and to initiate corrective measures against non-compliant units, with a particular emphasis on ensuring the installation and effective operation of wastewater treatment systems.



Figure 6.6: Wastewater Treatment Plant

The following table presents a comprehensive performance summary of the Unit from its establishment through the year 2025. Overall, the data reflect a robust enforcement effort alongside gradual improvements in wastewater management; however, some resistance to compliance persists.

Table 6.7. Consolidated Performance Summary

Indicator	Total Achieved	Performance Interpretation
Enforcement		
Hearing Notices (HN) Issued	1,406	Strong enforcement outreach
Environmental Protection Orders (EPOs) Issued	263	Targeted regulatory action
EPO Non-Complied Cases	61	Persistent non-compliance cases
Non-Compliance Cases Referred to PET	27	Legal escalation undertaken
Outcomes		
EPO Processing Time	<1 Month	Reduced action time, Improved efficiency
Wastewater Treatment Plants (WWTPs) Improved	15	Upgradation compliance achieved
New WWTPs Installed	5	New treatment capacity created
Primary Settling Tanks	-	Mandatory in all units
Septic Tanks in Housing Societies	-	Mandatory installation

6.11. Conclusion

In conclusion, the Government of Punjab's approach to water environment protection and wastewater management has undergone a fundamental transformation, shifting from fragmented, reactive responses to integrated, data-driven, and enforcement-oriented governance. The initiatives documented in this chapter collectively embody this transition. Industrial wastewater profiling has replaced guesswork with robust evidence, while GIS-based pollution mapping has transformed disparate field observations into a strategic tool for prioritising the most harmful pollution sources. The creation of specialised enforcement units has focused regulatory attention on critical industrial hotspots. Targeted interventions in the tannery sector—from the Kasur Common Effluent Treatment Plant (CETP) upgrades to the Sialkot tannery relocation programme demonstrate that even long-standing pollution challenges can be addressed systematically.

Monitoring of key water bodies, such as the Hudiara Drain, has extended environmental oversight to transboundary pollution issues, and mandatory water recycling at service stations alongside rainwater harvesting requirements

in new developments signal a broader cultural shift towards conservation at source.

Together, these initiatives constitute a comprehensive regulatory framework that addresses both the sources and impacts of water pollution throughout Punjab. Yet, the scale of the challenge demands sustained commitment. Looking forward, the Government of Punjab will continue to strengthen regulatory frameworks, close enforcement gaps, and invest in advanced treatment technologies tailored to the diverse and extensive wastewater burdens faced by the province. Equally crucial is meaningful engagement with industry, local communities, and institutional partners; lasting improvements in water quality and public health cannot be realised through regulation alone. Punjab's water future hinges on governance that is not only more stringent but smarter, better resourced, and designed for long-term resilience.

Punjab faces an escalating array of water security challenges that extend well beyond pollution control and require commensurate urgency in policy attention. Groundwater depletion represents perhaps the most pressing structural threat, as decades of unregulated extraction for agriculture, industry, and domestic use have resulted in alarming declines in water tables across vast swathes of the province, with some areas now drawing from aquifers that replenish far more slowly than they are consumed. Climate change exacerbates this vulnerability by altering the timing, intensity, and spatial distribution of monsoon rainfall, heightening the risks of both prolonged drought and destructive flooding events that overwhelm drainage infrastructure and simultaneously contaminate water sources.

In this context, treated wastewater reuse emerges not only as an environmental objective but as a strategic imperative for water security. Adequately treated municipal and industrial effluent constitutes a reliable, climate-resilient water source that can substitute for freshwater in agricultural irrigation, industrial cooling, groundwater recharge, and urban landscaping. The Government of Punjab therefore intends to integrate wastewater reuse targets into its broader water resource planning, develop the requisite legal and technical standards to

govern safe reuse, and incentivise investment in tertiary treatment infrastructure at scale.

Addressing these intertwined challenges—encompassing groundwater governance, climate adaptation, and circular water use—will determine whether Punjab can secure safe and sufficient water supplies not only for current populations but for generations to come.

CHAPTER 07

Environmental Approvals and Development Oversight



7.1 Introduction

Environmental Approvals and Development Oversight are essential components of modern environmental governance, ensuring that economic development is carried out in a responsible and sustainable manner. In Punjab, this framework is primarily guided by Section 12 of the Punjab Environmental Protection Act, which mandates that: "No proponent of a project shall commence construction or operation unless they have filed with the [Provincial Agency] an Initial Environmental Examination (IEE) or, where the project is likely to cause an adverse environmental effect, an Environmental Impact Assessment (EIA), and have obtained approval from the [Provincial Agency] in respect thereof."

This approval process is supported by the Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations 2022, which provide detailed procedures for assessing the potential environmental impacts of proposed developments.

Development oversight through the Environmental Approval (EA) regime has significantly influenced Punjab's development framework by ensuring that projects are planned and executed in accordance with environmental sustainability principles, rather than based solely on economic considerations. Through the IEE/EIA process, project proponents are required to evaluate land-use compatibility, waste management systems, emissions control measures, water and energy consumption, traffic impact, and future environmental risks before commencing development activities.

This mechanism has gradually shifted the development approach in Punjab towards more organised, regulated, and environmentally conscious planning. As a result, industries, housing schemes, commercial developments, and infrastructure projects increasingly incorporate pollution control technologies, green belts, wastewater treatment arrangements, and mitigation measures at the design stage itself.

In this way, the Environmental Approval framework functions as a development oversight instrument that not only regulates projects but also reshapes the overall development structure of Punjab towards sustainable and responsible

growth. To ensure proper development and structural growth of sectoral entities, EPA Punjab achieved a historic milestone in 2025 by processing and issuing 2,013 Environmental Approvals, surpassing all previous years.

7.2 Environmental Approvals Matrix

The Environmental Approvals Matrix of EPA Punjab ensures environmental compliance through a comprehensive regulatory framework under the Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) Regulations. These regulations have been meticulously and technically developed, considering various factors including the nature of the project, estimated costs, environmental impacts, operational risks, future projections, and sustainability considerations. Under this framework, projects of relatively smaller scale are required to obtain IEE approval, whereas large-scale and environmentally sensitive projects must secure an EIA approval prior to commencement of any construction activity.

The primary objective of this mechanism is to evaluate and mitigate potential environmental impacts at the planning stage, thereby preventing adverse effects on public health, natural resources, and surrounding communities. Furthermore, upon completion of construction and prior to the commencement of operations, project proponents must obtain confirmation of compliance from EPA Punjab, ensuring that all environmental safeguards, stipulated conditions, and mitigation measures approved in the IEE/EIA have been properly implemented.

Environmental Approvals issued by EPA Punjab remain valid for three years from the date of issuance. To continue operations beyond this period, project proponents are required to apply for renewal of the Environmental Approval, subject to verification of ongoing compliance with applicable environmental standards, conditions, and regulatory requirements.

The Environmental Approvals Matrix provides a consolidated and tiered account of all Environmental Approval activity conducted during the calendar year 2025 — the most productive year in EPA Punjab's history. Across all three tiers of the Environmental Approval system, a total of 2,317 applications were received, with 2,013 Environmental Approvals issued during the year. The matrix is organised into three administrative levels: the headquarters tier under the Director General EPA Punjab, the district tier under the District Environmental Approval Committees (DEACs) chaired by Deputy Commissioners in 38 districts, and the divisional tier under the Divisional Environmental Approval Committees (Div. EACs) led by Commissioners across 10 divisions of Punjab.

The environmental legal framework not only provides a robust mechanism for issuing Environmental Approvals but also rigorously addresses projects operating without the required approvals. Violations are handled through a formal legal and regulatory process under the law. According to Section 12 of the Punjab Environmental Protection Act 1997, commencing a project without obtaining an Environmental Approval, or failing to renew it before expiry, constitutes an offence under Section 16 of the Act (Penalties). Such offences are triable by the Punjab Environmental Tribunal established under Section 17 of the Act.

Additionally, the authority to review Environmental Approvals has been delegated to District Environmental Approval Committees (DEACs) and Divisional Environmental Approval Committees (Div. EACs) for specific project categories as outlined in the Power Delegation Notification, thereby establishing the three-tier Environmental Approval system currently operational in Punjab.

7.3 ISO-9000 Certification in Environmental Approval Regime

In 2025, EPA Punjab reached a significant institutional milestone by obtaining ISO 9001:2015 certification for its licensing regime, specifically relating to Environmental Approvals. The certification was awarded by ISOQAR, an entity accredited by both UKAS and PNAC, following a rigorous third-party conformity

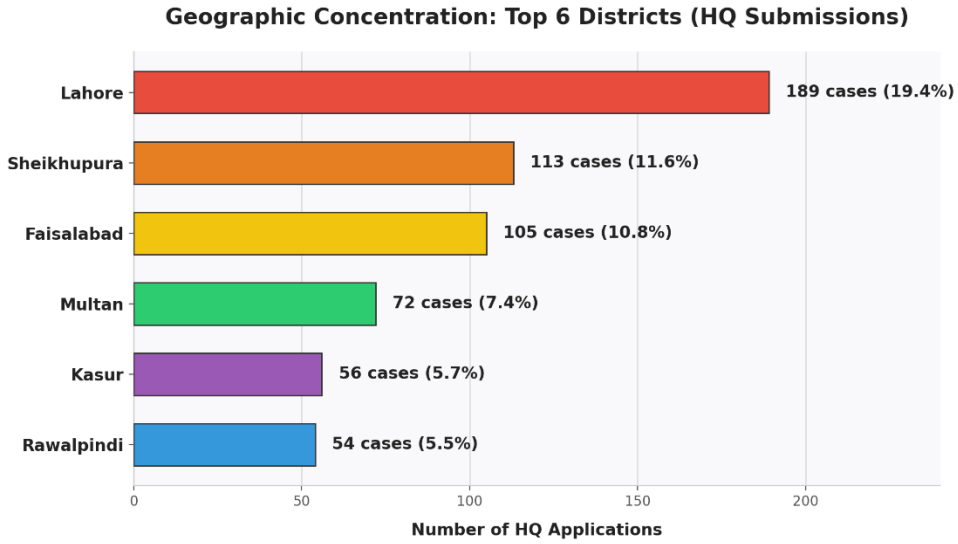
assessment audit. This audit thoroughly evaluated EPA Punjab's operational systems, regulatory frameworks, and service delivery mechanisms against the requirements of the ISO 9001:2015 standard.

The Quality Policy, formally promulgated on 5 February 2025, commits the Environmental Impact Assessment (EIA) Wing to strict adherence to all applicable environmental laws and regulations. It also mandates comprehensive technical reviews of EIA and Initial Environmental Examination (IEE) submissions, continuous improvement of the Quality Management System, ongoing capacity building of staff, and meaningful engagement with stakeholders.

By institutionalising standardised review procedures, risk-based decision-making, quality assurance protocols, and performance monitoring, the ISO 9001:2015 framework enhances the consistency, transparency, and effectiveness of environmental assessments and regulatory oversight. Consequently, this certification not only affirms the procedural integrity of EPA Punjab's approval and compliance verification processes but also bolsters the credibility of environmental decision-making. This, in turn, supports improved environmental protection outcomes while upholding internationally recognised standards of quality, accountability, and public service efficiency.

7.4 Provincial Level Environmental Approval Matrix

The concentration of headquarters (HQ)-level applications in a limited number of districts reflects the geographic distribution of large-scale industrial activity across Punjab. Lahore, as the provincial capital and principal industrial hub, dominated HQ submissions with 189 cases (85 EIAs and 104 IEEs), accounting for 19.4% of all HQ applications. Sheikhupura followed with 113 cases, Faisalabad with 105, Multan with 72, Kasur with 56, and Rawalpindi with 54. Together, these six districts accounted for 60.6% of all HQ-level filings, reaffirming that Punjab's large-scale industrial activity is largely concentrated along the Central Punjab



industrial axis.

Figure 7.1: Geographic concentration of top 6 districts

District-wise application data, when examined alongside individual project records, reveal distinct sectoral profiles for key districts receiving HQ-level Environmental Approvals in 2025. These profiles correspond with the industrial character of each district and provide a granular perspective on the types of development seeking environmental clearance. Lahore received the highest volume of HQ applications (189 cases: 85 EIA and 104 IEE). Of the EIAs, 25 Environmental Approvals (EAs) were issued covering a diverse array of sectors: oil, gas, and LPG storage facilities (7 EAs); pharmaceuticals (3 EAs); chemicals

and paints (2 NOCs); and assorted industrial units including automobile assembly, waste incineration, and synthetic textiles. The IEE NOCs issued for Lahore (40) were similarly varied, including urban development (6 EAs), plastic manufacturing (4 EAs), apparel and stitching units (3 EAs), energy projects such as biomass boilers and solar installations (3 EAs), and dyeing and textile units (3 EAs). Lahore's sectoral diversity at the HQ level reflects its status as a mixed industrial and commercial metropolis, where no single sector predominates, consistent with its description as a mixed industrial cluster comprising pharmaceuticals, chemicals, textiles, and light manufacturing simultaneously.

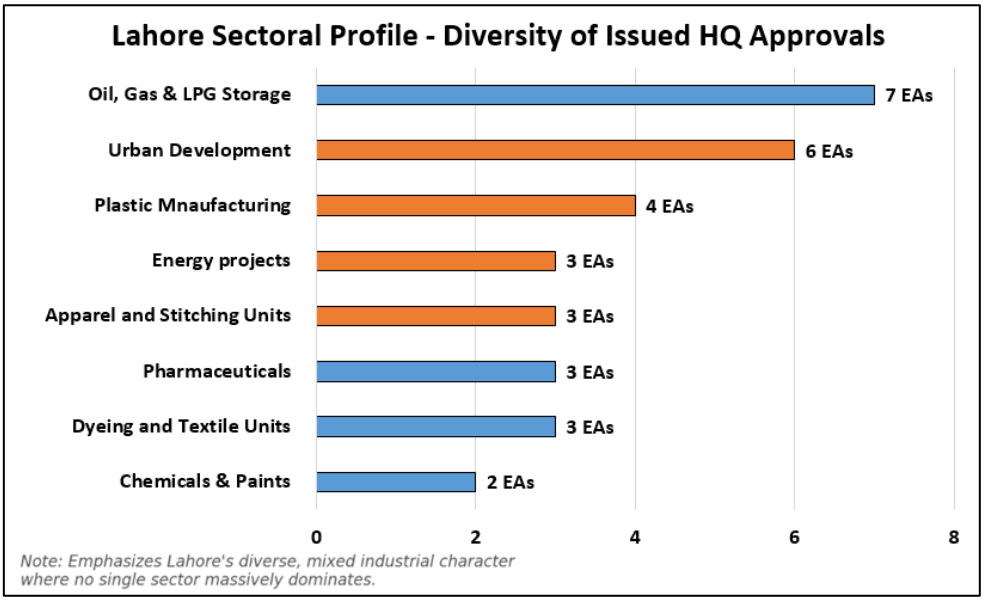


Figure 7.2: Lahore Sectoral Profile

Faisalabad, with 105 HQ applications (52 EIA and 53 IEE), is Punjab's most sector-concentrated industrial district at the HQ level. Among the 22 EIA EAs issued, textile dyeing and printing led the sectors with 4 EAs, followed by pharmaceutical units with 3 EAs, and food and beverage processing with 2 EAs. The IEE approvals (29 cases) were dominated by textile spinning and weaving units, which received 9 NOCs—the highest single district-category figure in the IEE dataset—confirming Faisalabad's role as Punjab's primary textile spinning centre. Other sectors included feed mills (6 EAs), plastics and synthetic units (3 EAs), and packaging material manufacturers (3 EAs).

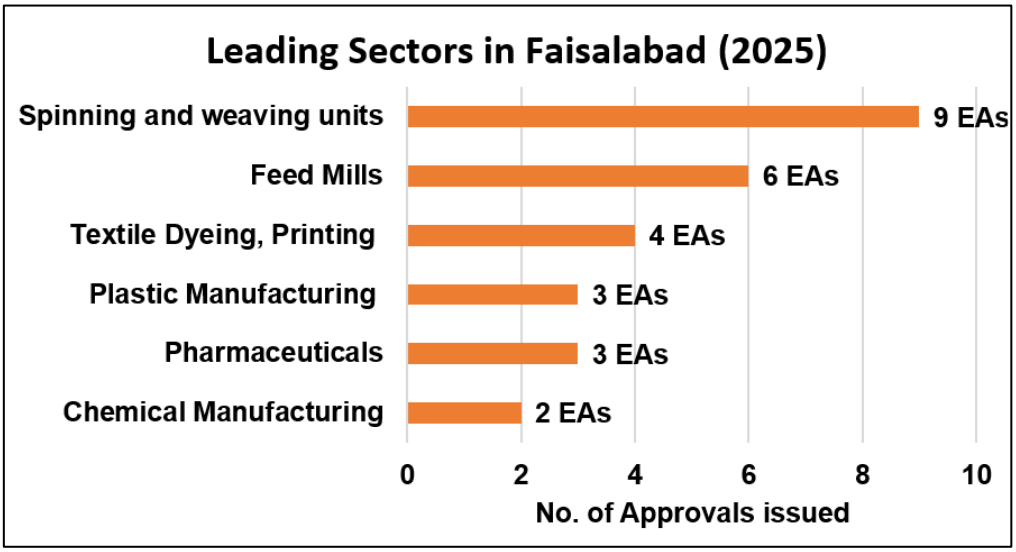


Figure 7.3: EA profile for Faisalabad

Sheikhupura, with 113 HQ applications (69 EIA and 44 IEE), reflects its character as a major manufacturing satellite of Punjab. Among the EIAs, textile manufacturing (dyeing) units, synthetic resins, and allied mills led with 5 EAs. Paper, board, and packaging manufacturers as well as oil and gas storage facilities each received 3 EAs. IEE approvals (29) were led by plastics and synthetic product manufacturers (5) and textile spinning and weaving units (5), underscoring Sheikhupura's role as a major hub for both polymer-based and fibre-based manufacturing.

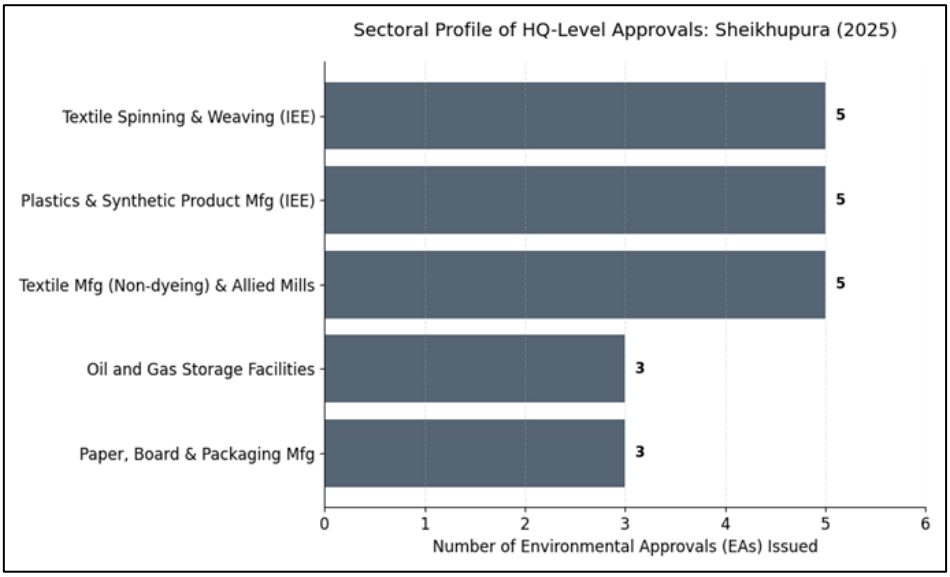
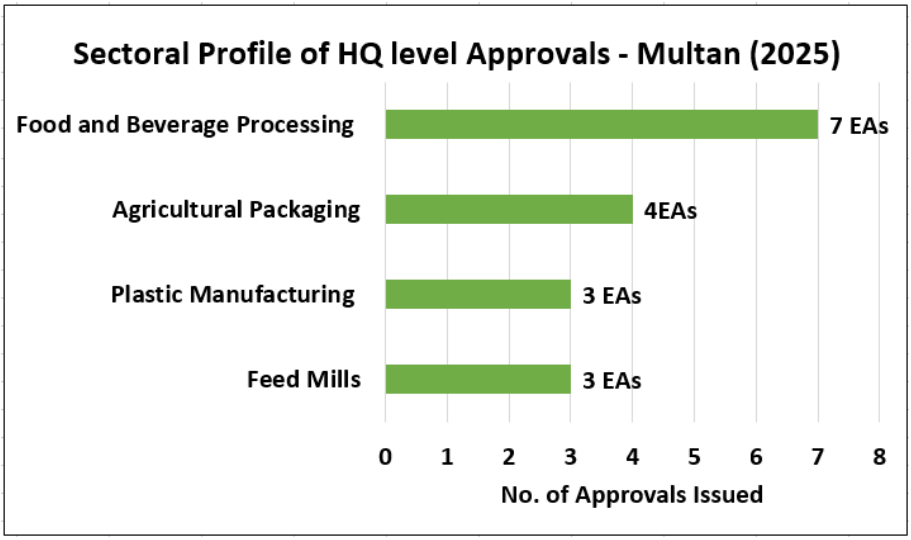


Figure 7.4: EA profile of Sheikhupura

Multan, with 72 HQ applications (20 EIA and 52 IEE), presents a notably distinct sectoral profile in the IEE categories. Food and beverage processing units dominated with 7 EAs—the highest single food-sector figure among districts—while plastics and synthetic manufacturers and packaging material producers each received 3 EAs. Feed mills and poultry units accounted for a further 3 EAs. Multan's prominence in food processing IEEs aligns with its role as the



commercial and agro-industrial capital of southern Punjab.

Rawalpindi, with 54 HQ applications (34 EIA and 20 IEE), was dominated at the EIA level by oil, gas, and LPG storage facilities, which received 15 EAs. Remaining EIAs covered miscellaneous industrial uses. IEE approvals (9) mainly encompassed housing schemes and commercial buildings (4 EAs) and plastic manufacturing (5 EAs). Rawalpindi's sectoral profile reflects its function as a strategic hub for peri-urban commercial development.

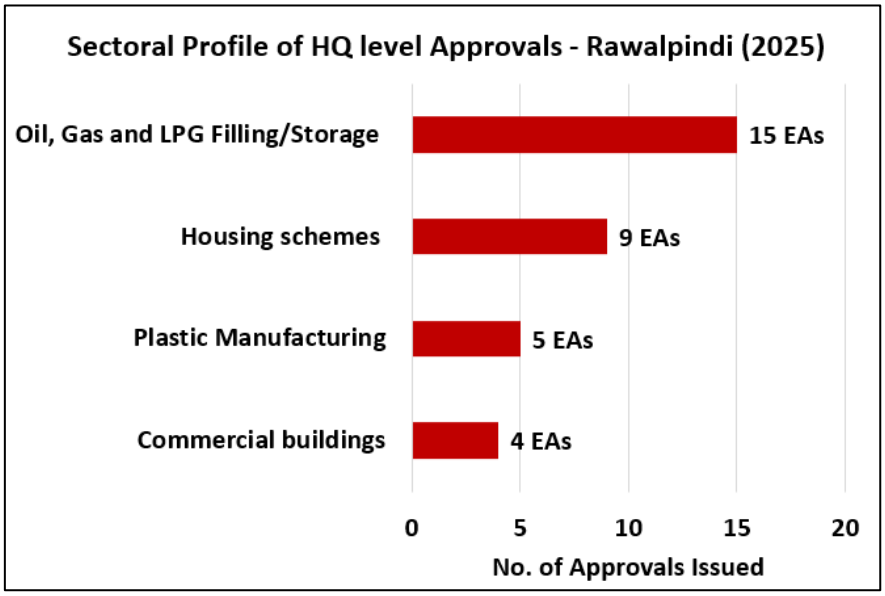


Figure 7.6: EA profile of Rawalpindi

Kasur, with 56 HQ applications (21 EIA and 35 IEE), exhibited a diverse industrial profile. The 12 EIAs issued covered sectors including food and beverage processing (2), leather and tannery units (1), and oil and gas infrastructure (1). Within the IEE approvals (16), sectors included feed mills and poultry units (2 EAs), cable and steel fabrication (2 EAs), energy projects (2 EAs), scrap yards (2 EAs), and food processing (2 EAs). Kasur's profile illustrates its dual character as a historically leather-processing district transitioning towards a more diversified industrial base.

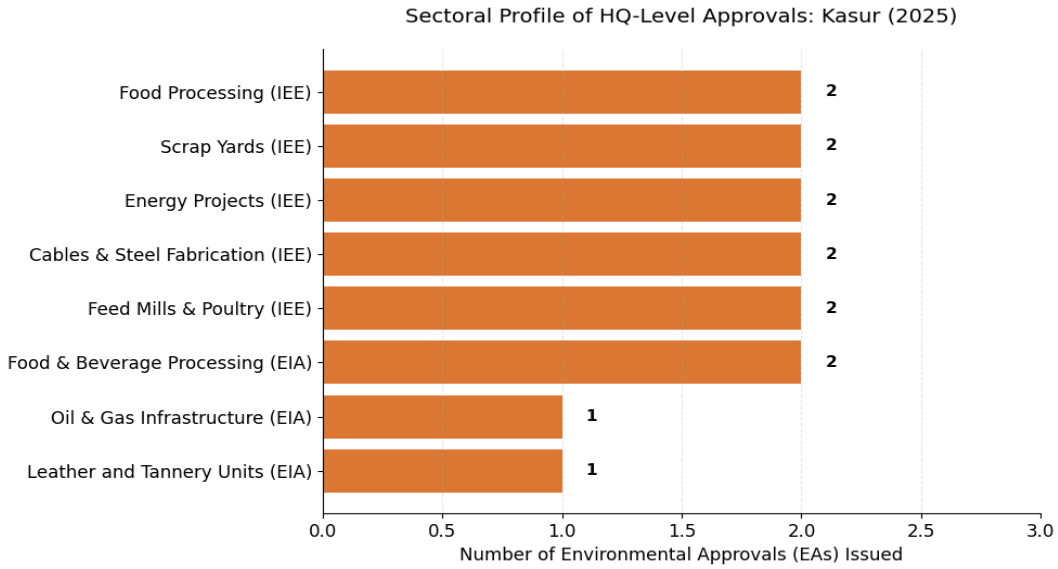


Figure 7.7: EA profile of Kasur

7.5 Divisional-Level Environmental Approvals Matrix

Divisional Environmental Approval Committees (EACs), chaired by Commissioners, assess a broad range of mid-scale projects including controlled-environment poultry farms, petrol and CNG stations, commercial buildings, cold storage facilities, and health units. Table 6.4 presents the divisional Environmental Approvals (EA) matrix for all ten divisions.

Multan Division recorded the highest volume of divisional applications with 144 submitted and 108 approvals issued, reflecting a 75% approval rate. Sargodha Division followed with 112 approvals out of 136 applications, achieving the highest approval rate among large-volume divisions at 82.4%. Sahiwal Division registered a 70.27% approval rate, with 78 approvals issued from 111 applications. Both Gujranwala and Gujrat Divisions demonstrated exemplary performance, each achieving a 100% approval rate with 58 and 51 approvals, respectively, from an equal number of applications. This consistency is largely attributed to the standardised and well-documented nature of their predominantly poultry-

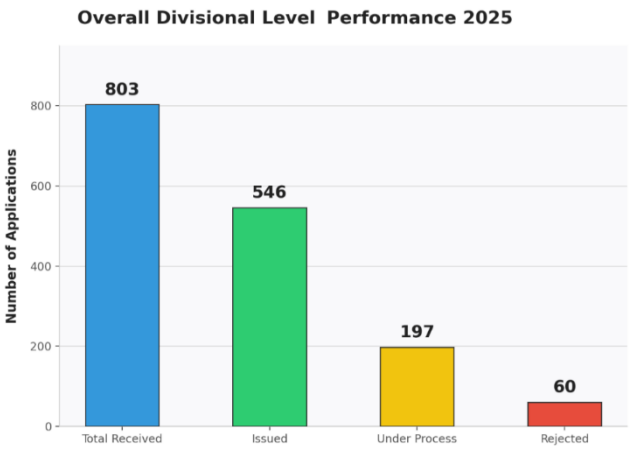


Figure 7.8: Overall divisional level performance

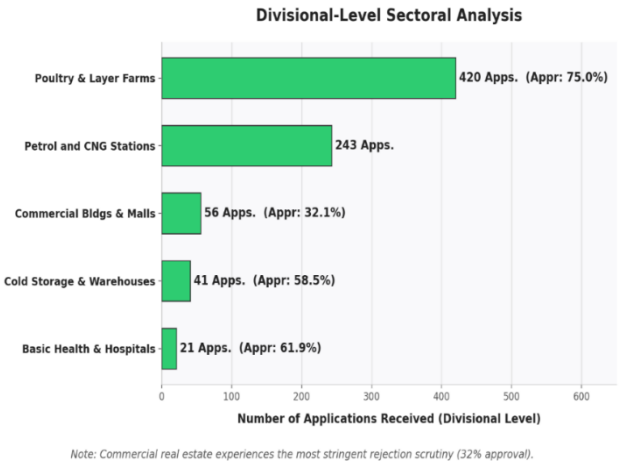


Figure 7.9: Divisional-Level Sector Breakdown

sector submissions.

Conversely, Rawalpindi Division and Lahore Division recorded the lowest approval rates—32.0% from 100 cases and 32.1% from 56 cases, respectively. These lower rates reflect the complexity and regulatory challenges inherent in handling commercial real estate and large infrastructure projects, which dominate the caseloads in these divisions.

7.6 District-Level Environmental Approvals Matrix

The District Environmental Approval Committees (DEACs) oversee smaller projects under delegated authority, primarily within sectors such as agro-processing, resource extraction, and local commercial development. The comprehensive district-wise Environmental Approval (EA) matrix for cases processed by DEACs in 2025, covering all 38 districts of Punjab, reveals that a total of 541 applications were received.

Mianwali accounted for the highest volume at the district level, with 55 applications, all classified under the Mining and Mineral Processing category. It was followed by Bahawalnagar with 53 applications, Chakwal with 52, and Khushab with 50 applications. Bahawalnagar (approving 50 of 53 cases) and Gujranwala (approving all 21 of 21 cases) demonstrated near-complete clearance rates, reflecting well-prepared submissions predominantly in the rice milling and agro-processing sectors.

Notably, six districts—Nankana Sahib, Okara, Bahawalpur, Mandi Bahauddin, Hafizabad, and Sheikhupura—approved a number of cases exceeding the applications received during the year, indicating that their respective DEACs addressed and cleared backlogs from prior years.

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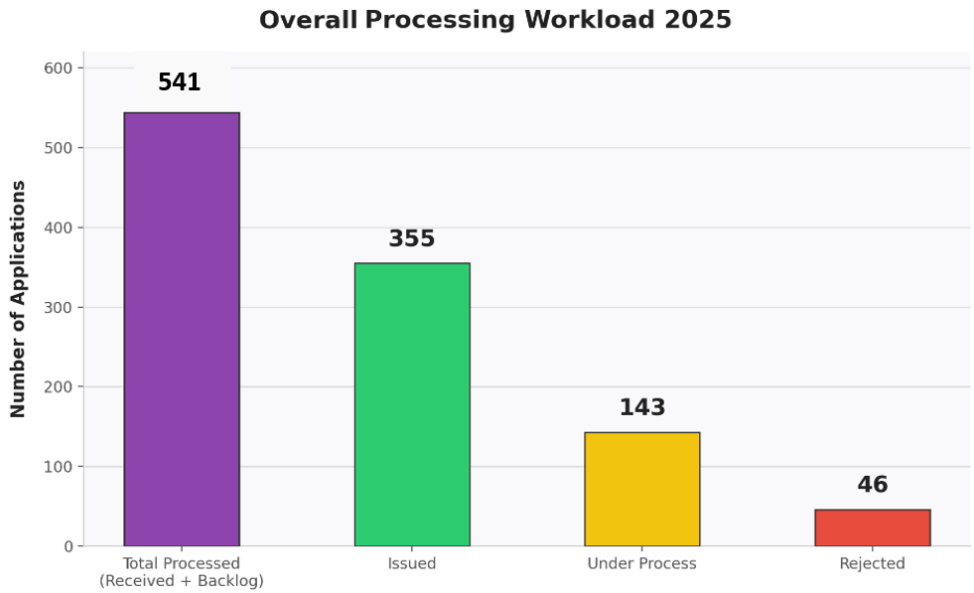
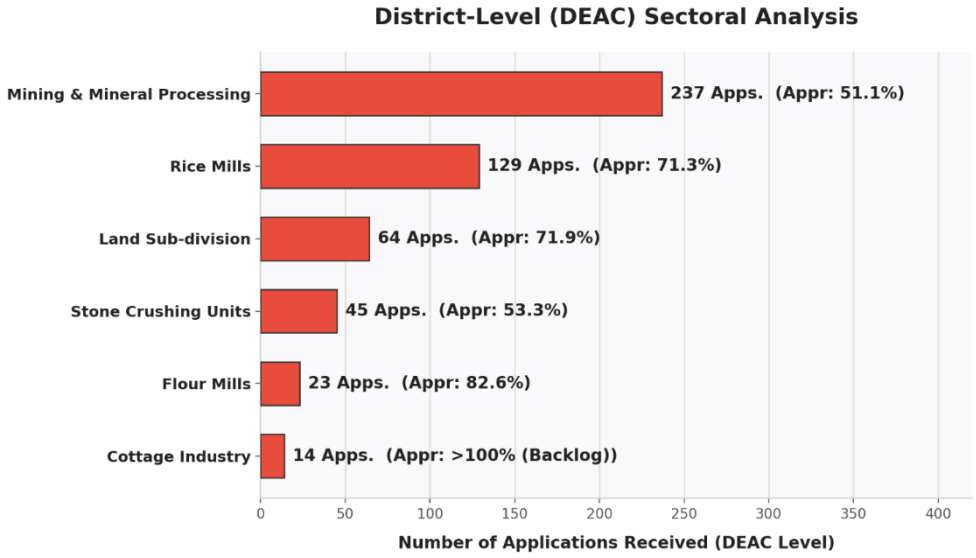


Figure 7.10: Overall district level performance



Note: Mining dominates volumetrically but suffers from very low baseline approval rates (51%).

Figure 7.11: District-Level Breakdown

Summary of Issuance of EAs (District and Divisional level)

Administrative Tier	Applications received	EAs Issued	Cases Rejected	In-process
District Level (DEAC)	541	355	46	143
Divisional Level (Divisional EAC)	803	546	60	197

Table 7. 1: Summary of EAs issued at Div. & Dist. levels

At the district and divisional levels combined, a total of 1,347 applications were received, with 901 Environmental Approvals (EAs) issued. The remaining 340 cases currently under process are primarily attributable to proponent non-responsiveness and interdependencies related to land-use clearances, reflecting trends consistent with those observed in previous years.

7.7 Compliance with the environmental conditions

Environmental Approvals granted under Section 12 of the Punjab Environmental Protection Act, 1997, are issued in two distinct phases: The Construction phase and the Operational phase. The Environmental Approval for the construction phase is valid for three years from the date of issuance. Upon completion of construction—or at any time within the three-year period if the project is completed earlier—the proponent must apply to EPA Punjab for Confirmation of Compliance under Regulation 13 of the Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2022.

Upon receipt of this application, the Agency conducts a physical inspection of the site, plant, and machinery to verify that all conditions stipulated in the original Environmental Approval have been satisfactorily fulfilled and requests additional information where necessary. If the compliance status report is deemed satisfactory, Confirmation of Compliance is issued within fourteen days of application receipt, in accordance with the Government of Punjab's service delivery timelines for business facilitation.

The Confirmation of Compliance functions not merely as a clearance certificate but also as the instrument through which operational, maintenance, and monitoring conditions are formally imposed on the facility. In addition to the standard conditions applicable to all project types, EPA Punjab incorporates project-specific requirements tailored to the nature and scale of each development. Construction-phase approvals mandate the installation of mist sprinkler systems to suppress dust generation. Housing schemes are required to install three-chamber septic tanks in each household to ensure adequate domestic wastewater treatment at source. Industrial units must plant between 500 and 2,000 indigenous trees—depending on project area—of six to seven feet in height within project premises. Plastic manufacturing units are obliged to comply with the Punjab Environmental Protection (Manufacturing and Use of Single-Use Plastic Products) Regulations, 2023. Furthermore, all projects are mandated to plan, design, construct, and operationalise rainwater harvesting

systems within their premises to facilitate appropriate recycling and reuse of rainwater.

Two significant enhancements were introduced to the Confirmation of Compliance framework during 2025. First, the Unique Identification Number assigned to each registered facility by EPA Punjab is now mandatorily incorporated into every Confirmation of Compliance issued, facilitating systematic tracking of approved facilities across the Agency's regulatory database. Second, projects generating wastewater discharges or air emissions are required to provide EPA Punjab with continuous CCTV access to their emission and discharge points, enabling real-time remote monitoring that supplements periodic physical inspections.

During 2025, EPA Punjab issued 403 Confirmations of Compliance/Environmental Approvals for the Operational Phase, each following verification of full adherence to all conditions specified in the respective Environmental Approval. This reflects both the volume of projects successfully completing their construction phase during the year and the Agency's capacity to conduct timely site inspections and compliance assessments across a diverse portfolio of industrial, commercial, and infrastructure projects.

Across all 36 districts, Punjab recorded the following aggregate compliance outcomes for 2025: a total of 752,201 trees were planted; 838 Emission Control Systems were installed; 164 Wastewater Treatment Plants commissioned; 141 Rainwater Harvesting Systems established; 150 Continuous Emission Monitoring Systems deployed; and 472 live CCTV camera accesses were granted to EPA offices.

The table below details these achievements.

Compliance Outcomes of Environmental Approval Condition (Jan - Dec, 2025)

Name of District	No. of Trees Planted	Emission Control System (ECS) Installed	Wastewater Treatment Plant (WWTP) Installed	Rainwater Harvesting System Installed	Continuous Emission Monitoring System (CEMS)	CCTV Camera Live Access Provided
Attock	11000	5	0	1	1	8

Bahawal nagar	7500	25	1	1	0	15
Bahawalpur	1470	8	8	1	11	11
Bhakkar	4560	1	0	1	1	1
Chakwal	5617	2	0	23	2	7
Chiniot	4850	1	1	0	1	3
Dera Ghazi Khan	6970	2	1	0	0	1
Faisalabad	1000	20	5	2	5	53
Gujranwala	13000	31	2	1	0	21
Gujrat	6000	10	2	0	1	1
Hafizabad	5300	7	1	13	0	5
Jhang	8500	8	2	0	2	4
Jhelum	17855	17	1	2	2	14
Kasur	9700	8	8	2	0	32
Khanewal	18743	8	0	1	28	13
Khushab	14000	2	1	0	0	6
Kot Addu	9000	5	3	0	0	0
Lahore	367,000	357	110	68	5	132
Layyah	10640	3	1	1	0	6
Lodhran	6520	1	0	0	0	4
Mandi Bahauddin	1400	0	0	0	0	0
Mianwali	8605	2	0	1	0	0
Multan	33420	172	0	0	2	0
Muzaffargarh	10607	6	1	0	0	5
Nankana Sahib	15000	41	0	2	51	79
Narowal	1300	1	0	1	0	0
Okara	6400	24	1	1	9	9
Pakpattan	0	0	0	0	0	0
Rahim Yar Khan	21394	2	2	0	9	9
Rajanpur	1200	1	1	0	0	1
Rawalpindi	8350	15	0	4	12	14
Sahiwal	18500	5	4	3	0	5
Sargodha	1800	4	0	2	0	0
Sheikhupura	64000	3	6	6	0	2
Sialkot	3700	2	0	3	0	0
Toba Tek Singh	12500	6	2	0	1	4
Vehari	14800	33	1	1	7	7
Total	**752,201**	**838**	**165**	**141**	**150**	**472**

7.8 Spatio-Temporal Governance

Spatio-temporal governance analysis evaluates the performance of EPA Punjab in issuing Environmental Approvals (EAs) across different geographic areas and time periods. It identifies administrative units that demonstrated processing efficiency, pinpoints locations where application rejections occurred, examines the causes of delays, and compares 2025's performance at the Headquarter level with that of previous years.

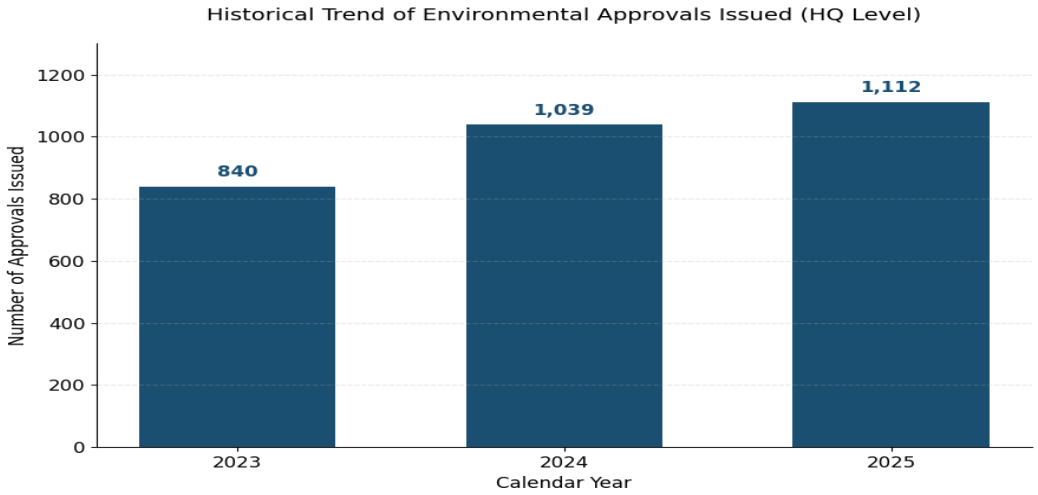
7.8.1 Three-Year Trend at HQ Level - A Record-Breaking Performance

The most significant governance development in 2025 was the record volume of Environmental Approvals (EAs) issued at the Headquarters (HQ) level. Table 6.5 presents a three-year comparative overview of HQ performance from 2023 to 2025. In 2025, EPA HQ issued 1,112 EAs—the highest annual output in the Agency's history—representing a 7.0% increase over 2024 (1,039 EAs) and a substantial 32.4% increase compared to 2023 (840 EAs). Applications received also reached a record high of 974 in 2025, compared to 701 in 2024 and 740 in 2023, indicating that more project proponents are utilising the formal EA pathway, possibly reflecting increased compliance among those who previously may have operated without clearance.

The 2025 data highlights two concurrent record-breaking achievements at the HQ level. Firstly, the number of applications received peaked at 974, signalling a sustained rise in regulatory demand and compliance. Secondly, the number of EAs issued reached 1,112, demonstrating that EPA HQ not only managed the increased application volume but also cleared a substantial backlog from preceding years. Notably, EAs issued for projects requiring an Environmental Impact Assessment (EIA) numbered 536, exceeding the 434 EIA applications received by 102, while EAs issued for projects requiring an Initial Environmental Examination (IEE) totalled 576, surpassing the 540 IEE applications received by 36. This confirms that backlog clearance was predominantly driven by the EIA stream.

The increase in applications received from 701 in 2024 to 974 in 2025, a rise of 38.9% is particularly significant. This increase is not merely an artefact of improved data capture but reflects genuine growth in development activity and,

importantly, enhanced compliance by proponents adhering to the EA requirement prior to commencing construction.



Level)

7.9 Tier-wise Development Volume

EPA Headquarters absorbed the largest volume of applications in 2025, processing a total of 974 submissions comprising 434 complex Environmental Impact Assessment (EIA) projects and 540 smaller Initial Environmental Examination (IEE) projects. At the divisional level, 802 applications were received, while the district tier managed 541 applications. Collectively, the districts of Lahore, Sheikhupura, and Faisalabad contributed 407 HQ-level applications, accounting for 41.7% of the total. This concentration reflects the significant industrial and commercial density within the central Punjab urban corridor.

At the divisional level, Multan (144 applications), Sargodha (136), Sahiwal (111), and Rawalpindi (100) recorded the highest volumes of project developments, together accounting for 61.1% of all divisional cases. Meanwhile, at the district level, the highest caseloads among the 38 districts were observed in Mianwali (55), Bahawalnagar (53), Chakwal (52), Khushab (50), and Vehari (40).

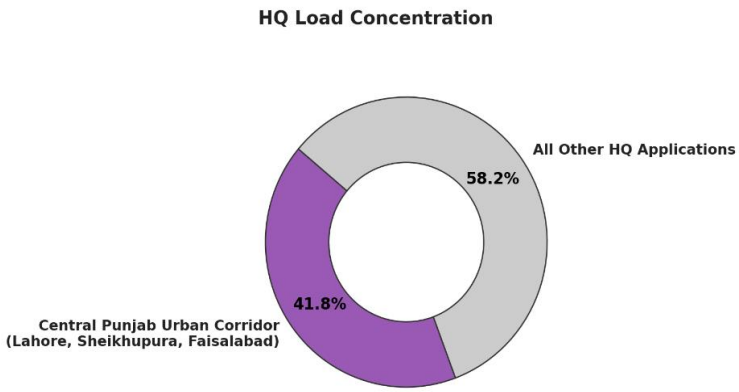


Figure 7.13: Load Concentration for HQ Projects

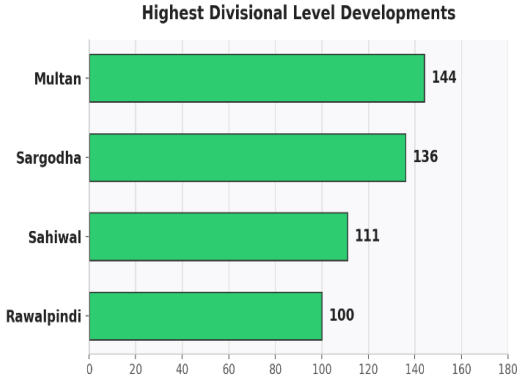


Figure 7.14: Highest Divisional Level Development

7.10 Enforcement Actions

During 2025, enforcement actions were initiated against 113 industrial units found to have commenced construction or operations without obtaining the mandatory Environmental Approval from EPA Punjab, in violation of Section 12 read with Section 17 of the Punjab Environmental Protection Act, 1997. These cases were formally referred to the Punjab Environmental Tribunal for prosecution. Upon adjudication, the Tribunal imposed penalties in accordance with the provisions of the Act. Following payment of the assessed fines and demonstration of environmental compliance, the units were brought within the regulatory framework, and Environmental Approvals were subsequently issued. This enforcement initiative underscores EPA Punjab's commitment to ensuring that all industrial and commercial facilities operate within the legal parameters of environmental oversight.

7.11 Rejection Patterns

The province-wide rejection rate at the district and divisional tiers combined stands at 8.0% (106 rejections from 1,343 applications), indicating a regulatory process that is effective and not merely permissive. However, rejection rates vary significantly by geography, largely due to EPA's refusal to approve extraction sites in the Potohar region where projects failed to meet location and safety criteria. This exemplifies the preventive environmental governance that the Environmental Approval (EA) system is intended to enforce.

Notably, six divisions—Gujranwala, Gujrat, Bahawalpur, Sargodha, Faisalabad, and Lahore—recorded no rejections, suggesting that projects in these regions either fully complied with regulatory requirements or remain under active review.

7.12 Pending Case Analysis

At year-end, 340 cases remained under process at the district and divisional levels, primarily due to proponent non-responsiveness, interdependencies related to land-use clearances, the technical complexities of certain cases, complaints and public grievances, and referrals to the Punjab Environmental Tribunal (PET). Notably, 113 Initial Environmental Examination (IEE) and

Environmental Impact Assessment (EIA) cases at the Headquarters level were formally referred to the PET for prosecution following violations of Sections 12, 13, or 16 of the IEE/EIA Regulations 2022. These cases involve proponents who either commenced construction or operations without obtaining the requisite Environmental Approval or failed to apply for an extension prior to the expiry of the three-year validity period of their Environmental Approval.

7.13 Pollution Risk Analysis

While an Environmental Approval ensures regulatory compliance, it also permits the establishment of a developmental project that will generate effluents, emissions, solid waste, noise, or land-use changes throughout its operational lifespan. This section presents the total pollution risk associated with the 2025 Environmental Approvals and highlights areas where pollution could potentially exceed the environment's assimilative capacity.

Sector-Specific Pollution Profiles

The 2025 approval portfolio includes several pollution-intensive sectors whose cumulative environmental burdens necessitate proactive monitoring and rigorous post-approval inspections. The following sectors pose the highest pollution risks:

Oil, Gas, and LPG Storage: With 85 EIAs approved, this is the largest single EIA sector. It carries significant risks including hydrocarbon spills, volatile organic compound (VOC) emissions, subsurface fuel contamination, and fire hazards. The geographic concentration of LPG and petroleum storage facilities in Rawalpindi, Lahore, and Faisalabad creates cumulative exposure risks, warranting clustered inspection programmes by EPA field enforcement teams.

Textile Dyeing and Printing (37 EIAs) and Chemical Manufacturing (33 EIAs): These process industries generate substantial organic pollutant loads, heavy metal effluents, and particulate matter. Their spatial concentration along the Lahore–Sheikhupura–Faisalabad–Kasur corridor creates one of Punjab's most significant industrial effluent zones, exerting pressure on receiving water bodies such as the Ravi and Chenab rivers and associated groundwater aquifers.

Pharmaceuticals (30 EIAs): These facilities discharge effluents containing active pharmaceutical ingredients at sub-therapeutic concentrations, contributing to antimicrobial resistance development in downstream water bodies. Pharmaceutical clusters in Lahore, Sheikhupura, Faisalabad, and Rawalpindi require targeted effluent monitoring integrated with EPA Punjab's existing pharmaceutical compliance inspections.

Coal Exploration (56 IEEs): Mining activities disrupt water tables, generate acid mine drainage, dust, and cause slope instability, particularly in the coal-bearing districts of Dera Ghazi Khan, Chakwal, and Khushab. The concentration of coal exploration IEEs in Dera Ghazi Khan (20 cases) is noteworthy as a new front of coal development in southern Punjab with potentially significant long-term hydrological and ecological impacts.

Controlled Environment Poultry and Layer Farms (315 Divisional EAC approvals): Ammonia is the principal pollutant from these operations, causing cumulative air quality impacts in poultry-dense divisions such as Sargodha and Multan. Secondary concerns include litter management, groundwater nitrate contamination, and biosecurity-related disease risks, necessitating standardised post-approval compliance protocols.

Mining and Mineral Processing (121 DEAC approvals): This sector produces dust (PM10 and PM2.5), mine drainage, and slope instability, especially within the Salt Range districts. The relatively low approval rate in this category (51.1%) reflects EPA's stringent review standards; however, the 121 approved sites constitute a substantial addition to the existing pollution burden in Mianwali, Khushab, and Chakwal.

Table 7.2 presents estimates of annual greenhouse gas emissions from 13 industrial categories, utilising internationally recognised emission factors derived from sources including the Intergovernmental Panel on Climate Change (IPCC), International Energy Agency (IEA), United Nations Industrial Development Organization (UNIDO), and United Nations Environment Programme (UNEP). The total projected emissions from 166 industrial units amount to approximately

3,042.5 kilotonnes of carbon dioxide equivalent (kt CO_2e) annually, indicating a considerable industrial carbon footprint.

The analysis reveals that a small number of heavy industries dominate emissions. Notably, a cement plant alone contributes approximately 900 kt CO_2e, making it the largest single emitter, followed by chemical manufacturing units (495 kt CO_2e), textile dyeing and printing units (444 kt CO_2e), and iron and steel re-rolling mills (400 kt CO_2e). These sectors are classified as high-load industries due to their energy-intensive operations and process-related emissions. Moderate-load industries—including apparel, paper and pulp, glass manufacturing, and chemical formulation units—also contribute substantially, primarily due to their larger numbers. Conversely, leather, beverage, and dairy manufacturing units exhibit comparatively lower emissions.

Overall, this table underscores that industrial emissions are heavily concentrated within a few carbon-intensive sectors, emphasising the urgent need for cleaner production technologies, enhanced energy efficiency measures, and strengthened environmental oversight to promote sustainable industrial development.

Sr. No.	Category	Units	EF Source	EF (tCO_2e/unit/yr)	Total Est. (kt CO_2e)	Load Level
1	Leather tannery	5	UNIDO	1500	8	Lower load
2	Beverage's manufacturing	7	IPCC Tier 1	3000	21	Lower load
3	Milk & dairy products manufacturing	17	FAO/IPCC	4000	68	Lower load
4	Paper/Board/Packaging	4	Science Direct	20000	80	Moderate
5	Glass floats/sheets manufacturing	3	IEA	30000	90	Moderate
6	Paper & paper pulp	4	Science Direct	25000	100	Moderate
7	Fertiliser manufacturing units	1	IFA/IPCC	120000	120	High load

8	Apparel manufacturing	25	Frontiers (2022)	5000	125	Moderate
9	Chemical formulation units	24	EPA NESHAP	8000	192	Moderate
10	Iron & steel re-rolling mills	5	WorldSteel	80000	400	High load
11	Textile dyeing & printing units	37	UNEP/EPA	12000	444	High load
12	Chemical manufacturing units	33	EPA NESHAP	15000	495	High load
13	Cement plant	1	IPCC/IEA	900000	900	High load
	Total (all 13 categories)	166			3042.5	

Table 7.2: Industrial Emissions Summary Table

7.14 Pollution Load Balancing Through Approval Conditionalities

EPA Punjab has been managing the intended pollution load through environmental approval conditionalities, aiming to mitigate the cumulative environmental burden arising from the 2025 project portfolio. Given the concentration of pollution-intensive sectors within already ecologically stressed districts, the imposition of stringent, sector-specific conditions at the approval stage serves as a proactive instrument to offset incremental impacts.

These conditionalities include mandatory installation of advanced effluent treatment systems, zero liquid discharge requirements for high-risk industries such as textile dyeing and chemical manufacturing, vapour recovery systems for oil and gas storage facilities, and standardised waste management protocols for poultry and mining operations. Additionally, conditional approvals mandate cumulative impact assessments, tree plantations, groundwater quality monitoring, and periodic environmental audits by the Agency, thereby ensuring that economic development does not exceed the carrying capacity of local ecosystems.

The pollution risk associated with approved projects is categorised below in a Pollution Risk Index, ranging from high to moderate risk based on project type and potential environmental impact.

In order to assess and direct the spatial redistribution of pollution-intensive projects, EPA Punjab is aligning its processes with relevant zoning regulations and

the Punjab Land Use and Reclassification Rules. This approach discourages the further concentration of hazardous industries in already overburdened districts and promotes the guidance of new developments towards less environmentally sensitive areas, provided that adequate environmental safeguards are maintained.

In coal and mining regions such as Dera Ghazi Khan, Chakwal, and Khushab, regulators are now required to submit comprehensive mine closure and land rehabilitation plans, supplemented by groundwater monitoring and slope stabilisation measures. In poultry-dense areas like Sargodha and Multan, standardised guidelines for litter management, nutrient recycling, and biosecurity protocols will be enforced to minimise cumulative impacts on air and water quality.

While the Pollution Risk Index effectively highlights the environmental pressures and potential risks associated with development activities, it is equally imperative to evaluate the socio-economic benefits generated through environmental approvals.

7.15 Socio Economic Benefit from the Environmental Approvals

The Controlled Environment Poultry and Layer Farms sector, with 315 divisional Environmental Approval Committee (Div EAC) approvals, underpins food security and rural economic development in Punjab. Poultry operations in the Sargodha and Multan divisions ensure a steady supply of meat and eggs to both urban and rural populations, thereby stabilising local food markets. The sector generates employment across the entire value chain—from farm labour and feed production to processing, distribution, and retail. By providing income-generating opportunities in rural areas, poultry farming strengthens livelihoods, fosters entrepreneurship, and supports ancillary industries such as transportation, veterinary services, and feed manufacturing, delivering wide-ranging socio-economic benefits to local communities.

The Mining and Mineral Processing sector, with 121 District Environmental Approval Committee (DEAC) approvals, is a vital contributor to regional infrastructure and industrial development. Mining activities within the Salt Range districts of

Mianwali, Khushab, and Chakwal supply raw materials essential for construction, manufacturing, and various industrial applications. These projects create employment opportunities in extraction, processing, and transport, while simultaneously bolstering local service sectors. By encouraging investment in these regions, the sector promotes economic diversification, infrastructure enhancement, and regional growth, ensuring that mining activities are not only industrially productive but also socio-economically transformative.

The Oil and Gas Separation and Storage sector, with 85 Environmental Impact Assessments (EIAs) approved in 2025, constitutes a critical pillar of Punjab's energy infrastructure. These facilities guarantee a stable supply of petroleum products and liquefied petroleum gas (LPG), essential for both industrial and domestic consumption. Beyond securing energy needs, the sector generates substantial employment ranging from technical roles in facility operations and maintenance to logistics and supply chain management. The geographic concentration of these facilities in Rawalpindi, Lahore, and Faisalabad also invigorates local economies by supporting subsidiary businesses such as transportation, equipment servicing, and construction, fostering socio-economic benefits that extend well beyond the core infrastructure.

The Coal Exploration sector, represented by 56 Initial Environmental Examinations (IEEs), contributes to Punjab's energy security by expanding domestic coal production, thereby supporting electricity generation and industrial fuel demands. In southern Punjab districts such as Dera Ghazi Khan, Chakwal, and Khushab, coal development has opened new employment avenues, encompassing mining operations, logistics, and local services. Further, infrastructure investments linked to mining—such as roads, electricity, and water supply—stimulate local economies. As a nascent frontier in coal extraction, this sector attracts significant investment and offers long-term socio-economic advantages to communities in historically underdeveloped areas.

The Textile Dyeing and Printing and Chemical Manufacturing sectors, with 37 and 33 EIAs approved respectively, form one of Punjab's most economically productive industrial corridors extending across Lahore, Sheikhupura, Faisalabad,

and Kasur. These sectors are indispensable contributors to export revenues, underpinning the country's trade balance and gross domestic product (GDP) growth. They create employment for a diverse workforce ranging from skilled technicians and chemical engineers to semi-skilled labourers engaged in production processes. Investments in modern manufacturing technologies within these sectors stimulate innovation, enhance productivity, and increase competitiveness in global markets, thereby generating broad-based economic growth for the region.

The Pharmaceutical Manufacturing sector, with 30 EIAs approved, plays a strategic role in public health and domestic industrial development. Through local production of essential medicines, it reduces reliance on imports and strengthens national health security. The sector offers high-value employment for scientists, laboratory technicians, and regulatory professionals, fostering skill development in a knowledge-intensive economy. Concentrated clusters in Lahore, Sheikhupura, Faisalabad, and Rawalpindi facilitate efficient supply chains, improving domestic medicine availability and export potential, thus contributing to economic resilience and regional prosperity.

The sectoral data summarised in the table below underscores these socio-economic contributions.

Sector	**Approvals / Projects**	**Key Districts / Divisions**	**Employment Intensity**	**Employment benefits**
Controlled Environment Poultry & Layer Farms	315 Div EAC	Sargodha, Multan	**High**	Large workforce across farms, feed, processing, retail
Oil & Gas Separation & Storage	85 EIAs	Rawalpindi, Lahore, Faisalabad	**High**	Technical facility roles, logistics, supply chain
Textile Dyeing & Printing	37 EIAs	Lahore, Sheikhupura, Faisalabad, Kasur	**High**	Skilled technicians, semi-skilled labor, export-driven
Coal Exploration	56 IEEs	DG Khan, Chakwal, Khushab	**Moderate**	Mining, logistics, local services, infrastructure-linked jobs

Pharmaceutical Manufacturing	30 EIAs	Lahore, Sheikhupura, Faisalabad, Rawalpindi	**Moderate**	High-value but smaller workforce: scientists, lab technicians
Mining & Mineral Processing	121 DEAC	Mianwali, Khushab, Chakwal	**Moderate**	Jobs in extraction, processing, transport, local services
Chemical Manufacturing	33 EIAs	Lahore, Sheikhupura, Faisalabad, Kasur	**Moderate**	Engineers, production line workers, industrial corridor jobs

Table 7. 3: Social Economic intensity of Projects

7.16 Recent Developments

The year 2025 also marked a structural transformation in the operational architecture of environmental governance in Punjab. The eBiz portal became operational on 15 January 2026, designed to replace the predominantly manual, paper-based, and partially digital processes (previously facilitated through the Business Facilitation Centre) with a fully integrated digital platform. This transition has fundamentally redefined the Environmental Approval (EA) lifecycle: application submission, fee payment, case allocation, technical review, and approval issuance are now conducted through a centralised online interface, replacing fragmented physical workflows.

The introduction of automated tracking mechanisms has enhanced transparency and reduced procedural opacity, enabling proponents to monitor the progress of their applications in real time while simultaneously improving internal accountability across various reviewing tiers. Furthermore, the portal's embedded timelines and digital communication channels have contributed to faster query resolution and substantially reduced administrative delays.

Under this new system, a structured two-week review cycle has been introduced, reducing the administrative processing targets for Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) applications from 45 and 30 days, respectively, to 14 days. Additionally, the traditional pay order method has been supplanted by a secure online fee payment system, allowing applicants to conveniently remit processing fees via digital channels. This

enhancement not only facilitates ease of doing business but also improves financial transparency and record-keeping.

Positioned as the backbone of Punjab's fully digitised, data-driven environmental regulatory regime, eBiz represents a significant advancement in streamlining environmental governance.

7.17 Conclusion

In 2025, Punjab's environmental governance achieved its highest performance to date under the framework of the Punjab Environmental Protection Act (PEPA) 1997 and the Initial Environmental Examination/Environmental Impact Assessment (IEE/EIA) Regulations 2022. A total of 2,317 applications were submitted across the headquarters, divisional, and district tiers, resulting in 2,013 approvals issued. The headquarters tier managed the largest share, processing 974 applications and issuing 1,112 approvals—a record-breaking accomplishment that also helped clear backlogs from previous years.

Lahore led in application volume with a diverse range of industrial projects; Faisalabad was dominated by textiles; Sheikhupura specialised in plastics and fibre-based manufacturing; Multan focused on food processing; Rawalpindi concentrated on petroleum storage; and Kasur exhibited a mixture of leather and agro-industrial units. At the district level, mining and rice mills were the most prominent categories, while divisional committees primarily processed approvals related to poultry farms, fuel stations, and commercial buildings.

Development pressures were clustered into four distinct zones: the Central Punjab industrial corridor, characterised by textiles, chemicals, and pharmaceuticals; the Salt Range mineral zone, dominated by mining and stone crushing activities; the southern agro-industrial belt, featuring rice, flour, oil mills, and poultry farms; and peri-urban areas of Rawalpindi and Chakwal, marked by real estate and fuel infrastructure developments.

Sectoral trends indicated that oil and gas storage, textile dyeing, chemical manufacturing, pharmaceuticals, and coal exploration constituted major activities at the headquarters level, whereas poultry farms and petrol stations

dominated divisional approvals. District committees faced challenges processing mining proposals due to inadequate baseline data, resulting in relatively low approval rates in this sector.

Spatio-temporal analysis revealed a steady increase in regulatory compliance, with applications rising nearly 39% from 2024 to 2025. Rejections were concentrated primarily on unsuitable mining projects, while cases pending at year-end often involved delays related to proponent responsiveness or land clearance issues. The province-wide rejection rate of 8.0% at the district and divisional levels reflects an effective and rigorous regulatory process rather than a merely permissive approval regime. Concurrently, 113 units were referred to the Punjab Environmental Tribunal for operating without the requisite Environmental Approval, demonstrating sustained enforcement action against non-compliant developments.

Balancing pollution load emerged as a critical concern, with sectors such as oil and gas facilities, textile dyeing, chemical manufacturing, pharmaceuticals, coal exploration, poultry farms, and mining identified as high-risk contributors. EPA Punjab sought to mitigate these impacts through the imposition of conditional approvals and stricter monitoring regimes, underscoring the agency's commitment to harmonising development objectives with environmental safeguards during what was Punjab's most intensive regulatory year to date.

CHAPTER 08

Pollution Risk Analysis of Ecological Site



8.1 Introduction

Across the developing world, rapid industrial growth has heightened a fundamental tension between economic development and environmental protection. As countries work to expand their industries and create jobs, the natural systems that support long-term human health—such as clean water, fertile soil, biodiversity, and a stable climate—are increasingly threatened by pollution, habitat loss, and the unchecked transformation of natural landscapes. This challenge goes beyond simply balancing competing interests; it raises the critical question of whether short-term industrial gains can be achieved without damaging the ecological foundations essential for future generations.

This issue is particularly evident in Pakistan, especially in the province of Punjab. As the most populous and economically active region of the country, Punjab contains a vast network of industrial estates, manufacturing hubs, and small-scale production units that have grown significantly over the last two decades. While this growth has been crucial for generating employment and boosting the economy, it has largely unfolded without careful consideration of the ecological vulnerabilities of the surrounding environment. Rivers, wetlands, forests, and wildlife habitats—many of which hold national and international conservation importance—have faced continuous degradation as industrial activities increasingly encroach on their borders.

In response, the concept of Ecologically Sensitive Zones (ESZs) has become a vital tool for environmental protection. ESZs are designated areas recognized for their rich biodiversity, ecological sensitivity, and the valuable ecosystem services they provide. These zones include diverse environments such as river corridors, protected wetlands, reserved forests, groundwater recharge areas, nationally designated parks, and biosphere reserves. Among the most internationally recognized protected areas are Ramsar Sites, wetlands of global importance listed under the Ramsar Convention. Several of these significant wetlands are located within Punjab, and they will be discussed in detail in later sections of this chapter.

Despite their recognised importance, Ecologically Sensitive Zones (ESZs) in Punjab have lacked effective, spatially informed regulatory oversight to address the cumulative impacts of nearby industrial activities. To remedy this, the Punjab Environmental Protection Agency (EPA) has launched a strategic initiative to systematically map industrial clusters adjacent to these vulnerable ecosystems. This represents a vital shift from reactive enforcement to proactive, evidence-based spatial planning and precautionary environmental governance.

This initiative reflects the critical ecological, environmental, and socio-economic values of ESZs and the growing necessity to integrate spatial intelligence into regulatory processes. It also aligns with existing frameworks for Environmental Impact Assessments (EIAs), No Objection Certificates (NOCs), and sustainable industrial development policies.

Comprehensive spatial analyses have been completed for seven key ESZs across Punjab, including Ramsar wetlands, EPA-designated sensitive zones, and protected forests. The results confirm that such systematic mapping lays the foundation for stronger, evidence-based decision-making, enhanced precautionary planning, and alignment with international sustainability commitments.

8.2 Ecologically Sensitive Sites in Punjab

Punjab encompasses a diverse array of ecologically sensitive sites, including wetlands, protected forests, riverine ecosystems, wildlife habitats, biodiversity hotspots, and environmentally fragile landscapes. These areas provide vital ecological services such as groundwater recharge, flood control, carbon sequestration, habitat preservation, and climate regulation. Several sites are internationally recognised under conservation frameworks like the Ramsar Convention on Wetlands, while others are designated or protected under provincial environmental, forestry, and wildlife management legislation.

Given increasing industrialisation, urban growth, land-use changes, and rising pollution pressures, it is imperative to strengthen spatial planning, enforce

precautionary environmental regulation, and adopt evidence-based governance to safeguard these critical ecological areas.

8.3 Criteria for Declaration as Ecological Sensitive Zones

Ecologically Sensitive Zones are areas recognised for their exceptional ecological value and vulnerability to harm. They support rich biodiversity, including rare and endangered species, and provide essential ecosystem services like groundwater recharge, flood control, and carbon storage. These zones are often fragile and cannot withstand much disturbance from physical, chemical, or biological changes.

ESZs also serve as vital corridors for wildlife movement, maintaining genetic diversity and ecosystem resilience. Many have deep cultural or spiritual significance to local communities and are often located near internationally protected sites such as Ramsar wetlands and biosphere reserves.

Recognising these qualities is critical for developing effective conservation strategies. As industrialisation and urban expansion increase, strengthening spatial planning, precautionary regulation, and evidence-based governance will be key to preserving Punjab's ecologically sensitive areas for the benefit of both nature and society.[47]

8.4 Classification of Ecologically Sensitive Zones in Punjab

Punjab, Pakistan's most populous and industrialised province, encompasses a diverse array of ecologically sensitive landscapes despite its predominantly agricultural and urban character. These include:

[47] Guidelines for Sensitive and Critical Area- Pak EPA

Riverine and riparian zones: The Ravi, Chenab, Jhelum, Sutlej, and Beas river corridors, along with their adjoining floodplains, support rich biodiversity and provide vital hydrological services.

Protected forest areas: Reserved and protected forests across the Pothohar Plateau and Salt Range represent fragile ecosystems with limited capacity for natural regeneration.

Wetlands and waterbodies: Sites such as Chashma Barrage, Head Islam, and numerous smaller wetlands serve as essential habitats for both migratory and resident bird species.

Groundwater recharge zones: Certain alluvial plains function as primary recharge areas for underground aquifers, making them highly vulnerable to contamination and land-use changes.

Peri-urban green corridors: Natural and semi-natural vegetation belts surrounding urban centres that help moderate local microclimates and sustain urban biodiversity.[48]

[48] The Punjab Protected Areas Act 2020

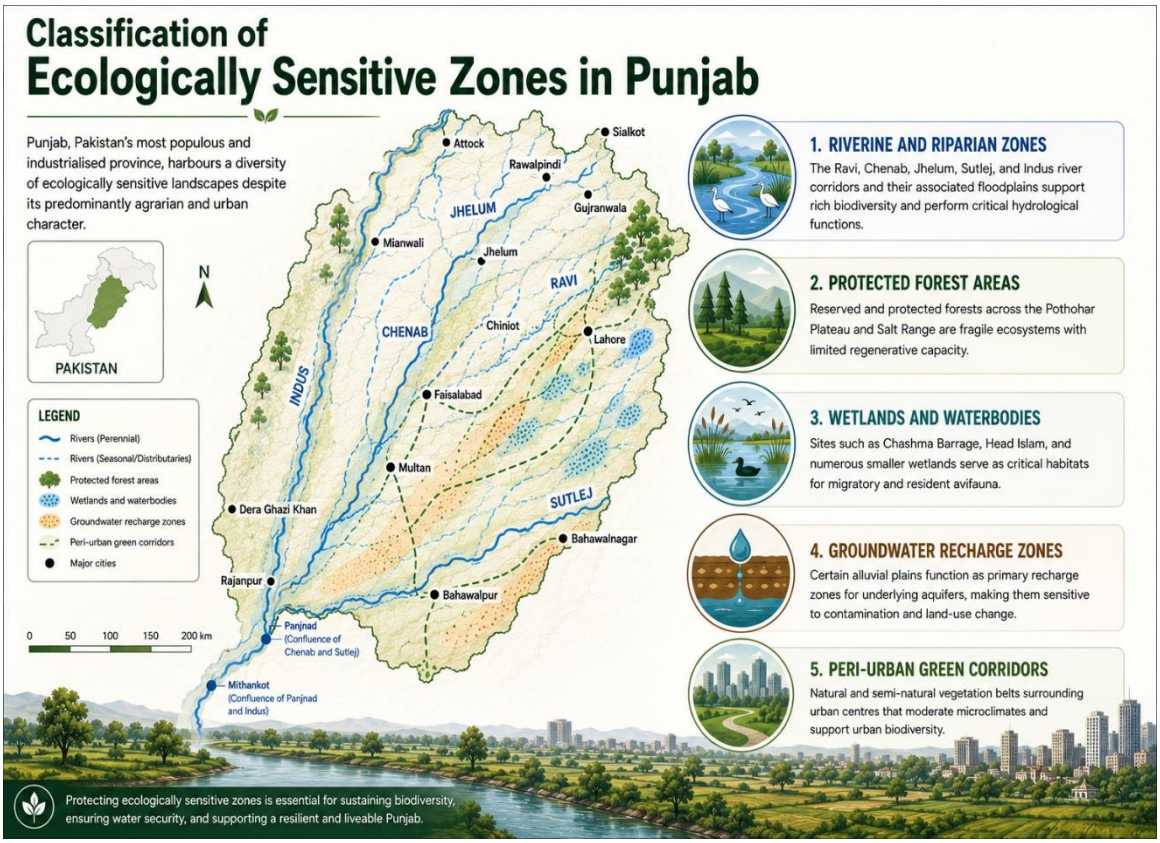


Figure 8.1: Classification of Ecological Sensitive Zones in Punjab

8.5 Significance of the Ecological Sensitive Zones

Ecologically Sensitive Zones (ESZs) act as refuges for species that cannot survive in the extensively altered landscapes of agricultural lands, urban centres, or industrial zones. They uphold genetic diversity, preserve vital evolutionary processes, and sustain the ecological networks foundational to food security and ecosystem resilience. In Punjab, where natural habitats have been widely modified, remaining ESZs hold exceptionally high conservation value relative to their limited size.

Beyond ecological significance, degradation of these zones has serious socio-economic repercussions. Many rural and peri-urban communities depend on ecosystem services for livelihoods, nutrition, and health. For example, industrial pollution of riparian zones adversely affects agricultural productivity, drinking water quality, and fisheries, undermining the well-being of communities reliant on these resources.

Furthermore, failure to adequately safeguard ESZs risks legal challenges for regulatory bodies and industry operators alike. Such lapses may undermine development approvals and provoke judicial interventions, as courts in Pakistan have increasingly taken active roles in environmental governance.

8.5.1 Ramsar Sites: Wetlands of International Importance

The Ramsar Convention on Wetlands, adopted in 1971 in the Iranian city of Ramsar, stands as one of the oldest and most widely ratified international environmental treaties. It establishes the principal global framework for the conservation and sustainable use of wetlands, recognising their extraordinary ecological, economic, cultural, scientific, and recreational significance. Under this Convention, a wetland is designated as a "Ramsar Site" when a signatory country formally lists it, based on compliance with at least one of nine internationally agreed criteria related to ecological, botanical, zoological, limnological, or hydrological importance.

Pakistan became a party to the Ramsar Convention in 1976 and currently maintains nineteen designated Ramsar Sites. These sites collectively cover approximately 1.34 million hectares and represent a highly diverse spectrum of wetland types. This diversity includes coastal mangrove forests, high-altitude mountain lakes, river delta systems, as well as inland freshwater and brackish wetlands. Together, these areas provide indispensable habitats for millions of migratory waterbirds travelling along global flyways, serve as breeding and feeding grounds for numerous threatened fish and bird species, and deliver critical ecosystem services such as water regulation and flood buffering that are vital to surrounding communities.

Within the province of Punjab, two wetland complexes have been accorded official Ramsar Site status and bear direct relevance to the analysis presented in this chapter: Uchali Lake and Jahlar Lake, both situated in the Soon Valley of Khushab District. Uchali Lake is internationally recognised for its distinctive brackish-saline water chemistry and its role as a crucial wintering refuge for thousands of migratory birds using the Central Asian Flyway. Jahlar Lake, which is endorheic (meaning it has no natural outlet), provides an irreplaceable

sanctuary for the globally endangered White-headed Duck. Notably, both lakes have also been designated as EPA-Notified Sensitive Areas under Pakistan's environmental legislation and are examined in detail in Sections 8.6.3 and 8.6.5, respectively.

Designation as a Ramsar Site carries profound regulatory implications within Pakistan's environmental governance framework. It triggers the highest level of scrutiny during the Environmental Impact Assessment (EIA) process, bolsters the legal basis for issuing No Objection Certificates (NOCs) by the Environmental Protection Agency (EPA), imposes more stringent siting restrictions, and ensures alignment with Pakistan's binding obligations under international conservation law. In the context of EPA Punjab's strategic initiative to map industrial clusters, Ramsar Sites rank among the highest-priority categories of Ecologically Sensitive Zones (ESZs). This prioritisation underscores the need for proactive monitoring, the implementation of precautionary buffer zones, and rigorous enforcement of regulations prohibiting harmful industrial development within these critical wetlands.

In summary, Ramsar Sites are cornerstones of wetland conservation in Punjab and Pakistan at large. Their international recognition strengthens environmental oversight and highlights the importance of integrating global conservation standards into provincial development planning. Effective management and protection of these wetlands are essential to safeguarding biodiversity, supporting sustainable livelihoods, and maintaining ecosystem services upon which local communities heavily depend.

8.5.2 EPA Punjab's Initiative: Mapping Industrial Clusters around Ecologically Sensitive Zones

The Environmental Protection Agency (EPA) Punjab's decision to undertake systematic mapping of industrial clusters near Ecologically Sensitive Zones (ESZs) reflects the understanding that effective environmental regulation must be guided by spatial information. Without a comprehensive grasp of the geographic relationship between sources of industrial pollution and vulnerable

ecological areas, regulatory actions risk remaining reactive, fragmented, and inadequate.

This initiative pursues five primary objectives:

Establishing a detailed spatial database of industrial establishments operating within defined buffer zones around ESZs across Punjab;

Characterising the nature, scale, and pollution profiles of industrial clusters, focusing on effluent generation, emissions, solid waste, and land-use intensity;

Assessing cumulative environmental pressures on ESZs from nearby industrial activity;

Identifying regulatory gaps, including unregistered or non-compliant units operating without valid environmental authorisations;

Creating an evidence base to inform the calibration of environmental standards, zoning regulations, and the prioritisation of enforcement actions.

i. Environmental Impact Assessment (EIA) Enhancement: Spatial data on industrial clusters will strengthen the baseline information required for EIA processes. Developers seeking environmental approvals for new or expanded industrial projects near ESZs will be mandated to consult the ESZ-industrial cluster database as part of their baseline environmental assessment. This will ensure that EIAs accurately reflect existing cumulative pollution pressures rather than assuming a pristine baseline—an earlier methodological weakness that has historically compromised EIA reliability in Pakistan.

ii. No Objection Certificates (NOCs) and Siting Decisions: The mapping data will provide a robust empirical foundation for issuing NOCs, enabling EPA Punjab to impose location-specific conditions, restrict particularly polluting industries within critical buffer zones, and apply the precautionary principle with greater precision. Industries seeking to establish operations within sensitive buffer areas will face stricter scrutiny, enhanced monitoring requirements, and, where necessary, outright restrictions on activities incompatible with ESZ conservation.

iii. Cumulative Impact Management:

A key advancement offered by this initiative is the ability to assess cumulative environmental impacts—a dimension of governance that remains underdeveloped in Pakistan. Cumulative impacts occur when the combined effect of multiple projects, each potentially within permissible limits, results in significant ecological damage. By maintaining an up-to-date, spatially referenced database of industrial activity around ESZs, EPA Punjab can identify pollution hotspots, evaluate total pollutant loads impacting ESZs, and set aggregate emission caps to prevent the gradual degradation of sensitive ecosystems.

iv. Compliance Monitoring and Enforcement:

The mapped database will serve as a strategic tool for prioritising EPA Punjab's inspection and enforcement efforts. By pinpointing industrial clusters adjacent to ESZs, the agency can allocate its resources more effectively, targeting audits at facilities whose non-compliance poses the greatest environmental risk. This risk-based approach marks a significant improvement over the previous ad hoc inspection regime.

8.6 Proximity Assessment: Industrial Impact on Ecological Sensitive Zones

The spatial analysis conducted across Punjab's identified Ecologically Sensitive Zone (ESZ) buffer zones, illustrating industrial concentration, cluster typology, and proximity-based pollution risks, is discussed below:

8.6.1. Lal Suhanra National Park, Bahawalpur

Lal Suhanra National Park is a premier conservation area and the first UNESCO-declared Biosphere Reserve in Pakistan. Its global environmental significance stems from the rare convergence of three distinct ecosystems within its boundaries. The park functions as a "living laboratory" under UNESCO's Man and

the Biosphere (MAB) programme, testing sustainable desert management and eco-tourism models.

Within a 15-kilometre radius of the park, there are 52 industrial units and, within 25 kilometres, 216 brick kilns. This represents a substantial concentration of industrial and brick kiln activity. The high density of brick kilns, in particular, poses significant risks of air and soil pollution to this protected biodiversity hotspot, necessitating thorough environmental assessments and strategic planning for any new development projects in the vicinity.

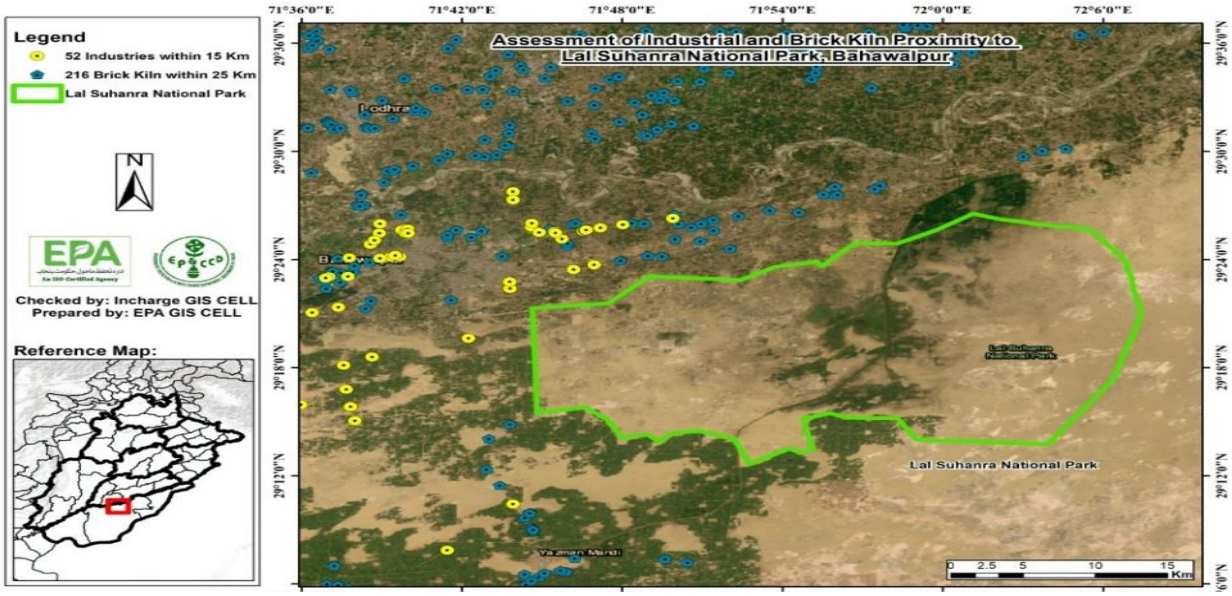


Figure 8.2: Industrial and Brick Kilns Cluster around Lal Suhanra National Park

The accompanying map displays the locations of industrial units and brick kilns surrounding Lal Suhanra National Park.

8.6.2. Changa Manga Plantation Forest, Kasur

The environmental significance of Changa Manga Forest is increasingly highlighted by its role as a defensive ecological barrier against severe industrial encroachment. Situated in the Kasur District, the forest is encircled by a dense "industrial ring" comprising 108 industrial units and 152 brick kilns within a 15-kilometre radius. This concentration exposes the ecosystem to extreme levels of particulate emissions and chemical pollutants. The close proximity of these high-emission industries poses an existential threat to the forest through air pollution,

heavy metal accumulation in soils, and an elevated risk of illegal deforestation driven by industrial expansion.

To safeguard Changa Manga amid this industrial pressure, the Punjab Environmental Protection Agency (EPA) enforces a stringent regulatory framework focused on technological upgrades and spatial containment. A cornerstone of this approach is the mandatory conversion of the 152 brick kilns surrounding the forest to Zigzag Technology, which optimises airflow to significantly reduce coal consumption and curtail emissions. Additionally, the EPA requires all 108 nearby industries to comply with the Punjab Environmental Quality Standards (PEQS) by installing pollution control equipment such as scrubbers and precipitators to prevent the deposition of toxic pollutants on the forest canopy.

To further counteract the impact of this "industrial ring," the EPA plans to introduce designated Ecological Buffer Zones around clustered industrial units, requiring them to maintain their own green belts. These vegetated buffers will act as biological filters, helping to mitigate pollution before it reaches the forest ecosystem.

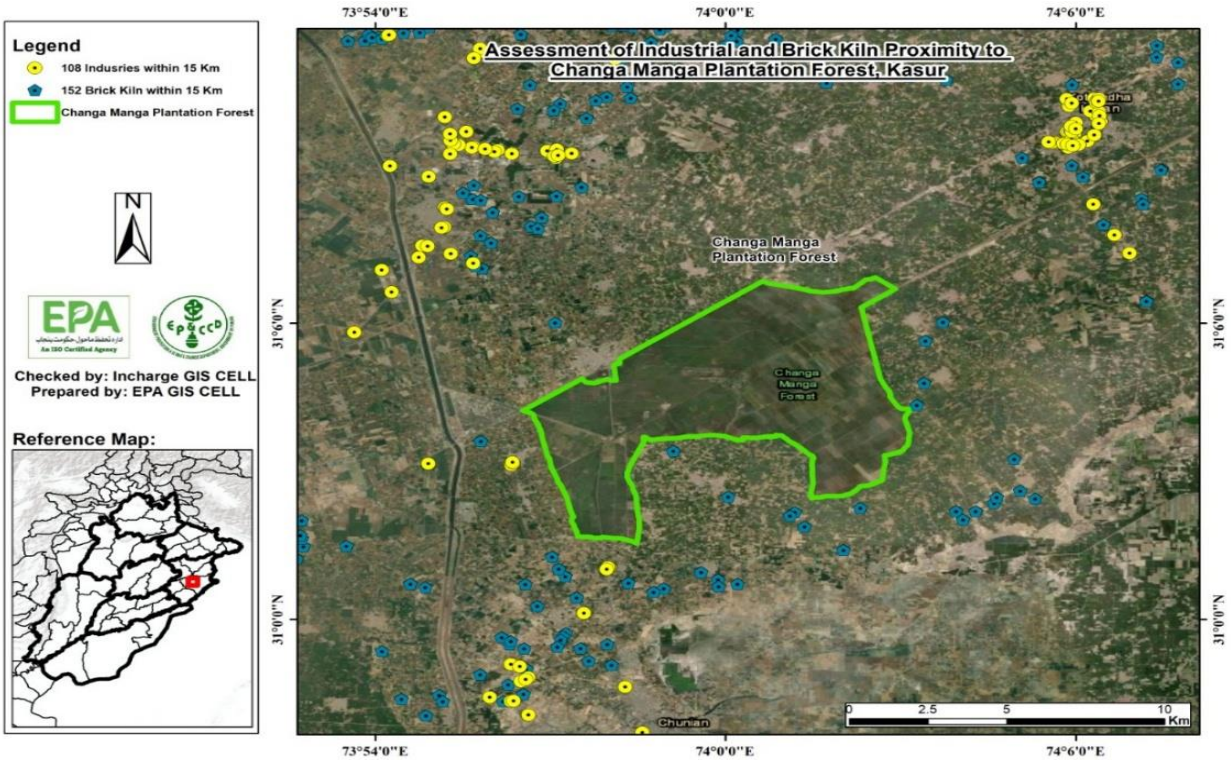


Figure 8.3: Industrial and Brick Kilns Clusters around Changa Manga Plantation Forest

8.6.3. Uchali Lake, Soon Valley (EPA-Notified Sensitive Area)

Uchali Lake, a focal point of the Soon Valley in Khushab, is internationally recognised as a Ramsar Site and legally protected as an EPA-Notified Sensitive Area. Its environmental importance stems from its role as a crucial wintering refuge for thousands of migratory birds travelling along the Central Asian Flyway. The lake is managed under a "Strict Protection" mandate by the Punjab Environmental Protection Agency (EPA), which prohibits industrial development and imposes stringent controls on agricultural runoff to preserve its delicate brackish-saline water chemistry.

As an endorheic basin—meaning it has no natural outflow—Uchali Lake is considered a high-risk zone for toxic accumulation. Consequently, the EPA deploys real-time environmental monitoring and enforces zoning regulations to

balance the lake's hydrological vulnerability with controlled ecotourism activities. This protective status ensures that any proposed project within the vicinity must undergo the most rigorous environmental impact assessment to prevent irreversible damage to one of Pakistan's rare and unique high-altitude wetland ecosystems.

Currently, seven industrial units operate within a 15-kilometre radius of the lake; their locations have been geographically mapped and are presented in the figure below.

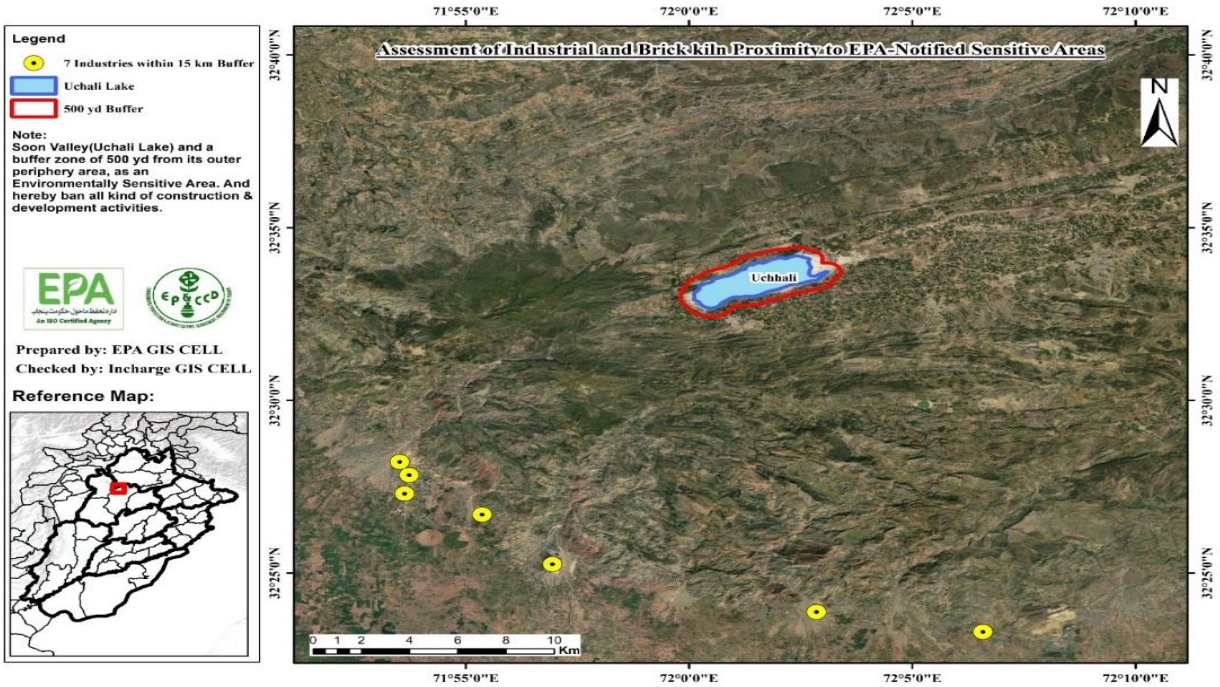


Figure 8.4: Industrial and Brick Kilns Clusters around Uchali Lake

8.6.4. Kahuta Tehsil (EPA-Notified Sensitive Area)

Kahuta Tehsil has been designated as an Environmentally Sensitive Area (ESA), a status that imposes a strict legal prohibition on all construction and development activities to safeguard its vital ecological and watershed functions. This protection faces considerable pressure from an "industrial ring" comprising

84 industrial units within a 6-kilometre buffer zone and one unit located directly on the tehsil boundary.

Given this dense concentration of industries, the Punjab Environmental Protection Agency (EPA) enforces a stringent regulatory regime. By halting new developments within the tehsil and maintaining a rigorous oversight buffer, the EPA seeks to protect the region's natural landscape from the cumulative threats posed by particulate emissions, unauthorised industrial expansion, and habitat fragmentation.

The accompanying map below illustrates the spatial distribution of these industries around Kahuta Tehsil.

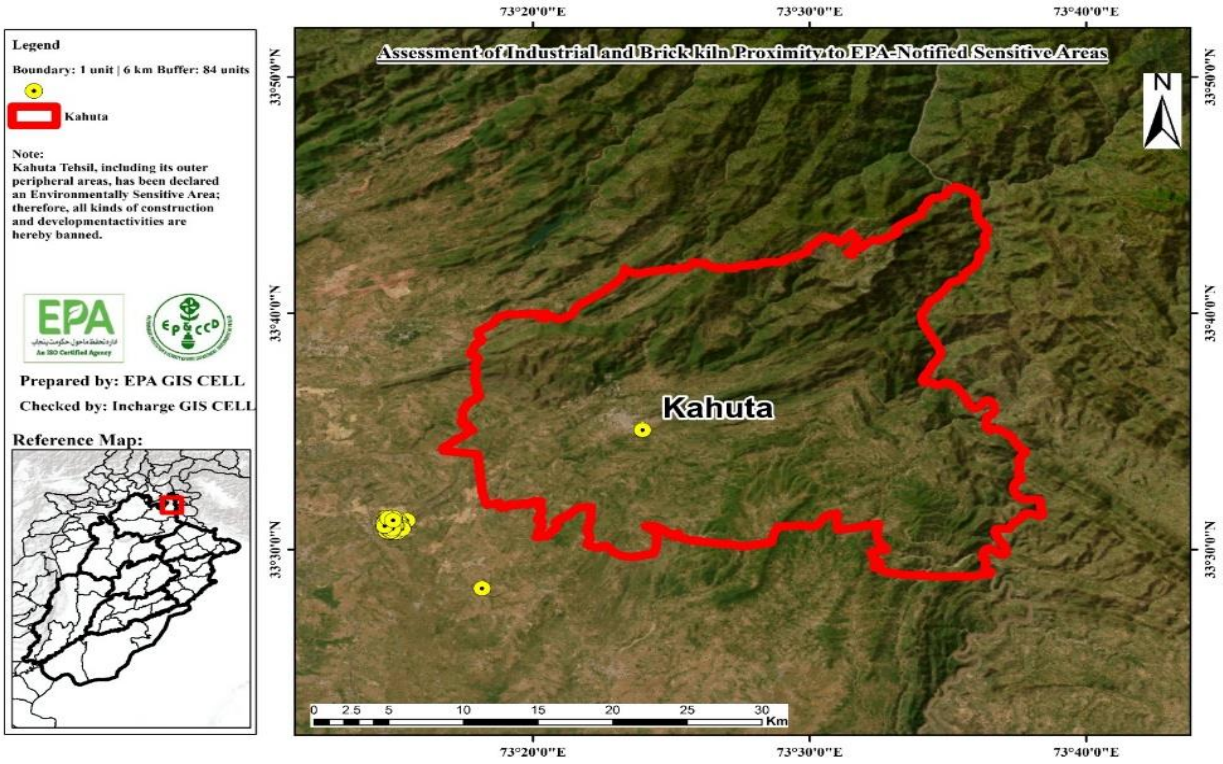


Figure 8.5: Industrial Cluster near Tehsil Kahuta

8.6.5. Jahlar Lake, Soon Valley (EPA-Notified Sensitive Area)

Jahlar Lake, located within the ecologically fragile Soon Valley, is a highly sensitive brackish wetland designated both as a Ramsar Site and an EPA-Notified

Sensitive Area. Currently, the lake faces minimal industrial encroachment, with only two industrial units within its 15-kilometre buffer zone. Nonetheless, a mandatory 500-yard buffer zone around the lake protects its environmental integrity, within which all development is strictly prohibited.

As an endorheic basin with no natural outlet, Jahlar Lake is particularly vulnerable to toxic accumulation from even minor industrial or agricultural runoff. This presents a serious threat to the lake's role as a critical refuge for the globally endangered White-headed Duck. Although the current low density of industrial activity is encouraging, the inherent fragility of the surrounding landscape demands continued and vigilant monitoring by the Punjab Environmental Protection Agency (EPA) to prevent encroachments and ensure that this vital "biological oasis" remains safeguarded amid ongoing regional development pressures.

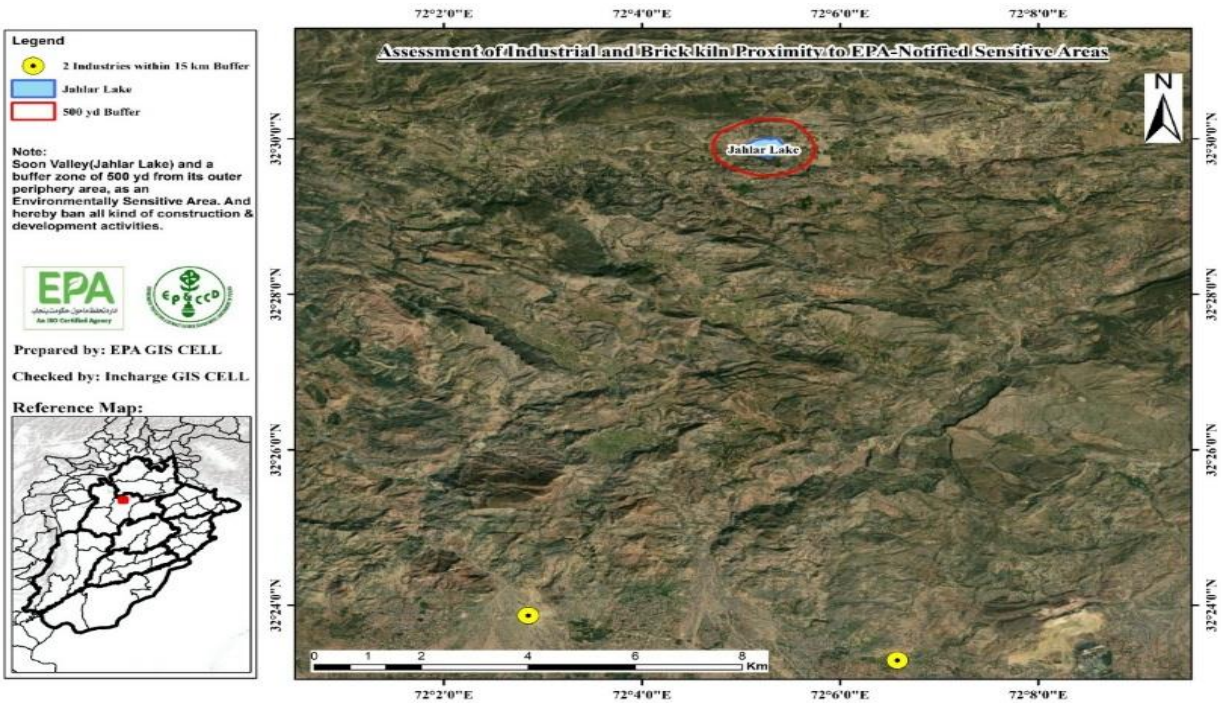


Figure 8.6: Industrial Cluster around Jahlar Lake

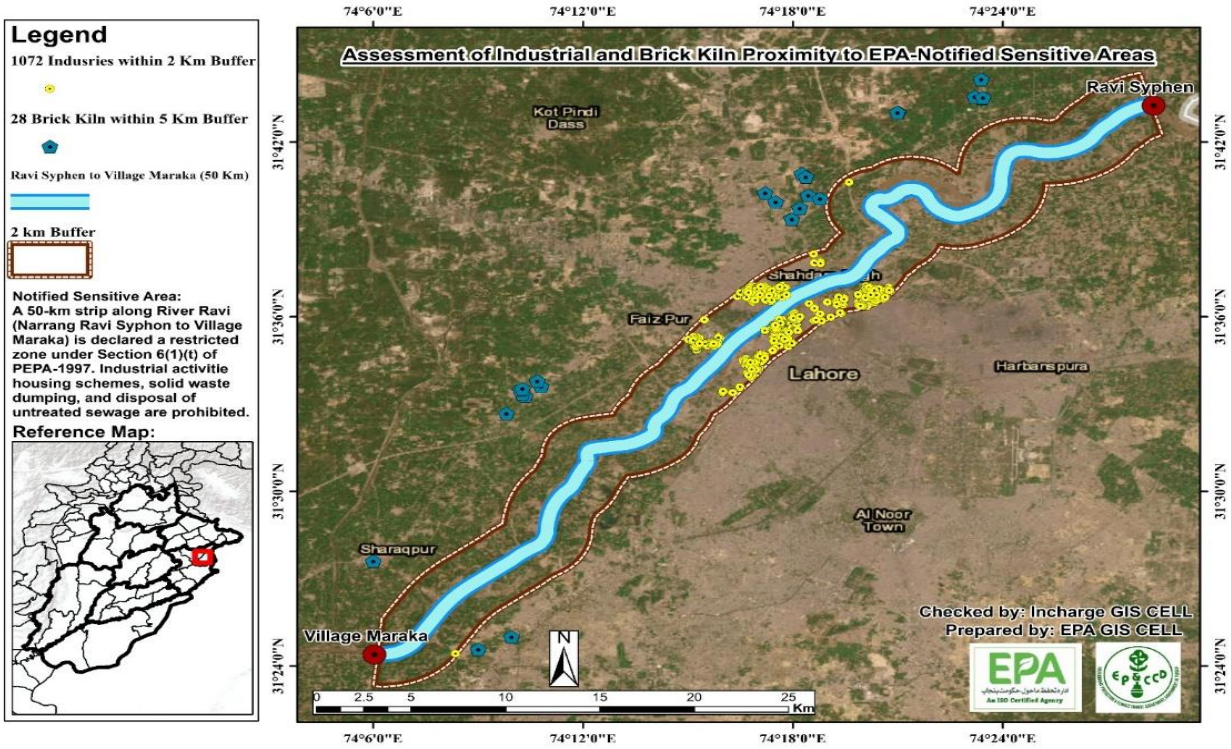
8.6.6. River Ravi Corridor – Ravi Syphon to Village Maraka (50 km stretch)

The 50-kilometre environmentally sensitive corridor along the River Ravi is one of Punjab's most strategically important ecological and hydrological zones. In response to mounting environmental pressures within this corridor, EPA Punjab has conducted a focused spatial assessment to identify industrial and brick kiln clusters operating in close proximity to the river ecosystem. This initiative aims to strengthen evidence-based environmental governance and support targeted enforcement actions.

The spatial analysis identified approximately 1,072 industrial units within a 2-kilometre buffer zone, alongside 28 brick kilns located within a 5-kilometre radius of the corridor. These findings reveal a substantial industrial footprint surrounding the river system and underscore the necessity for enhanced environmental oversight. The River Ravi also functions as a critical groundwater recharge area for Lahore, further emphasising the need for robust ecological protection and pollution control measures.

In response, EPA Punjab has launched regulatory surveillance and enforcement-focused environmental mapping to facilitate compliance monitoring, industrial profiling, and identification of environmentally non-compliant activities within the designated sensitive corridor. To bolster enforcement, a dedicated Special Wastewater Squad has been established to monitor wastewater discharge, manage industrial effluents, and prevent illegal disposal that jeopardises the River Ravi corridor. This squad supports targeted inspections, verifies compliance, and initiates enforcement against polluting units within this ecologically sensitive stretch.

The comprehensive spatial database developed through this initiative, combined with proactive field enforcement, is anticipated to enhance cumulative pollution assessments, enable risk-based inspections, and inform future planning decisions related to industrial siting, environmental approvals, and ecological risk management. This approach exemplifies EPA Punjab's transition toward data-driven environmental regulation, integrating spatial intelligence, industrial mapping, and specialised enforcement to improve the protection of ecologically sensitive areas and vital environmental receptors



across the province.

Figure 8.7: Industrial and Brick Kiln Cluster around River Ravi Corridor

8.6.7. Dharab Lake (EPA-Notified Sensitive Area)

Dharab Lake, the largest water reservoir in the Potohar region, is a legally protected EPA-Notified Sensitive Area and serves as a vital hydrological and ecological anchor for Talagang District. To preserve water quality and the surrounding habitat, Punjab EPA enforces a strict 2-kilometre protected buffer zone where development is heavily restricted. However, current data indicates

moderate pressure from seven industrial units and ten brick kilns operating within a 10-kilometre radius.

Although these figures are comparatively lower than those observed in other industrial corridors, the proximity of these potential pollution sources to a primary freshwater body necessitates targeted regulatory action to prevent sediment runoff and particulate deposition. As of 2026, Dharab Lake is managed through continuous digital surveillance and geo-fencing technology, ensuring that even moderate industrial activity is rigorously controlled to safeguard this crucial regional water resource and designated wildlife sanctuary.

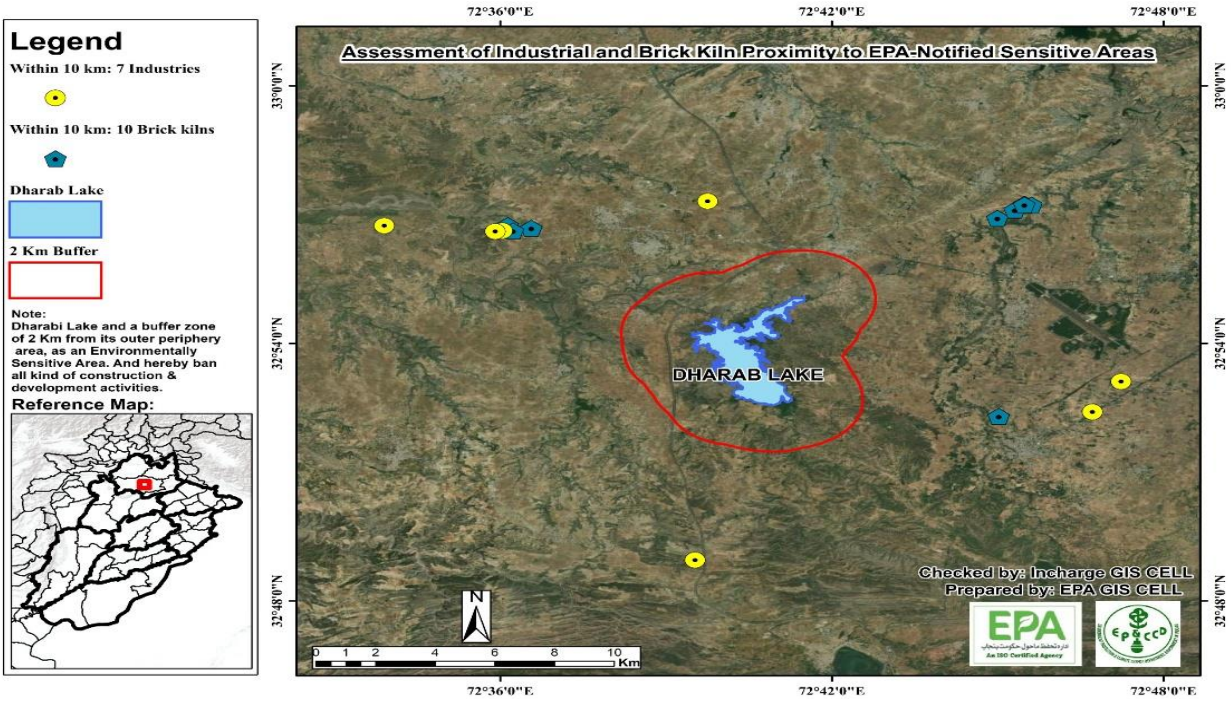


Figure 8.8: Industrial Cluster around Dharab Lake

8.7 Conclusion

EPA Punjab's initiative to map industrial clusters surrounding Ecologically Sensitive Zones (ESZs) represents a critical shift from reactive to proactive environmental governance. The spatial analysis conducted across Punjab's ESZs reveals a consistent and concerning pattern: substantial industrial and brick kiln activity operating in proximity to some of the province's most ecologically vulnerable landscapes.

The findings underscore that many ESZs are subjected to cumulative pollution pressures, which no single Environmental Impact Assessment (EIA) or No Objection Certificate (NOC) review can adequately capture in isolation. Addressing this challenge demands a sustained, spatially informed regulatory framework—one that incorporates the ESZ-industrial cluster database into EIA baseline assessments, reinforces NOC siting decisions, and enables risk-based enforcement prioritising the protection of ecologically sensitive areas.

Ultimately, the long-term sustainability of Punjab's biodiversity, water resources, and ecosystem services hinges on the institutional commitment to translate this spatial evidence into enforceable protections. Implemented consistently, this initiative could establish a replicable model of evidence-based environmental governance for Pakistan as a whole.

CHAPTER 09

Plastic and Hazardous Waste Management



9.1. Introduction

Plastic and hazardous waste management has emerged as one of the most significant environmental governance challenges in Punjab. Rapid urbanisation, industrial expansion, population growth and changing consumption patterns have substantially increased the generation of municipal, industrial, medical, electronic and plastic waste across the province. According to national estimates, Pakistan generates approximately 3.3-3.9 million tonnes of plastic waste annually[49], with Punjab likely accounting for the largest share because of its large dense population and concentration of industrial and commercial activities.

The increasing accumulation of plastic waste has become a major environmental and public health concern across the province. Improper disposal, open dumping and uncontrolled burning of waste contribute to air pollution, contamination of water bodies, blockage of drainage infrastructure, urban flooding and degradation of soil quality. Unlike biodegradable waste, plastics can persist in the environment for decades and gradually fragment into microplastics, which can enter ecosystems and food chains. At the same time, hazardous waste generated by industries, healthcare facilities, laboratories, chemical processes and electronic waste streams poses additional environmental and health risks because of its toxic, corrosive, flammable, reactive, or infectious properties. Under the Punjab Environmental Protection Act 1997, hazardous waste is defined in terms of its potential to cause significant harm to human health, living organisms, property, or the environment if it is improperly handled, stored, transported, treated, or disposed of. The limited availability of scientifically managed treatment and disposal facilities further

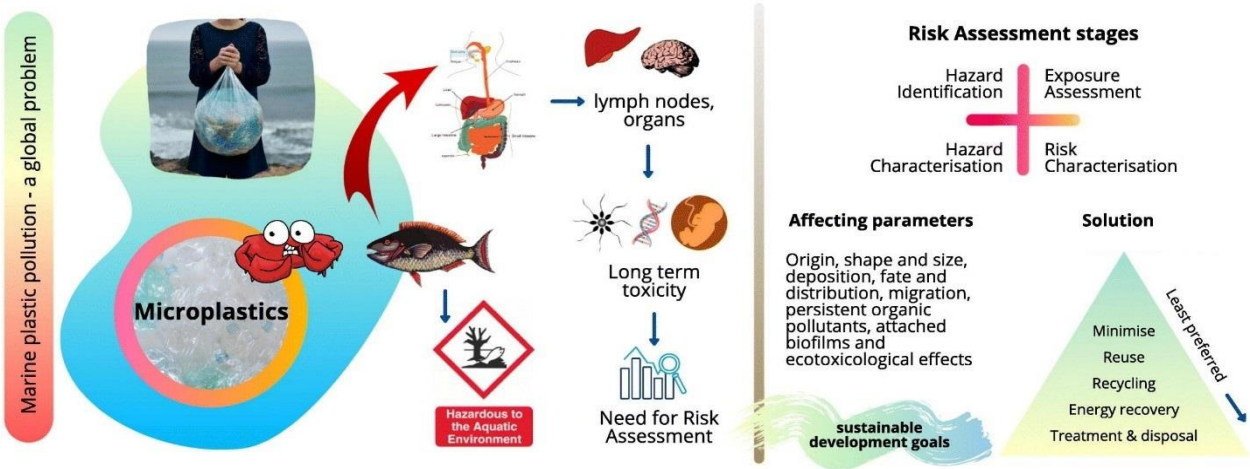
[49] Pakistan generates 3.9m tonnes of plastic waste annually: report

intensifies these risks, particularly in rapidly expanding urban and industrial centres.

Recognizing the growing severity and complexity of these challenges, the Environmental Protection Agency Punjab has increasingly adopted an integrated, regulatory and technology-oriented approach to plastic and hazardous waste management. EPA has strengthened environmental enforcement against harmful waste management practices while promoting safer waste handling, recycling, recovery and disposal mechanisms across the province. Regulatory interventions including restrictions on single-use plastics, monitoring of industrial waste generation, compliance inspections, enforcement actions against non-compliant facilities and promotion of environmentally sound waste management practices reflect the evolving environmental governance framework in Punjab. Simultaneously, initiatives such as Extended Producer Responsibility (EPR), scientific landfill planning and recycling facilitation, and cleanliness campaigns like Suthra Punjab are contribute towards the development of a more resilient and sustainable waste management system. Collectively, these measures can help protect public health, reduce environmental pollution, improve resource recovery and long-term environmental sustainability in Punjab.

9.1.1. Escalating Plastic Pollution and Its Environmental Consequences

Plastic waste in Punjab had become a serious environmental and infrastructural challenge, particularly in major cities like Lahore, Faisalabad and Multan, where non-biodegradable materials including polyethylene bags and PET bottles, clog drainage and sewerage systems and contribute to recurrent urban flooding. The situation is particularly critical in the River Ravi, which has become an ecologically stressed system due to the large-scale discharge of untreated municipal and industrial wastewater and solid waste into the river. This has led



to the accumulation of plastic

Figure 9.1 Micro Plastic in Food Chain[50]

debris in downstream areas like Head Balloki, effectively transforming the river into a plastic corridor. A major component of this pollution is microplastics, which are tiny plastic particles primarily composed of polymers such as polyethylene and polypropylene. These particles have been reported at concentration exceeding 16,000 particles per cubic metre near urban drainage channels. These microplastics particles are dominated by fine fibres and posed significant

[50] Yuan, Z., Nag, R., & Cummins, E. (2022). Human health concerns regarding microplastics in the aquatic environment-From marine to food systems. *Science of the Total Environment*, *823*, 153730.

ecological and health risks because they can be readily ingested by aquatic organisms and are difficult to remove through conventional water and wastewater treatment systems.50 Alongside plastic pollution, Punjab is also facing a parallel challenge from hazardous industrial waste generated by rapidly expanding industrial clusters.

9.1.2. Hazardous Waste and Industrial Vulnerability

The hazardous waste crisis in Punjab extends across major urban and industrial centres, including Lahore, Faisalabad, Sialkot, Gujranwala and Gujrat, creating a province wide ecological challenge in which industrial development has been accompanied by significant environmental presurres. [51] In Sialkot, leather tanneries discharge untreated chromium laden effluents into drainage such as Aik Nullah, contributing to contamination of surrounding soils.[52] In Gujranwala, metal finishing industries release contaminants, including lead and mercury, which can enter surrounding ecosystems. [53] Faisalabad's extensive textile industry generates substantial quantities of dyes, acid and other chemical residues that enter canals and drainage networks, affecting both soil and water quality. [54] In Lahore, chemical, pharmaceutical and steel recycling industries generate hazardous material, including toxic sludge, oils and solvents. Improper disposal of these wastes at informal sites and inadequately managed landfills can result in leaching into groundwater and contamination of surface water bodies, including the River Ravi.[55] Across these industrial clusters, the historical absence or limited availability of centralised Treatment, Storage and Disposal

[51] Urbanunit.gov.pk | Regional Development Plan of Gujranwala.pdf
[52] Assessment of various heavy metals level in groundwater and soil at tannery manufacturing areas of three mega cities (Sialkot, Lahore and Karachi) of Pakistan – Science Direct
[53] Comparative analysis of heavy metals toxicity in drinking water of selected industrial zones in Gujranwala, Pakistan | Scientific Reports
[54] 12339297_03.pdf
[55] EIA River Training.pdf

Facilities (TSDFs), together with inadequately engineered landfills and weaknesses in regulatory enforcement has increased the risk of hazardous substances entering soil, groundwater and surface water systems. These cumulative pressures pose persistent environmental and public health risks and may adversely affect agricultural productivity, urban sustainability, and the well-being of affected communities. Addressing these challenges requires integrated hazardous waste management, improved treatment and disposal infrastructure, stronger regulatory enforcement, and enhanced monitoring of industrial waste streams.

9.2. The Regulatory Shift and Future Outlook

To strengthen long-term environmental sustainability, Punjab is gradually shifting from conventional waste management practices towards more integrated and circular economy approaches. The province has introduced several initiatives including the Suthra Punjab (Clean Punjab) campaign, alongside strengthened enforcement of the Punjab Environmental Protection Act. The province is also promoting Extended Producer Responsibility (EPR), under which producers are increasingly expected to assume responsibility for the environmental impacts associated with their products and packaging, including their management at the end of life stage. Furthermore, integrating the informal waste sector including the number of waste pickers who contribute substantially to recycling and material recovery, into a formal, protected workforce is essential. Moving forward, greater attention is being given to Waste to Energy options and the development of scientifically designed sanitary landfills and other appropriate disposal facilities to ensure the safe management of residual and hazardous waste while reducing risks to groundwater and surrounding ecosystems. Building on these regulatory reforms and sustainability objectives, Punjab further strengthened its plastic reduction commitments during 2025.

9.2.1. Plastic Reduction Commitments and Strategies

The Government of Punjab advanced its Plastic-Free Punjab vision in 2025 as a comprehensive environmental and socioeconomic reform agenda. Under the leadership of the Chief Minister, the Mission Zero Plastic initiative progressed from policy formulation towards implementation focused measures aimed at reducing non-biodegradable and single use plastics while promoting a circular economy principles. A key development during the year was the introduction of the Green Credit Program, which encouraged public private partnerships to establish plastic collection machines in major cities and educational institutions. These systems offered financial incentives of up to Rs. 1,000 for bulk deposits to encourage public participation. The initiative was integrated with the broader Suthra Punjab campaign, which emphasised resource recovery, including the use of recycled plastics in road construction and other public infrastructure.[56]

[56] Green Credit Program

The regulatory framework in 2025 was firmly anchored in the Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Products) Regulations, 2023, which were enforced across the province. These regulations prohibited the manufacture, sale and distribution of plastic bags with a thickness of less than 75 microns and dimensions smaller than 12x16 inches.57



Figure 9. 1: Single Use Plastic Enforcement

A major institutional advancement was the mandatory implementation of the Plastic Licence Management Information System (PLMIS), which required producers, collectors and recyclers to register and obtain the relevant environmental approvals. By early 2025, strengthened enforcement had improved regulatory oversight and brought previously informal operations within the formal compliance framework.

To ensure effective implementation at the grassroots level, District Plastic Management Committees were made operational across the province. Working

[57] Punjab launches "Plastic-Free Punjab Pledge" campaign

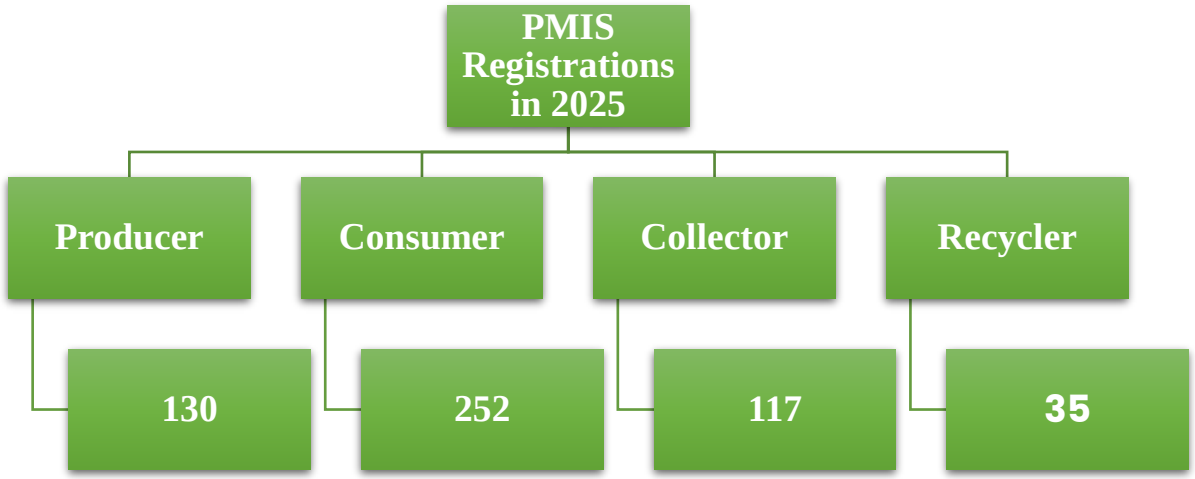
under the supervision of deputy commissioners, these committees coordinated inspections, engaged local businesses and addressed violations in both urban and rural markets. Enforcement efforts were further strengthened through the deployment of Environment Protection Force (EPF) squads, which carried out 113,153 inspections and confiscated more than 419 tons of illegal plastic during the year. In addition, EPA Punjab issued 7942 notices and imposed fines of more than 8.1 million to the violators.[58] A standardised penalty regime-imposed fines ranging from Rs. 5,000 to Rs. 50,000, while stricter provisions under the Suthra Punjab Authority Act 2025 introduced penalties of up to Rs. 500,000, along imprisonment for serious environmental violations.[59] As part of these reforms, EPA Punjab also introduced mandatory registration mechanisms to improve transparency, traceability and accountability across the plastic supply chain.

9.2.2 Producer Responsibility & Mandatory Registration

A major regulatory milestone in 2025 was the mandatory registration of all stakeholders in the plastic value chain through the Plastic Management Information System (PMIS). Effective from January 1, 2025, this system required producers, suppliers, collectors and recyclers to create digital profiles, disclose production volumes and provide details of their recovery mechanisms as a

[58] Daily Situation Report - EPA Punjab
[59] The Suthra Punjab Authority Act 2026

prerequisite for lawful operation. As a result of this initiative, a total of 130 producers, 252 consumers, 117 collectors and 35 recyclers were registered in the system. In addition, 361 licences were issued, while 173 applications remained under process. This reform enhanced transparency and enabled the Environmental Protection Agency (EPA) Punjab to improve its understanding and



mapping of the plastic supply chain across the province.

To facilitate compliance, EPA Punjab conducted stakeholder engagement sessions and training workshops in key industrial cities including Lahore, Faisalabad, Gujranwala and Multan. The PMIS framework played an important role in formalizing previously undocumented sector, strengthening enforcement capacity and establishing a foundation for future Extended Producer Responsibility (EPR) mechanisms. By linking registration data with enforcement activities, authorities were better positioned to identify high risk operators, reduce unauthorized plastic flows and promote a more accountable and traceable

Figure 9.2: Data of PMIS Registrations in 2025

system for plastic production and recycling.

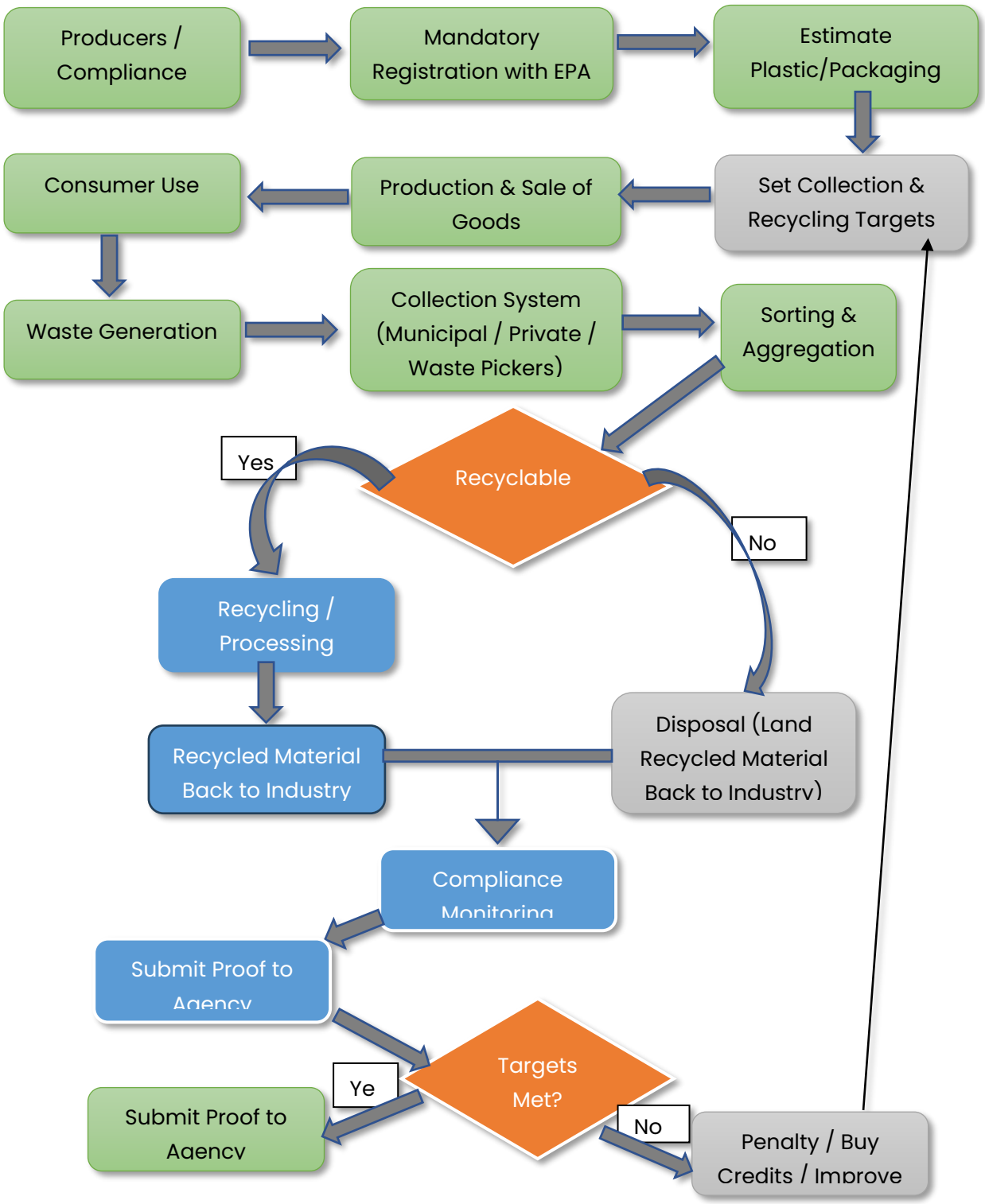


Figure 9.3: EPR Mechanism under Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Products) Regulations, 2023[60]

9.2.3 Transition from Plastic Waste to Circular Economy

While the implementation of PMIS and mandatory stakeholder registration strengthened regulatory oversight and traceability across Punjab's plastic value chain, EPA Punjab also recognised that sustainable plastic waste management could not rely on enforcement mechanisms alone. The growing scale of plastic consumption and waste generation required a broader transition towards circular economy principles, with greater emphasis on waste recovery, recycling and public participation. In this context, the province gradually moved from a predominantly compliance-based approach towards incentive-driven environmental governance, aimed at encouraging behavioural change among citizens, businesses and local communities. This transition provided a foundation for innovative initiatives that sought to link environmental responsibility with economic incentives, thereby promoting plastic waste recovery, resource recovery, and greater circularity at the community level.

9.2.4 Green Credit Program, 2025

A cornerstone of Punjab's 2025 plastic recycling and circular economy strategy is the Chief Minister Punjab Green Credit Program (CMPGCP), an incentive-based mechanism designed to operationalise sustainable environmental practices among citizens and institutional stakeholders. The CMPGCP establishes a quantifiable reward system through which verified environmental actions are could be converted into Green Credits, with each valued at PKR 10,000 and a maximum incentive of PKR 100,000 per participant programme cycle.[61] The programme's scope encompasses a multi-dimensional sustainability framework, incentivising activities.

[60] Plastic Regulations 95 of 2023

[61] CM Punjab Green Credit Program 2026 – Earn Up to Rs100,000

The CMPGCP 2025 initiative aimed at promote public participation in sustainable practices.[62] The programme encouraged citizens, institutions and communities to undertake environmentally responsible activities, including tree plantation, waste recycling, renewable energy adoption, rooftop gardening and environmentally friendly transportation through a green credit incentive mechanism.[63]

The programme also supported climate resilience, cleaner urban environments and Punjab's broader sustainable development objectives by encouraging long-term environmental responsibility and public stewardship. Among its notable interventions was the Cash for Bottle Initiative, which operationalised the programme's circular economy objectives through a targeted mechanism for plastic collection and recycling.

[62] CM Punjab Green Credit Program | CM Special Monitoring Unit
[63] CM Punjab Green Credit Program 2025 – Full Guide

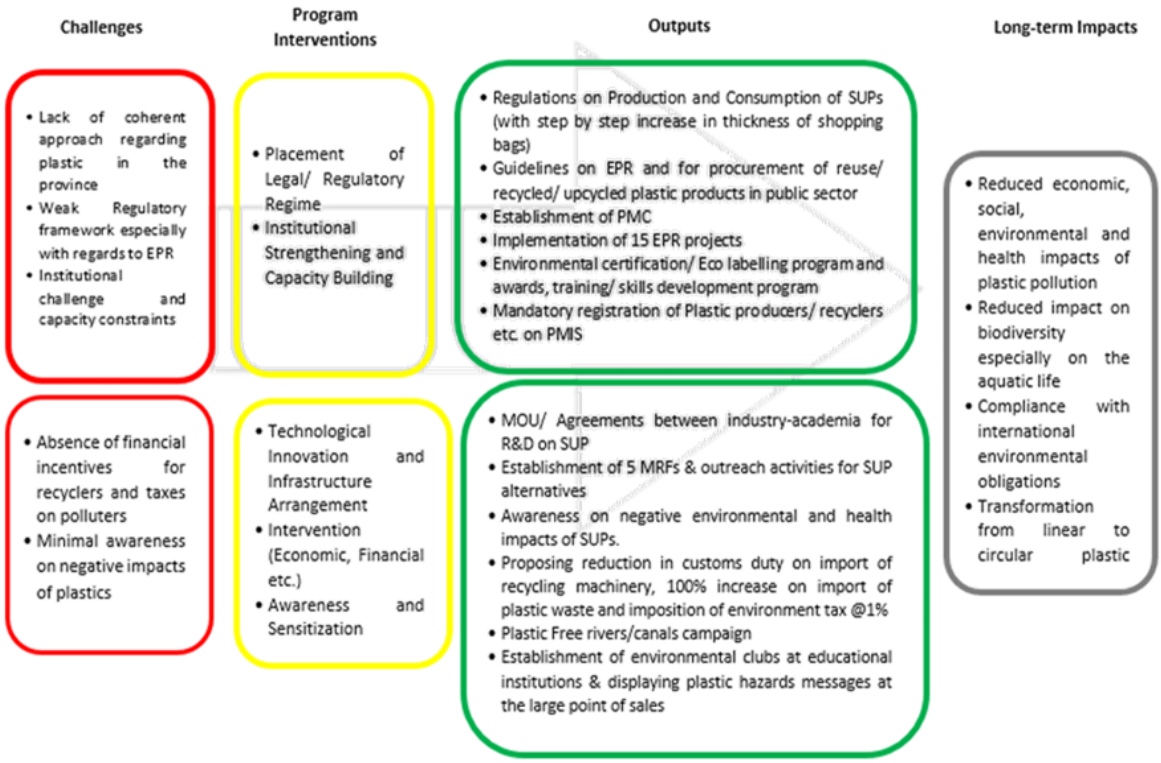
9.3. Plastic Recycling in Punjab

Plastic recycling in Punjab has gradually moved beyond basic collection measures towards a structured circular economy framework under the oversight of the EPA Punjab. These recovery efforts have been linked with provincial enforcement operations, through which confiscated plastic materials can be redirected to regulated recycling and repurposing streams. Rather than treating plastic waste as residual refuse, the policy direction increasingly emphasises its potential as a recoverable resource, integrating recycling objectives into broader



environmental governance and sustainable production strategies adopted during the year.

Beyond enforcement and seizures, districts also pursued public education, stakeholder registration and compliance initiatives. Producers, distributors, recyclers and collectors were encouraged to register with EPA systems to improve tracking and accountability, while media campaigns and direct outreach by EPA officials were used to raise awareness and promote compliance. Across the province, public awareness campaigns, the imposition of fine ranging from thousands to tens of thousands of rupees, confiscations of prohibited plastic material, sealing of non-compliant premises and coordination with law enforcement agencies reflected a broad and sustained effort to implement the



plastic regulation and strengthen compliance throughout 2025.

Figure 9.4: Theory of Change Diagram for Plastic Management Strategy[64]

Following large-scale enforcement activities, EPA Punjab developed structured post-confiscation recovery mechanisms for seized plastic materials.

9.3.1. Post-Confiscation Handling and Recovery

Rather than treating confiscated plastic as waste destined for disposal, Punjab has adopted a recovery-oriented approach aligned with circular economy principles. The province has promoted an integrated recovery framework that seeks to reduce reliance on conventional disposal methods such as landfilling or incineration which can generate secondary environmental hazards including soil contamination and harmful emissions.[64] Under this approach, confiscated plastics is treated as a recoverable resource, supporting the province's broader circular economy objective and long-term environmental sustainability strategy.

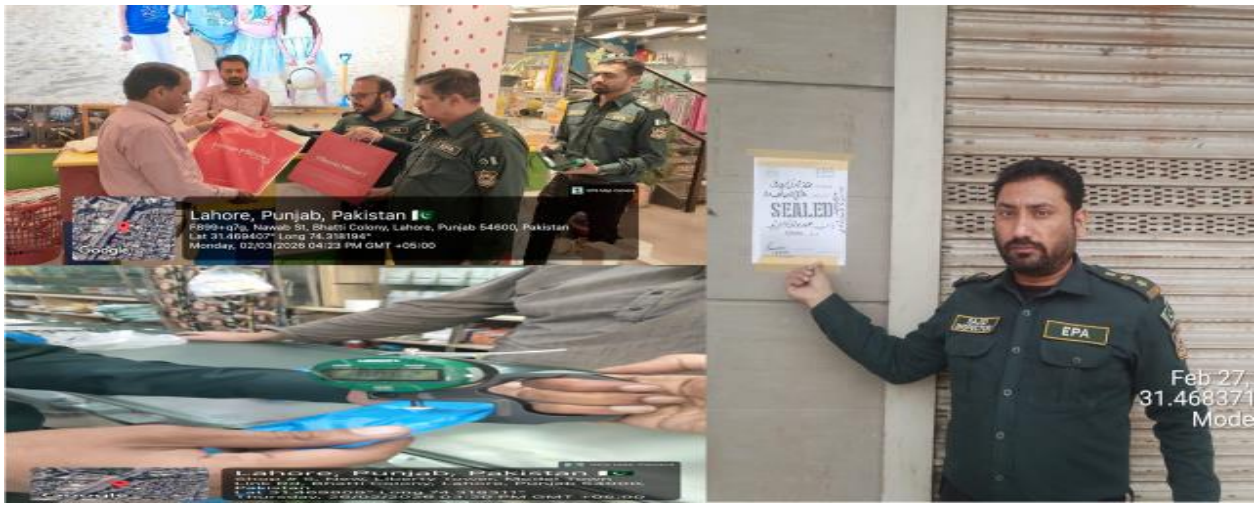


Figure 9. 5: Single Use Plastic Inspection and Confiscation Activities

The first step in the process involved systematic segregation and characterization of seized plastics material. The materials were sorted according to polymer type, such as polyethylene and polypropylene and assessed based on their level of contamination to determine the most appropriate recycling or repurposing pathway. Contaminated or mixed waste streams were processed under controlled conditions to minimise potential health environmental risk. This

[64] the-plastic-management-strategy-punjab-pdf.pdf

step improved the efficiency of subsequent recycling operations and enhanced the quality of recovered materials, increasing their suitability for conversion into durable products and construction material.

Recovered plastics were subsequently repurposed into a range of value-added products, including eco-bricks, pavement tiles, road maintenance aggregates, school furniture, hospital benches and public seating. Notably, 100 chairs made from recycled material were provided to a Government Primary School in



Figure 9. 6: Plastic into Chairs

Sahianwala, Faisalabad, demonstrating the potential social impact of these initiatives.[65]

These efforts served multiple objectives, including reducing the volume of plastic waste sent to landfills, supporting local infrastructure development and generating tangible social benefits for communities. By incorporating recovered plastics into infrastructure and public use products, Punjab linked environmental enforcement activities with resource recovery, urban improvement and public welfare, demonstrating a practical application of circular economy principles.

[65] Directorate of EDH, EPA Punjab

To promote accountability and transparency, Punjab established digital tracking and reporting mechanisms to monitor the movement of confiscated plastics from seizure through to final utilisation. These mechanisms enabled enforcement units, district administrations and recycling partners to coordinate more effectively, minimise material loss or diversion and support regulatory compliance. Training and capacity building programmes were also introduced for enforcement personnel and recycling facility operators, with emphasis on safe handling, proper segregation techniques and documentation procedures. Such measures were particularly important for managing mixed or contaminated waste streams, which may present greater environmental and occupational hazards.



Figure 9.7: Playground Structure made of Recycled Plastic Installed by EPA in a Public Park

Additionally, post confiscation handling was linked with public engagement and awareness initiatives. Local communities, educational institutions and NGOs were encouraged to participate in recovery initiatives including eco-brick production, community infrastructure projects and small-scale recycling operations. These collaborative measures not only expanded the reach of recovery programmes but also reinforced the social value of responsible waste management and encouraged fostering long-term behavioural change.

While enforcement actions, recovery mechanisms and recycling initiatives have strengthened Punjab's plastic waste management framework, achieving long-term environmental sustainability requires a broader societal transition towards responsible consumption and environmentally sustainable behaviour. Recognising that regulatory interventions alone could not fully address the growing challenge of plastic pollution, Punjab has increasingly emphasised community participation, institutional commitment and public ownership of environmental responsibility. In this context, awareness campaigns, voluntary environmental commitments and the establishment of plastic-free zones have emerged as important components of the province's broader strategy to reduce single-use plastic consumption and promote sustainable environmental practices at both institutional and community levels.

9.3.2 Plastic Pledges and Plastic-Free Zones

Plastic pledge initiatives and the establishment of plastic free zones are important measures aimed at reducing the use of single-use plastics and promote environmentally responsible behaviour across Punjab. These initiatives encourage institutions, businesses and communities to adopt sustainable alternatives and minimise plastic waste generation. By establishing district-wise



Figure 9.8: Plastic Pledge and Public Awareness Campaign by EPA Punjab

targets and monitoring performance over time, the programme promote structured implementation and accountability. The categorisation of districts according to size allows for realistic target setting while promoting equitable participation. Overall, these efforts contribute to improving waste management practices and support the province's broader circular economy objectives.

The implementation progress of plastic pledge initiatives and plastic-free zone activities across districts in Punjab. Among the districts, Lahore (5,634), Faisalabad (4,560) and Gujranwala (3,488) demonstrated particularly strong engagement, reflecting substantial participation from communities and institutions. Other districts, including Bahawalpur (3,045), Sargodha (2,315), Sheikhupura (1,638) and Vehari (1,220), also made significant contributions to the province-wide efforts. Collectively, these seven districts accounted for 21,900 plastic pledge activities, accounting for more than half of the total activities and indicating where initiatives achieved the greatest participation. Across Punjab, the EPA recorded a total of 41,238 plastic pledge activities, indicating substantial participation in efforts to reduce single use plastic consumption at both local and provincial levels. The widespread participation highlights the role of awareness campaigns, community mobilization and institutional support in promoting plastic free practices. Overall, these activities represent progress towards encouraging behavioural change, strengthening sustainable waste management practices and advancing Pakistan's broader objectives for environmental sustainability and circular economy development.

9.4. Plastic-Free Zones

Data from districts across Punjab indicate considerable progress in establishing of single use plastic free shopping malls, demonstrating growing participation by the commercial sector in environmental stewardship. The highest number of plastic free areas has been recorded in Lahore with 81 shopping malls adopting plastic-free practices. Other districts have also shown active participation, including 27 areas in Gujrat, 26 malls each in Rawalpindi and Toba Tek Singh and

25 malls in Sahiwal. Similarly, 20 malls in Mianwali and 19 areas in Kasur have implemented plastic-free policies. Additional districts, including Bahawalnagar (13), Dera Ghazi Khan (16), Khanewal (14), Multan (14), Faisalabad (10), Jhelum (10), Kot Addu (10), Okara (10) and Sargodha (10) have also established designated plastic free shopping facilities. These initiatives indicate growing awareness among commercial stakeholders of the environmental impacts of plastic pollution and their willingness to support more sustainable consumption practices.

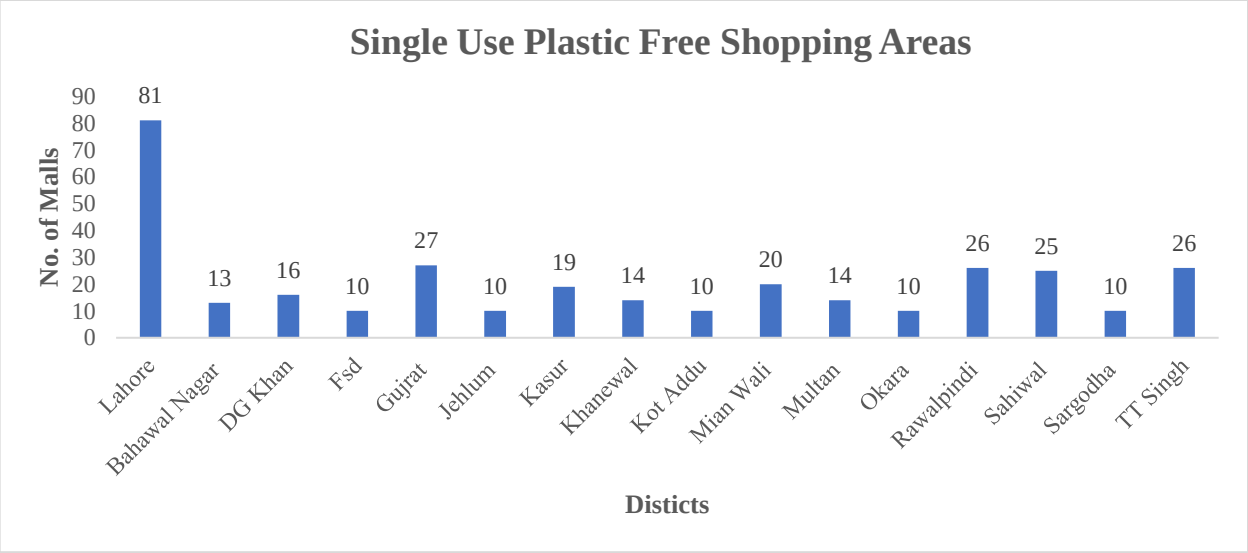


Figure 9.9: Single Use Plastic Free Shopping Areas across Punjab

Beyond commercial shopping centres, these initiatives were also extended to high-footfall motorway service areas across Punjab. Along the major motorways (M-2, M-3, M-4 & M-11) corridors in Punjab, a total of 14 service areas were designated as single use plastic free zones. Of these, five service areas are located along the M-2 motorway, which connects Lahore and Islamabad and is one of the busiest transportation routes in the country. Similarly, five service areas on the M-3 motorway, which connects Lahore with Faisalabad, have adopted plastic free practices. In addition, two service areas each along the M-4 and M-11 motorways have been designated as plastic free zones. These initiatives target locations with high consumer activity and have the potential to reduce the

distribution and disposal of single-use plastic items including plastic bags, disposable cutlery and packaging materials.

The establishment of plastic free malls and motorway service areas contributes to efforts to reduce plastic waste generation and promote more sustainable consumption patterns. By encouraging businesses and service providers to replace disposable plastics with biodegradable or reusable alternatives, these initiatives can help minimise plastic leakage into drainage systems, landfills and natural ecosystems. Such measures may also contribute to reducing microplastic contamination in soil and water resources and lowering the environmental burden associated with plastic waste management. Overall, 438 shopping malls/centres, 14 points on motorways and 37 Sahulat Bazar were designated as single use plastic free zones, as shown in below given figure.

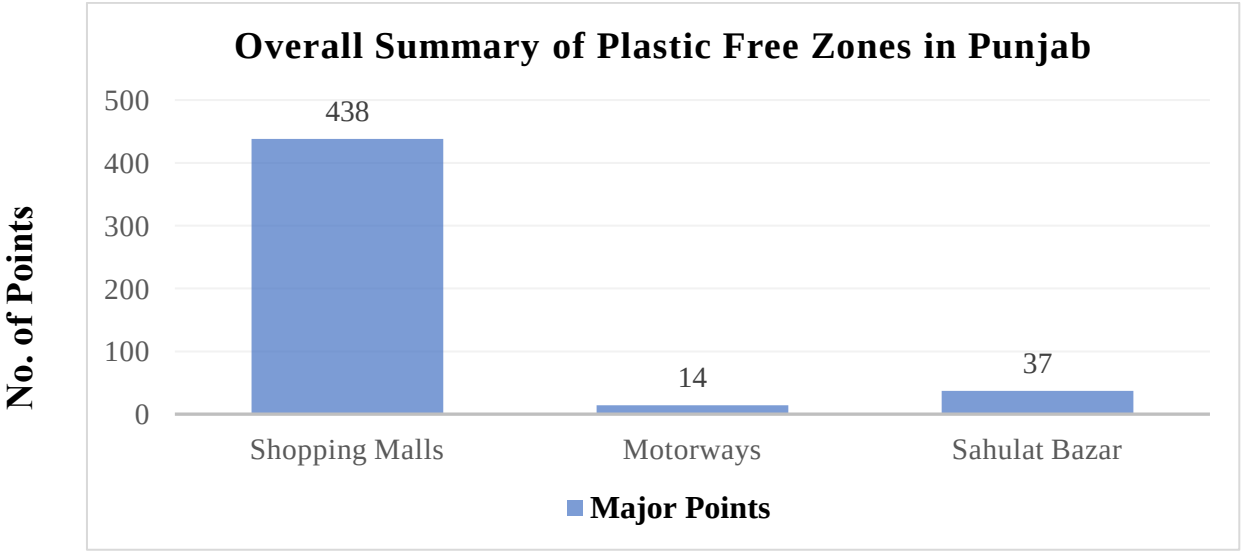


Figure 9.10: Overall Summary of Plastic Free Zones in Punjab

9.4.1 Voluntary Environmental Commitments and Policy Integration

Punjab expanded its strategy for addressing plastic pollution in 2025, by introducing voluntary plastic reduction pledges alongside regulatory interventions under the provincial environmental governance framework. These initiatives were coordinated by the Environmental Protection Agency Punjab to encourage institutions, businesses and civil society organisations to formally

commit to reducing the consumption of disposable plastic products and adopting environmentally sustainable alternatives such as reusable bags and biodegradable packaging materials. [66] Voluntary commitments have been widely recognised in international environmental policy as an important complementary mechanism to regulatory enforcement for addressing plastic pollution and promoting more sustainable consumption patterns. [67] These commitments were further supported through community-based implementation in commercial markets and public spaces.

9.4.2 Plastic-Free Markets and Community Participation

In Punjab, several commercial areas across major cities were targeted for the development of plastic free markets. Overall, 37 markets were declared plastic free across the province. In Lahore, key markets such as China Scheme, Chung, Harbanspura, Mian Plaza, Raiwind, Sabzazaar, Sher Shah, Thokar Niaz Baig, Township, Baghbanpura Bazaar and Wahdat Road were included. Faisalabad also implemented similar initiatives in areas such as Jhang Road and Millat Road. These plastic-free markets campaign expanded across the province in 2025. These efforts were implemented with the active support of district administrations in collaboration with local market associations and trader unions. Retailers participating in these initiatives were encouraged to adopt sustainable practices, including providing reusable shopping bags and discouraging the use of conventional single-use plastics, thereby promoting more environmentally responsible consumer behaviour. Awareness campaigns targeting shopkeepers and consumers were also conducted to highlight the environmental impacts of plastic waste and encourage responsible purchasing

[66] Welcome to Environment Protection Department | Environment Protection Department
[67] Intergovernmental Negotiating Committee on Plastic Pollution | UNEP - UN Environment Program

practices.[68] Community participation played a critical role in these initiatives, particularly through engagement with schools, universities and civil society organisations which promoted responsible waste management practices and sustainable consumption at the household level.[69]

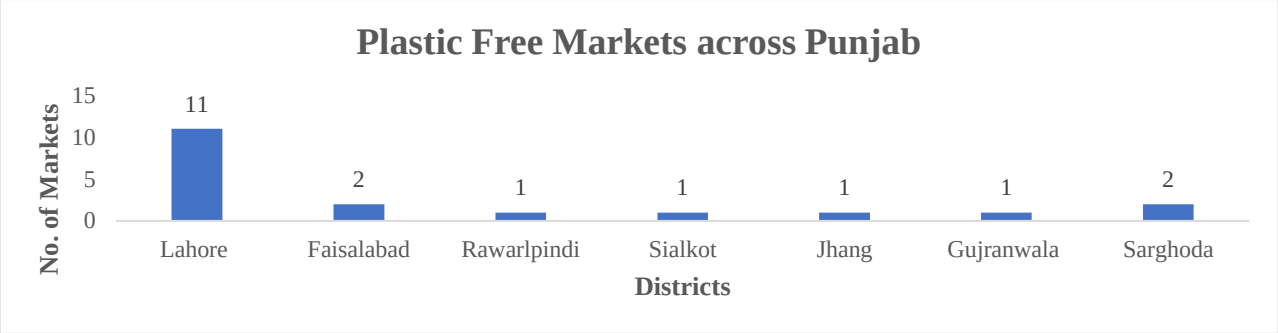


Figure 9.11: Plastic Free Markets across Punjab

9.4.3 Integrated Plastic and Waste Management Approach

EPA Punjab's plastic management initiatives in 2025 reflected a multifaceted strategy encompassing regulatory enforcement, resource recovery, recycling promotion, circular economy integration and community participation. Rather than relying solely on punitive measures, the province adopted a resource recovery approach in which confiscated plastics were channelled into the production of useful products, including construction materials and public infrastructure components. At the same time, initiatives such as plastic pledges, plastic-free zones, voluntary environmental commitments and public awareness campaigns enhanced community participation and encouraged more sustainable consumption practices across Punjab. These measures strengthened regulatory oversight and institutional coordination, reduced the

[68] Ministry of Climate Change and Environmental Coordination
[69] Punjab Government Takes Historic Step to Combat Plastic Pollution | Punjab Portal

potential burden on landfills, and promoted environmentally responsible behaviour at both institutional and community levels.

At the same time, EPA Punjab recognised that long-term environmental sustainability could not be achieved through plastic reduction initiatives alone. Accordingly, alongside plastic management interventions, the Agency broadened its focus to include wider waste management practices, such as waste segregation, recycling awareness and institutional engagement programmes aimed at promoting environmental responsibility among communities and educational institutions. Looking ahead, Punjab environmental strategy should focus on strengthen recycling infrastructure, adopting advanced resource recovery technologies, enhance public-private partnerships and expanding integrated waste management systems to support long-term environmental sustainability and circular economy development across the province.

9.5. Waste Wise School Campaign by EPA Punjab

The EPA Punjab launched the Waste Wise School Campaign in 2025 to promote sustainable waste management practices within the education sector, with schools serving as potential catalysts for long-term behavioural change. Recognizing the important role of schools in shaping environmental habits, the campaign aimed to establish structured practices for source segregation, proper waste disposal and recycling among students and staff. As part of the



Figure 9. 12: Waste Wise Certification of Schools by EPA

initiative, 10 model schools across Punjab were selected as pilot institutions, to serve as demonstration sites for scalable waste management practices.[70] The primary objectives were to improve the efficiency of waste handling, reduce the contamination of recyclable materials, and develop practical knowledge of organised waste management within school environments. The initiative also sought to strengthen environmental awareness among students and encourage them to adopt responsible waste-management practices that could extend beyond the school environment into their homes and communities.

9.5.1. Integrated Waste Wise Management Implementation across Schools

The programme's foundation was strengthened when EPA Punjab officially notified the "Waste Wise Management" framework, a regulatory mechanism designed to standardise waste management practices across educational institutions. This notification provided a formal framework for implementation, transforming waste management from a voluntary practice into a structured institutional initiative. By formalizing these guidelines, EPA Punjab provided schools with a clear framework for compliance and encouraged the adoption of consistent environmental standards aimed at reducing waste and improving resource recovery.

Following this official notification, schools were equipped with five colour-coded bins specifically designed for the separate collection of paper, glass, organic waste, metal and plastic. To facilitate source segregation, the bins were strategically placed in high-traffic areas including classrooms, laboratories, cafeterias and playgrounds. This placement helped integrate waste segregation

[70] 'Waste wise management bins': Coca-Cola Pakistan partners with EPA - Business & Finance - Business Recorder

into routine school activities and made appropriate disposal more accessible to students and staff.

To complement the physical infrastructure, the initiative incorporated a comprehensive visual environmental education component. Schools received environmental education boards and instructional signage illustrating the principles and importance of waste segregation. These materials served as regular reminders of the Waste Wise Management protocols and helped reinforce environmentally responsible waste-disposal practices. This combination of infrastructure and visual education was intended to support positive behavioural change among students and promote longer-term sustainable waste-management practices.

The initiative combined infrastructure, education and monitoring to strengthen waste management across 41 districts. A total of 7,246 waste bins were installed, including 4,476 in public schools and 2,770 in private schools, indicating broad implementation across Punjab.

To complement the waste bins, a visual learning component was introduced in 4,177 certified schools, benefiting 4,475 students participating in waste wise activities. Districts such as Faisalabad (331 schools), Gujranwala (264 schools) and Lahore (83 schools) demonstrated the integration of waste management infrastructure and awareness. Similarly, in Sahiwal (297 schools) and Kasur (165 schools) were certified under the waste wise management framework. The use of instructional boards and signage helped students understand appropriate waste segregation practices. On the operational side, schools were equipped to

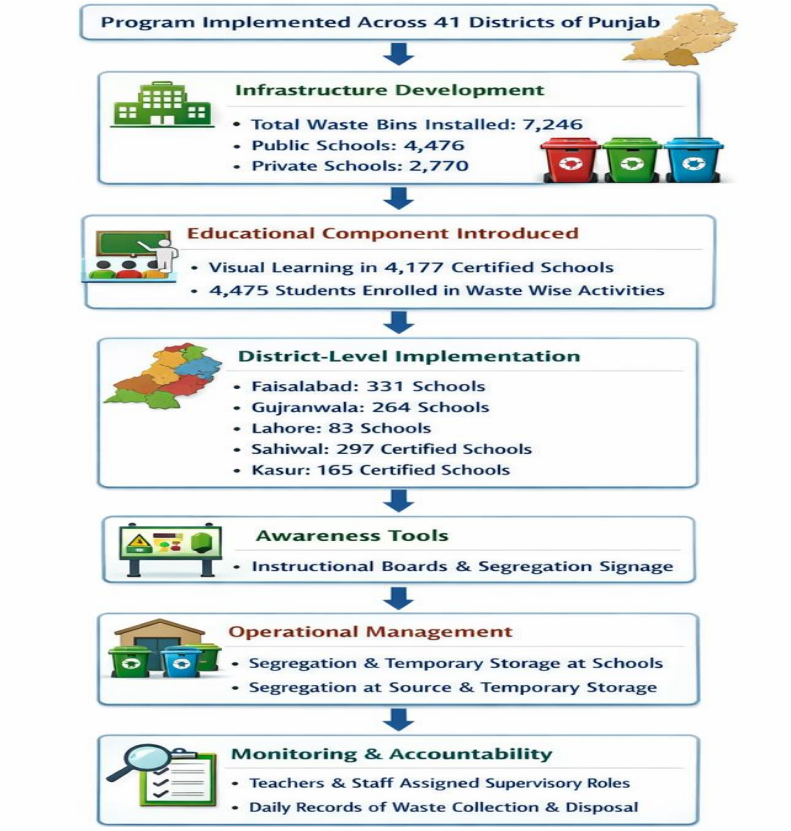


Figure 9. 13: Integrated Waste Wise Management Implementation

manage and temporarily store segregated waste effectively, helping ensure that waste collection efforts remained effective. Teachers and administrative staff across the districts were assigned supervisory responsibilities and maintained daily records of waste collection and disposal, thereby strengthening accountability and monitoring.

9.5.2. Operational and Environmental Benefits

The campaign generated several tangible operational benefits. Source segregation enabled schools to streamline waste collection and minimise the mixing of recyclable and non-recyclable material. This improved the efficiency of subsequent recycling and recovery processes and reduced the volume of waste requiring final disposal. Schools also reported lower levels of contamination in recyclable waste streams, contributing to improve quality of recovered materials and potential cost savings for waste management authorities. Moreover, by implementing structured segregation and monitoring within a controlled institutional environment, schools provided a practical model that could potentially be adapted for other institutional settings, including healthcare facilities. The experience demonstrates how consistent procedure, staff engagement and routine monitoring can support improved compliance, resource recovery and sustainable waste management outcomes.[71]

9.5.3. Public Health and Community Linkages

While primarily focused on schools, the campaign also had broader public health and community implications. By introducing structured waste handling





[71] 'Waste wise management bins': Coca-Cola Pakistan partners with EPA

practices, students learned how source segregation can reduce the risk of contamination, unpleasant odours and pests activity associated with poorly managed waste. When these practices were carried over into homes and communities, they supported provincial objectives related to cleaner neighbourhoods and safer environmental conditions. The programme also demonstrated the potential of educational institutions to serve as operational testbeds for waste management initiatives, linking institutional practices with community engagement. In addition, the emphasis on safe handling, segregation, record-keeping, and responsible disposal reinforced principles that are relevant to **healthcare waste management**, where proper handling and traceability are essential for protecting public health and the environment.

9.5.4. Outcomes and Future Prospects

Participating schools documented measurable improvements in waste segregation and material recovery following the implementation of the Smart Waste Management initiative. Under the EPA Punjab directive, educational institute were required to install five colour coded waste bin for the separate collection of **paper, glass, organic waste, metal, and plastic** by 30 September 2025. The requirement facilitated source segregation and supported the routing of recyclable materials into appropriate recovery streams. Schools complying with the EPA requirements were eligible for **"Smart Waste Certified"** status, providing an additional mechanism for promoting adherence to waste-segregation and monitoring practices.[72]

Operational monitoring by relevant education authorities and EPA field teams indicated improved compliance with designated waste disposal protocols following implementation. The introduction of source segregation enabled better

[72] Educational institutions: EPA makes placement of waste segregation bins mandatory - Pakistan - Business Recorder

separation of recyclable material including paper, plastic and metal, compared with previous practice of disposing of mixed waste. EPA inspections commenced on **1 October 2025** following the government directive, providing a mechanism for monitoring compliance and identifying gaps in implementation.[73]

Municipal waste collection arrangements were also linked with the initiative through mechanisms such as the Punjab Waste Management Helpline (1139) and supported by the provincial Suthra Punjab integrated waste management framework. These arrangement provided a mechanism for the collection and onward management of segregated waste, supporting the objectives of source segregation and resource recovery. [74] The initiative therefore provides a potentially replicable operational framework for extending structured waste segregation to additional educational institutions in both urban and rural areas of Punjab. It is also consistent with the broader objectives of the Suthra Punjab programme, which integrates waste collection, resource recovery, recycling, and related waste-management services across the province.[75]

Moving forward, EPA Punjab can integrate lessons from the Waste Wise School Campaign with wider provincial waste initiatives, Structured engagement with educational institutions can support the development of sustainable waste management practices while strengthening environmental awareness among student and staff. Improved linkages between source segregation, reliable collection, recycling infrastructure, and monitoring systems could contribute to reduced waste disposal, enhanced resource recovery, and improved environmental outcomes.[74] Similar principles can also be adapted to other institutional settings, including the healthcare sector, where appropriate

[73] CM Maryam launches 'smart waste management' drive in Punjab schools - Pakistan Today - Pakistan Today

[74] Punjab schools ordered to install colour-coded bins

[75] Suthra Punjab – Clean Punjab Program, Services, Portal, Billing & Jobs

segregation, safe handling, treatment, and traceable disposal are essential for managing high-risk medical waste streams.

9.6. Hospital Waste Management and Compliance

The management of hazardous and biomedical waste in Punjab has become a critical component of public health governance, particularly within the healthcare sector. If improperly handled, biomedical and hazardous waste poses serious risks to healthcare workers, patients and the surrounding environment. Punjab's dense population and extensive network of hospitals, clinics and laboratories generates substantial volumes of both infectious and non-infectious waste daily. Over time, the province has developed a more structured waste management system incorporating legal regulations, operational protocols, certified waste management firms and more recently, digital tools for monitoring and compliance. By 2025, Punjab had taken further steps to formalise waste-management procedures, strengthen institutional accountability, and promote the use of innovative technologies to support safer, more efficient, and environmentally sustainable healthcare-waste management practices.

9.6.1. Hospital Waste Generation in the Healthcare Sector

Punjab had developed one of the largest and most extensive healthcare systems in the country, significantly contributing to the generation of hospital waste. The province's healthcare network comprised 1,188 dispensaries, 2,583 Basic Health Units (BHUs) and 359 Rural Health Centres (RHCs), which formed the backbone of primary healthcare services, particularly in rural and underserved areas. These facilities played an important role in providing preventive care, basic treatment and maternal and child health services.[76]

[76] Hospital_Waste_Study_EDH

At the secondary and tertiary levels, the public healthcare system included 128 Tehsil Headquarters Hospitals (THQs) and 29 District Headquarters Hospitals (DHQs), which served as important referral centres for more advanced medical care. In addition, 59 teaching hospitals operated across Punjab, offering specialised healthcare services while also serving as training institutions for

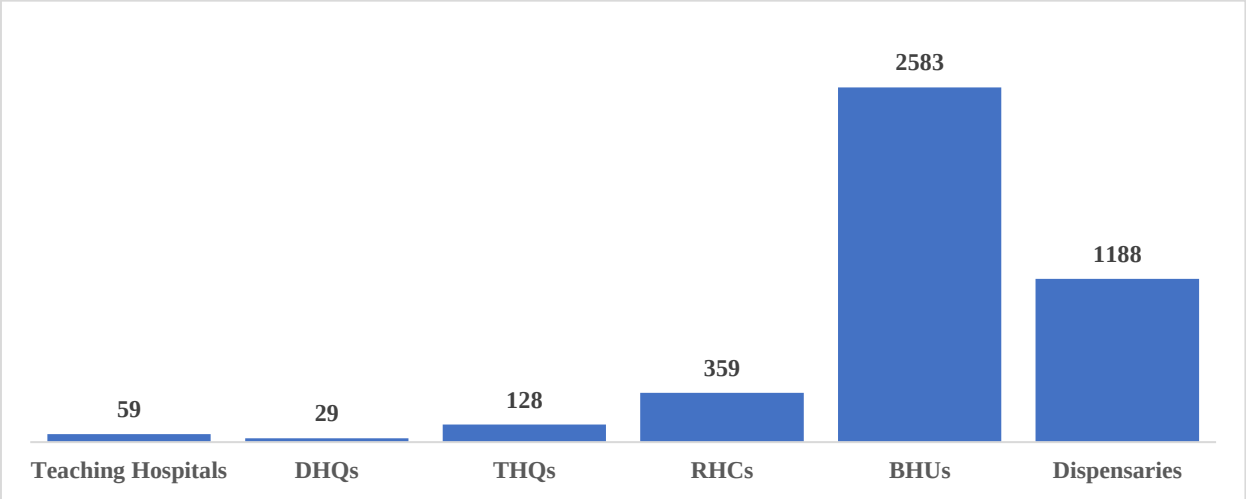
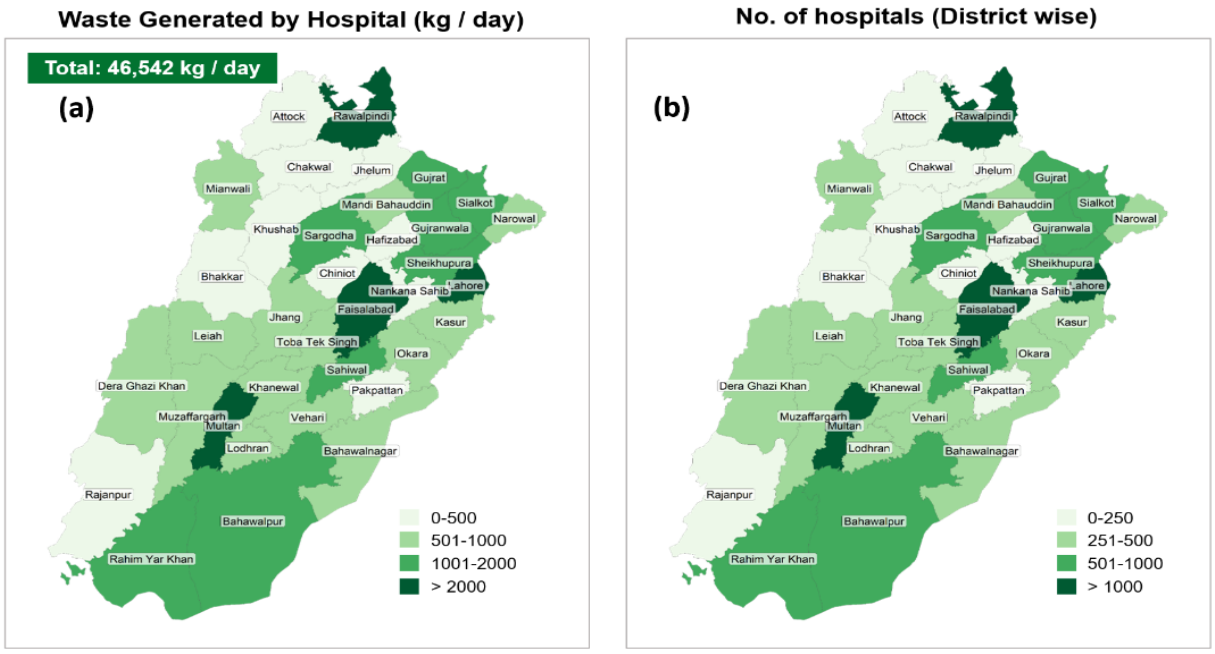


Figure 9.15: Network of Healthcare Facilities across Punjab[76]

healthcare professionals. Alongside the public sector, the private healthcare industry had expanded rapidly, with more than 19,000 private hospitals, clinics and diagnostic centres contributing significantly to healthcare delivery.[76]

The scale of Punjab's healthcare infrastructure resulted in the generation of approximately **46,542 kg of biomedical waste per day**, including infectious materials, sharps, pathological waste, and pharmaceutical residues. The substantial volume and potentially hazardous nature of these waste streams present significant challenges for their safe segregation, handling, treatment, and disposal, with potential risks to public health and the environment.

Recognising these challenges, the **Environmental Protection Agency (EPA) Punjab** undertook regulatory and capacity-building measures in accordance with the **Hospital Waste Management Rules (HWMR), 2014**. These measures included regulatory oversight, compliance monitoring, capacity building, promotion of source segregation, implementation of colour-coded waste-management systems, and adoption of appropriate treatment technologies.



Collectively, these interventions were aimed at strengthening healthcare-waste management practices and reducing the associated risks to healthcare workers, communities, and the environment.

9.6.2. Regulatory Framework and Risk Waste Classification

The regulatory framework for healthcare waste management in Punjab is anchored in the Punjab Hospital Waste Management Rules (2014), which establish clear definitions for risk and non-risk waste categories and outlines responsibilities across the healthcare system. Risk waste includes infectious waste, sharps, pathological materials, laboratory residues and chemical or pharmaceutical by-products with potential to cause harm. Non-risk waste encompasses everyday hospital waste such as paper, packaging and general refuse.[77]

The classification of risk waste ensures that hazardous materials are handled safely and efficiently. Infectious, sharps, pathological, chemical and laboratory wastes are segregated at the point of generation into colour-coded, labeled

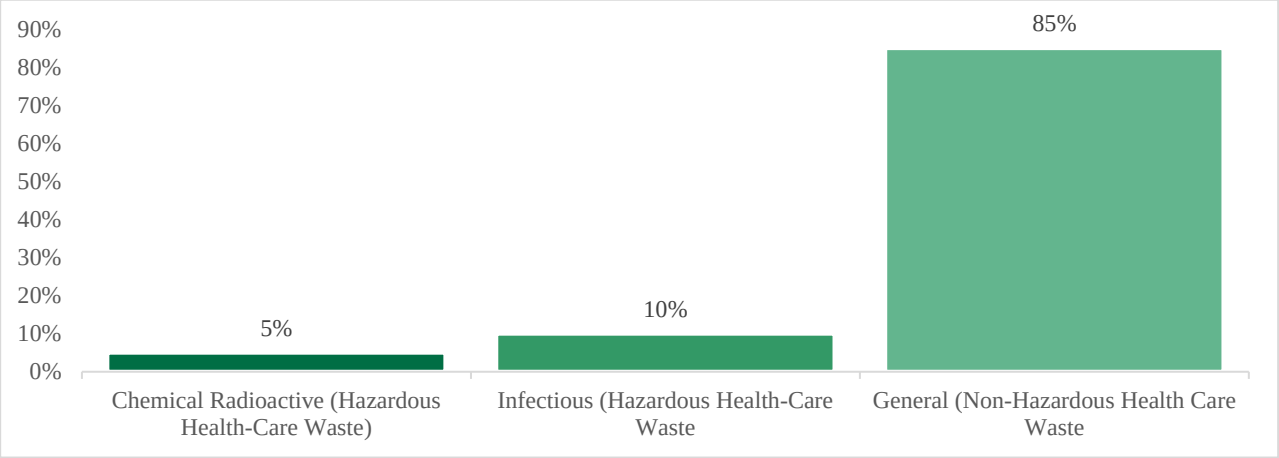


Figure 9.17: Waste Composition in Healthcare Facilities[76]

containers, enabling targeted treatment such as autoclaving, chemical disinfection, or incineration. Non-risk waste is separated for routine disposal without specialised treatment.

[77] Hospital Waste Management Rules (2014)

As illustrated in Figure 9.21, **approximately 85% of healthcare waste generated during the reporting period was classified as non-hazardous**, while infectious waste accounted for approximately **10%**, and chemical and radioactive hazardous waste represented approximately **5%**. This distribution is important for waste-management planning because, although the majority of the waste stream is relatively low risk, the smaller proportion of hazardous waste requires specialised handling, treatment, and disposal to minimise risks to healthcare workers, patients, communities, and the environment.

By clearly classifying and segregating waste into these categories, healthcare facilities can improve worker safety, optimise treatment processes, reduce environmental risks, and strengthen regulatory compliance. In 2025, EPA Punjab further strengthened healthcare-waste governance through enhanced monitoring and compliance mechanisms, including digital approaches to reporting and oversight. These measures can improve transparency, facilitate more timely identification of non-compliance, and complement periodic field inspections. Clear regulatory standards also promote consistency across healthcare facilities of different sizes and capacities by providing defined requirements for the safe management of healthcare waste.[77]

9.6.3. Segregation and On-Site Handling

Segregation of risk waste at the point of generation is a critical measure for preventing contamination and minimising environmental hazards across healthcare facilities in Punjab. In accordance with the Punjab Hospital Waste Management Rules 2014, healthcare facilities required to separate waste into



Figure 9. 18: Segregation of risk waste

designated categories using colour-coded and labeled bins. Segregation should take place immediately at the point of generation, including in wards, operating theatres, laboratories, and diagnostic areas, to prevent hazardous materials from being mixed with general or recyclable waste.

As illustrated in Figure 9.23, the waste-management process begins with **segregation at source using colour-coded containers**, followed by safe collection by designated personnel using appropriate **personal protective equipment (PPE)**. Infectious waste bags are then weighed, labelled, and securely sealed before being transported to designated storage areas. Where applicable, infectious waste is transferred to **temperature-controlled yellow rooms** for temporary storage prior to collection and treatment. The figure indicates that these storage areas are maintained at approximately **3–8°C**, with infectious waste generally collected within **24 hours** and subsequently transported to

authorised treatment facilities. At the treatment facility, the waste is weighed before undergoing appropriate treatment, including incineration where applicable.

This structured workflow demonstrated that segregation is not an isolated activity but an integral component of the broader healthcare waste management chain. Effective segregation at source can reduce the mixing of hazardous and non-hazardous waste, improve the efficiency of subsequent collection and treatment processes, and reduce potential occupational and environmental risks.

Effective segregation can also generate operational and environmental benefits. By ensuring that infectious waste is appropriately separated from general waste, healthcare facilities can avoid unnecessarily subjecting non-hazardous materials to energy-intensive treatment processes such as incineration. This can reduce the volume of waste requiring specialised treatment, improve storage and transportation efficiency, and potentially reduce associated management costs. Proper segregation also helps minimise the risk of accidental exposure and environmental contamination. Published studies in comparable healthcare jurisdictions have shown that poor segregation contributes to over 30% of occupational exposure incidents, highlighting the critical role of this first step in the risk waste management chain.

9.6.4. Storage, Transportation and Treatment

Safe storage and transportation of risk waste are critical for minimising human and environmental exposure. Hospitals and healthcare facilities maintain dedicated storage areas, commonly referred to as "yellow rooms," for the temporary containment of infectious waste. These areas are maintained under controlled temperature conditions between 3°C and 8°C, to support safe temporary storage prior to treatment and disposal. In accordance with the Punjab Hospital Waste Management Rules 2014, storage areas should be secure,

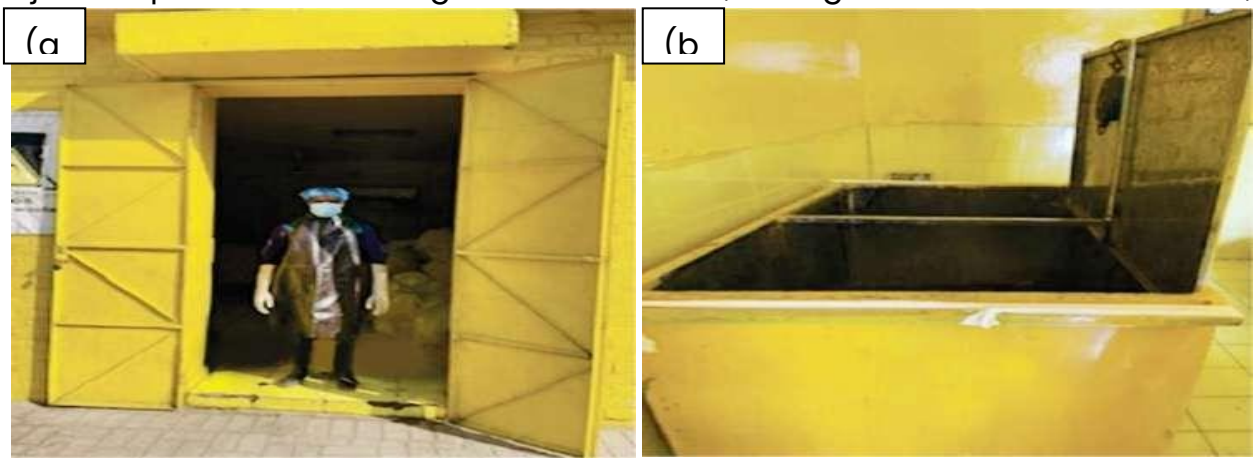


Figure 9.19: Hospital Waste Storage (a) Yellow Room & (b) Waste Trolley

well-ventilated and clearly marked with appropriate biohazard signage. Facilities should also maintain records of waste type, documenting type, quantity, point of generation and storage duration to ensure traceability and compliance with applicable storage requirements.[77]

EPA Punjab and provincial health authorities strengthened monitoring of healthcare waste storage practices during 2025. Monitoring focused on storage conditions, access control, ventilation, hygiene and proper documentation. Physical security measures, including restricted access and CCTV surveillance, were also strengthened where required. Staff training and internal monitoring further supported compliance with safe handling and storage procedures.

Transportation of risk waste was also formalised across healthcare facilities to improve accountability throughout the collection and transfer process. Vehicles

used for off-site transportation were required to use secure, leak-proof containers or compartments to minimise the risk of spillage and exposure. Where available, GPS tracking and digital consignment documentation supported real-time monitoring and traceability of waste movement. Personnel involved in

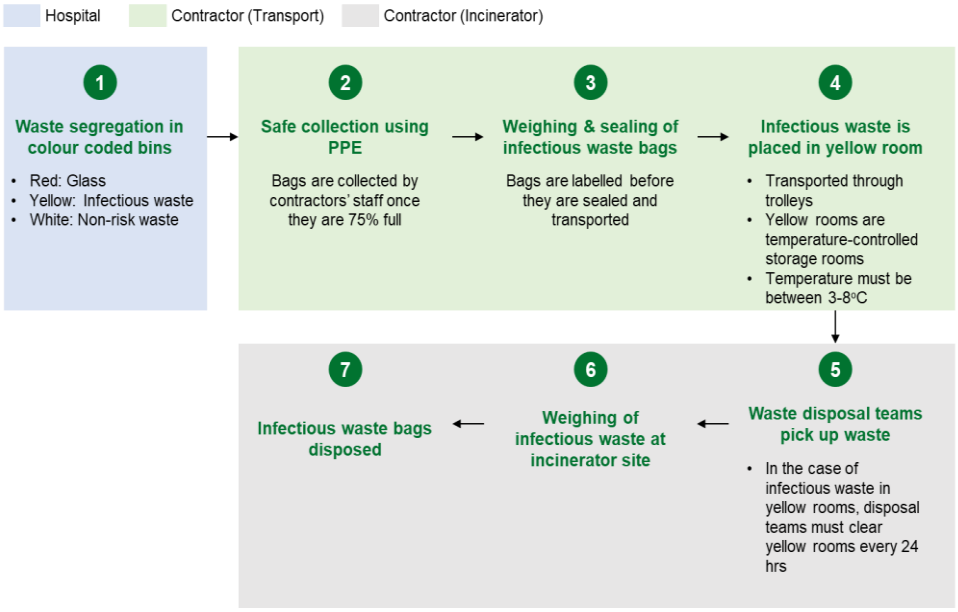


Figure 9. 20: Process for disposing infectious hospital waste

collection and transportation were required to follow appropriate **personal protective equipment (PPE)** protocols. These measures are consistent with the principles of the 2014 Rules, which require healthcare waste to be safely collected, contained, transported and appropriately documented.

Healthcare waste management involves a systematic process beginning with segregation at the point of generation, followed by collection, safe storage, transportation and appropriate treatment or disposal. Colour-coded containers are used to separate different waste categories, while infectious waste is transferred to designated storage areas before treatment. Depending on the nature and characteristics of the waste, appropriate treatment technologies may include incineration, autoclaving, microwave treatment or chemical disinfection.

According to Punjab Health Statistics (2024), an estimated 21,256 kg of hospital waste was generated daily in Punjab's public healthcare sector, including

approximately 3,188.9 kg of infectious waste. Punjab had 48 public-sector incinerators, with a combined installed capacity of approximately 4,450 kg per hour. Of these, eight were reported as non-functional. Nevertheless, the reported installed capacity was considered sufficient to accommodate the estimated infectious waste generated by the public healthcare sector.[78]

Treatment practices during 2025 increasingly incorporated alternatives to conventional incineration, including **autoclaving, microwave treatment and chemical disinfection**, where appropriate for specific waste categories. The use of treatment methods suited to different waste streams can improve treatment efficiency and reduce unnecessary environmental impacts associated with inappropriate disposal or treatment. .[77]

Overall, Punjab made progress in strengthening risk-waste management during 2025. The **Punjab Hospital Waste Management Rules, 2014**, together with strengthened monitoring and operational practices, provided a regulatory foundation for safer storage, transportation and treatment of healthcare waste. Continued investment in treatment infrastructure, staff capacity, monitoring systems and compliance enforcement will be important for further reducing

[78] Source: Punjab Health Statistics, 2024

occupational and environmental risks and improving healthcare-waste management across the province.

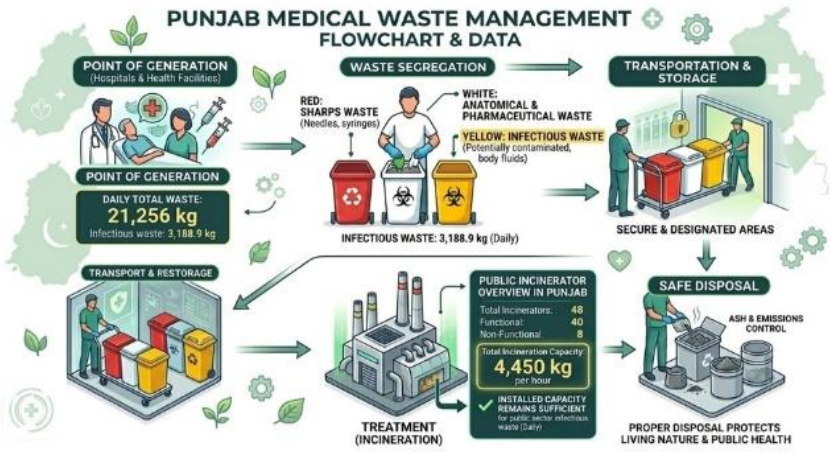
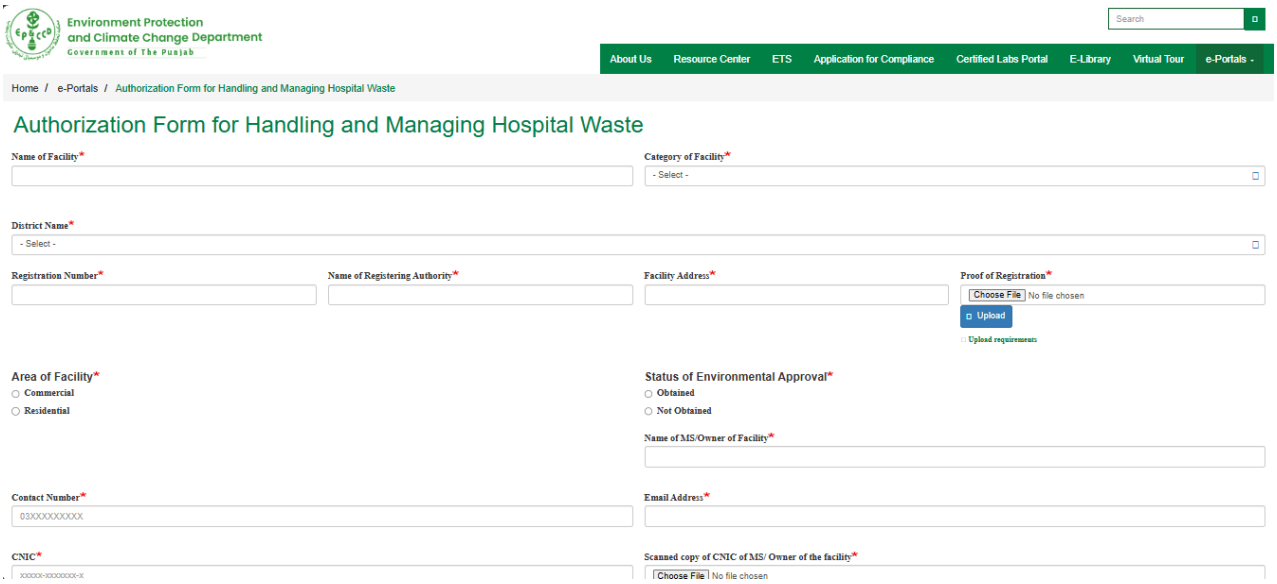


Figure 9. 21: Flowchart and Data of Medical Waste Management in Punjab

9.6.5. Authorisation of Certified Waste Management Firms

Previously, hospitals often relied on in-house waste-handling systems or unregulated third-party operators, resulting in inconsistent practices, weak oversight and significant compliance gaps. These informal arrangements frequently lacked standardised procedures for segregation, transportation and disposal, increasing the risks of environmental contamination and exposure to infectious materials.

In 2025, the Environmental Protection Agency (EPA) Punjab introduced a structured and formal certification system for hospital waste management firms, marking a major step towards institutionalising safe and compliant practices across the sector. Under this system, firms are required to meet defined technical, operational and occupational safety standards before being authorised to operate. This includes the availability of appropriate treatment technologies, trained personnel, proper transportation mechanisms and adherence to environmental safeguards. Certified firms are also subject to periodic audits,



inspections and mandatory documentation to ensure transparency and continuous compliance.[79]

Figure 9.22: Authorisation form for Handling and Managing Hospital Waste[80]

This initiative is closely aligned with Rule 28 of the Punjab Hospital Waste Management Rules "(PHWMR), 2014" which emphasises the authorisation, monitoring and regulation of waste-management service providers by the EPA. The rule provides a legal framework to ensuring that only qualified and authorised entities handle hazardous healthcare waste, thereby strengthening accountability and standardisation across the province.

The certification system has significantly contributed to the professionalisation of the waste management sector. It has encouraged private investment in modern and environmentally sound technologies such as incinerators, autoclaves and secure waste transportation systems. At the same time, it has created a competitive environment where service providers are incentivised to maintain high standards of performance and compliance.

[79] Authorisation Order under Rule 28 of PHWMR 2014.pdf

[80] Authorisation Form for Handling and Managing Hospital Waste | Environment Protection Department

Hospitals have also benefited from this development, as they are now able to outsource waste management responsibilities to certified and competent firms. This allows healthcare professionals to focus more effectively on patient care, while ensuring that waste is handled safely and in accordance with regulatory requirements. Furthermore, the introduction of performance tracking

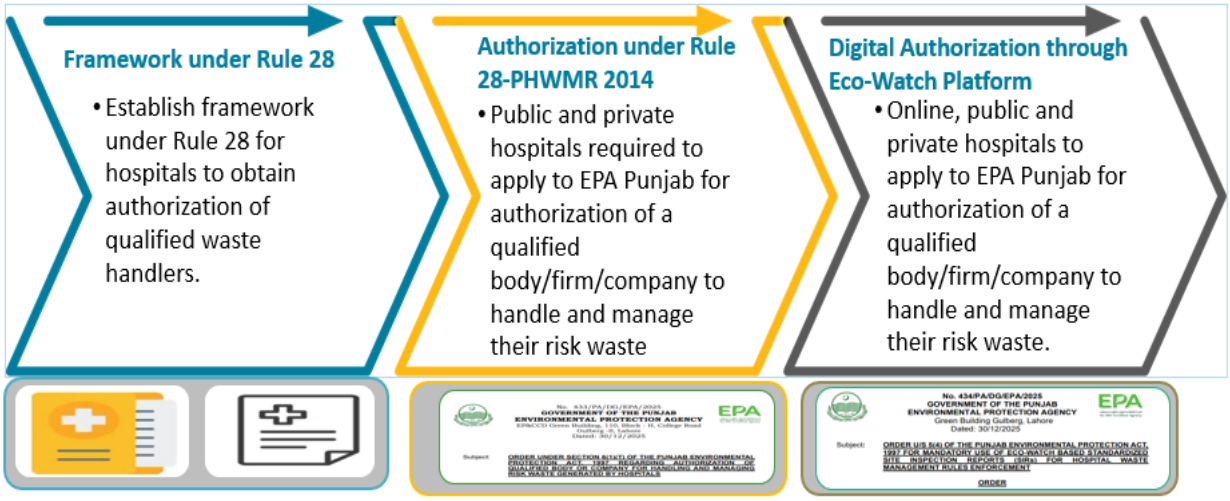


Figure 9.23: Authorisation under Rule 28 of PHWMR, 2014

mechanisms and digital reporting systems has enhanced regulatory oversight. These tools enable real-time monitoring, improve record keeping and make it easier to identify, report and correct violations.

Overall, the integration of a certification regime under the framework of Rule 28 of PHWMR 2014 has established a more reliable, transparent and accountable hospital waste-management system in Punjab, contributing to improved public health protection and environmental sustainability.

9.7. Hospital Waste Mitigation Infrastructure and Compliance

Hospital waste mitigation infrastructure and compliance in Punjab refer to the integrated system of regulatory controls, physical facilities and operational procedures established to ensure the safe segregation, storage, transportation, treatment and disposal of healthcare waste. Governed by the Punjab Hospital Waste Management Rules, 2014 and overseen by EPA Punjab, this framework

combines standardised infrastructure with digital monitoring and enforcement mechanisms to minimise environmental and public health risks, while ensuring consistent compliance across healthcare facilities.

9.7.1. Monitoring, Inspection and Compliance Enforcement

The effectiveness of hospital waste mitigation infrastructure was closely linked to monitoring and enforcement mechanisms during the reporting period. The Environmental Protection Agency (EPA) Punjab conducted regular inspections to evaluate compliance with established standards and to assess the operational status of waste management infrastructure within healthcare facilities. These inspections played a crucial role in identifying gaps between policy requirements and on-ground practices.



Figure 9. 24: Hospital Waste Management Practises in Punjab

Figure 9.29 highlights the conditions observed during inspections, including instances of non-compliance such as improper segregation, inadequate storage, or delays in waste transfer. These observations underscored the persistent challenges faced by healthcare facilities in fully implementing the prescribed waste management protocols. They also emphasised the importance of continuous monitoring to ensure that mitigation measures remained effective and that risks to human health and the environment were minimised.

Enforcement actions were supported by regulatory provisions under the Punjab Hospital Waste Management Rules, 2014, which required healthcare facilities to promptly address identified deficiencies. Through follow-up inspections, warnings and penalties, when necessary, the EPA ensured that ensure continued

compliance over time. During the last year, this combination of monitoring, visual verification and enforcement reinforced the overall integrity of the hospital waste management system, ensuring that mitigation infrastructure operated effectively across the healthcare sector.

Enforcement actions are supported by regulatory provisions, ensuring that healthcare facilities address deficiencies and maintain compliance over time.

9.7.2. Infrastructure Performance and Waste Generation Trends

Punjab's healthcare waste generation continues to be substantial and is expected to increase in line with population growth and the expansion of healthcare services. Public hospitals generated approximately 19,467 kilograms of infectious waste daily, while private hospitals contributed about 27,076 kg, highlighting the significant cumulative burden on the provincial waste management system. Seasonal fluctuations, such as increases in infectious disease cases during monsoon months or outbreaks of communicable diseases, further intensify waste volumes. Additionally, patient load, specialised procedures and high-turnover surgical or diagnostic services contribute to variations in daily waste generation, posing operational challenges for timely collection, storage, treatment and disposal.

However, increasing demand and operational complexity can strain existing infrastructure if not proactively addressed. In 2025, provincial interventions focused on scalability and preparedness, aligning hospital authorisation processes, resource allocation and digital monitoring to anticipate higher future volumes. This included ensuring that storage facilities had sufficient capacity to temporarily hold infectious waste without exceeding safe limits, that treatment

facilities had the throughput to handle peak loads and that transport fleets were ensure sufficient storage capacity.

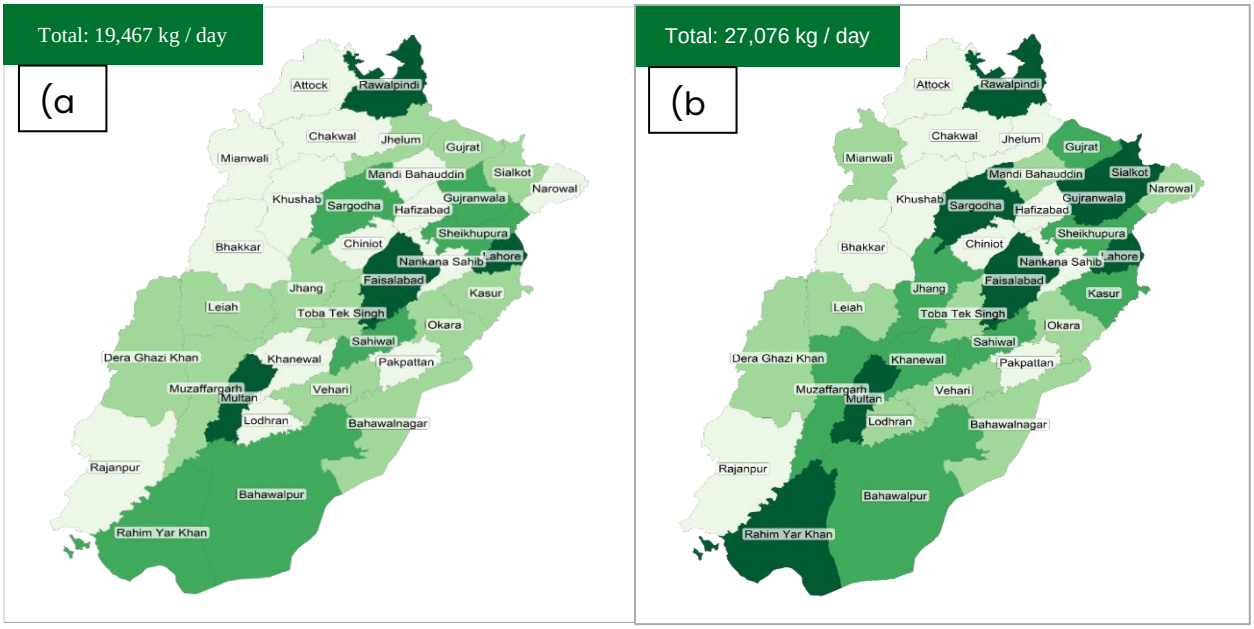


Figure 9.25: Infectious Waste Generation in kg/day by (a) Public Hospitals and (b) Private Hospitals

A key component of the 2025 strategy was capacity building for hospital staff and waste management personnel. Proper training in handling increased volumes of risk waste, maintaining segregation integrity and adhering to safety protocols was emphasised to prevent occupational exposure or accidental contamination. Digital monitoring systems introduced in 2025 enabled real-time tracking of waste generation, storage utilisation and transport schedules, allowing authorities to identify bottlenecks and redistribute resources dynamically. These interventions were designed to prevent system overload, reduce environmental and public health risks and maintain compliance with regulatory requirements, despite growing pressures from urbanisation, healthcare expansion and population growth. Ensuring sufficient storage capacity, trained personnel and treatment infrastructure is crucial to prevent system overload and maintain safe operations under growing pressures.

9.7.3. Compliance Monitoring and Capacity Building

Sustainable compliance goes beyond regulations, it depends on training, awareness and instilling a culture of responsibility. In 2025, EPA Punjab expanded capacity building initiatives, including workshops on safe handling of sharps, infection control protocols and emergency spill response and documentation practices. Regular field inspections were supplemented by guidance and support rather than relying solely on punitive measures.

This dual approach combining enforcement with education ensures that healthcare personnel understand the rationale behind procedures, reducing errors and improving compliance. For long-term sustainability, these programmes also aim to create in-house compliance champions within hospitals who can mentor new staff and maintain continuous improvement.

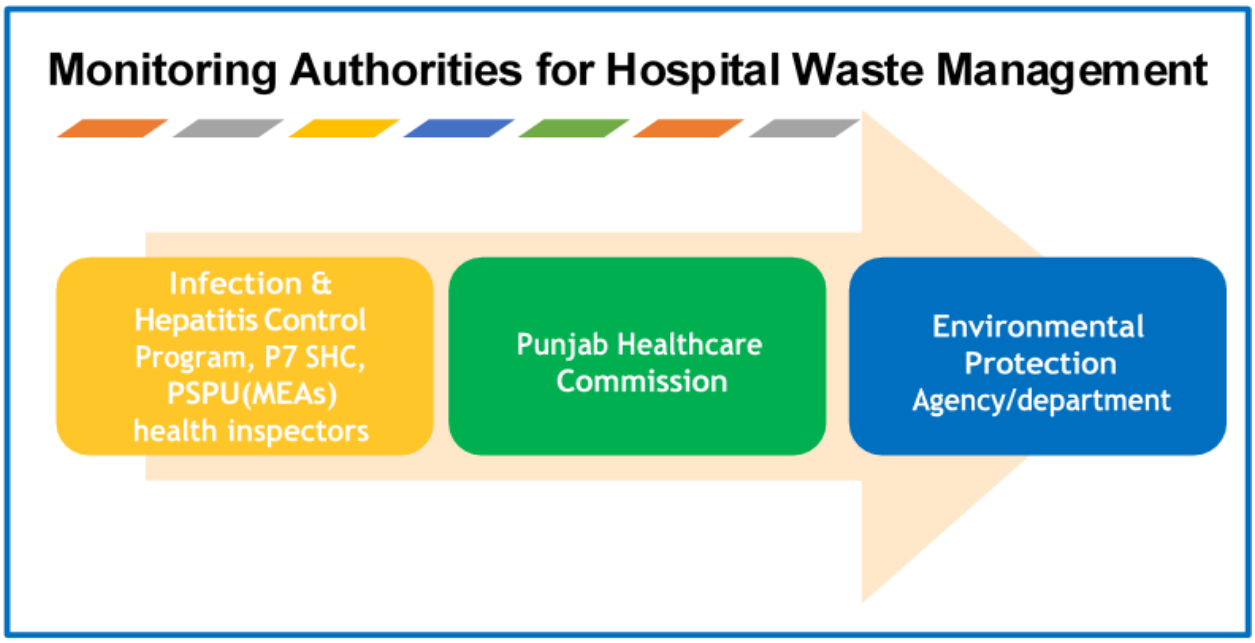


Figure 9.26: Monitoring Authorities for Hospital Waste Management [76]

9.7.4. Future Perspective

Encouragingly, healthcare waste management in Punjab is moving in a positive direction. With growing awareness among healthcare staff and stronger institutional support, practices are gradually improving across many districts. Training programmes are helping doctors, nurses and waste handlers better

understand appropriate waste segregation and handling practices, while new infrastructure such as improved storage facilities and treatment equipment is being introduced. Monitoring systems are also becoming more systematic, which is helping authorities maintain better oversight of waste management activities and ensure accountability.

Although challenges remain, these ongoing efforts show that steady progress is being made. With continued investment in staff training, better facilities and modern technologies, the system is expected to become more efficient and reliable over time. Sustaining this momentum could help, Punjab can successfully overcome current gaps and build a safer, more efficient and environmentally sustainable healthcare waste management system that protects both public health and the environment across all districts.

9.8 Conclusion

Punjab has significantly strengthened its environmental governance framework by adopting a comprehensive and integrated approach towards plastic, municipal, industrial and hazardous waste management. Over the years, the province has gradually shifted from conventional waste disposal practices towards a more modern system centered on regulatory enforcement, waste recovery, recycling, circular economy integration, technological innovation and community participation. Through initiatives such as restrictions on single-use plastics, implementation of the Plastic Management Information System (PMIS), post-confiscation recovery mechanisms, plastic-free zones, waste segregation campaigns and institutional awareness programmes, EPA Punjab has demonstrated a clear commitment towards reducing pollution and promoting sustainable environmental practices across the province.

Simultaneously, substantial progress has been made in strengthening broader waste management systems, including municipal solid waste operations, hospital risk waste management, recycling infrastructure and environmentally sound treatment and disposal mechanisms. Programmes such as Suthra Punjab

and the Waste Wise School Campaign further expanded public participation and institutional engagement, helping promote responsible waste handling and long-term behavioural change at the community level. Despite growing waste generation pressures associated with rapid urbanisation and industrialisation, Punjab's evolving policy framework, technology-enabled monitoring systems and integrated waste governance strategies have laid the foundation for a more resilient, efficient and sustainable waste management ecosystem aimed at protecting public health, minimising environmental degradation and supporting the province's long-term environmental sustainability goals.

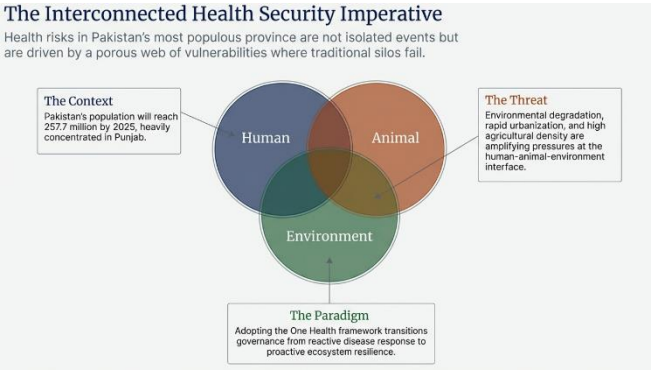


CHAPTER 10

One Health and

10.1 Introduction and Background

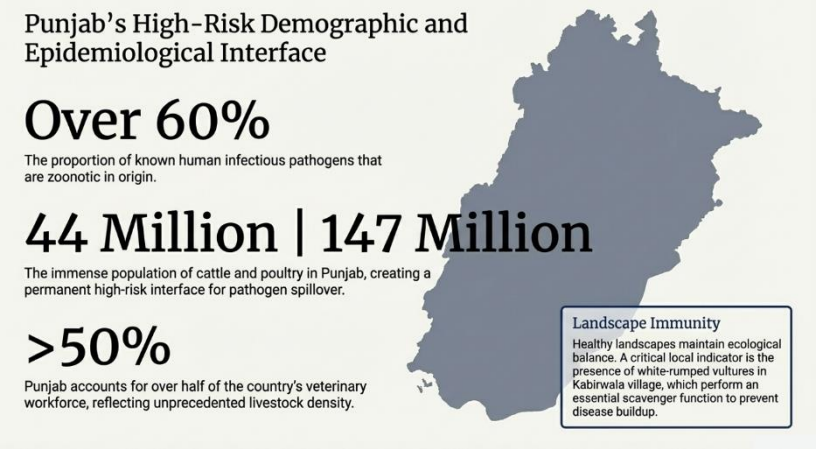
One Health is an integrated and unifying approach that aims to sustainably balance and optimise the health of people, animals and ecosystems. It recognises that the health and well-being of humans, domestic and wild animals, plants and the broader environment are closely interconnected and interdependent.[81]



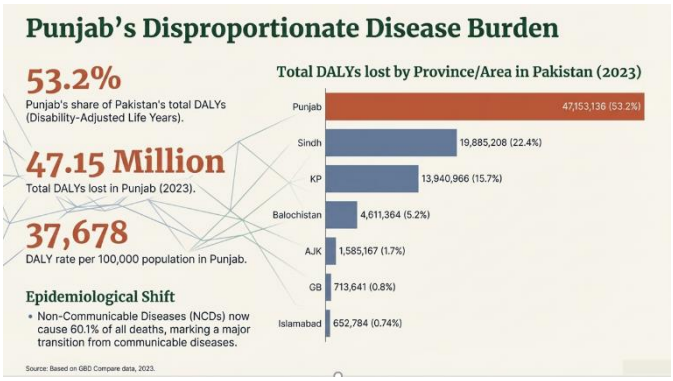
This framework has become increasingly important in addressing emerging and persistant global health threats, including antimicrobial resistance (AMR), zoonotic diseases and food safety hazards. The application of a One Health approach is essential for achieving the United Nations Sustainable Development Goals (SDGs).[82] It has direct relevant to several SDGs, including SDG 3 (Good Health and Well-Being), SDG 1 (No Poverty), SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), SDG 14 (Life Below Water) and SDG 15 (Life on Land). Effective implementation of the One Health approach can contribute to improved global health security, poverty reduction, environmental protection and biodiversity conservation.[83]

[81] Operational-framework-for- strengthening-human-animal-and-environmental-public-health-systems-at-their-interface
[82] Revised-Public-World-Bank-One-Health-Framework-2018.
[83] Pakistan JEE report 2023

10.2 Punjab's Disease Burden and Epidemiological Context



Punjab is Pakistan's most populous and economically vibrant province, with approximately 127.7 million people in 2023, accounting for 56% of the national population.[84] The province has the highest population density in the country, at approximately 643.4 people per km², reflecting a high concentration of population that is contributing to rapid urbanisation and significant changes in land use.[85]



This demographic pressure is associated with the highest burden of disease (BoD) in Pakistan, with Punjab accounting for 53.2% of the national burden and an estimated 47.15 million disability-adjusted life years (DALYs) lost in 2023. The province is undergoing an epidemiological transition in which non-communicable diseases (NCDs), including cardiovascular disease, diabetes and cancers, now account for more than half of all deaths. However, persistent infectious diseases tuberculosis (TB), hepatitis and malaria, along with neonatal disorders, remain significant public health threats.[86]

[84] National-Census-Report-2023.pdf
[85] UHC Monitoring Report 2024
[86] Level of Readiness of PHC in Pakistan Beta 2025

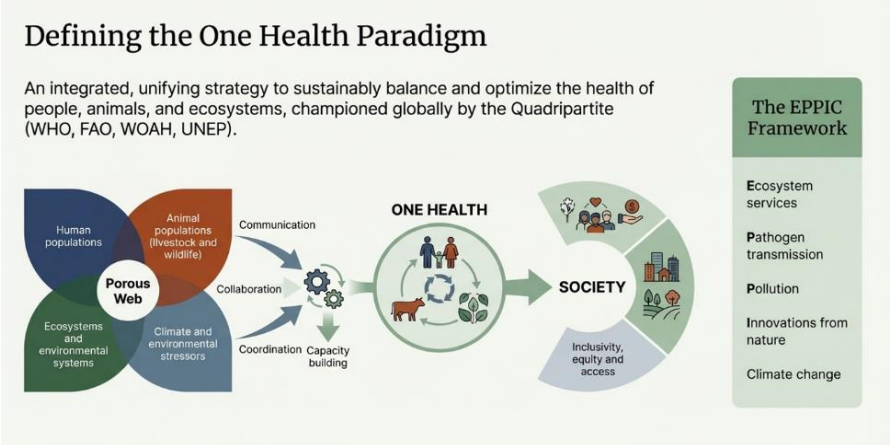
10.3 Conceptual Framework: Human, Animal, Ecosystem and Climate

The One Health framework conceptualizes health risks as emerging from **interactions between four key domains**:

- Human populations
- Animal populations (livestock and wildlife)
- Ecosystems and environmental systems
- Climate and environmental stressors

In Punjab, the One Health approach is defined as an integrated and unifying strategy that aims to sustainably balance and optimise the health of people, animals and ecosystems. Within this regional context, health risks should not be viewed as isolated events; rather, they emerge from a "porous web of vulnerabilities" in which traditional sectoral silos may limit the ability to identify and address underlying causes. This interconnectedness highlights the need for coordinated action across human, animal, environmental and climate related sector to effectively prevent manage health risks.

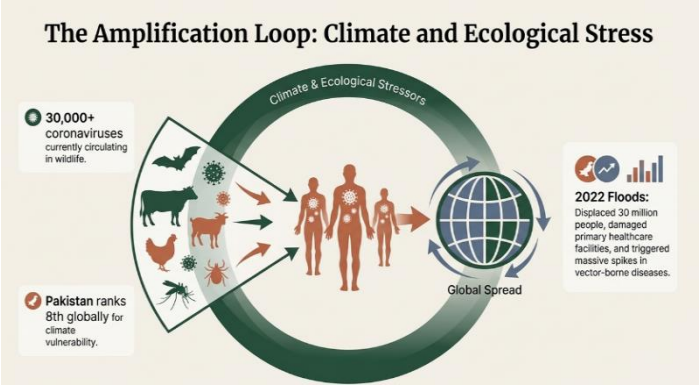
These interconnected dynamics create a complex nexus of environmental and health risks, whereby ecological changes can facilitate the emergence and transmission of disease, while environmental degradation can adversely affect both



human and animal health.[87]

Recognizing these interconnected challenges, four international organizations- the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), World Organization for Animal Health (WOAH) and United Nations Environment Programme (UNEP) collectively known as the Quadripartite, have called for stronger global adoption and implementation of the One Health approach. [88] The One Health framework also contributes directly to the achievement of several United Nations Sustainable Development Goals (SDGs), particularly those related to health, clean water and sanitation, climate action and the conservation of biodiversity.[89]

10.3.1 The Animal-Human Interface:



Pakistan is the world's fifth most populous country, with its population projected to reach 257.7 million by 2025. Punjab accounts for approximately 56% of the national population and consequently faces intense urbanisation and land-use change, which place substantial pressure on natural habitats. The province's status as a major livestock and poultry-producing hub creates a permanent "high-risk interface". Punjab is home to more than half of Pakistan's veterinarians and para-veterinarians; however, its high density of livestock and poultry increases opportunities for pathogens transmission within and between species.

[87] One Health ChJekel Epi& Public Health
[88] One Health and The United Nations
[89] One Health Joint Action Plan

Approximately 60% of known infectious diseases and 75% of emerging infectious diseases are zoonotic, with many originating in animal populations.[90]

10.3.2 Animal and Livestock Density: Agriculture and livestock production are the backbones of Punjab's economy. The province hosts a substantial proportion of the country's 44 million cattle and 147 million poultry. This high density of livestock and poultry creates a persistent "high-risk interface" that may increase opportunities for pathogen transmission and spillover.91

10.3.3 Ecosystem Resilience: Healthy ecosystems provide a form of "landscape immunity," in which ecological interactions remain relatively balanced and contribute to the regulation of disease risk. A notable example in Punjab is the presence of white-rumped vultures in kabirwala village. These scavengers perform an essential ecological function by removing animal carcasses, thereby reducing the accumulation of decomposing biological material and potentially limiting opportunities for pathogen proliferation.

10.3.4 Climate Change as a "Threat Multiplier": Pakistan is highly vulnerable to the impact of climate change. Climate change acts as a "threat multiplier" by intensifying existing environmental stressors, altering the distribution and abundance of disease vectors, and increasing the frequency and severity of extreme events. For example, the 2022 floods displaced millions of people and were followed by substantial increases in water born diseased risk including malaria and dengue.92

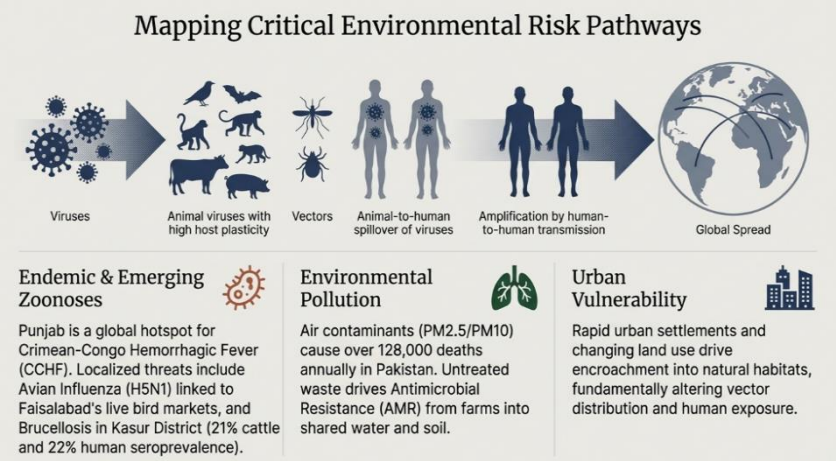
10.3.5 Coordination Mechanism: From the livestock perspective, One Health coordination in Punjab is formally recognised but remains only partially operational. At present, coordination between the livestock and human health sector is primarily facilitated through established government mechanisms, particularly the One Health Secretariat and official interdepartmental meetings.

[90] Pakistan Multisectoral Health workforce Strategy PMHWS (2025-35)
[91] World Health Organization, Joint External Evaluation of IHR Core Capacities of The Islamic Republic Of Pakistan. 2016.
[92] Pakistan Universal Health Coverage Monitoring_Report_2024

However, further strengthening of cross-sectoral collaboration, information sharing, and joint surveillance is necessary to ensure more effective implementation of the One Health approach.

10.4 Environmental Risk Pathways Affecting Health

The disease burden at the human-animal-environment interface is substantial, with approximately 60% of known human infectious pathogens reported to be zoonotic in origin. Key environmental risk pathways include the contamination of water and soil, which can facilitate the dissemination of antimicrobial-resistant microorganisms and resistance determinants through communities and the food supply chain.[93]



Stress itself can act as a critical risk amplifier; for example, wildlife experiencing habitat loss may becomes more susceptible to infection and more likely to shed pathogens. [94] Healthy landscapes can provide a form of "landscape immunity," whereby balanced ecosystem dynamics help buffer against pathogen emergence and disease spillover. COVID-19 represents a major recent example of a pandemic caused by a zoonotic pathogen. Other important zoonotic disease include severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS-CoV), zoonotic influenza (H5N1, H7N9, H1N1), Mpox and Ebola virus diseases. These diseases originate from animal

[93] World Bank's 2018 One Health Operational Framework
[94] WWF's "One Health Approach to Conservation

reservoirs and have the potential to cause epidemics and pandemics in human population.[95]

Pollution from pesticides, industrial waste and air contaminants poses direct toxicity risks and may also increase susceptibility to infectious diseases. In Punjab, these risks operate through three critical pathways: disease burden, environmental pollution and urban vulnerability.

10.4.1 Disease Burden: Endemic and Emerging Zoonoses Punjab is a hotspot for Crimean-Congo hemorrhagic fever (CCHF), with outbreaks peaking during livestock-associated festivals such as Eid al-Adha. Specific local threats include:

- **Brucellosis:** Outbreaks reported in **Kasur District** highlight the vulnerability of smallholder dairy farmers. Seroprevalence has been reported to be as high as 21% among cattle and 22% among high-risk human populations.
- **Avian Influenza**: Since 1994, Punjab has experienced recurrent outbreaks of H5N1 avian influenza, including cases reported in [96]**Faisalabad** that have been associated with semi-commercial broiler production and live bird markets.[97]
- **Neglected Zoonotic Diseases (NZDs):** Rabies remaina a major public health concern in Pakistan, causing an estimated 2,000–5,000 deaths annually, primarily following dog bites. Despite the availability of effective post-exposure prophylaxis, awareness of appropriate treatment options remains limited among a substantial proportion of the population.[98]

[95] ECDC One Health Framework One-Health-Framework-Directors
[96] National Bridging Workshop on the International Health Regulations (IHR) and the OIE Performance of Veterinary Services (PVS) Pathway,2017
[97] Pakistan Multisectoral Health workforce Strategy PMHWS (2025-35)
[98] One Health Zoonotic Disease Prioritisation & One Health Systems Mapping and Analysis Resource Toolkit™ For Multisectoral Engagement

10.4.2 Environmental Pollution: Air, Water and Soil Punjab's extensive industrial activity, agricultural practices and open burning contribute to significant environmental pollution and associated health risks.

- **The Smog Crisis:** Major cities such as **Lahore, Faisalabad and Gujranwala** frequently experience severe air pollution episodes. Exposure to particulate matter, particularly $PM_{2.5}$ and PM_{10}, is associated with substabtial morbidity and mortality and represents a major public health concern in Pakistan.[99]
- **Toxic Bioaccumulation:** Environmental contaminants, including heavy metals and pesticides used in agricultural and food production systems, can enter aquatic and terrestrial ecosystem and accumulate in livestock and fish. Through the food chain, these contaminants may subsequently reach human populations and adversely affect human health.

10.4.3 Economic Burden: Environmental degradation and climate change pose significant risks to Pakistan's economic stability and long-term development.

- **Immediate Disaster Costs:** The 2022 floods caused extensive economic losses and infrastructure damage across Pakistan. Within the health sector, the floods resulted in an estimated USD 134 million in losses and damages.
- **Long-term GDP Impact:** Climate change, environmental pollution, and ecosystem degradation are projected to significantly affect Pakistan's economic growth. Under continued high climate and environmental risks, GDP losses could reach approximately 18–20% by 2050 if current trends are not effectively addressed.
- **Agricultural Vulnerability:** Agriculture is a cornerstone of Pakistan's economy and is highly vulnerable to climate variability and extreme weather events. The 2022 floods, for example, destroyed approximately 3 million acres of crops and killed more than 1.2 million livestock, severely

[99] WHO Environmental Health Report, 2023

affecting agricultural productivity and the livelihoods of rural communities, particularly vulnerable and low-income households.

10.4.4 Antimicrobial Resistance (AMR): The overuse and inappropriate use of antibiotics in livestock production, coupled with the dissemination of antimicrobial-resistant bacteria and resistant genes through manure and wastewater into soil and water, contributes to the emergence and spread of antimicrobial resistance (AMR), often described as a "silent pandemic".[100]

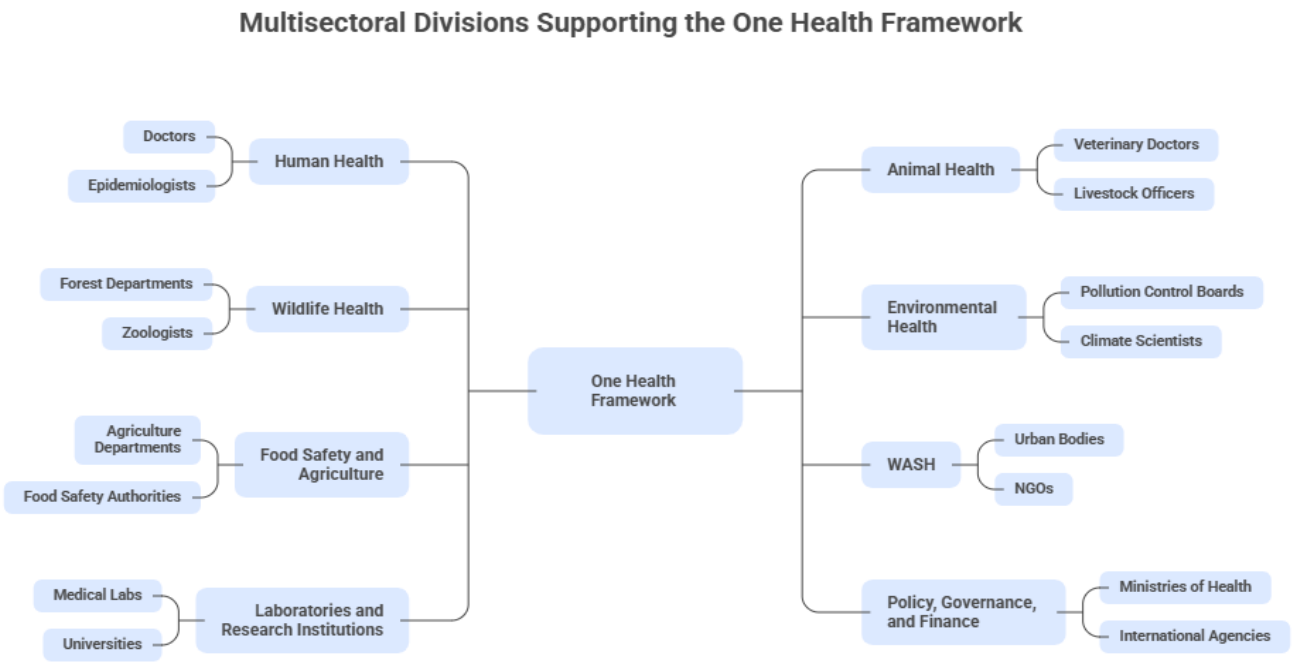
10.4.5 Urban Vulnerability and Habitat Change Urban vulnerability is heightened in densely populated areas where unplanned urbanisation contributes to inadequate waste management, environmental degradation and increased human-animal contact. For example, the use of contaminated water sources for drinking and recreational activities can facilitate the transmission of waterborne pathogens and contribute to disease outbreaks affecting both humans and livestock.[101]

System Failure: High population density, combined with inadequate **WASH (Water, Sanitation and Hygiene)** infrastructure, can facilitates the transmission of waterborne diseases such as cholera and typhoid.[102]

[100] Pakistan Multisectoral Health workforce Strategy PMHWS (2025-35)
[101] OneHealth-SimpleGuideforPolicyandPractise.pdf
[102] About One Health WORD.pdf

10.5 Multisectoral Divisions Supporting the One Health Framework

The **One Health framework** operates through the integration of multiple specialised divisions, moving beyond isolated sectoral approaches towards unified system for addressing health threats at their source. Effective



implementation of One Health requires a "whole-of-society" approach, that brings together all actors holding a piece of the health puzzle.

The One Health approach brings together institutions that contribute to the broader health, environmental and disease-prevention system. In Punjab, effective implementation of One Health depends on coordinated contributions from departments and institutions responsible for human health, animal health, environmental protection, food safety, agriculture, water and sanitation, laboratory services, research, governance and finance.

These sectors should not be viewed as separate or isolated actors. Each performs a specific institutional function that contributes to disease prevention, surveillance, environmental management, food safety and emergency preparedness. Human health institutions support diagnosis, treatment, vaccination and outbreak response; livestock and veterinary services monitor

and control animal diseases; environmental institutions address pollution, waste, water quality and ecological risks; while food safety, agriculture and WASH systems help reduce exposure to contaminants and prevent the transmission of infectious diseases.

Laboratories, universities and research institutions provide the evidence base required for diagnosis, antimicrobial resistance surveillance, pathogen detection and risk assessment. At the same time, governance and finance institutions establish policy direction, facilitate coordination and mobilise the resources necessary to sustain multisectoral action. Collectively, these institutional functions form the operational foundation of an effective and resilient One Health framework in Punjab.

Strengthening this framework requires improved interdepartmental coordination, integrated data-sharing systems, joint planning and clear defined roles and responsibilities. By linking these sectors through a common health security agenda, Punjab can transition from fragmented responses to a more integrated, preventive and resilient system for managing zoonotic diseases, antimicrobial resistance and environmental health risks.

10.5.1 Human Health

The human health sector plays a central role in disease prevention, diagnosis, treatment and public health surveillance. Hospitals, clinics, public health departments and community health workers contribute to the early detection of infectious diseases, vaccination, infection prevention and control. Effective surveillance systems are essential for identifying unusual patterns of fever, respiratory illness, diarrhoeal disease and other public health conditions that may indicate emerging health risks.

10.5.2 Animal Health

The animal health sector is essential for preventing and control of zoonotic diseases that can be transmitted from animals to humans. Veterinary services, livestock departments, dairy and poultry institutions contribute to disease surveillance, vaccination, farm biosecurity and animal health reporting. Effective

animal disease surveillance provides an important early warning function, particularly in areas where livestock, poultry, wildlife and human populations interact closely.

10.5.3 Wildlife Health

Wildlife health monitoring is an important component of the One Health approach because many emerging infectious diseases originate in or involve wildlife populations. Forest, wildlife and ecological institutions contribute to One Health by monitoring high-risk species, identifying disease hotspots and reporting unusual wildlife mortality. Strengthening wildlife surveillance can facilitate the early detection of potential spillover events before diseases spread to livestock or human populations.

10.5.4 Environmental Health

Environmental health provides the foundation for the One Health approach by addressing the ecological and environmental conditions that influence disease transmission and health outcomes. Environmental institutions monitor air and water quality, pollution, waste management, ecosystem degradation and climate-related risks. Effective environmental management can reduce exposure to pollutants, limits conditions that support disease transmission and promote healthier ecosystems for both humans and animals.

10.5.5 Food Safety and Agriculture

Food safety and agriculture sectors play a critical role in protecting public health by managing risks throughout the food chain, from production to consumption. Agriculture departments, food safety authorities and farming institutions help prevent contamination from pathogens, pesticides, heavy metals and other hazards associated with unsafe production practices. Effective food safety regulation and agricultural biosecurity can reduce the risk of foodborne illness and zoonotic disease transmission.

10.5.6 Water, Sanitation and Hygiene

Water, sanitation and hygiene services are critical for preventing transmission of infectious disease. Access to safe drinking water, effective sanitation, solid waste management and adequate wastewater treatment can reduce the spread of diseases such as cholera, typhoid and diarrhoeal infections. Effective wastewater management is also important for limiting the environmental dissemination of antimicrobial resistance and protecting community health.

10.5.7 Laboratories and Research Institutions

Laboratories and research institutions provide the diagnostic capacity and evidence base required for effective One Health decision-making. Medical, veterinary, environmental and academic laboratories support pathogen detection, antimicrobial resistance surveillance, genomic sequencing and outbreak confirmation. Integrated laboratory networks and shared databases can improve the speed and accuracy of risk identification across human, animal and environmental sectors.

10.5.8 Policy, Governance and Finance

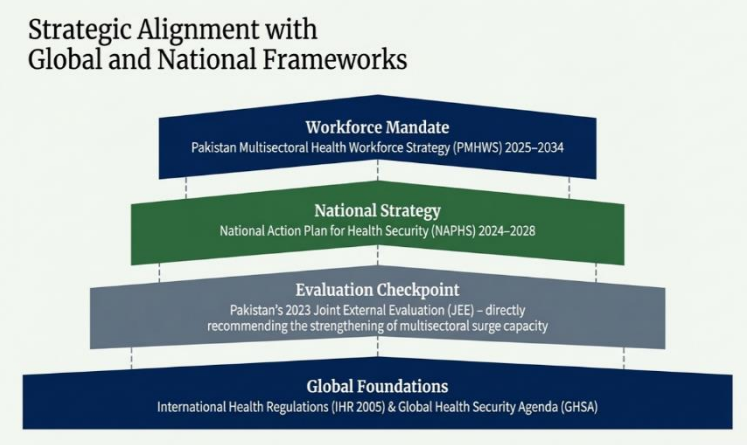
Policy, governance and finance systems provide the leadership, coordination and resources required to sustain One Health implementation. Health, livestock, environment, agriculture, food safety, local government and finance institutions need to operate within clear legal frameworks, defined institutional responsibilities and dedicated budgetary mechanisms. Governance tools such as joint risk assessments, preparedness reviews and performance monitoring can help identify institutional gaps and guide investment in integrated health security.

Overall, these sectoral components demonstrate that One Health in Punjab requires coordinated institutional action rather than isolated departmental activity. Strengthening linkages between these sectors can improve disease prevention, environmental management, surveillance capacity and emergency preparedness across the province. A coordinated and integrated approach can

also strengthen the province's capacity to anticipate, detect, and respond to emerging zoonotic, environmental, and antimicrobial resistance-related threats.

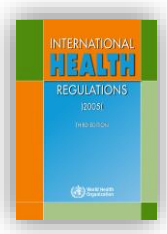
10.6 Regulatory Role in Risk Reduction

10.6.1 Strategic Policy and Legal Frameworks for One Health: Needs Assessment and Prioritisation



Before examining Punjab's Perspective and the current regulatory landscape. It is critical to understand the relevant international and national agendas. This provides essential context for assessing the role of regulation in advancing national progress in health security and the implementation of One Health approach. Pakistan has taken significant steps to strengthen its health security system by aligning national policies and capacities with the requirements of the International Health Regulations (IHR). As a signatory since 2007, the country has committed to developing the necessary systems and capacities to prevent, detect and respond to public health emergencies. Progress towards these commitments has been periodically assessed through Joint External Evaluations (JEEs), which were conducted for Pakistan in 2016 and again in 2023.

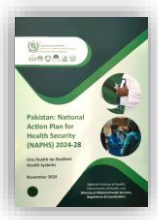
Global Health Security Agenda (GHSA), a global partnership established in 2014 to promote international collaboration in addressing infectious disease threats. Pakistan became a member in 2015 and strengthened its engagement in 2020 by joining the GHSA Steering Group.



The International Health Regulations, developed by the World Health Organization, provide a legally binding framework that guides countries in developing and maintaining essential capacities to prevent, detect, assess, report and respond to public health threats. Through the JEE process, countries receive an independent assessment of their national preparedness capacities, along with recommendations for strengthening health system and addressing identified gaps.



Pakistan's most recent Joint External Evaluation (JEE) conducted in 2023, provided an updated assessment of the country's health security landscape. While the evaluation identified several existing strengths, it also highlighted the importance of clearly defining institutional roles and responsibilities. Established tools such as the IHR Joint External Evaluation (JEE) framework, together with stakeholder mapping conducted at both the national and provincial level, can help identify and clarify the roles of relevant actors. A comprehensive analysis of stakeholders including government agencies, non-governmental organisations (NGOs), academia, and the private sector—is essential for strengthening coordination and accountability across the health security system.



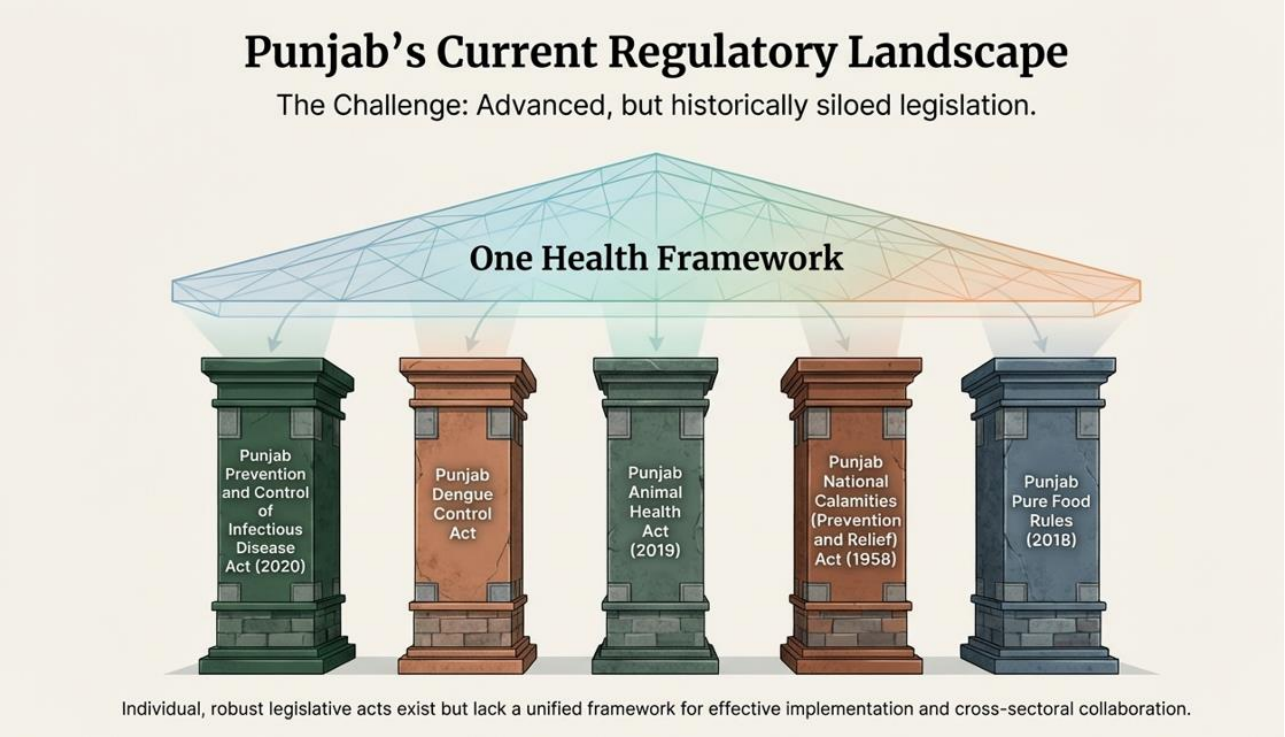
Pakistan also introduced the **National Action Plan for Health Security (NAPHS) 2024–2028**, a strategic roadmap aimed at strengthening the country's preparedness and response capacities. The plan focuses on expanding workforce capacity across the human, animal and environmental health sectors, strengthening health infrastructure and enhancing multisectoral coordination to address emerging health threats more effectively.

The Pakistan Multi-sectoral Health Workforce Strategy (PMHWS) underscores the importance of workforce governance, surge capacity and equity, with a strong focus on district-level realities and operational readiness. As the first strategy of its kind in Pakistan and, more broadly, in the region, this landmark effort highlights Pakistan's commitment to advancing health security through strategic workforce development.



10.6.2 Punjab's Current Regulatory Landscape: Challenges and the Need for Integration

Punjab has enacted a range of important legislative measures aimed at addressing public health, environmental protection and safety concerns. These include legislation governing infectious disease control, dengue prevention, animal health, disaster risk management and relief and food safety.



Individually, these legislative instruments are comprehensive and demonstrate a relatively advanced regulatory framework for addressing specific public health and safety concerns. For example, the Punjab Prevention and Control of Infectious Disease Act (2020) provides a legal framework for the prevention and control of infectious diseases, while the Punjab Dengue Control Act specifically addresses dengue prevention and control. Similarly, the Punjab Animal Health Act (2019) focuses on animal health, veterinary services and zoonotic disease management; the Punjab National Calamities (Prevention and Relief) Act (1958) provides a framework for disaster preparedness, response and relief; and the Punjab Pure Food Rules (2018) establish standards for food safety.

However, despite the strength of these individual legislative instruments, a significant challenge remains: these frameworks largely operate independently, resulting in institutional and regulatory "silos.". This fragmented approach can limit their collective effectiveness by constraining coordination among sectors responsible for human health, animal health, environmental protection and disaster management. When legislation is implemented independently with limited intersectoral coordination, it may result in duplication of efforts, gap in response and inefficiencies in implementation.

In 2025, Punjab demonstrates relatively strong institutional capacity for implementing the functions of the International Health Regulations (IHR 2005), with an overall IHR capacity index of 46.8%. This indicates a gradual transition from foundational capacity towards a more structured and institutionalised preparedness framework. Nevertheless, further strengthening of cross-sectoral coordination, integrated surveillance, information sharing, and joint preparedness mechanisms is necessary to translate these institutional capacities into a fully integrated One Health system.

10.6.3 EPA Punjab as a regulatory bridge



The Environmental Protection Agency (EPA) Punjab serves as an important regulatory interface within the One Health framework by linking environmental governance with broader public health risk management. Its core functions, including environmental monitoring, pollution control, environmental impact assessment, industrial effluent regulation, air quality management and compliance enforcement, contribute directly to reducing environmental conditions that may increase health risks to human, animal and ecosystem health.

Rather than functioning as a direct human health or livestock agency, EPA Punjab regulates and monitors environmental determinants that can influence disease emergence, antimicrobial resistance and community exposure to environmental pollutants. Poor waste management, contaminated water, untreated industrial discharge, air pollution and unsafe waste disposal practices can create pathways for human, animal and environmental health risks.

Strengthening EPA Punjab's regulatory capacity and coordination with health, livestock, local government, agriculture and other relevant departments can improve early identification and management of environmental hazards and support more integrated risk reduction. In this way, EPA Punjab contributes to the One Health approach by ensuring that environmental protection, regulatory compliance, environmental monitoring and pollution control are recognised as essential components of health security and sustainable development.

10.7 Punjab's One Health Governance Infrastructure

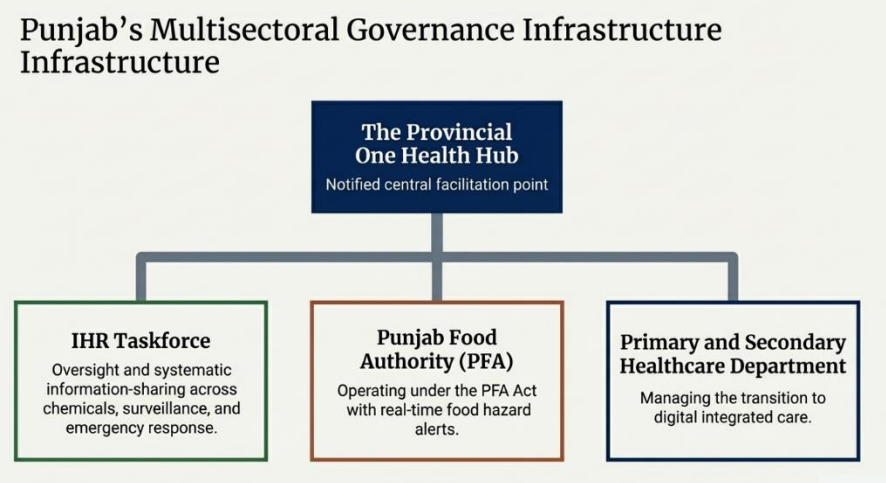
Punjab has taken important steps toward strengthening One Health governance by developing coordination mechanisms that bring together public health, livestock, environmental protection and other relevant sectors. Rather than relying solely on separate departmental mandates, emerging governance arrangements provide a foundation for joint planning, risk communication, surveillance and emergency response.

Key coordination mechanisms, including One Health platforms, IHR-related coordination structures and interdepartmental working arrangements, support a more integrated approach to managing zoonotic diseases, antimicrobial resistance and environmental health risks. These mechanisms can facilitate information sharing among sectors and create opportunities for coordinated decision making at both district and provincial levels.

However, further institutional strengthening is required to ensure that these mechanisms are fully operational, adequately resourced and consistently linked with field-level implementation. Clearly defined roles and responsibilities, regular data sharing, joint monitoring and effective district-level coordination will be essential for translating Punjab's One Health governance infrastructure into measurable public health and environmental outcomes.

10.7.1 One Health Hub:

A provincial One Health hub has been formally notified to facilitate collaboration between the health, livestock and environment departments.



10.7.2 IHR Coordination:

The **Director of CDC** at the Department of Health serves as the provincial IHR Focal Point for the international Health Regulations (IHR), coordinating with the national level and overseeing multisectoral implementation.

10.7.3 District-Level Implementation:

District Multisectoral Workforce Coordination Committees (DMWCCs), led by Deputy Commissioners, act as the primary operational units for local implementation, workforce tracking and emergency surge activation.

10.7.4 Legal Framework:

Governance is supported by robust legislative framework, including the **Punjab Prevention and Control of Infectious Disease Act (2020)**, the Punjab Dengue Control Act and the **Punjab Animal Health Act (2019)**. A Comprehensive mapping of public health legislation is currently underway to further align them with multidisectoral requirements of the International Health Regulations (IHR).

10.7.5 Punjab Food Authority (PFA):

The PFA operates under the **Punjab Food Authority Act**, using real-time reporting dashboards and food hazard alerts to mitigate outbreaks.

10.7.6 Smog Prevention:

Provincial regulations and **smog prevention laws** are in place to address the workforce safety risks associated with extreme air pollution.

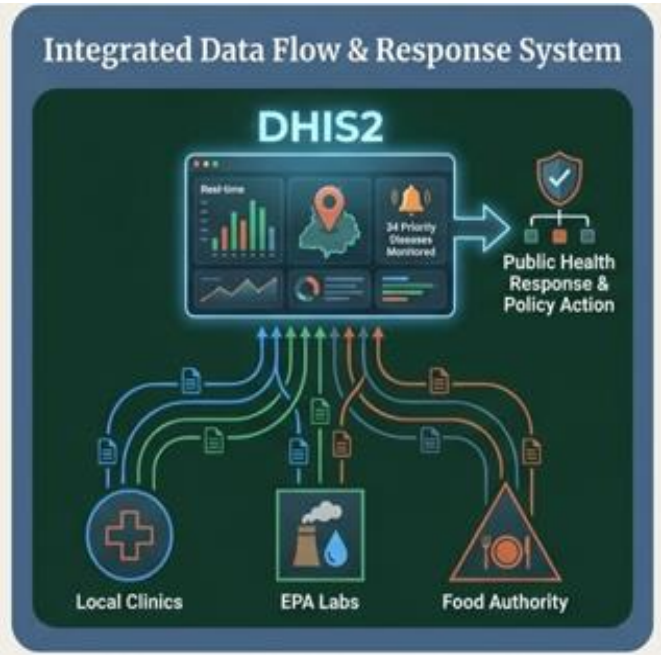
10.7.7 National Alignment:

These efforts are aligned with the **International Health Regulations (IHR 2005)** and the findings of the **2023 Joint External Evaluation (JEE)**, which recommended strengthening institutional and technical capacities for disease surveillance, laboratory systems, emergency preparedness and response, multisectoral coordination, and the effective implementation of health security measures

10.8 Current Progress and Technical Strengths (2025 Lens)

Punjab's performance is strongest in the **detect domain (50.9%)**, driven by advanced laboratory and surveillance systems:

10.8.1 Digital Surveillance



Punjab has transitioned from traditional, predominantly paper-based disease reporting systems to a modern, web-based digital platform known as **DHIS2** (District Health Information System 2). This platformfacilitate the real-time collection, analysis and reporting of health data. The adoption of DHIS2 across Punjab has been completed, enabling daily and weekly monitoring of 34 priority diseases. This digital transformation facilitates timely data flow and strengthens the capacity of public health authorities to detect outbreaks rapidly, make evidence based decisions and deploy appropriate interventions efficiently.

10.8.2 Integrated Data Flow and Response System

The DHIS2 platform integrates health and environment data from multiple sources local clinics, EPA labs and the Food authority into a centralized system that facilitates rapid analysis and coordinated response. This integrated data flow enables continuous monitoring of priority diseases and environmental health indicators, thereby supporting timely public health interventions, risk assessment, and evidence-based policy decisions.

10.8.3 Laboratory Networks

Complementing digital surveillance system is a tiered laboratory network designed to support diagnostic testing, pathogen detection and environmental monitoring. This network comprises several key components:

The **Provincial Public Health Reference Laboratory (PHRL)**, which serves as a central facility for disease diagnosis, laboratory confirmation and reference testing.

Environmental Protection Agency (EPA) certified labs that monitor industrial effluent and other environmental parameters that may affect public ecosystem health.

Food Authority diagnostic setups that ensure food safety by analyzing food samples for pathogens, contaminants, and other potential hazards.

Together, these laboratory facilitates provide essential diagnostic and analytical capacities that strengthen disease surveillance, support environmental monitoring and contribute to evidence-based public health decision making.

10.8.4 Pandemic Fund Grant: A major milestone in 2025 was the approval of a USD 18.7 million Pandemic Fund grant to strengthen integrated surveillance systems in Punjab. The grant supports improved coordination among human, animal and environmental health sectors, including upgrades to the Animal Disease Reporting and Surveillance (ADRS) system. This investment represents an important step towards operationalising the One Health approach by strengthening early detection, information sharing, reporting and coordinated response to emerging health threats.

10.8.5 Immunization: Punjab has demonstrated strong performance in vaccine delivery, with Full Immunization Coverage (FIC) previously reaching 89%. This represents a significant public health achievement and demonstrates the province's capacity to implement large-scale preventive health programmes. Maintaining and further improving immunization coverage remains essential for

reducing vaccine-preventable diseases, improving child health outcomes and strengthening broader disease prevention under the One Health approach.

10.9 Ongoing Challenges and Risk Trends

Despite progress, significant gaps remain in prevention and sustainable resource management:



10.9.1 Antimicrobial Resistance (AMR):

Prevention and control of multi-drug resistant organisms remain areas of limited capacity, indicating an urgent need to strengthen antimicrobial stewardship programmes.

10.9.2 Workforce Disparities:

Although Punjab has the largest share of physicians and medical specialists in the country, rural areas remain comparatively under-resourced. The province also faces a critical shortage of environmental health professionals, with only one professional available for every **183,787 people**.

10.9.3 Financing:

Financing remains one of the major challenges to effective implementation of the International Health Regulations (IHR), as dedicated and sustainable provincial budget lines for health security have not yet been fully institutionalized.

10.9.4 Infection Prevention and Control (IPC):

Current programmes require further strengthening and systematic monitoring of healthcare-associated infections (HAIs) to achieve a higher level of operational maturity.

10.9.5 Rising Vector-Borne Threats:

Climate models predict that a **2–3°C increase in global mean temperature** could expand the geographic range of mosquito vector, thereby increasing the risk of malaria and dengue transmission in the region.

10.10 Strengthening One Health Frameworks in Punjab

Strengthening the **One Health** framework in Punjab requires a shift from broad policy commitments to practical, coordinated and measurable action. The province should align its One Health priorities with national health security strategies, technical assessments and international commitments, while developing a provincial implementation framework tailored to Punjab's environmental, livestock, public health and governance context.

First, Punjab should establish a formal provincial One Health coordination mechanism involving the environment, health, livestock, agriculture, food safety, local government and disaster management sector. This mechanism should facilitate joint planning, shared risk assessment, information exchange and coordinated emergency response for zoonotic diseases, antimicrobial resistance and environmental health threats.

Second, integrated surveillance systems should be strengthened by linking environmental monitoring, animal disease reporting, human health data and laboratory networks. Improved data sharing among departments would help facilitate earlier identification of emerging risks and support evidence-based decision-making at both provincial and district levels.

Third, district-level One Health coordination should be operationalised through multisectoral committees capable of translating provincial strategies into local action. These committees should focus on field surveillance, outbreak response, public awareness, waste management, water safety and local risk communication.

Fourth, workforce capacity should be strengthened through joint training programmes for environmental inspectors, public health officials, veterinarians, laboratory staff and local government officers. A skilled and adequately resourced multisectoral workforce is essential for translating One Health policies into effective field level implementation.

Finally, Punjab should establish a clear monitoring and evaluation framework with measurable indicators to track implementation and outcomes. These indicators may include improvements in disease surveillance, outbreak response times, interdepartmental coordination, laboratory capacity, AMR monitoring, environmental compliance and community-level risk reduction. Collectively, these measures would support Punjabs transition toward a more integrated, preventive and resilient One Health system.



10.10.1 Align with National and Global Health Security Frameworks

Punjab should align its provincial One Health priorities with national health security strategies and use technical assessments, including the Joint External Evaluation (JEE), to identify and address gaps preparedness and response capacity. Provincial policies and implementation plan should also remain

consistent with international commitments, particularly the International Health Regulations (IHR) to strengthen preparedness for emerging and re-emerging health threats.

10.10.2 Establish Strong Governance and Coordination

Punjab should establish a high-level inter-ministerial coordination mechanism to oversee collaboration among the health, environment, livestock, agriculture food safety and other relevant sectors. A dedicated One Health coordination unit could support joint risk assessments, facilitate information sharing, monitor implementation and coordinate multisectoral responses during outbreaks and other public health emergencies.

10.10.3 Develop Policy and Legal Frameworks

Punjab should develop a comprehensive provincial One Health strategy aligned with national health security priorities and relevant international frameworks. The legal and regulatory framework should clearly define institutional mandates, roles, responsibilities and provide mechanisms for coordinated disease surveillance, risk assessment, information sharing and emergency response across sectors.

10.10.4 Strengthen Integrated Surveillance and Workforce Capacity

Integrated surveillance systems should facilitate the collection, analysis and sharing of data across human, animal and environmental health sectors. Standard operating procedures should be developed for joint outbreak investigations, risk assessment and coordinated response activities. Multi-sectoral training programmes, including the Field Epidemiology Training Program (FETP), should be strengthened to develop a skilled workforce capable of applying One Health principles in routine surveillance and emergency.

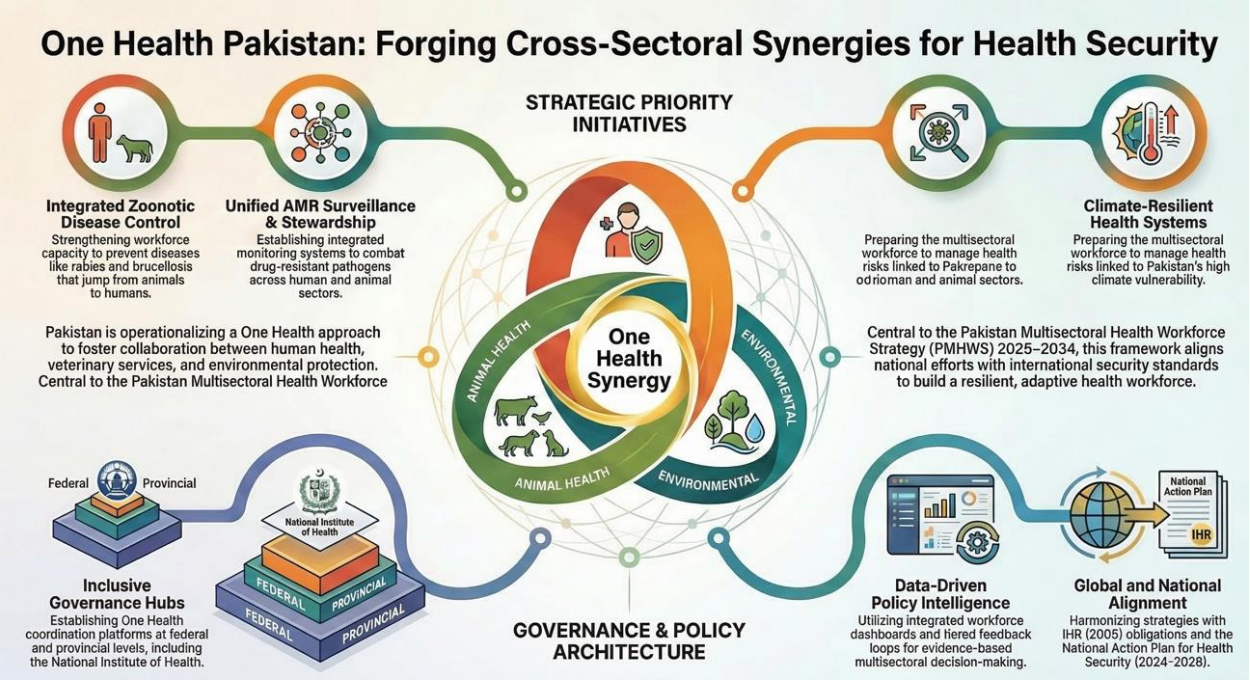
10.10.5 Focus on Prevention and Community Engagement

One Health strategies should address upstream drivers of disease emergence and environmental health risks, including climate change, habitat degradation

unsustainable agricultural practices, pollution and inadequate waste management. Meaningful engagement with local communities is essential to ensures that prevention and risk-reduction measures are context specific, equitable, culturally appropriate and sustainable.

10.10.6 Monitor Progress with Measurable Indicators

Punjab should implement a robust monitoring and evaluation framework based on SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) indicators. Key indicators could include the operational functionality of the provincial One Health coordination mechanism, completion of periodic JEE assessments, the number and quality of joint surveillance activities, the proportion of relevant professionals trained in One Health principles, the timeliness of multisectoral outbreak responses, and improvements in data sharing and laboratory capacity. Regular monitoring and reporting against these indicators would enable decision-makers to identify implementation gaps, allocate resources effectively, and assess progress towards a fully operational One Health system.



10.11 Conclusion

This chapter examined the growing importance of strengthening the One Health (OH) framework in Punjab to address complex health risks arising at the intersection of human, animal and environmental systems.

Environmental degradation, climate change, antimicrobial resistance and zoonotic disease transmission are increasingly interconnected risks that affect human health, animal health, ecosystem stability and long-term development outcomes. This chapter has demonstrated that these risks cannot be managed through isolated sectoral responses. A stronger One Health approach is therefore essential for Punjab, as it provides an integrated framework for prevention, preparedness, surveillance and coordinated response across environmental, health, livestock, agriculture and local government systems.

Punjab already has an important institutional foundation for advancing One Health governance. Alignment with national and international frameworks, including the Pakistan Multisectoral Health Workforce Strategy 2025–2034, the National Action Plan for Health Security 2024–2028, the International Health

Regulations and the Global Health Security Agenda, can strengthen provincial preparedness and improve coordination across sectors. However, policy alignment alone is insufficient. Effective implementation requires clearly defined institutional responsibilities, functional coordination mechanisms, integrated data-sharing systems and district-level structure capable to translating policy commitments into practical action.

Environmental regulatory institutions, particularly EPA Punjab, have a critical role in this process because environmental quality, pollution control, waste management, water safety and ecosystem protection are closely linked to public health risk reduction. Strengthening environmental regulatory governance can therefore help operationalise the One Health by connecting environmental monitoring with disease prevention, risk assessment and emergency response. District-level coordination structures, including multisectoral workforce committees, can further strengthen local preparedness by supporting joint planning, field surveillance and timely response to emerging threats.

Moving forward, Punjab's One Health framework should be supported by robust monitoring, evaluation and accountability mechanisms. Regular assessment of surveillance performance, interdepartmental coordination, workforce capacity and environmental health indicators can help ensure that interventions remain evidence-based, responsive and sustainable. In conclusion, strengthening One Health in Punjab is not only a public health priority but also an environmental sustainability and risk-management imperative. By improving integrated governance, surveillance, regulatory enforcement and multisectoral capacity, Punjab can build a more resilient system capable of protecting communities, animals and ecosystems from present and future health threats.

CHAPTER 11

Bird Strike Risk Reduction



11.1 Introduction

Bird strikes, which involve collisions between aircraft and birds, represent one of the most significant safety hazards in aviation. These incidents occur most frequently during takeoff, landing, and low-altitude flight phases. A single bird strike can result in catastrophic engine failure, damage to the cockpit windshield, or loss of aircraft control, posing serious risks to passenger and crew safety.

Globally, bird strikes cause hundreds of millions of dollars in aircraft damage annually, and several fatal crashes have been directly attributed to bird ingestion by engines. This risk is well documented, and airports worldwide actively manage it through dedicated wildlife control programmes.

Birds are attracted to areas near airports by the availability of food, water, shelter, and nesting sites. Landfills, agricultural fields, and waste disposal areas provide ample food sources, while ponds, wetlands, and drainage systems draw waterfowl. Vegetation such as trees, shrubs, and tall grasses, along with urban structures, offer shelter and nesting opportunities. These factors increase bird activity in the vicinity of airports, elevating the risk of bird strikes and underscoring the importance of effective wildlife and habitat management for aviation safety.

For Lahore, this concern is particularly acute. The city's dense urban environment—characterised by slaughterhouses, open garbage dumps, unauthorised poultry farms, and widespread bird-feeding at shrines and public spaces—attracts large avian populations near the flight paths of Allama Iqbal International Airport. Consequently, bird hazard management is a primary aviation safety priority, rather than merely an ancillary environmental issue.

According to civil aviation records, 198 bird strike incidents were reported at Allama Iqbal International Airport between 2018 and 2022, out of 622 reported nationwide. In 2022 alone, 57 Pakistan International Airlines (PIA) flights were affected by bird strikes, with Lahore recording the highest number of incidents, resulting in damage to five aircraft. Within the first half of 2024, 38 PIA flights

encountered bird strikes across Pakistan, including 14 incidents at Lahore, where an additional 28 incidents occurred between 2024 and 2025.[103]

The issue is further exacerbated by rapid urban development surrounding the airport. As commercial and residential activities expand near flight corridors, increased human-generated food waste and land uses attractive to birds contribute to elevated bird populations near the airport, thereby increasing the likelihood of serious incidents without appropriate regulatory intervention.

To mitigate this, the Wildlife and Parks Department Punjab declared seven localities surrounding the airport as No Bird Zones. In response, EPA Punjab issued a formal order in July 2025 establishing a comprehensive set of enforceable control measures across these zones to address the environmental and urban factors driving increased bird concentrations near the airport.

11.2 Enforcement by EPA Punjab

On 9 July 2025, EPA Punjab issued a formal order to address bird hazards near Allama Iqbal International Airport. The order delineates seven No Bird Zones encompassing all cardinal directions around the airport—from Lahore Eastern Bypass in the north to Chungi Amer Sidhu in the south-west, and from Icchra in the west to Dahuriwala in the east. The rationale behind this spatial designation is grounded in aviation safety concerns: Lahore's urban environment fosters conditions that attract birds near flight paths, thereby increasing the risk of bird-aircraft collisions which can lead to catastrophic engine failure and loss of life.

EPA Punjab prohibits the following activities within these zones:

- Open dumping of garbage, offal, and slaughterhouse remains
- Unauthorised poultry farms or bird breeding facilities
- Feeding of birds at public gatherings or religious shrines

[103] Bird strikes threaten aviation safet | The Express Tribune

- Operation of slaughterhouses, tandoors, and bakeries without effective waste management
- Unregulated scattering of grain on rooftops and feeding of birds or animals
- Use of uncovered waste collection bins

In addition to these operational bans, EPA Punjab has imposed a comprehensive freeze on the processing of environmental approval applications for poultry farms, hatcheries, tanneries, meat shops, slaughterhouses, and organic waste storage facilities located within the designated zones. Non-compliant units are subject to sealing, and violators may face legal proceedings entailing fines of up to PKR 5 million.

Direction	Locality	Latitude	Longitude
North	Lahore Eastern Bypass	31.609738	74.402379
North-East	Manawan Hospital	31.592223	74.459308
East	Dahuriwala	31.529229	74.491999
South-East	PKLI	31.455102	74.464801
South-West	Chungi Amer Sidhu	31.44851	74.352172
West	Icchra	31.532469	74.318276
North-West	Chah Miran	31.589146	74.344794

Table 11. 1: The declared No Bird Zones and their coordinates

11.3 Enforcement Data (2025)

In 2025, EPA Punjab conducted an enforcement campaign titled “No Bird Zones.” Field teams issued notices to violators and removed bird cages across five designated areas. The results of this campaign are summarised in the table below.

During the enforcement period, a total of 634 notices were issued, and 128 bird cages were removed. Icchra recorded the highest level of activity with 257

notices issued and 71 cages removed, followed by Chah Miran with 227 notices and 33 removals. Chungi Amar Sadhu accounted for 81 notices and 23 removals. Manwan Hospital and the Pakistan Kidney and Liver Institute (PKLI) collectively registered 69 notices but only one cage removal, indicating relatively lower non-compliance levels in these localities.

Area	**Notices Issued**	**Cages Removed**
Chah Miran	227	33
Chungi Amar Sadhu	81	23
Icchra	257	71
Manwan Hospital	38	0
PKLI	31	1
Total	**634**	**128**

Table 11. 2: Enforcement Actions by EPA

The significance of cage removal extends beyond mere numbers. Pigeon and bird cages maintained on rooftops and within commercial areas sustain a permanent resident bird population in the designated zones. Their removal directly contributes to a reduction in local bird density. The elimination of 128 cages within less than two months represents a substantive early achievement. This intervention is noteworthy as it exemplifies EPA Punjab's capacity to operate at the confluence of environmental law and public safety. It reframes bird hazard management not merely as a specialised aviation concern but as a direct consequence of waste mismanagement and unregulated urban activities—both firmly within the EPA's regulatory purview.

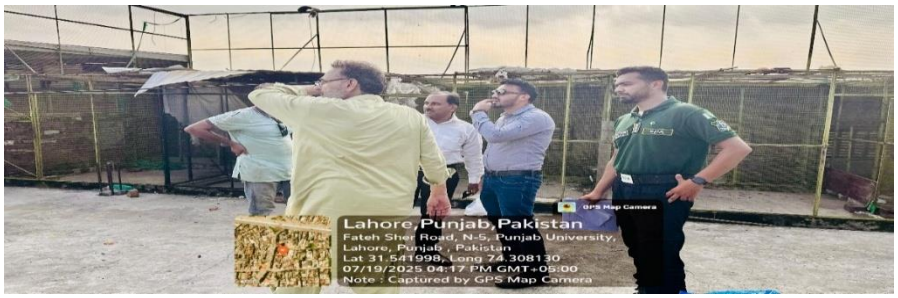
11.4 Conclusion

Bird strike risk reduction around Allama Iqbal International Airport constitutes a coordinated regulatory response to a well-recognised aviation safety hazard. The Wildlife & Parks Department's declaration of No Bird Zones, supported by EPA Punjab's enforcement efforts and active field operations, has established a clear legal and operational framework. Early enforcement outcomes, including the



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issuance of 634 notices and removal of 128 bird cages across five designated

zones within two months, demonstrate that the initiative is actively being implemented on the ground.

Sustained success will hinge on continued enforcement, robust inter-agency coordination among EPA, local governments, airport authorities, and wildlife agencies, as well as increased public awareness of the risks associated with bird-attracting activities near airports. While the legal framework is firmly in place, consistent and diligent implementation will be critical to achieving meaningful and durable reductions in bird strike risks around the airport.

CHAPTER 12

Stubble Burning and Smog Mitigation



12.1 Overview

Punjab's land use pattern is predominantly agricultural, with approximately 60% of its 20.6 million hectares dedicated to cultivation, equating to roughly 12.5 million hectares of arable land. The Indus Basin Irrigation System, one of the world's largest contiguous irrigation networks, supplies water to over 80% of this cultivated area. The agricultural landscape is dominated by key crops: wheat occupies approximately 9 million hectares, rice covers around 4.5 million hectares, cotton spans roughly 2.5 million hectares, and sugarcane extends over approximately 1.3 million hectares.

In stark contrast, forest cover remains critically limited at just 3%—approximately 0.5 million hectares. Urban areas are rapidly expanding, currently comprising about 12% of the province's land area, with major cities like Lahore alone sprawling across 400,000 hectares. Rangelands and barren lands account for approximately 10% and 5%, respectively, of the remaining land uses. This intense agricultural focus underscores the complex interplay between land use dynamics and environmental challenges confronting the province.

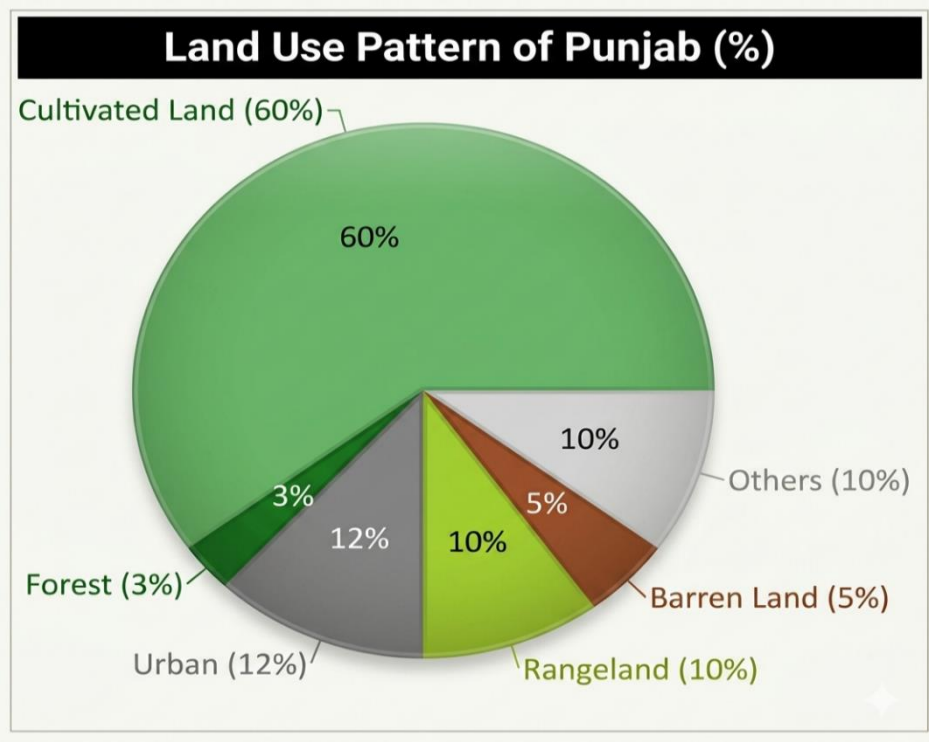


Figure 12.1: Land Use Distribution of Punjab

Source: Bureau of Statistics, Punjab (2023). *Land Utilisation Statistics.*

This land use distribution underscores the predominance of agriculture in Punjab and provides essential context for understanding how crop residue management practices affect seasonal air quality. Within this agricultural landscape, smog has emerged as a persistent environmental challenge, particularly during the post-harvest period when practices such as stubble burning significantly exacerbate air pollution. Punjab's agricultural calendar comprises two main cropping seasons: Kharif (April to September) and Rabi (October to March). The narrow interval between these seasons necessitates rapid field clearance following rice harvest to prepare land for wheat sowing. In central Punjab, where crop rotation between rice and wheat is prevalent, rice is planted in May and wheat in November. To expedite land preparation for wheat and other crops requiring fine seedbeds, many farmers resort to burning residual paddy stubble. This practice has intensified alongside the expansion of rice cultivation in the region, markedly contributing to the worsening of air quality.

The magnitude of stubble burning is reflected in official estimates and satellite observations tracking seasonal burning incidents, establishing a direct link to smog formation. According to the Smog Commission Report of 2017, stubble burning accounts for approximately 20% to 25% of total smog concentrations during peak periods. With Punjab's rice cultivation extending over approximately 4.5 million acres, a substantial volume of crop residue is annually burned openly. SUPARCO's 2024 anomaly reports documented numerous stubble burning incidents, particularly along major motorways, underscoring the urgency of targeted intervention. Given Punjab's expansive cultivated lands and the demonstrated contribution of stubble burning to smog, the serious health, environmental, and economic consequences call for the implementation of a dedicated, resource-supported mitigation strategy focused on reducing seasonal burning and improving air quality throughout the province.

12.2 Environmental Impacts of Stubble Burning

The recurring practice of stubble burning during crop harvesting seasons constitutes a significant and multifaceted environmental pressure in Punjab,

contributing to severe smog, environmental degradation, and public health hazards. The immediate consequences include acute air pollution, with particulate matter ($PM_{2.5}$ and PM_{10}) often reaching hazardous levels that pose substantial health risks, particularly to vulnerable populations. Additionally, this practice contributes to greenhouse gas emissions, depletes soil organic matter, and diminishes microbial activity essential for soil health. Long-term effects include declining soil fertility, increased dependency on chemical fertilisers, and influencing regional climate change dynamics.

Addressing this challenge requires more than outright prohibition. The persistence of residue burning highlights the structural and economic constraints within which many farmers operate; for many, the quickest and most affordable option is not environmentally sustainable. Therefore, policy approaches must integrate enforcement with practical support, access to appropriate technology, and the promotion of gradual behavioural changes in farming practices. In this context, farmer awareness and capacity building are crucial initial steps, as meaningful progress depends on enabling farmers to understand the impacts of burning and to adopt viable alternatives in their fields.

12.2.1 Farmer Awareness and Capacity Building Campaigns

Recognising the importance of awareness and capacity building, an extensive multi-channel Information, Education, and Communication (IEC) campaign was launched entitled **"Piloting the Solutions for Environmentally Sound Management of Crop Residues in Punjab."** Executed through a collaboration between the Environment Protection and Climate Change Department (EP&CCD), EPA Punjab, and the Social Protection and Inclusion Unit (SP&IU), the initiative commenced with an allocation of Rs. 300 million for the 2025–26 fiscal year.

The campaign was designed to promote sustainable alternatives to stubble burning, including biochar production, waste-to-energy technologies, and industrial biomass utilisation, while raising awareness among farmers and stakeholders regarding the health and environmental risks associated with

traditional burning practices. Although the project initially contemplated incorporating subsidies and surveillance measures, its scope was subsequently



Figure 12.2 Capacity building Workshop & demonstration of Biochar making Plant from the Crop Residue

refined through interdepartmental consultations to avoid duplication of existing initiatives such as the Agriculture Department's machinery distribution programme and the Chief Minister Punjab Green Credit Program. Consequently, the project adopted a specialised focus on farmer orientation, capacity building, and fostering direct engagement between crop growers and industrial residue users. This strategic pivot ensured that resources were prioritised towards promoting sustainable behavioural change through education, rather than duplicating existing financial support schemes.

12.2.2 Community Engagement through Seminars and Screenings

The community engagement strategy was centred on a series of seminars, field visits, and practical demonstrations conducted across Punjab's principal rice-growing districts. These initiatives provided farmers with direct exposure to waste-to-energy projects and alternative residue management technologies, effectively bridging the gap between theoretical knowledge and field application.

A highlight of this outreach was a purpose-produced docudrama illustrating the environmental and health impacts of stubble burning. Screened in over 100 villages with intensive cultivation, the film was complemented by interactive dialogue sessions featuring agricultural and environmental experts. These forums offered farmers a valuable platform to exchange experiences and discuss the practical challenges involved in transitioning to non-burning residue



management practices.

(a) Community members attending docudrama screening session



(b) Mobile awareness unit conducting outdoor docudrama screening in rural areas

Figure 12.3 (a,b) Village-Level Screening of Stubble Burning Awareness Docudrama

Additionally, larger-scale conferences, workshops, and demonstrations were organised in key rice-growing districts, bringing together progressive farmers, extension workers, district administration officials, and technical experts. These gatherings facilitated in-depth discussions on strategies to expand the adoption of sustainable residue management practices and to overcome implementation challenges.

12.2.3 Awareness through Mass Media and Digital Communication Campaigns

The campaign exploited mainstream media channels—including radio, television, and print—to disseminate information beyond direct farming communities, thereby fostering broader public awareness of the smog problem and the contribution of stubble burning. Targeted digital media campaigns were launched on social media platforms to engage younger demographics and urban populations, who could act as advocates for environmental protection.

Digital poster and video competitions were organised on social media to incentivise public participation in climate awareness content creation. The IM4Climate programme, an innovative initiative, encouraged content creators to develop and share climate awareness materials, establishing a community-driven ecosystem for environmental education. Digital streaming displays were also installed across major cities in Punjab to reach urban audiences and amplify awareness of environmental challenges.

All project activities—including seminars, field visits, exhibitions, and workshops—were extensively publicised through digital platforms, social media (notably Facebook), and mainstream media outlets. This multifaceted communication strategy ensured maximum reach and engagement across diverse segments, encompassing rural farming communities, urban residents, and policymakers.

12.2.4 Information, Education and Communication Materials

Extensive Information, Education, and Communication (IEC) materials were developed and disseminated to ensure consistent messaging across all communication platforms. The campaign produced 2,000 banners displayed at strategic locations throughout rice-growing regions, 2,000 streamers for visibility in public spaces and alongside roadways, and 20,000 flyers in four distinct formats tailored to convey targeted information on various aspects of residue management. Additionally, 10,000 trifold brochures providing comprehensive guidance on alternatives to stubble burning were distributed, alongside 30 roll-up standees used during seminars, workshops, and public events.

These materials were purposefully designed to communicate key messages through accessible formats, catering to diverse audiences ranging from farmers with limited literacy to educated urban populations. The extensive use of visual media such as banners and streamers ensured outreach to individuals who might not engage with text-heavy materials. All communication efforts emphasised raising awareness, building capacity, and fostering orientation towards sustainable, non-burning options for crop residue management.



Figure 12.4 Social Media Outreach Material for Anti Crop-Residue Burning Campaign

The IEC materials were distributed and prominently displayed at all seminars and screening events held across the 100 selected villages, ensuring consistent reinforcement of awareness messages throughout the campaign period.

Table 12.1: Awareness Campaign Components and Outreach (2025)

Campaign Component	Details and Outreach
Project Budget	Rs. 300 million (FY 2025-26)
Docudrama Production and Screening	Awareness docudrama screened in 100+ villages with rice cultivation

Seminars and Conferences	Conducted in Khanewal, Sahiwal, Okara, Kasur, Sheikhupura, Sialkot, Bhakkar and Lahore
Banners	2,000 units
Streamers	2,000 units + Digital streamers in main cities
Flyers	20,000 units
Trifold Brochures	10,000 units
Roll-up Standees	30 units
SMS and Robo-calls	1.25 million monthly messages during harvest season
Digital Media Campaign	Targeted social media campaigns, digital competitions, IM4Climate programme
Mainstream Media	Radio, television and print media campaigns

Source: SP&IU, EP&CCD Punjab

While the awareness campaign effectively communicated the risks associated with stubble burning and fostered behavioural change, prevention also necessitated the provision of practical tools and technologies enabling farmers to manage crop residue without resorting to open-field burning.

12.3 Preventive Instruments

The preventive approach focused on providing farmers with viable alternatives to stubble burning and creating awareness about the environmental and agricultural benefits of sustainable residue management practices.

12.3.1 Distribution of Super Seeders and Rice Straw Shredders

EPA Punjab, in collaboration with the Agriculture Department, implemented a major initiative distributing Super Seeders and rice straw shredders to farmers as

sustainable alternatives to the traditional practice of burning rice straw. Super Seeders allow farmers to sow wheat directly into fields with standing rice stubble, effectively incorporating the residue into the soil. This technology enhances soil health by increasing organic matter content, reduces the necessity for residue burning, and conserves valuable time during the critical transition period between crop seasons.



Figure 12.5 Super Seeder Distributed by the Government of Punjab Clean Air Programme

Rice straw shredders complement this approach by fragmenting stubble into manageable pieces that decompose more rapidly and can be readily incorporated into the soil. The shredded residue enriches soil organic content and enhances soil structure, benefiting subsequent crop growth. The distribution programme was strategically focused on hotspot areas along major motorways (M-2, M-3, M-4, and M-11), identified based on the frequency of stubble burning incidents in prior years, as illustrated in Figure 12.6. A total of 5,000 Super Seeders were distributed to farmers during 2024 and 2025, with 301 machines deployed in priority locations and plans to deploy the remaining units by November to ensure comprehensive coverage of targeted regions.

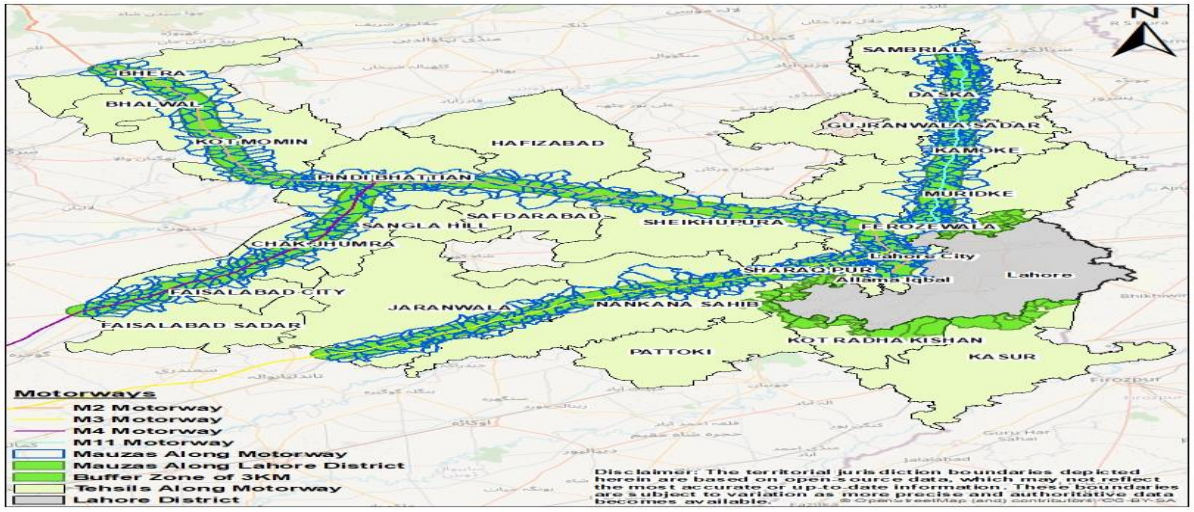


Figure 12.6 Hotspot Area along Motorways and sensitive tehsils

12.3.2 Impact of Preventive Measures

The deployment of Super Seeders and rice straw shredders, complemented by comprehensive farmer training, yielded measurable outcomes. The programme encompassed approximately 356,000 acres of rice fields, effectively preventing stubble burning on these lands. The use of Super Seeders enabled farmers to incorporate rice straw directly into the soil, obviating the need for burning while concurrently enhancing soil quality through the recycling of organic matter.

The widespread adoption of these technologies, supported by training initiatives, resulted in an estimated 40 to 50 percent reduction in stubble burning incidents in areas where Super Seeders were deployed. By integrating rice straw into the soil, the programme promoted improved soil fertility and mitigated environmental degradation previously associated with burning. Full deployment of the planned equipment is projected to reduce stubble burning incidents by 50 to 60 percent in hotspot regions, fostering cleaner air and healthier soils across Punjab.

12.3.3 Phased Delivery Strategy

The distribution of Super Seeders and rice straw shredders was executed through a strategically phased approach, designed to systematically cover priority areas while building implementation capacity and adapting to emerging field realities. The delivery plan comprised three primary phases, supplemented by a

dedicated allocation targeted at motorway corridors notorious for concentrated stubble burning incidents.

Phase I focused on initial deployment within identified hotspot districts, delivering 1,000 units to establish operational infrastructure and demonstrate the technology's viability. This initial phase served as proof of concept, enabling refinement of distribution processes, training protocols, and farmer support systems based on early implementation feedback.

Phase II marked a significant scale-up, distributing 2,000 units to broaden coverage across additional rice-growing areas. Benefiting from lessons learned in Phase I, deployment efficiency improved through established distribution networks and the involvement of trained extension personnel. This expansion reflected increased farmer demand and enhanced administrative capacity to support widespread adoption.

Phase III delivered 1,163 units to areas identified as requiring supplemental support, based on monitoring data from preceding phases and ongoing assessments of stubble burning patterns. This phase emphasised closing coverage gaps to ensure all priority areas had adequate access to alternative residue management technologies.

Recognising the particular visibility and environmental importance of motorway corridors—where stubble burning along major routes significantly contributes to smog formation and hazardous driving conditions—a dedicated allocation of 602 units was deployed along motorways M-2, M-3, M-4, and M-11. This targeted intervention ensured intensive coverage in zones with the highest public exposure and regional air quality impact.

Across all phases, including the motorway-specific allocation, a total of 4,819 Super Seeders and rice straw shredders were delivered to farmers at subsidised rates. This extensive deployment exemplifies a substantial public investment aimed at providing viable alternatives to stubble burning, illustrating the Government of Punjab's commitment to addressing the smog crisis through preventive, rather than strictly punitive, measures. The subsidised pricing

strategy was instrumental in ensuring accessibility for small- and medium-scale farmers who might otherwise be unable to afford such technology.

The phased distribution model conferred multiple strategic advantages: facilitating systematic capacity building among implementing agencies and farmers; enabling adaptive management informed by iterative feedback; supporting quality control and performance monitoring of equipment; and optimising budgetary utilisation over successive fiscal periods. The concentrated deployment along motorway corridors was informed by data-driven targeting, leveraging SUPARCO satellite anomaly reports and surveillance squad observations to maximise environmental impact.

Table 12.2: Phased Delivery of Super Seeders and Rice Straw Shredders

Delivery Component	Phase-I	Phase-II	Phase-III	Motorways
Units Delivered	1,000	2,000	1,163	602
Total Units Delivered	4,819 Units			

Source: Agriculture Department, Government of Punjab

The successful delivery of 4,819 units across all phases, including the motorway-specific allocation, constituted approximately 95 percent of the total target of 5,000 Super Seeders set forth in the programme objectives. This high delivery rate reflects effective programme implementation and robust administrative coordination among the implementing agencies. The remaining units are scheduled for deployment in subsequent distribution cycles, based on ongoing assessments of farmer demand and identification of emerging hotspot areas.

Table 12.3: Impact of Super Seeder Distribution Program

Impact Area	Details
Area Covered	356,000 acres of rice fields
Super Seeders Distributed (2024-2025)	4819 units
Super Seeders Deployed in Hotspots	602 units (out of 900 planned for hotspot area along Motorways)
Expected Reduction in Stubble Burning	40-50% reduction in incidents

Source: Agriculture Department, Government of Punjab

12.4 Need for Strategic Surveillance

Despite the implementation of awareness campaigns and preventive tools aimed at discouraging stubble burning, the persistence of such incidents across hotspot areas underscored that preventative measures alone were insufficient to secure effective field-level compliance. In numerous regions, crop residue burning continued unabated due to operational convenience, limited uptake of alternative methods, inadequate ground-level oversight, and the constrained temporal window between harvesting and sowing cycles. This challenge was particularly acute in zones adjacent to major motorways and urban settlements, where even localized burning has the potential to rapidly degrade visibility, disrupt traffic flow, and compromise ambient air quality.

These circumstances emphasised the necessity for an active monitoring and enforcement mechanism capable of real-time incident detection, field condition verification, and prompt intervention in high-risk areas. In response, the Environmental Protection Agency Punjab established a structured monitoring and surveillance framework that integrates field inspections, technological surveillance, public reporting mechanisms, and coordinated enforcement into a cohesive operational response system.

12.5 EPA's Monitoring Framework

Building on a targeted approach, the Environmental Protection Agency (EPA) Punjab established a comprehensive monitoring and surveillance framework in 2025 to regulate stubble burning in priority areas. The Agency adopted a six-layer strategic surveillance and response model designed specifically to control stubble burning. The initiative commenced with the identification of hotspot areas based on rice cultivation intensity, historical burning patterns, and proximity to major motorways and urban settlements.

Following hotspot delineation, specialised surveillance squads were deployed for continuous field monitoring and prompt incident detection. To enhance reporting coverage, EPA integrated public participation through digital platforms such as the Green Punjab App, Helpline 1373, and community-based reporting initiatives. To facilitate rapid field responses, Quick Response Centres (QRCs) were established at strategic locations, supported by Quick Response Units (QRUs) equipped to provide immediate firefighting and intervention.

Simultaneously, EPA developed an interdepartmental coordination mechanism engaging district administrations, the Agriculture Department, Police, and other relevant agencies to ensure effective coordination of enforcement and operational support. Collectively, these components constitute an integrated strategic surveillance and response framework for the control of stubble burning.

12.5.1 Surveillance Squad Deployment

A total of nine surveillance squads were strategically deployed across designated beats along major motorways. These beats were specifically designed to ensure comprehensive coverage of hotspot districts, with each squad assigned to oversee particular sections of key transportation corridors:

Table 12.4. Surveillance Beat Segmentation and Coverage Lengths along Motorways and Lahore Periphery

Surveillance Beat	Coverage Corridor (From-To)	Length (Km)
Beat 1	Ravi Toll - Khanqah Dogran Toll (M-2)	88
Beat 2	Khanqah Dogran Toll - Makhdom Toll (M-2)	24
Beat 3	Makhdom Toll - Bhera Toll (M-2)	85
Beat 4	Pindi Bhattian Toll - Faisalabad (M-4)	70
Beat 5	Ravi Toll - Jaranwala Toll (M-3)	55
Beat 6	Kala Shah Kaku Toll - Sialkot (M-11)	60
Beat 7	Eastern Bypass - Kot Pindi Das (area around Lahore)	63
Beat 8	Raiwind - Phoolnagar - Kot Radha Kishan (area around Lahore)	62
Beat 9	Lahore - Kasur and Raiwind (area around Lahore)	70

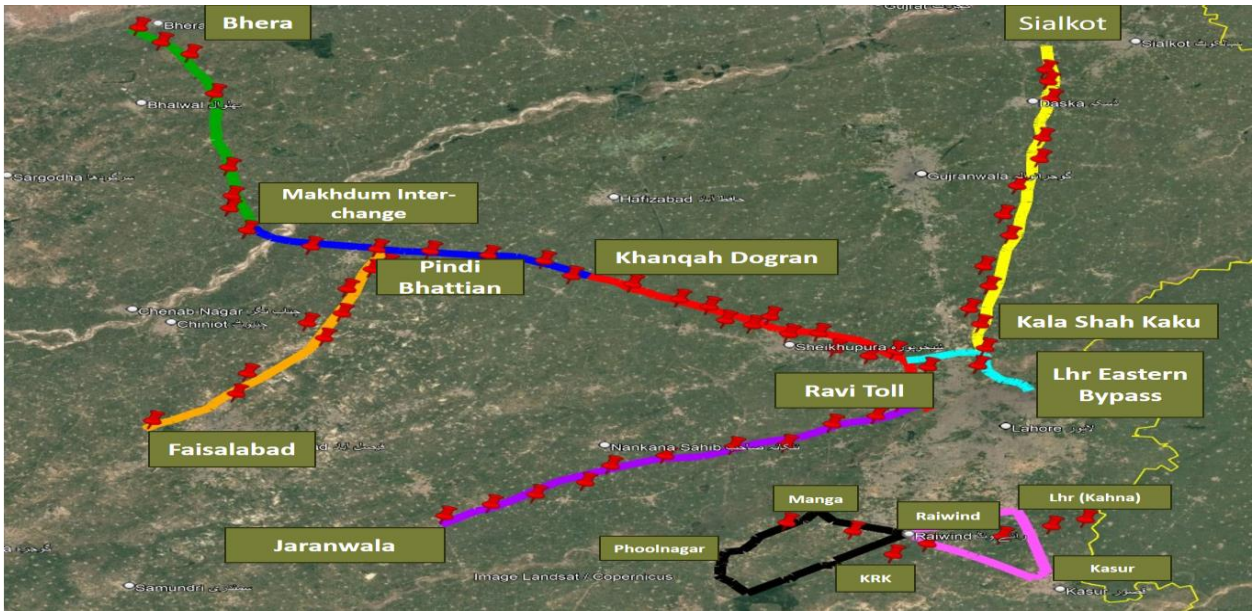


Figure 12.7 Geographic Alignment of Surveillance Beats along Motorways

Each surveillance squad comprised one Inspector, one Field Assistant, and a driver, equipped with a vehicle to patrol their designated beat. The inspectors and field assistants operated in rotating shifts to maintain continuous, round-the-clock monitoring of agricultural fields. While these field squads conducted direct ground-level surveillance, the integration of remote sensing technologies and digital tools enhanced detection capabilities, enabled verification of on-site observations, and extended monitoring coverage beyond the limits of physical patrol routes.

12.5.2 Remote Sensing and Technology Integration

EPA Punjab integrated satellite-based monitoring through SUPARCO's anomaly detection system, which provides real-time data on fire incidents across the province. These anomaly alerts are disseminated daily to Deputy Commissioners in all districts of Punjab via an official WhatsApp group, facilitating immediate access and prompt resolution by designated authorities. The fusion of remote sensing data with ground-level surveillance has established a robust, multi-layered monitoring framework capable of detecting stubble burning incidents across extensive agricultural regions. To augment official surveillance, the system also incorporates public reporting mechanisms, empowering citizens

and local communities to contribute timely information on suspected burning events.



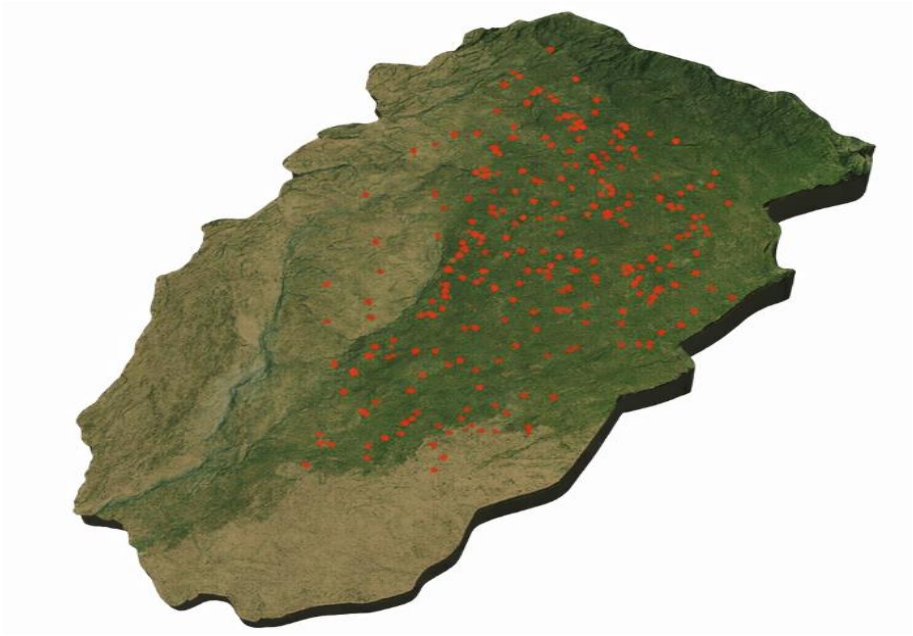


Figure 12.8 Stubble Burning Alerts Facilitated by SUPARCO & NASA Fire Maps

12.5.3 Public Reporting Mechanisms

EPA Punjab has established multiple channels to facilitate public participation in environmental monitoring efforts. The Green Punjab App was launched as a comprehensive platform enabling citizens to report complaints related to air pollution and stubble burning incidents. Complementing this digital tool, a dedicated helpline (1373) was instituted to receive and register complaints concerning stubble burning, operating on a 24-hour basis.

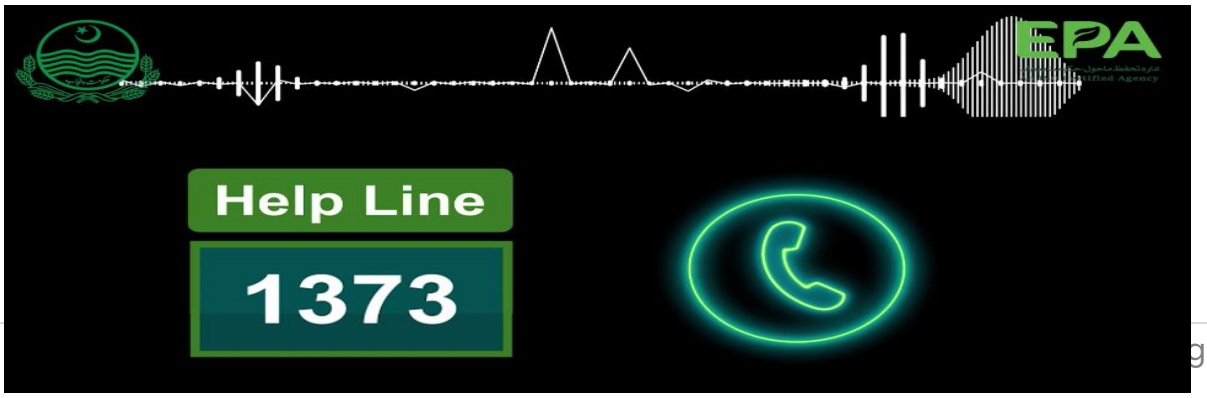


Figure 12.9 1373 Helpline System for Public Reporting

An innovative community engagement approach involved the registration of 13,600 school teachers stationed within rice cultivation hotspot districts. Recognising that teachers occupy a unique position as local observers with influence in their communities, this network was mobilised through automated Robo-calls. These calls, placed twice daily, invited teachers to report stubble burning incidents by selecting 'Yes' or 'No' responses via their keypads (pressing 1 or 2). Affirmative responses automatically initiated the lodging of formal complaints, prompting immediate field verification by enforcement teams. This



Figure 12.10 Teacher-based Robo-call reporting system

community-based surveillance model significantly broadened monitoring coverage and enhanced early detection capabilities through proactive grassroots participation.

The teacher-based Robo-call system effectively transformed local community presence into a structured reporting channel. However, the utility of these reports hinged upon timely verification, field response, and enforcement, necessitating close coordination among EPA, district administrations, agricultural authorities, and other relevant agencies.

Effective control of stubble burning required more than incident reporting and surveillance alone. The growing volume of field alerts generated through surveillance squads, Helpline 1373, the Green Punjab App, teacher-based reporting, and satellite anomaly detection underscored the need for an operational response mechanism capable of prompt field intervention and coordinated enforcement. To address this, EPA Punjab established a comprehensive implementation framework under the project titled "Establishment of Environmental Protection Force in 10 Zones of Punjab." This initiative integrates surveillance, rapid response, technological monitoring, and interdepartmental coordination into a unified operational system, targeting stubble burning control in identified hotspot districts along motorways and the outskirts of Lahore.

12.5.4 Quick Response Centres (QRCs)

A total of sixty-seven Quick Response Centres (QRCs) were strategically established (see Figure 12.11) within a three-kilometre radius along the motorways (M-2, M-3, M-4, and M-11) and adjacent areas of Lahore. Each QRC was located in or near a Union Council office of the Agriculture Department, ensuring access to infrastructure and facilitating coordination with agricultural extension services.

Each QRC was equipped with essential firefighting apparatus, comprising a tractor coupled with a water bowser holding between 5,000 and 6,000 litres. This Quick Response Unit (QRU) enabled rapid and direct intervention in fires identified by surveillance teams. The QRC was staffed by a Field Assistant from EPA serving as the focal point, supported by firefighting personnel. The squad members were provided with motorcycles (125cc) to ensure swift field assessment and mobility. Operations were conducted in two shifts—day and

night—to guarantee continuous availability and responsiveness to stubble burning incidents at any hour.

The Agriculture Department played a coordinating role in identifying suitable QRC sites and securing nearby tube wells for water replenishment, thereby ensuring that response teams maintained sustained access to critical water resources necessary for effective fire suppression.

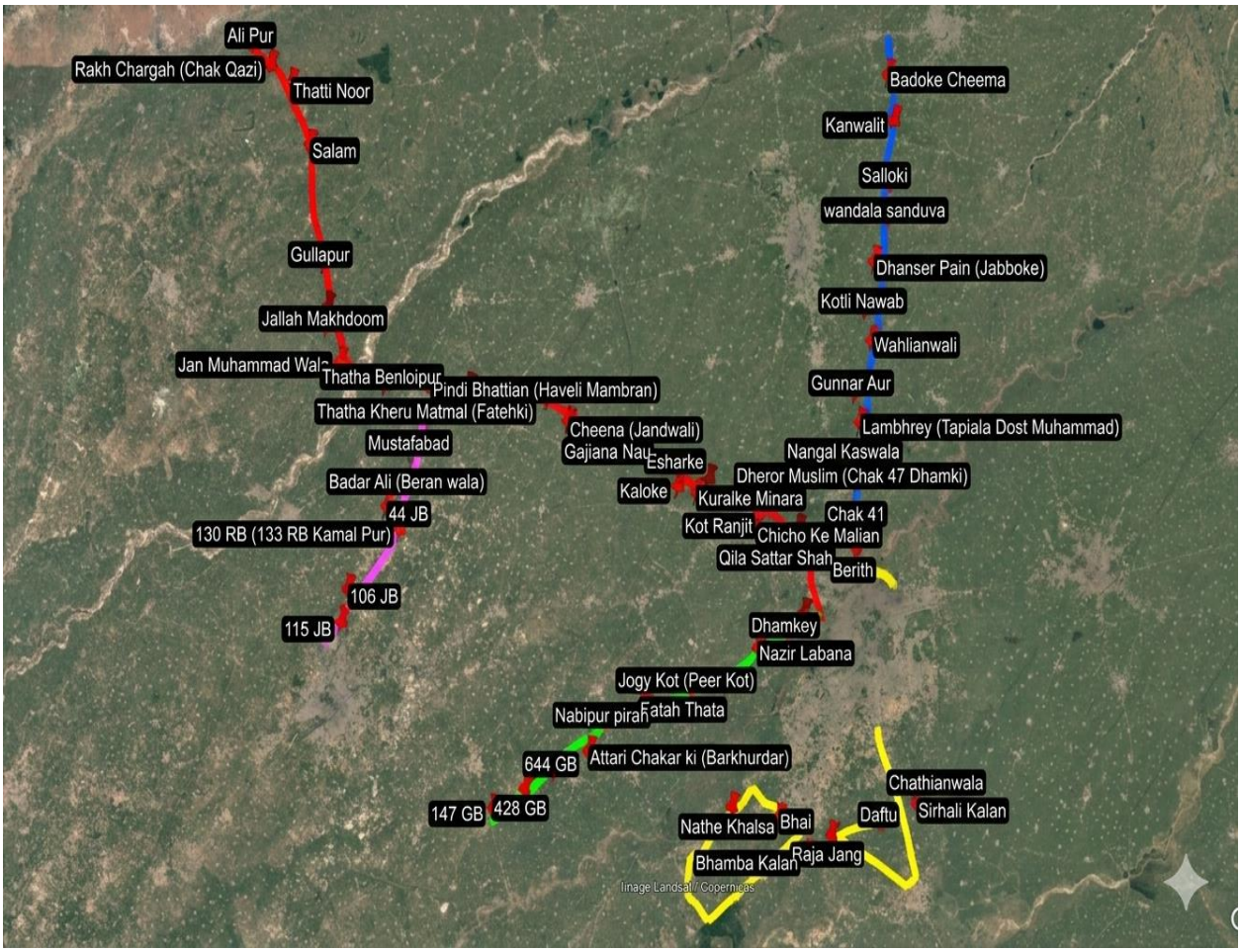


Figure 12.11 Locations of 67 Quick Response Centres (QRCs)

12.5.5 Incident Reporting and Response Mechanism

A streamlined incident reporting and response protocol was established to facilitate the rapid mobilisation of resources. When a surveillance squad detected a stubble burning incident, it immediately reported the event—complete with GPS coordinates to the nearest Quick Response Centre (QRC). Upon receipt of the report, the QRC squad promptly deployed its water bowser and firefighting personnel to the site, aiming to extinguish the fire and mitigate further damage.

This rapid response mechanism enabled timely intervention, significantly reducing the duration and severity of stubble burning incidents. The close coordination between surveillance squads and QRCs constituted an effective early warning and response system, capable of addressing incidents within critical timeframes.



Figure: 12.12 EPA's Quick Response Units (QRUs) providing immediate intervention to control stubble burning

12.5.6 Green Punjab App and Digital Monitoring Platform

All complaints received through multiple channels—including the Green Punjab App, Helpline 1373, teacher reports, and SUPARCO satellite anomaly data—were consolidated and displayed on the Green Punjab App Dashboard. This

dashboard offered real-time visualisation of complaint locations, the status of complaint resolutions, deployment of surveillance squads and Quick Response Units (QRUs), as well as evolving patterns and trends in stubble burning incidents.

12.6 Inter-departmental Coordination & Enforcement

Recognising that effective control of stubble burning necessitates coordinated action across multiple departments and administrative levels, EPA Punjab established a comprehensive interdepartmental coordination framework. This framework facilitates seamless collaboration among key stakeholders, ensuring the unified implementation of anti-stubble burning measures.

12.6.1 Collaboration with Agriculture Department

The Agriculture Department played a pivotal role in facilitating the establishment of Quick Response Centres (QRCs) at strategically selected locations to optimise effectiveness. The Department identified and coordinated the utilisation of Union Council offices for housing the QRCs and secured access to nearby tube wells for water refilling operations. This collaboration ensured that the QRCs were equipped with essential infrastructure and resources necessary for rapid fire suppression.

Extensive coordination meetings were convened at senior administrative levels between the Environment Department and the Agriculture Department to finalise operational strategies and guarantee effective implementation of crop residue burning control measures. These collaborative efforts also delineated clear roles and responsibilities and established a unified operational framework for field activities across districts.



Figure 12.13 High-Level Coordination Meetings between Environment and Agriculture Departments for Crop Residue Burning Control

Joint teams, comprising personnel from EPA Punjab and the Agriculture Department, conducted field operations within designated clusters, integrating regulatory enforcement with farmer engagement and technical assistance. This multifaceted approach enabled not only prompt action against violations but also the promotion of sustainable, long-term adoption of alternative crop residue management practices.

12.6.2 District and Tehsil-Level Coordination Mechanisms

EPA Punjab activated Anti-Smog Committees at district and tehsil levels to facilitate localised coordination and implementation of anti-stubble burning strategies. These committees included representatives from agriculture, environment, police, and district administration, collaboratively developing integrated response plans tailored to local conditions. Regular meetings ensured continuous monitoring, information sharing, and coordinated enforcement actions against violators.

In partnership with district administrations, thirty sub-tehsil clusters were designated along motorways, each encompassing 30–35 villages. These clusters functioned as operational units for prevention and control activities, with joint teams from the Agriculture Department and EPA Punjab conducting coordinated interventions within their allocated jurisdictions.

12.6.3 Police Department Coordination

EPA Punjab coordinated with the Provincial Police Officer to instruct all District Police Officers to secure sureties from individuals who had violated stubble burning regulations in previous years, ensuring their commitment to abstain from such practices during the current season. This preventive approach leveraged enforcement records to proactively reduce recidivism among known offenders. Police collaboration was also instrumental in facilitating access to remote areas and ensuring the safety of surveillance and Quick Response teams during field operations.

12.6.4 Centralised Coordination through Smog War Room

EPA Punjab established a Smog War Room to serve as the central command and coordination hub for all anti-stubble burning operations. To ensure seamless interdepartmental collaboration, focal persons from the Agriculture Department and other key stakeholders were deputed to the War Room, with a mandate to attend regularly throughout the stubble burning season. This arrangement facilitated real-time data sharing and synchronised field activities across all administrative levels.

The War Room supervised the real-time monitoring of the Green Punjab App Dashboard, overseeing complaint resolution tracking, coordination of Quick Response Unit deployments, and strategic decision-making informed by emerging patterns and trends.

Complaints received through various channels including the Green Punjab App, Helpline 1373, teacher reports via automated Robo-calls, and SUPARCO satellite anomaly alerts—were consolidated and visualised on the Green Punjab App Dashboard. Access to this dashboard was provided to Deputy Commissioner offices, where designated System Network Administrators (SNAs) served as district focal points. This centralised information system enhanced coordinated responses across jurisdictions and ensured accountability in complaint resolution.

12.7 Environmental Outcomes

The comprehensive anti-stubble burning strategy implemented by EPA Punjab, integrating preventive measures, surveillance systems, and rapid response mechanisms, yielded significant environmental outcomes during the 2025 paddy harvesting season.

12.7.1 Reduction in Fire Anomalies

The rice stubble burning season officially commenced on 28 September 2025. Subsequently, satellite data from SUPARCO revealed a substantial reduction in fire anomalies during October 2025 compared to the same period in 2024. The timely deployment of surveillance squads, coupled with coordinated interventions involving the Agriculture Department, district administrations, and law enforcement agencies, resulted in a 65 percent decrease in reported anomalies during October (see Figure 12.14). This pronounced decline attests to the effectiveness of an integrated strategy combining prevention, monitoring, and enforcement.

The reduction in fire anomalies was particularly notable in regions serviced by operational Quick Response Centres and the distribution of Super Seeders. The confluence of alternative technologies, farmer capacity-building initiatives, enhanced surveillance, and rapid response capabilities created a synergistic effect, significantly lowering the incidence of stubble burning within targeted hotspot areas.

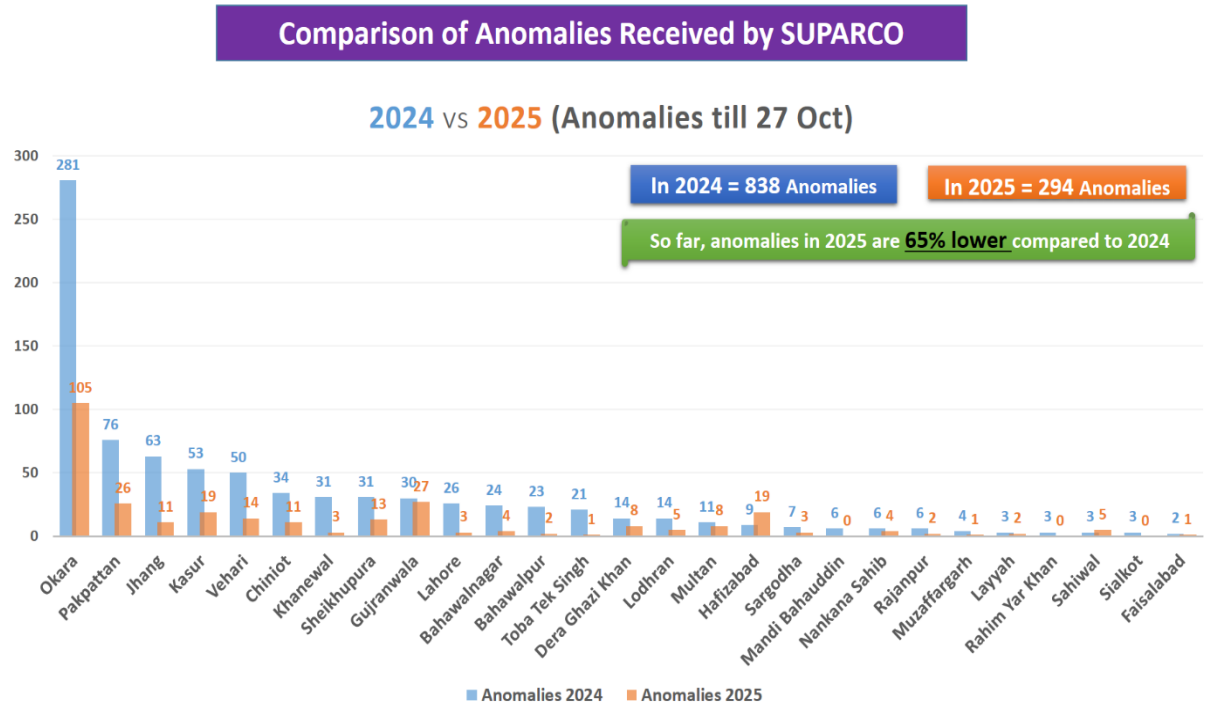


Figure 12.14: Comparison of Anomalies 2024 vs 2025

12.7.2 Emergency Response Performance

The Quick Response Units (QRUs) commenced operations in November during the peak smog season on an emergency basis. Within just two weeks of deployment, the QRUs successfully responded to and extinguished 101 fire incidents in hotspot districts along major motorways and the periphery of Lahore. Notably, in two specific hotspot districts and their respective beats, no fire suppression activities were necessary as rice harvesting had been completed prior to the QRUs' arrival. Despite the late commencement of operations, this rapid response capability demonstrated the effectiveness of the deployment strategy, underscoring that timely intervention can successfully mitigate stubble burning before incidents escalate.

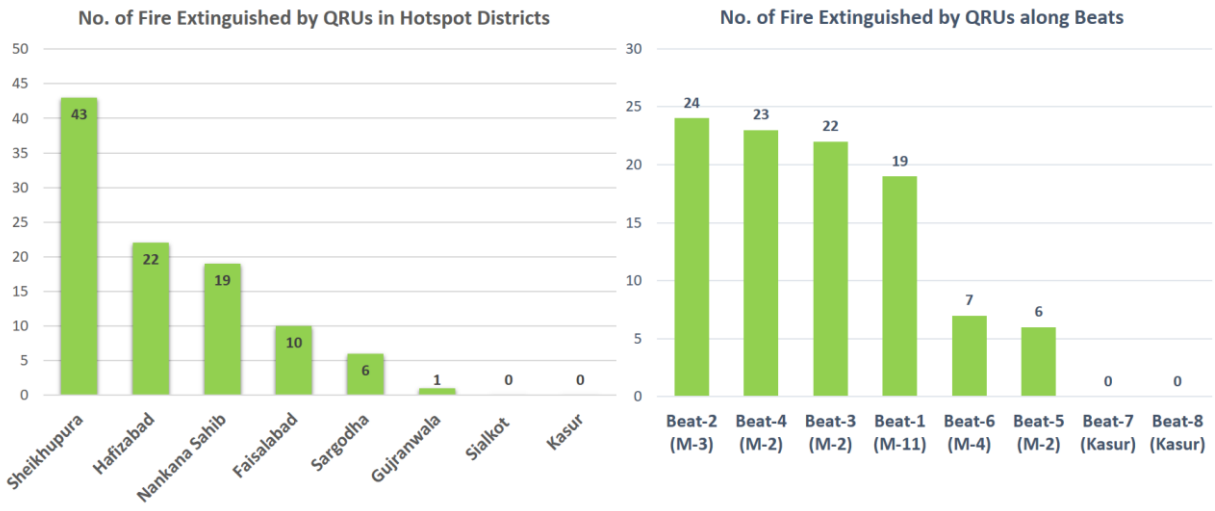


Figure. 12.15 Operational performance of Quick Response Units (QRUs) showing district-wise and beat-wise distribution of fire incidents addressed in priority intervention zones

The successful extinguishment of 101 fires within two weeks constituted a significant achievement in mitigating air pollution that would have otherwise arisen from uncontrolled crop residue burning. Each suppressed fire prevented the emission of particulate matter, carbon monoxide, methane, and other pollutants known to contribute to smog formation and pose substantial health risks to vulnerable populations.

12.7.3 Air Quality Improvements

The substantial reduction in stubble burning incidents contributed to improved air quality during the critical post-harvest period. By preventing the burning of crop residue on over 356,000 acres through the deployment of Super Seeders and extinguishing 101 fires via rapid response, the programme effectively avoided the emission of significant quantities of air pollutants. These interventions led to a marked decrease in concentrations of particulate matter ($PM_{2.5}$ and PM_{10}) in targeted areas, thereby reducing respiratory health risks for local populations and diminishing the contribution of agricultural burning to regional smog formation.

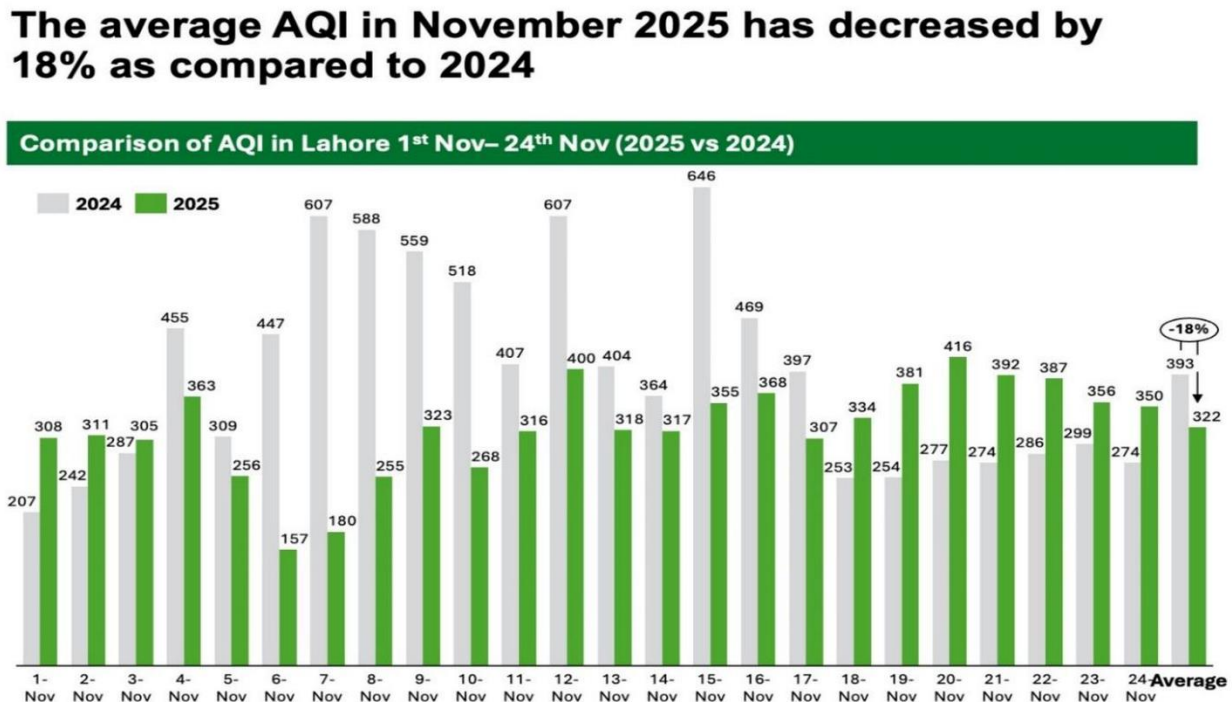


Figure: 12.16 Daily and average Air Quality Index (AQI) values in Lahore from 1–24 November, comparing 2024 and 2025, showing an overall 18% reduction in average AQI in 2025.

Source: data from EPA monitors reports published on www.epd.gov.pk

12.7.4 Soil Health and Agricultural Benefits

Beyond air quality improvements, the adoption of Super Seeders and stubble incorporation practices has yielded significant benefits for soil health. By integrating rice straw into the soil rather than burning it, farmers contribute organic matter to their fields, which enhances soil structure, water retention capacity, and nutrient cycling. Over time, these gains in soil quality are anticipated to improve agricultural productivity and diminish reliance on chemical fertilisers, delivering both environmental and economic advantages to farming communities.

12.7.5 Behavioural Change and Long-term Sustainability

The comprehensive strategy, integrating technology provision, farmer training, surveillance, and enforcement, facilitated gradual behavioural change within farming communities. Training programmes increased awareness of the environmental and agricultural consequences of stubble burning and

introduced viable alternative practices. This heightened awareness, coupled with access to Super Seeders and the credible deterrent effect of enforcement through surveillance systems, fostered conditions conducive to the sustainable adoption of alternative residue management methods.

The establishment of interdepartmental coordination mechanisms and community-based monitoring networks has enhanced institutional capacity, providing a robust foundation to sustain progress in controlling stubble burning. The successes achieved through the 2025 interventions lay the groundwork for scaling up both preventive and responsive measures in subsequent years, with the potential to further reduce stubble burning and its associated environmental impacts.

12.8 Way Forward

The anti-stubble burning initiatives implemented during 2025 demonstrated that a comprehensive and multi-faceted approach—integrating preventive measures, advanced surveillance technology, rapid response capabilities, and interdepartmental coordination—can significantly reduce crop residue burning and its associated environmental impacts. The 65 percent reduction in fire anomalies reported by SUPARCO, the successful extinguishment of 101 fires within two weeks by Quick Response Units, and the coverage of over 356,000 acres through the distribution of 4,819 Super Seeders represent substantial achievements in addressing one of Punjab's most pressing environmental challenges.

The success of these interventions underscores several critical factors, including the strategic targeting of hotspot areas, the effective integration of prevention with enforcement, the utility of technology-enabled monitoring systems, and the foundation laid for long-term behavioural change through direct farmer engagement.

Looking ahead, sustaining and augmenting these accomplishments will necessitate continued investment in alternative agricultural technologies, expansion of Quick Response Centre coverage, and enhancement of surveillance and monitoring systems. The comprehensive framework established during the

2024–2025 period offers a replicable model for combating stubble burning, which can be scaled across additional districts and refined through ongoing operational experience.

Ultimately, the environmental benefits achieved—including improved air quality, enhanced soil health, reduced greenhouse gas emissions, and diminished public health risks—demonstrate that effective environmental management in the agricultural sector requires the seamless integration of regulatory enforcement, provision of viable alternatives, and capacity building within farming communities. Punjab's experience in controlling stubble burning offers valuable lessons for other regions confronting the dual imperatives of agricultural productivity and environmental sustainability.

PART 03

Digital Transformation & Coordinated Environmental Governance

CHAPTER 13

Digital Environmental Governance



13.1 Introduction

A defining moment in the evolution of environmental governance occurred in 2025, as the Environmental Protection Agency (EPA) Punjab embarked on a bold and comprehensive digital transformation across the province. Faced with escalating environmental challenges and the complexity of governing forty-one diverse districts, the Agency recognised that its traditional paper-based systems were inadequate. These legacy processes impeded regulatory responsiveness, constrained transparency, and diminished enforcement efficacy. The imperative for a decisive transition towards a more agile, data-centric framework became both urgent and unavoidable.

In response, EPA Punjab adopted a forward-looking strategy centred on digital integration, real-time monitoring, and streamlined operations. By replacing fragmented workflows with interconnected systems, the Agency sought to enhance the speed, precision, and accountability of its regulatory functions. This transformation reflects a strategic commitment to bolstering institutional performance while addressing the dynamic environmental challenges confronting the province.

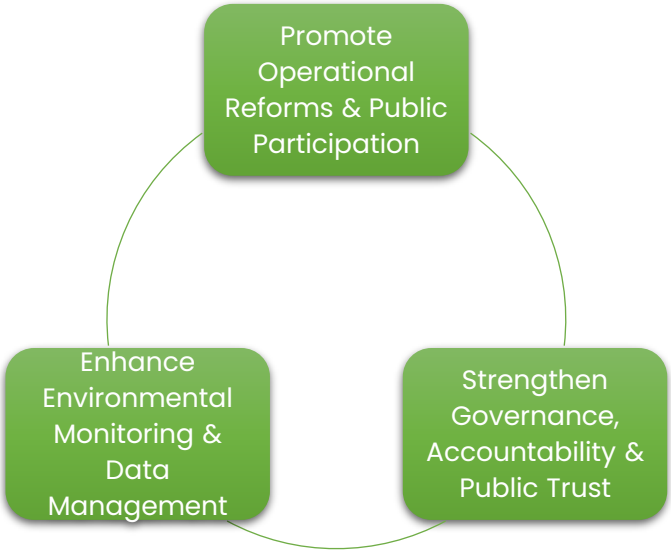
The digital transformation extended far beyond mere digitisation of existing records; it entailed the creation of a comprehensive and interconnected digital ecosystem. By incorporating artificial intelligence-driven industrial monitoring, real-time analytical dashboards, and electronic adjudication platforms, EPA Punjab fundamentally restructured its operational framework. These innovations supplanted time-consuming manual procedures with streamlined, transparent, and automated systems, enabling more rapid regulatory responses and ensuring greater consistency in enforcement throughout Punjab.

Today, these initiatives have positioned EPA Punjab as a leader in smart regulation, establishing a new benchmark for environmental governance in Pakistan.

13.2 EPA Punjab's Digital Transformation Framework

EPA Punjab conceptualises its digital transformation through three interconnected strategic priorities: strengthening regulatory oversight, enhancing ease of doing business, and promoting internal accountability. Rather than perceiving digitisation merely as an administrative task, the Agency designed its new framework to support expedited enforcement actions, transparent regulatory decision-making, and citizen-centric service delivery.

Within this approach, digital dashboards and analytical systems were deployed to bolster regulatory scrutiny and real-time monitoring; online application



portals and streamlined approval mechanisms were developed to facilitate ease of doing business by minimising procedural delays and increasing transparency; and internal accountability tools—including performance tracking systems and centralised monitoring platforms—were established to ensure institutional efficiency and operational oversight across all districts.

Collectively, these three pillars underpin EPA Punjab's evolving digital governance model and constitute the operational framework for the integrated systems, dashboards, applications, and public engagement platforms detailed in the subsequent sections.

Figure 13.1: Three Strategic Priorities of new Framework

13.3. Digital Monitoring System and Dashboards

The strategic deployment of digital dashboards—including the ECO Watch Dashboard, Internal Accountability Dashboard, and Industrial Directory Dashboard—alongside applications such as the Green Punjab App and ECO Watch App, has significantly enhanced the digital governance capacity of EPA Punjab. These platforms function not merely as tools for information dissemination but as integral components of a transparent, traceable, and performance-driven regulatory framework.

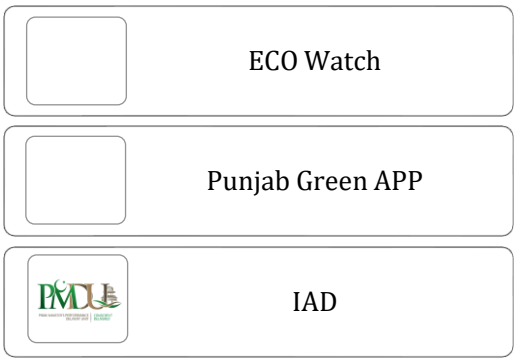


Figure 13.2: Some of EPA's Digital Monitoring Systems – LOGOs

The transition from manual reporting to live digital monitoring has improved EPA Punjab's capacity to detect violations, coordinate inspections, allocate field teams efficiently, and evaluate enforcement performance through real-time data analytics.

A major advancement in governance is the reduction in lag time between violation occurrence, detection, and regulatory response. AI-powered cameras installed on industrial stacks transmit live video feeds to regulatory authorities, allowing emissions-related violations to be identified remotely and more rapidly than through traditional inspection methods. This capability enables EPA Punjab to conduct continuous monitoring of industrial activities rather than relying solely on periodic site visits. The system's effectiveness can be measured by indicators such as average response time to detected violations, the number of industrial units under live monitoring, detection frequency via digital surveillance, and the proportion of cases where enforcement action was initiated within stipulated timeframes.

Digital dashboards have also enhanced operational efficiency during field inspections. Inspectors can now upload inspection reports, photographs, geotagged evidence, and compliance observations in real time, which minimises

duplication, reduces paperwork delays, and lowers the risk of incomplete or inaccurate manual records. Key performance metrics to assess these improvements should include the number of digitally documented inspections, the percentage of inspections accompanied by geotagged evidence, reductions in manual file processing duration, and the volume of inspections reviewed by senior officers via the Internal Accountability Dashboard. These metrics will help ascertain whether the adoption of digital tools has substantively enhanced administrative efficiency rather than merely introducing technological changes.

The Industrial Directory Dashboard further supports evidence-based regulation by maintaining a structured database of industries, detailing their locations, compliance statuses, and risk profiles. This facilitates a shift from routine, schedule-based inspections to targeted, risk-based enforcement. High-risk industries—those with recurrent violations, significant emissions, or incomplete compliance records—can be prioritised for inspection. Evaluation of this risk-based approach should consider indicators such as the percentage of high-risk industries inspected, the number of repeat violations discovered, rates of compliance improvement following enforcement, and reductions in pending inspection backlogs.

Overall, the digital monitoring system holds the potential to elevate environmental governance by rendering enforcement more data-driven, transparent, and accountable. Nonetheless, its success should not be measured merely by the presence of dashboards or mobile applications but by tangible outcomes including faster response times, expanded inspection coverage, improved compliance rates, decreased complaint backlogs, increased detection of violations, and observable enhancements in environmental quality. Accordingly, future reporting by EPA Punjab should incorporate a performance dashboard presenting baseline figures, current results, and annual targets to enable an objective assessment of the true governance impact of digital monitoring.

13.3.1. AI-Driven Smart Monitoring

The Smart Industrial Monitoring Dashboard signifies a major advancement in continuous industrial surveillance by leveraging CCTV cameras augmented with artificial intelligence (AI) and machine learning capabilities. This platform automatically detects and flags regulatory violations in accordance with the Ringelmann Scale. Unlike conventional inspection methods reliant on periodic site visits, the Dashboard provides uninterrupted visual monitoring of industrial operations. AI algorithms are trained to recognise abnormal smoke patterns, unauthorised discharges, and operational anomalies in real time. **The Monitoring mechanism is structured as follows.** The system ensures prompt and systematic responses to detected emissions and environmental violations. Through automated alerts and coordinated enforcement actions, it facilitates timely intervention and enhances the effectiveness of regulatory compliance. The process begins with the detection of emissions or visible smoke from industrial units. Upon detection, the system automatically generates an alert, triggering an immediate response via the EPA helpline (1373), through which the concerned industry owner is promptly contacted and informed of the violation. This swift communication mechanism ensures that issues are addressed at the earliest possible stage, minimising environmental impact and encouraging timely corrective action by the operator. If the issue is resolved following the initial intervention, the case is formally closed within the system. However, in instances where violations persist, the system escalates the matter to the respective district office for further action.

This escalation initiates on-ground field enforcement, wherein compliance is ensured through inspections and the implementation of necessary regulatory measures. If non-compliance continues, the process culminates in legal proceedings, supported by digital evidence collected through the monitoring system. This structured, stepwise framework fosters transparency,

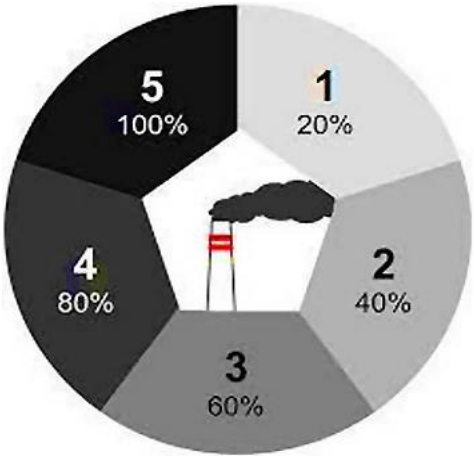


Figure 13.3: Ringelmann scale chart

accountability, and reinforces a shift towards proactive environmental governance.

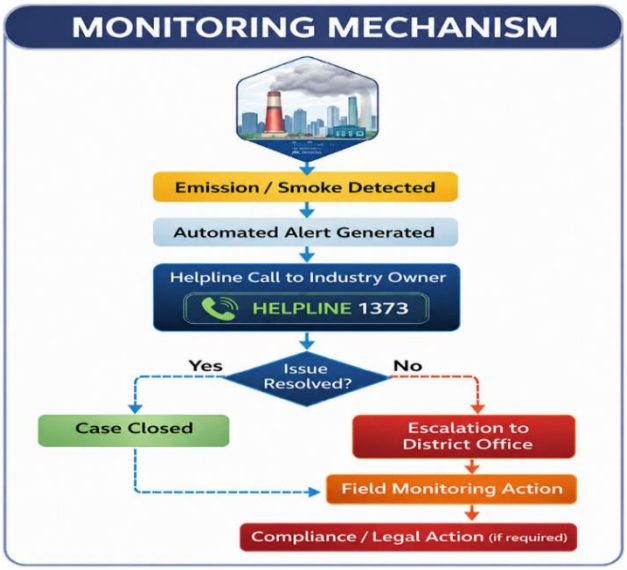




Figure 13.4: Online Industrial Monitoring and Response from 1373

While smart monitoring and automated enforcement mechanisms significantly enhanced EPA Punjab's real-time regulatory oversight, the Agency recognised that environmental governance cannot rely solely on enforcement. An equally pressing challenge was the modernisation of environmental approvals and regulatory clearances, which had traditionally been hampered by protracted procedures, fragmented documentation, and operational delays. To address these structural inefficiencies and promote responsible industrial growth through a transparent and efficient regulatory process, EPA Punjab introduced the Environmental Approval Management System (EAMS), a dedicated digital platform designed to streamline environmental approvals across the province.

13.3.2. Environmental Approval Management System (EAMS)

Environmental approvals constitute a critical regulatory domain necessitating a clear, dedicated, and methodically structured system to ensure that prospective environmental impacts are thoroughly assessed, managed, and mitigated. Concurrently, an effective approval mechanism must facilitate responsible industrial and commercial development by offering a transparent, efficient, and predictable regulatory pathway. In this context, the Environmental Approval Management System (EAMS) was developed as an in-house digital platform to

modernise and streamline the environmental approval process throughout Punjab.

EAMS has substantially transformed the conventional approval process by digitising the submission and processing of Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) applications across all 41 districts of Punjab. Under the previous system, proponents were frequently required to physically visit the Lahore Headquarters for submission and follow-up, causing delays, inconvenience, and procedural inefficiencies. The digital platform now enables applicants to submit cases from any district within the province, reducing travel requirements, saving time, and improving accessibility for businesses and project proponents.

A key strength of EAMS lies in its transparent and user-oriented design. The system provides stepwise email notifications at every stage of case processing, allowing proponents to remain informed from submission to final decision. This functionality dramatically simplifies file tracking, eliminating reliance on manual correspondence or repeated office visits. For the first time, final environmental approvals are generated digitally and communicated directly to applicants via automated email alerts, enhancing both procedural efficiency and institutional credibility.

Beyond streamlining case management, EAMS creates a comprehensive digital record for each registered industry and project. This centralised database facilitates the systematic archiving of submissions, approvals, imposed conditions, and follow-up actions, rendering industrial compliance more traceable and manageable over time. The system further supports quarterly monitoring and compliance reviews by linking environmental approvals with subsequent oversight activities, thereby reinforcing governance beyond the issuance of permits.

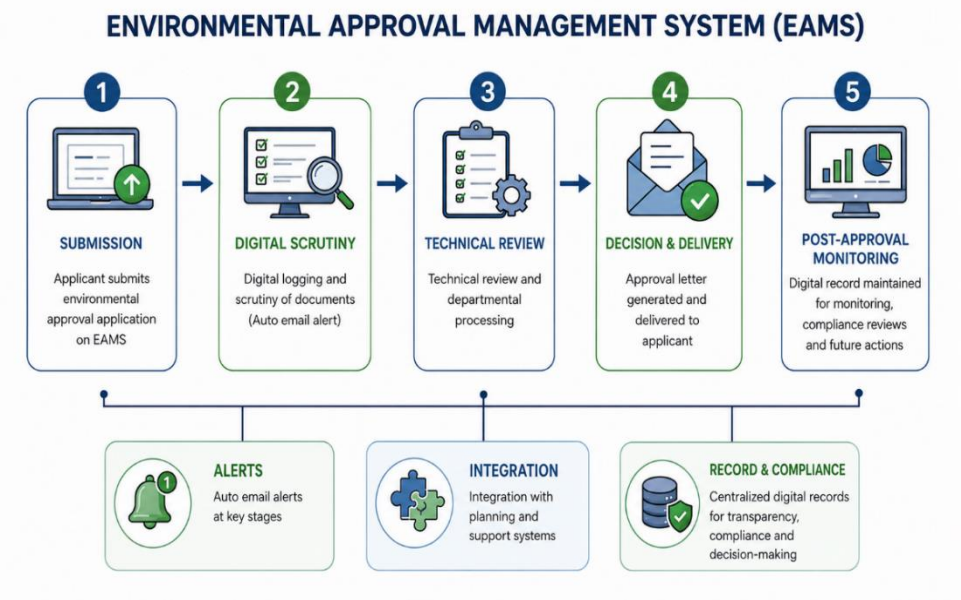
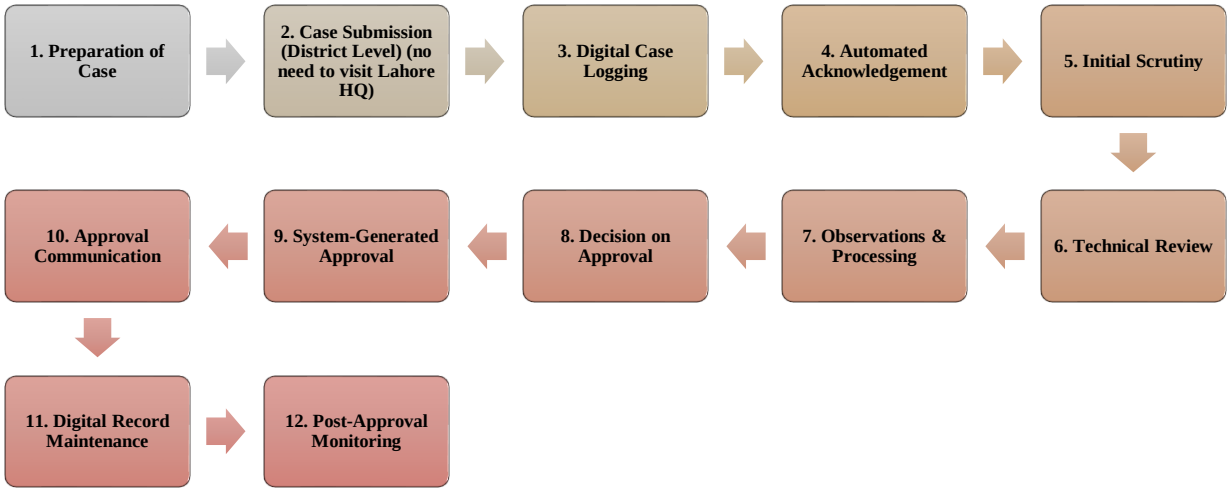


Figure 13.5: EAMS workflow chart

Furthermore, EAMS is integrated with the broader Planning Support System within



the Environmental Management System framework, facilitating informed decision-making by linking environmental approvals with geospatial, planning, and regulatory data. This integration ensures that approval decisions are made in a holistic manner, supported by comprehensive environmental and spatial information. Such an approach enhances the quality, consistency, and defensibility of regulatory outcomes while concurrently reducing overall processing timelines.

Figure 13.6: EAMS Process Flow

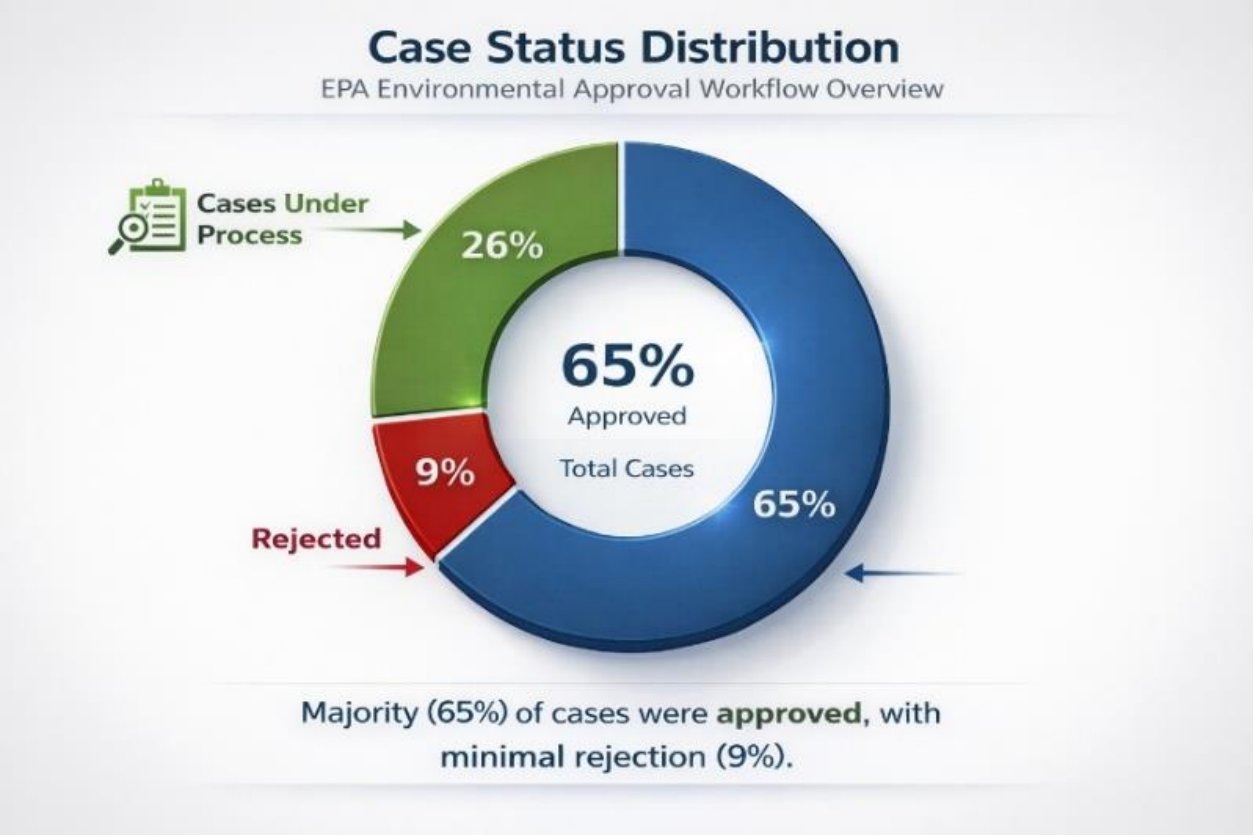
The operational workflow of the Environmental Approval Management System (EAMS) follows a clear digital sequence. Initially, the project proponent submits the Environmental Impact Assessment (EIA) or Initial Environmental Examination (IEE) application at the district office, eliminating the need for physical visits to the Lahore Headquarters. Upon submission, the case is digitally logged and becomes fully traceable within the system.

The proponent receives automated email notifications as the application progresses through various stages, including scrutiny, technical review, and departmental processing. During the review phase, designated officers examine the submitted documentation, record observations as necessary, and process the case in accordance with applicable regulatory requirements. Upon conclusion of the evaluation and approval stages, the final environmental

approval is generated within the system and electronically delivered to the proponent via email.

Subsequently, the application remains part of the digital archive, facilitating future compliance evaluations, ongoing monitoring, and traceability of the relevant industrial or development activity.

In 2025, a total of 541 cases were successfully submitted through the Environmental Approval Management System (EAMS), with approximately 65 percent receiving approval. These figures not only underscore the increasing operational adoption of the platform but also highlight its tangible utility in facilitating transparent, efficient, and technology-enabled environmental



governance throughout Punjab.

Figure 13.7: 2025 EAMS cases status distribution

13.3.3. Unique Identification System and E-Mapping of Industries

Following the launch of the Environmental Approval Management System (EAMS), the Punjab Environmental Protection Agency (EPA) undertook a strategic initiative to fortify its regulatory framework, with a particular emphasis on enhancing industrial tracking, ensuring historical traceability, and standardising data across the province. Initial assessments revealed that a significant proportion of industrial units operating within Punjab were either entirely unregistered or lacked a coherent digital record, despite many possessing environmental approvals. This fragmentation of data and the absence of a centralised inventory generated substantial gaps in regulatory oversight, impeding the Agency's capacity to monitor, evaluate, and enforce environmental compliance effectively. Additionally, inspection practices were predominantly unstructured, often resulting in selective monitoring where specific sectors received disproportionate scrutiny while others remained neglected due to the lack of comprehensive tracking mechanisms.

To address these systemic challenges, EPA Punjab developed and implemented a province-wide digital Unique Identification (UID) and E-Mapping system aimed at integrating all industrial units—both registered and previously untracked—into a unified, transparent, and traceable regulatory framework. This initiative was complemented by the creation of a comprehensive digital industrial inventory, ensuring exhaustive coverage of industrial establishments across all districts. A core element of this system involved the standardisation of industrial



Figure 13.8: UIDs Generation Mechanism

sectors through the introduction of structured short classification codes. Each industrial category was assigned a unique three-letter identifier—for example, Rice Mills were designated as "RIM"—facilitating uniform classification, straightforward identification and consistent data management throughout the province. Furthermore, districts were assigned standardised short codes, and industries within each district were sequentially numbered, thereby enabling the creation of a coherent and meaningful UID format.

The generation of the Unique Identification Number (UID) follows a systematic, rule-based methodology incorporating five critical data elements to ensure accuracy, uniqueness, and traceability. These elements include the name of the industrial unit, its precise geographic coordinates (latitude and longitude), sector classification, sub-sector categorisation, and its geographic location (district). Based on these inputs, the UID is constructed as a composite code, typically combining the district short code, industry (sector) short code, and a unique serial number representing the individual industry within that district—for example, a UID such as "NNS-RIM-003" clearly indicates the district, industry type, and its sequence. This structured approach ensures that each UID is both human-readable and compatible with information systems, enabling rapid identification while maintaining database integrity.

The implementation process entailed rigorous groundwork, including extensive field surveys, consolidation of existing records, verification of industrial data, geo-tagging of units using GPS coordinates, and sector-wise classification followed by digital standardisation. Through this comprehensive effort, over 14,000 industrial units were successfully identified, categorised, and incorporated into the digital inventory, marking a significant landmark in environmental data management for the province. The integration of e-mapping further augmented this system by embedding each industrial unit within a Geographic Information System (GIS), allowing regulatory authorities to visualise spatial distributions, assess environmental risk zones, and optimise inspection planning based on geographic and sectoral clustering.

Moreover, each UID links to a comprehensive digital profile of the industrial unit, serving as a central repository of all relevant information, including inspection histories, compliance statuses, issued notices, enforcement actions, and environmental approval records such as No Objection Certificates (NOCs) and permits. This unified platform supplants fragmented manual record-keeping with a real-time, transparent, and easily accessible system, thereby significantly enhancing accountability and operational efficiency.

Collectively, the integration of UID generation, sectoral standardisation, and e-mapping has established a robust digital foundation for industrial regulation in Punjab. It enables real-time tracking, eliminates duplication, ensures exhaustive coverage of industrial units, and supports data-driven decision-making. This system not only augments regulatory efficacy and inspection planning but also promotes transparency, consistency, and sustainable environmental governance throughout the province.

The subsequent critical phase involved spatial mapping and geo-tagging of industrial units. A detailed geospatial framework was developed, incorporating multiple layers of tagging and classification. Industries were categorised based on pollution characteristics, including air, water, and combined emission sources (refer to Annexure 1). This granular mapping facilitated the identification of pollution hotspots at the district level and supported the formulation of cluster-based classifications.

Leveraging this geospatial intelligence, Punjab was further subdivided into three major industrial zones based on cluster distribution. This classification informed the strategic deployment of human resources, ensuring the alignment of regulatory staff allocation with the density and typology of industrial activity in each region.

13.3.4. EPA Punjab Industrial Directory

Following the successful implementation of the Unique Identification (UID) system, the subsequent critical challenge was to manage industrial inspections and field visits in a more intelligent, efficient, and targeted manner. Concurrently, it was imperative to foster environmental awareness among industrial

stakeholders, encouraging voluntary compliance by recognising environmental protection as a shared, collective responsibility.

To this end, EPA Punjab developed a comprehensive digital record management system encompassing all industries assigned a Unique ID. Detailed profiling was undertaken during initial field visits, capturing extensive information across approximately 30 standardised parameters. This approach ensured that an industry's operational and environmental profile was recorded once, obviating the need for repetitive data collection during subsequent inspections.

The primary objective of this initiative was to establish a province-wide environmental profile of industries, enabling the identification of sector-wise and district-wise industrial patterns, as well as distinguishing between seasonal and year-round operations. Consequently, inspection planning evolved into a focused, risk-based process, directing regulatory efforts toward environmentally sensitive and high-risk industries while minimising unnecessary disruption to low-risk or seasonal enterprises.

The cornerstone of the District Industrial Profiling initiative was the creation of a centralised digital record system, providing secure storage and easy access to industrial data for legal and regulatory purposes. This methodology reduces duplication, curtails enforcement delays, and minimises the need for repeated field visits by enabling authorities to make informed decisions based on readily available, verified information. Overall, this system enhances regulatory efficiency, conserves time, and supports more effective, transparent, and evidence-based governance.

This approach has significantly bolstered stakeholder confidence in government processes, as industries have observed a shift toward transparent, data-driven, and non-intrusive regulatory practices. As a result, many industrial units have voluntarily contributed their data, further enriching the system.

The digital profiling system has substantially augmented EPA Punjab's capacity for smart monitoring, furnishing the Agency with a comprehensive and dynamically updated database of environmentally critical industries across the

province, thereby facilitating precise decision-making and optimised enforcement interventions.

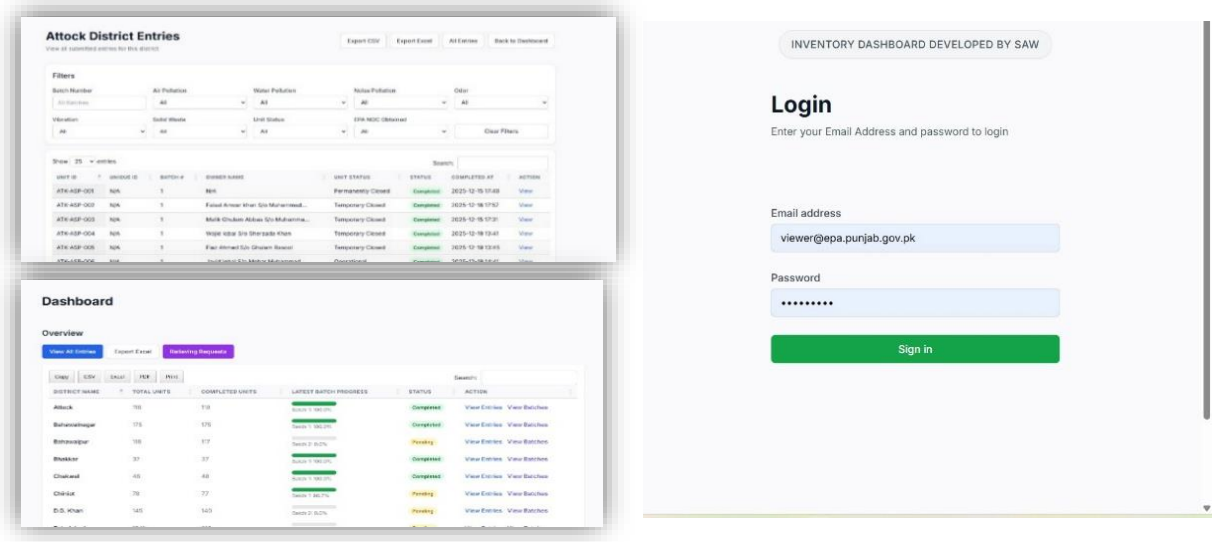


Figure 13.9: Industrial Directory Dashboard View

Operationally, the Unique Identification Number (UID) system is fully integrated with the Environmental Approval Management System (EAMS). When a new industrial unit obtains construction approval through EAMS, it is automatically assigned a UID. Upon issuance of the UID, a comprehensive digital profile of the unit is created through a one-time data collection process. Furthermore, through specialised surveys—including drone-based assessments—previously unmapped industrial units are identified, assigned UIDs, and promptly incorporated into the digital profiling system.

This dynamic, continuously updated system ensures complete industrial coverage throughout Punjab, forming the backbone of a modern, data-driven, and efficient environmental regulatory framework.

13.3.5 Certified Private Laboratory Digital Portal

Building on the establishment and enhancement of reference-grade laboratories, the Punjab Environmental Protection Agency (EPA Punjab) has further strengthened its regulatory framework by integrating certified private laboratories into a structured and digitally monitored system. This reform aims

to ensure credible third-party verification of industrial emissions while enhancing transparency, accountability, and coordination between EPA Punjab, private laboratories, and industrial operators.

Historically, private laboratories conducted environmental testing and submitted reports using manual, paper-based methods. This practice resulted in several regulatory weaknesses, including fragmented record-keeping, limited oversight of sample collection, inconsistent reporting formats, and insufficient monitoring of laboratory testing capacities. Additionally, there was no centralised mechanism to verify laboratories' adherence to their approved scope of testing, monthly sample limits, or direct linkage of reports with corresponding industrial facilities.

To address these gaps, EPA Punjab introduced a dedicated Certified Private Laboratory Digital Portal. Through this portal, certified laboratories are digitally connected to EPA Punjab's wider regulatory ecosystem, including the UID-based industrial database and central dashboard system. Laboratories undergo a formal departmental certification process assessing their technical capacity, equipment standards, staff expertise, and testing capabilities. Once approved, laboratories are certified for specific environmental parameters and assigned monthly testing quotas according to verified capacity.

Subsequent to certification, laboratories are onboarded digitally onto the portal, through which they receive sample requests online, upload test results electronically, manage certification status, and submit reports directly. This digitalisation replaces paper-based laboratory reporting with a secure electronic system, reducing delays, missing records, manual errors, and inconsistent documentation.

A principal strength of the portal lies in its integration with the UID system. Every test report uploaded by a certified laboratory is mandatorily linked to the UID of the relevant industrial unit, ensuring that emission data is accurately mapped to the correct industry profile. This allows EPA Punjab to maintain a comprehensive compliance history for each facility. Moreover, the system enables regulators to review historical testing records, identify recurrent violations, monitor laboratory

workloads, and verify that testing is conducted within the laboratory's authorised scope.

The portal also enhances regulatory accountability by creating a complete digital audit trail. Each stage—sample request, testing, report submission, and compliance review—is transparently tracked within the system. This bolsters the reliability of third-party verification and reduces dependence on informal or manual report submissions. It also fosters equitable enforcement by basing regulatory decisions on digitally recorded, traceable, and verifiable laboratory evidence.

Overall, the Certified Private Laboratory Digital Portal constitutes a significant institutional reform within EPA Punjab's digital transformation journey. By linking certified laboratories with the central dashboard and UID-based industrial database, the Agency has improved data integrity, reporting transparency, and regulatory oversight. The system not only strengthens industrial compliance monitoring but also ensures that private laboratories operate within defined technical boundaries, thereby enhancing the credibility, accountability, and scientific rigour of third-party environmental testing aligned with evidence-based governance.

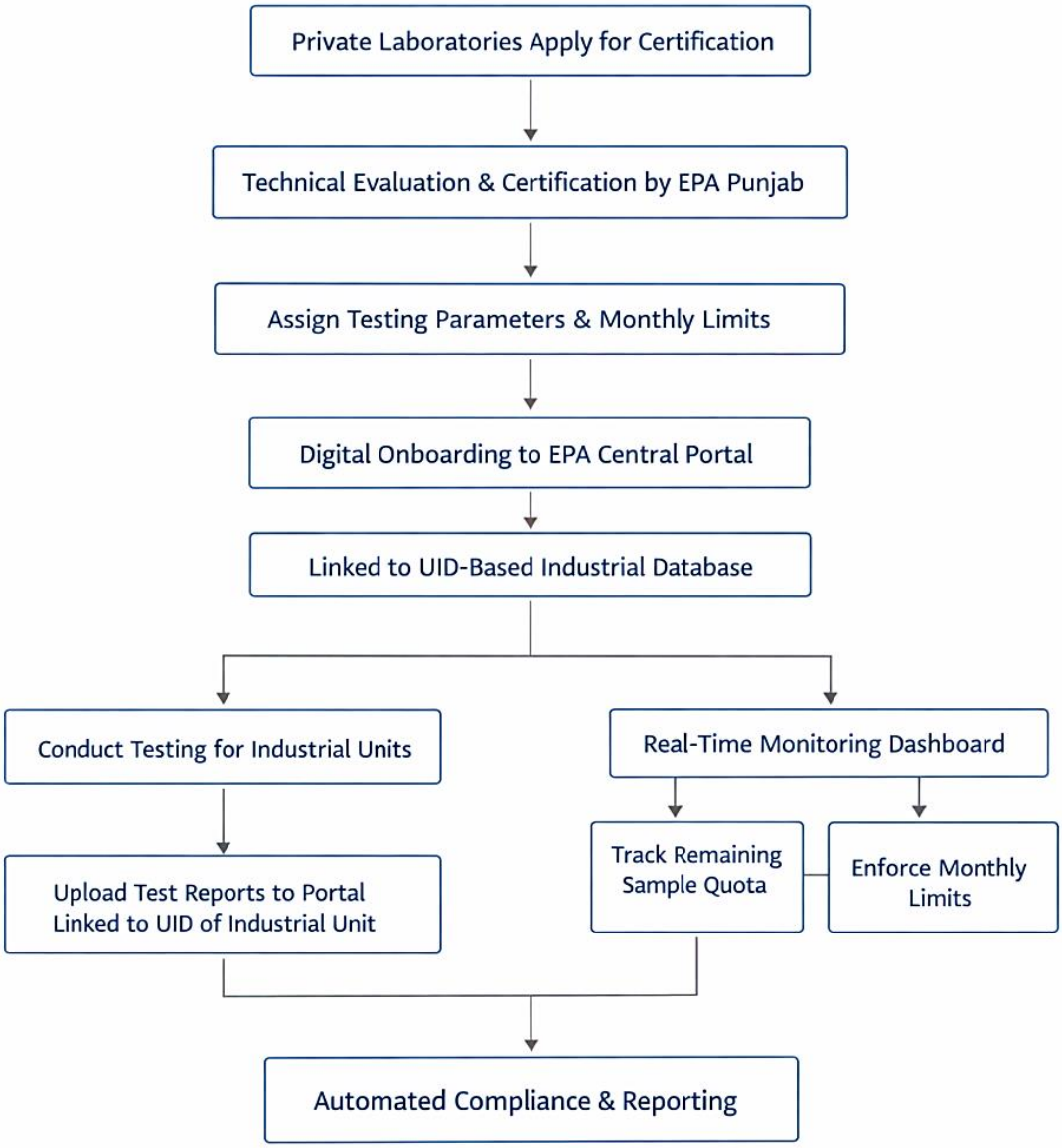


Figure 13.10: Private Lab Certification Process

A key strength of this system is its real-time monitoring and control functionality. Laboratories can continuously track their remaining monthly sample quota for each approved parameter via the digital dashboard. Once the assigned limit for a specific parameter is reached, the system automatically restricts further submissions related to that parameter, thereby enforcing strict compliance with certified testing capacities. This automated control effectively eliminates the

possibility of over-reporting or unauthorised testing, addressing a significant limitation of the previous manual system.

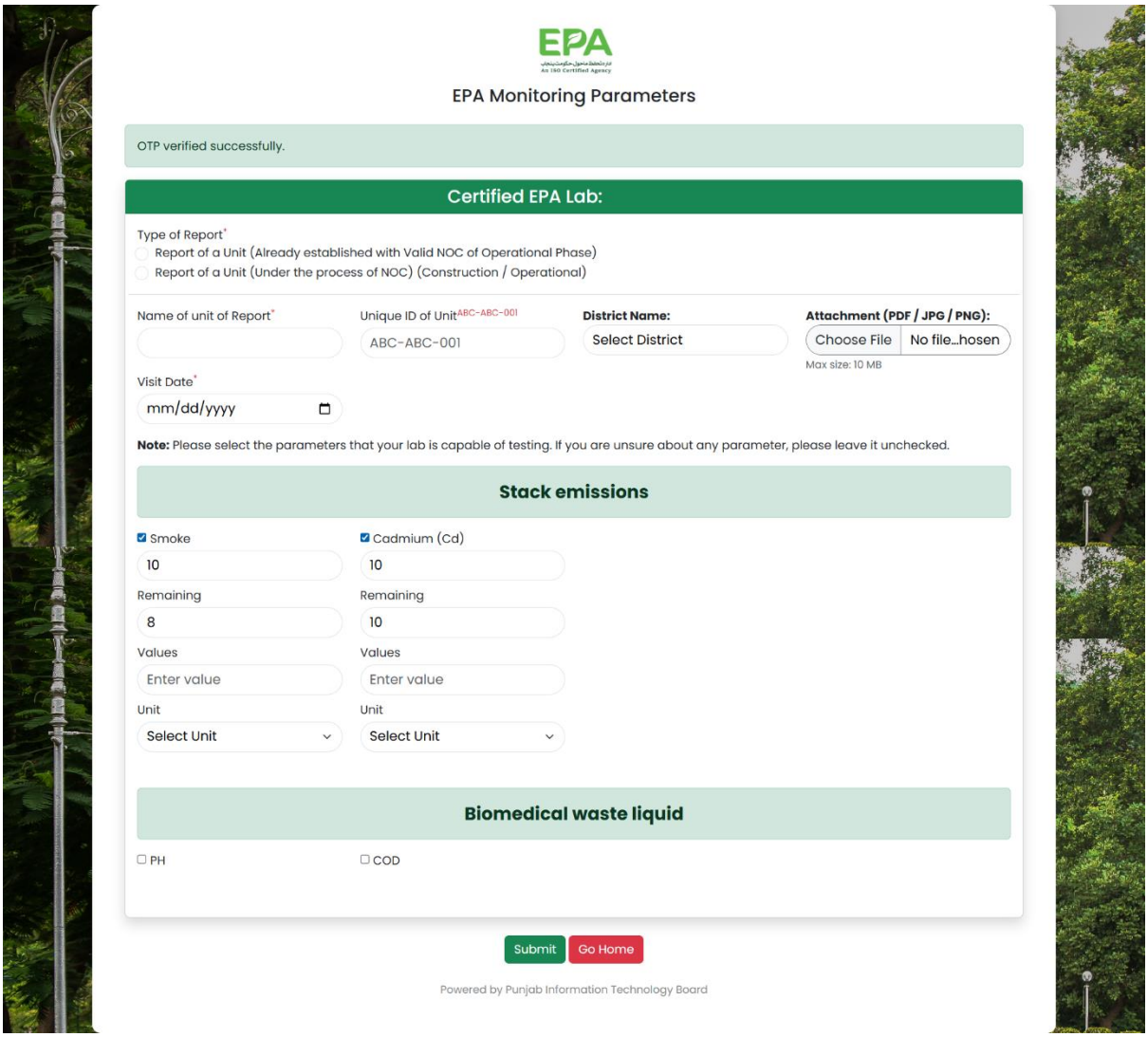


Figure 13.11: Monitoring parameters – Private Laboratory Digital Portal

Furthermore, all submitted laboratory reports are immediately accessible to the relevant field officers and regulatory authorities through the system. This digital accessibility eliminates the need for physical report submissions and significantly reduces administrative delays. It also ensures that data is available

in real time for verification, inspection planning, and enforcement actions, thereby enhancing regulatory responsiveness and informed decision-making. In 2025, over 1,500 reports were entered into the system. The district-wise categorisation is as follows:

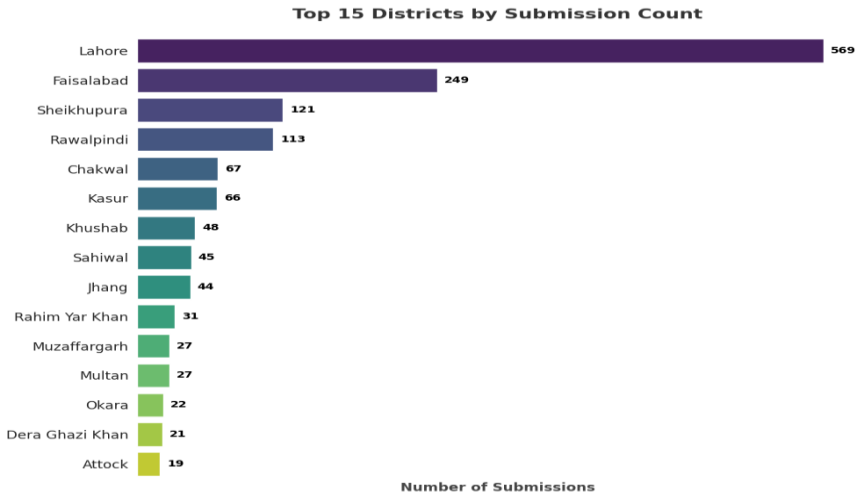


Figure 13.12: 15 Districts Submission count – Private Laboratory Digital Portal

13.3.6. Air Quality Monitoring System

While significant progress was made through the development of the Environmental Approval Management System (EAMS), implementation of the Unique Identification (UID) system, and the adoption of smart monitoring technologies, a critical gap persisted in the availability of reliable, reference-grade air quality data. Without scientifically credible monitoring infrastructure, digital systems can optimise administrative efficiency but cannot fully underpin evidence-based environmental regulation, pollution control planning, or targeted enforcement.

Until 2024, the Punjab Environmental Protection Agency (EPA Punjab) operated only three reference-grade air quality monitoring stations, all situated within Lahore. This limited infrastructure constrained the Agency's capacity to accurately characterise the causes, concentration levels, and spatial distribution of air pollution across other districts, resulting in decision-making that relied heavily on localisation-based data, complaint-driven reports, and generalised assumptions rather than a comprehensive province-wide evidence base.

Recognising this critical shortfall, EPA Punjab achieved a major breakthrough in 2025 with the substantial expansion of its Air Quality Monitoring System (AQMS). The Agency enhanced its monitoring capabilities by installing a network of reference-grade stations across multiple districts, becoming the first government body in Pakistan to provide publicly accessible, real-time data from its own metrological-grade monitoring network. The system currently operates 41 stations across 18 districts, recording pollutant concentrations hourly.

The value of this expanded network depends on not only station quantity but also the reliability, accuracy, and usability of the data produced. Consequently, EPA Punjab must uphold rigorous data quality assurance and control protocols. These include regular calibration of instruments, adherence to standard operating procedures for data collection, periodic sensor and analyser maintenance, validation of anomalous readings, and comprehensive technical audits to ensure scientifically robust data. Without these safeguards, erroneous or unverified data could compromise policy formulation, enforcement efficacy, and public confidence.

The AQMS must be complemented by clear data validation protocols. Hourly air quality readings require assessment for missing data, instrument errors, extreme outliers, and inconsistencies between proximate stations. Corrected or invalidated data points should be transparently flagged, enabling policymakers, researchers, and the public to readily appraise data reliability. This transparency is paramount as real-time air quality data heavily influences public health advisories, industrial enforcement decisions, and emergency smog-control actions.

Furthermore, AQMS data should be actively harnessed for policy development and enforcement rather than being restricted to public display. EPA Punjab can utilise this data to identify pollution hotspots, monitor seasonal trends, evaluate industrial cluster contributions, facilitate targeted inspections, and assess the effectiveness of anti-smog interventions. For instance, regions repeatedly exceeding permissible pollutant limits may be prioritised for enforcement visits, fuel quality inspections, industrial audits, and traffic or construction regulation.

Longer-term AQMS datasets can underpin district-level air quality management plans and evidence-based regulatory standards.

Overall, the AQMS expansion represents a significant advance towards modern, evidence-based environmental governance in Punjab. Nevertheless, its institutional impact will depend on the robustness of calibration systems, data validation mechanisms, quality assurance processes, and the active application of data in policymaking and enforcement. To maximise this investment's value, EPA Punjab should regularly publish data quality reports, maintenance logs, calibration timetables, and analytical summaries that demonstrate how AQMS findings inform environmental decisions.

These stations continuously collect high-resolution environmental data, including concentrations of key pollutants and meteorological parameters. Data from all monitoring stations is transmitted in real time to a centralised dashboard known as AQI Punjab, accessible via the official platform at aqi.punjab.gov.pk. This system ensures uninterrupted data flow, centralised monitoring, and strengthened regulatory oversight.

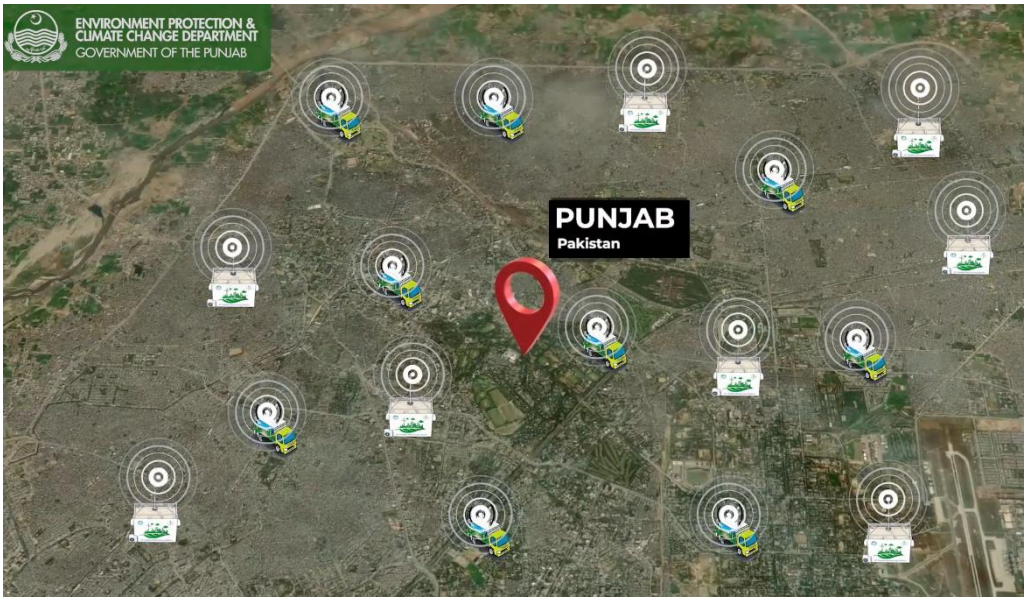


Figure 13.13: AQI Monitoring Stations – 18 Districts



Figure 13.14: AQI Mobile Van

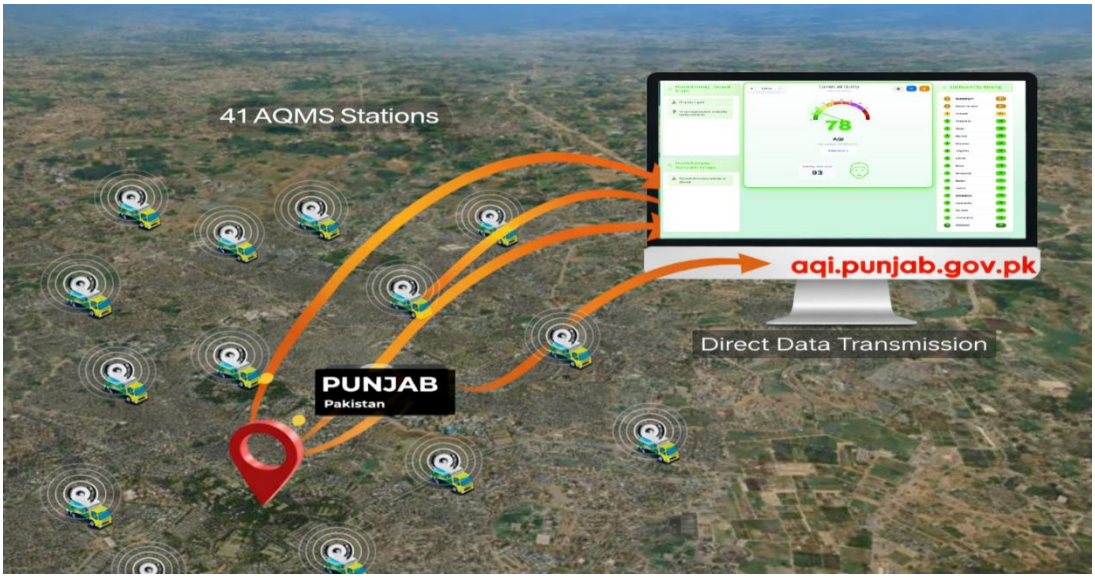


Figure 13.15: Air Quality Monitoring System — Province-Wide Station Network

13.3.6.1 Features of AQI Punjab Dashboard

i. Current AQI

At its core, the system provides real-time Air Quality Index (AQI) monitoring, continuously streaming and dynamically displaying pollutant concentrations from all connected stations. This encompasses all major criteria pollutants, including $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and O_3, alongside concurrent meteorological parameters. The integration of weather stations ensures that each Air Quality Monitoring Station (AQMS) not only reports pollution levels but also records localised atmospheric conditions, which are critical for understanding pollutant behaviour and dispersion. The platform is constructed on a centralised architecture where all incoming data is processed and visualised instantaneously, facilitating comprehensive situational awareness across the province.



Figure 13.16: Current hour Air Quality Index — EPA Punjab

ii. Health Advisory System

A key feature of the system is the health advisory engine, which automatically translates Air Quality Index (AQI) values into accessible, human-readable guidance. The advisory framework is based on standard AQI categories—such as Good, Moderate, Unhealthy—and is closely aligned with public health recommendations.

The system classifies users into different sensitivity groups, dynamically updating precautionary measures accordingly, including guidelines to limit outdoor exposure, reduce physical activity, or employ protective equipment. This design

ensures that the dashboard functions not only as a monitoring tool but also as an effective public health communication system.

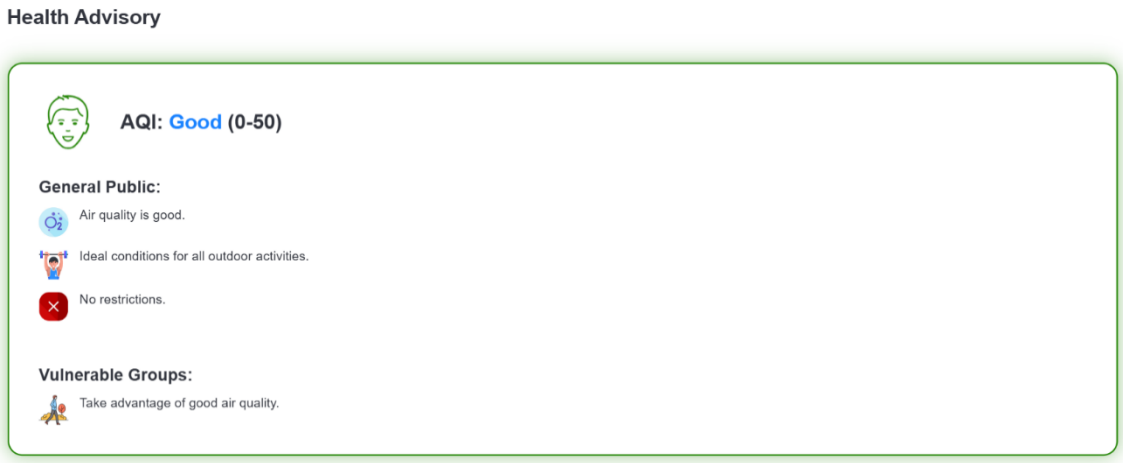


Figure 13.17: Health Advisories – AQI Punjab

iii. Forecast

The platform features a forecasting and predictive analytics module, particularly focused on Lahore, where 24-hour Air Quality Index (AQI) forecasts are produced. These forecasts are not mere extrapolations but are generated by machine learning models that integrate multiple data sources. Real-time data from Air Quality Monitoring Stations (AQMS) is combined with meteorological inputs and further refined through satellite observations, enabling highly localised and accurate predictions. The models also incorporate advanced atmospheric parameters, such as mixing layer height, to better understand the vertical dispersion of pollutants, thereby significantly enhancing forecast reliability, especially during smog episodes.

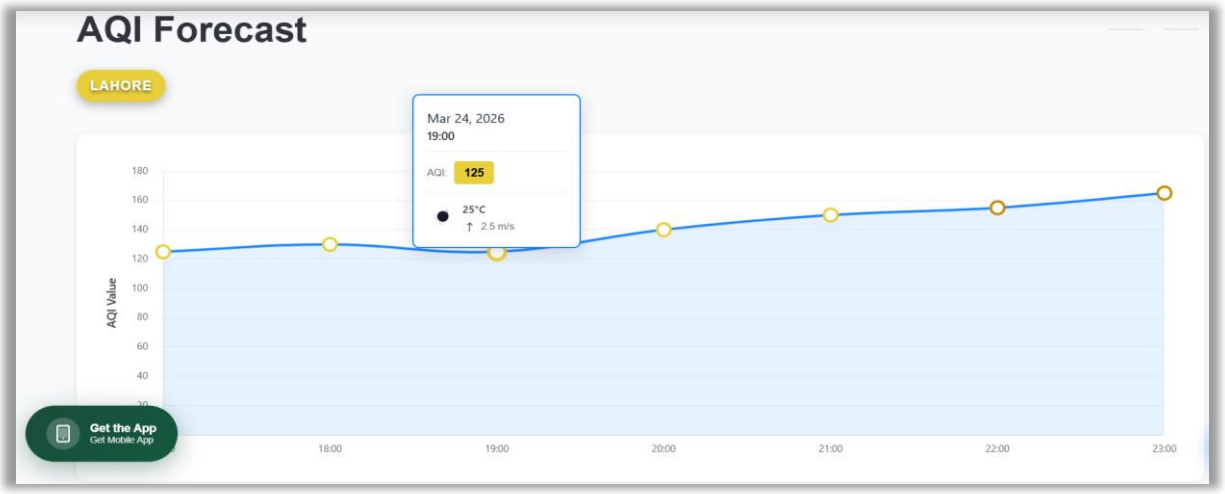


Figure 13.18: Forecasted AQI for next 24 hours — EPA Punjab

iv. Trends

Another important analytical component is the trend analysis system, which displays air quality patterns over time. The dashboard presents weekly trends using standardised colour coding, aligned with environmental policy frameworks. These visual indicators enable rapid interpretation of whether air quality is improving or deteriorating. The consistent use of colour bands ensures coherence with regulatory thresholds and enhances usability for both policymakers and the general public.

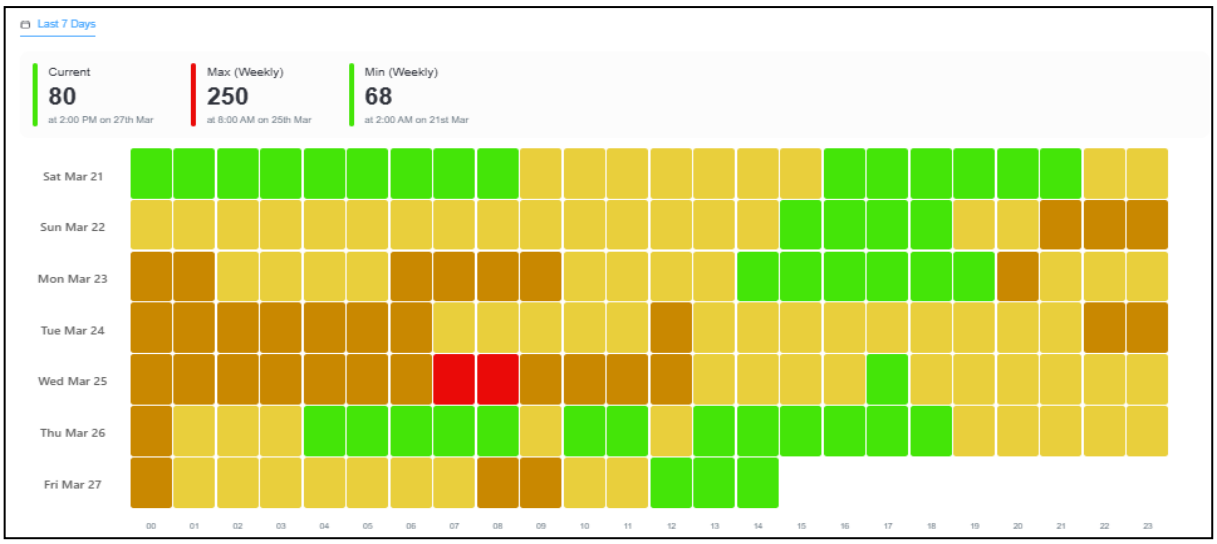


Figure 13.19: AQI Trends — EPA Punjab

v. Town-Wise

The system incorporates advanced spatial analysis capabilities through town-wise and city-wise data segmentation, particularly in urban centres equipped with multiple Air Quality Monitoring Stations (AQMS). This disaggregation facilitates micro-level environmental assessments, enabling the precise identification of localized pollution hotspots and supporting targeted, rather than broad, city-wide interventions. Each monitoring station provides pollutant-specific data, thereby allowing detailed source apportionment and enabling sector-specific policy responses.

Additionally, AQMS stations are equipped with localised meteorological sensors that record key parameters such as wind speed and direction. These data aid in understanding pollutant dispersion patterns and elucidate how fluctuations in the Air Quality Index (AQI) are influenced by particular pollutants under prevailing atmospheric conditions.



Figure 13.20: Major Pollutants of AQI — EPA Punjab

PM2.5 (fine particulate matter)

PM10 (coarse particulate matter)

CO (carbon monoxide)

SO_2 (sulphur dioxide)

NO_2 (nitrogen dioxide)

O_3 (ozone)

AQI is calculated separately for each pollutant. In any given area, one pollutant may be dominant and responsible for the overall AQI value. The data is updated every hour to provide real-time conditions.



Figure 13.21: Town wise AQI — EPA Punjab

vi. Map

A key visualization feature of the dashboard is the interactive geospatial map, which displays all Air Quality Monitoring Stations (AQMS) in real time. Each station presents current Air Quality Index (AQI) values, pollutant concentrations, and meteorological parameters. This spatial interface enables users to compare multiple locations simultaneously and discern patterns of regional pollution distribution. The integration of ground-based weather monitoring systems with AQMS data enhances the map's analytical capabilities, rendering it a valuable tool for both operational monitoring and the validation of forecasting models.

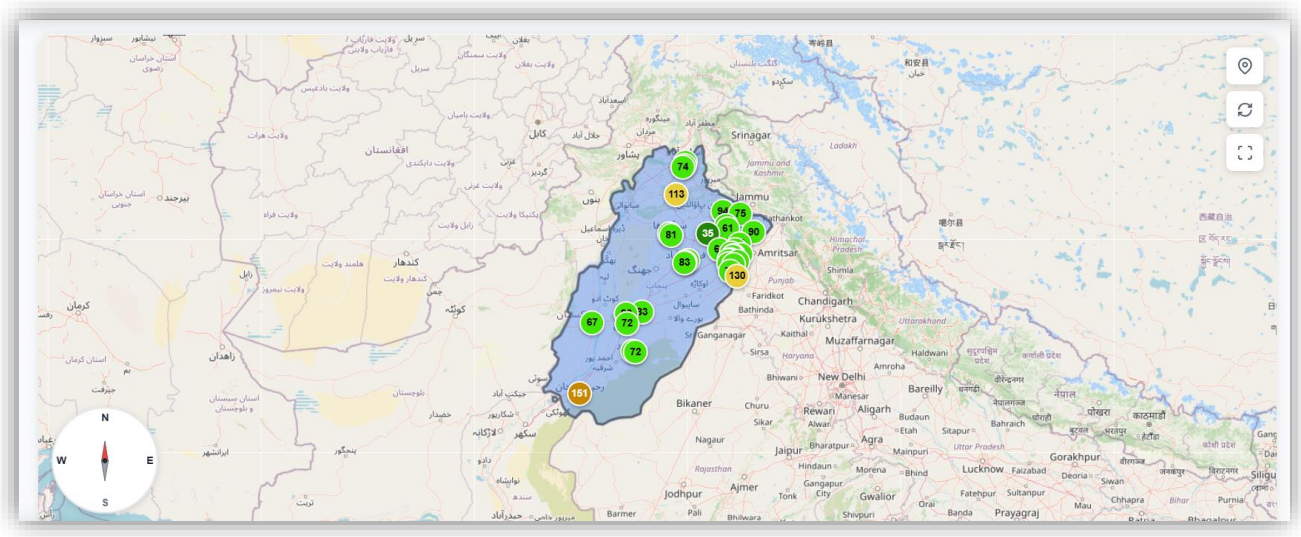


Figure 13.22: Station-wise Local Wind Map — EPA Punjab

The platform also incorporates temporal analytics features such as AQI calendars and historical datasets. These tools provide day-by-day records of AQI values throughout the year, facilitating long-term trend analysis, identification of seasonal patterns, and evaluation of the effectiveness of environmental policies. The availability of historical data ensures that the system extends beyond real-time monitoring, supporting research, reporting, and evidence-based decision-making.

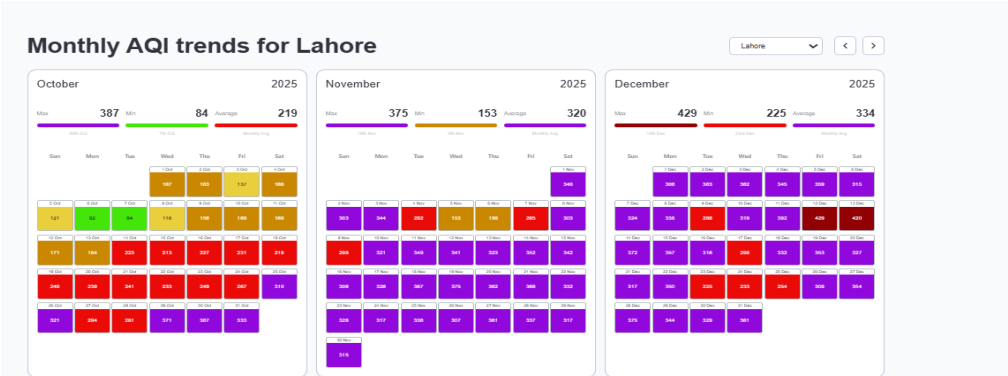
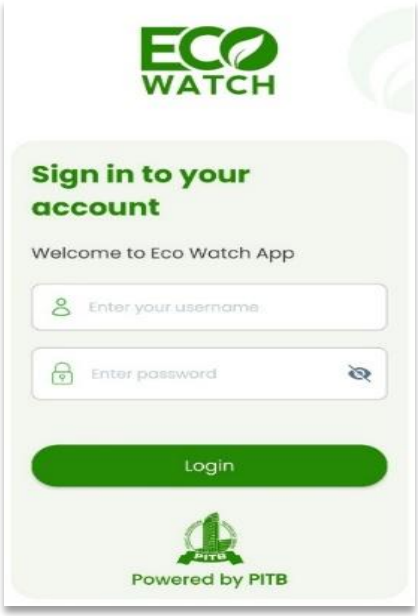


Figure 13.23: Monthly AQI trends for Lahore

13.4 Digital Transformation of Field Operations

Following the establishment of centralised dashboards and digital monitoring systems, EPA Punjab further enhanced its field operations by expanding and upgrading the Eco Watch Application. This platform was developed into a comprehensive field surveillance and oversight tool aimed at improving real-time monitoring, inspection management, and operational accountability across the province. Through Eco Watch, field teams are empowered to conduct inspections digitally, document violations on-site, upload geo-tagged evidence, and maintain centralised records accessible by provincial authorities. The application also facilitated a shift in operational oversight from traditional manual reporting to a live digital monitoring framework, enabling senior management to track field performance, enforcement activities, and inspection statuses in real time. This transition has considerably augmented coordination, transparency, and responsiveness within EPA Punjab's regulatory functions.



13.4.1 Revamping of the Eco Watch Application

The initial version of the Eco Watch Application was limited in scope and functionality, primarily concentrating on industrial inspections with a constrained set of parameters. The system lacked a structured revisit mechanism, impeding the tracking of follow-up inspections, monitoring of compliance progress, and maintenance of a continuous environmental history for regulated facilities. Furthermore, the absence of sectoral diversification restricted its efficacy in addressing the

Figure 13.24: Revamped ECO Watch

broader spectrum of environmental challenges across Punjab. As EPA Punjab expanded its regulatory remit to encompass multiple domains, it became apparent that the existing application architecture was inadequate to support integrated, traceable, and scalable operations.

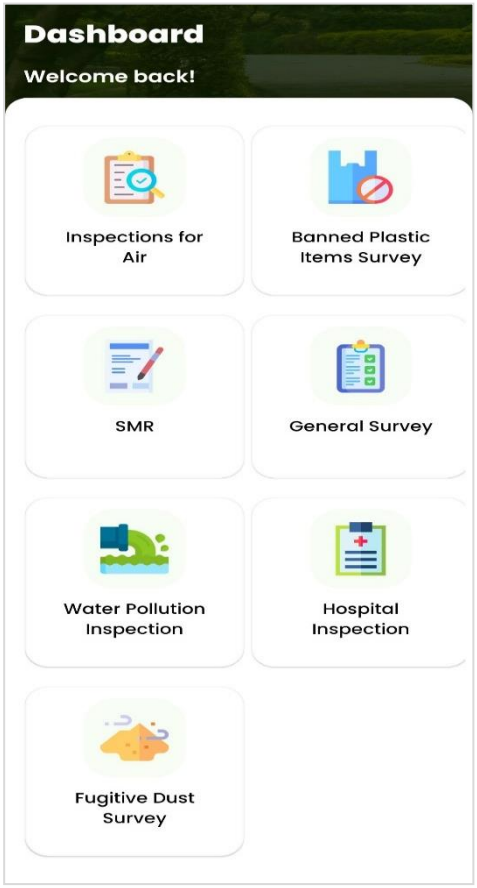


Figure 13.25: ECO Watch Dashboard

In response to these limitations, EPA Punjab undertook a comprehensive restructuring of the Eco Watch Application to better align it with contemporary regulatory requirements and digital governance objectives. The revamped system was designed to support multi-sectoral operations, incorporate a robust revisit and compliance tracking mechanism, and ensure that all environmental interventions are seamlessly interconnected through a unified digital platform. This transformation laid the groundwork for a more comprehensive, transparent, and data-driven environmental monitoring system, capable of effectively supporting EPA Punjab's evolving field operations throughout the province.

A key component of this transformation is the development and deployment of seven dedicated operational modules within the Eco Watch system, each tailored to address specific environmental domains. These modules include Air Emissions Monitoring, Water and Effluent Inspection, Hospital Waste Management, Fugitive Dust Control, Plastic Regulation, Brick Kiln Monitoring, and General Industry Inspections. Each module features customised digital inspection forms, standardised parameters, and structured reporting formats. All inspection activities, observations, and recorded violations within these modules are linked to unique facility identification numbers, ensuring that

every industrial entity maintains a comprehensive and continuously updated environmental compliance profile. This system enables regulators to monitor pollution trends, review historical violations, and execute informed enforcement actions with enhanced precision and consistency.

The application has been further enhanced with the integration of a robust ePay system, reinforcing EPA Punjab's commitment to transparency and a fully cashless regulatory environment. This integration enables all penalties to be digitally generated, recorded, and tracked in real time. Each financial transaction is linked directly to the specific violation and corresponding facility, ensuring comprehensive auditability and eliminating risks associated with manual payment processing. This advancement not only augments financial transparency but also improves the efficiency of compliance enforcement and revenue management.

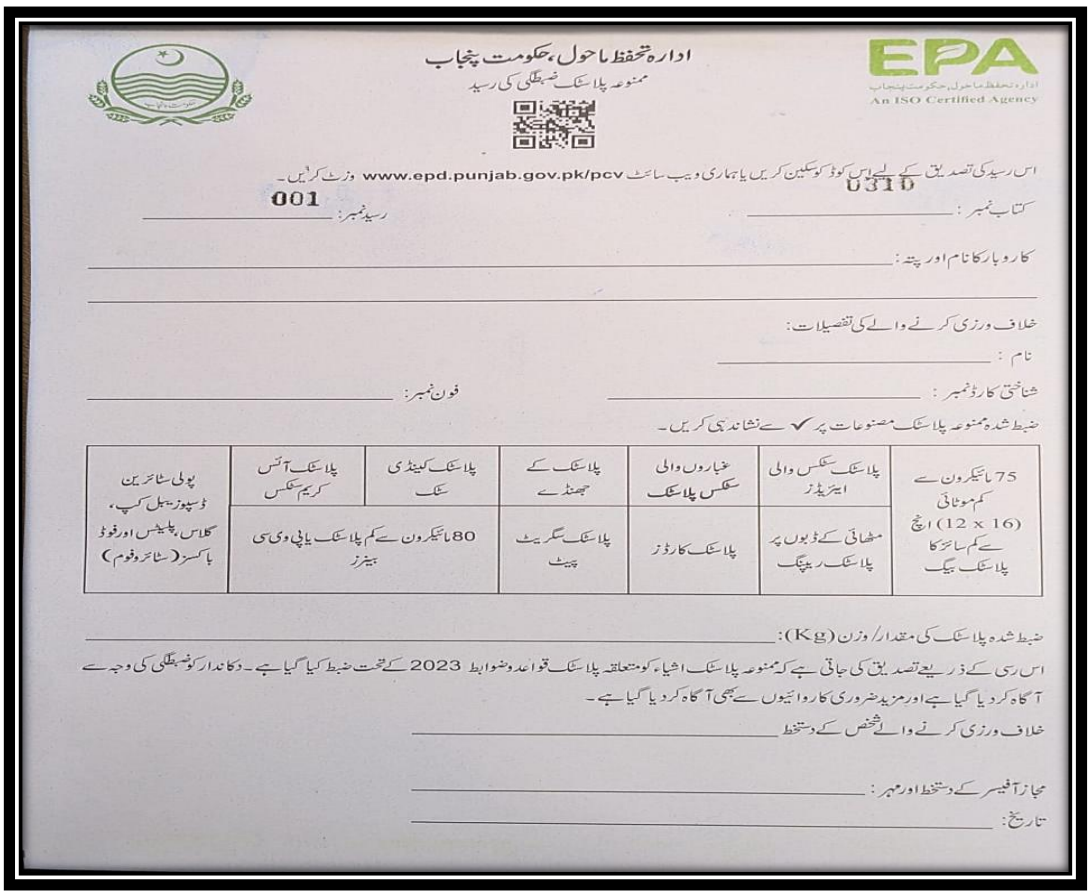
A significant outcome of the Eco Watch system revamp is the complete digitisation of field operations across Punjab. All inspection activities are now conducted, recorded, and monitored through the application, effectively phasing out the previous manual system. In the past year alone, more than 150,000 field operational activities have been logged digitally, reflecting widespread adoption and institutionalisation. Field officers can perform inspections, issue notices, document violations, and update compliance status in real time, ensuring immediate data availability to district offices and headquarters.

Furthermore, the system integrates district profiling and performance monitoring functionalities, enabling EPA Punjab to analyse sector-wise inspection coverage, identify underperforming regions, and allocate regulatory focus more equitably across environmental sectors. Built on these insights, a structured weekly progress review mechanism has been established, supplanting the traditional monthly review process. Over 50 weekly performance reports have been generated to date, facilitating KPI-based ranking of districts and fostering a culture of accountability and healthy competition among field formations.

13.4.2 Plastic Confiscation Verification System

Building upon the comprehensive digitisation of field operations and the integration of sector-specific modules within the Eco Watch Application, EPA Punjab further enhanced transparency and accountability by introducing a QR code-based plastic confiscation system. While plastic inspections were already conducted through Eco Watch, a significant gap existed in public visibility and verification of confiscation activities. To address this, a dedicated digital mechanism was developed to ensure that every enforcement action related to plastic is not only recorded but also accessible for public verification.

Under this system, uniquely QR-coded challan books were designed, printed, and distributed to field officers via a user-specific allocation process within Eco Watch. Each challan is system-generated, securely linked to an individual officer, and strictly non-transferable, thereby ensuring personal accountability. During field operations, when a challan is issued for plastic confiscation, the officer is required to upload photographic evidence through the application. This evidence is digitally linked to the QR code on the challan, establishing a complete, traceable enforcement record.



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75 مائیکرون سے کم موٹائی (12 x 16) انچ سے کم سائز کا پلاسٹک بیگ	پلاسٹک سکس والی ایریڈز	غباروں والی سکس پلاسٹک	پلاسٹک کے جھنڈے	پلاسٹک کینڈی سٹک	پلاسٹک آئس کریم سکس	پولی سٹائرین ڈسپوزیبل کپ، گلاس، پلیٹس اور فوڈ پاکسز (سٹائروفوم)
مٹھائی کے ڈبوں پر پلاسٹک ریپنگ	پلاسٹک کارڈز	پلاسٹک سگریٹ پیٹ	80 مائیکرون سے کم پلاسٹک پی وی سی بینرز			

ضبط شدہ پلاسٹک کی مقدار/ وزن (Kg):

اس رسی کے ذریعے تصدیق کی جاتی ہے کہ ممنوعہ پلاسٹک اشیاء کو متعلقہ پلاسٹک قواعد وضوابط 2023 کے تحت ضبط کیا گیا ہے۔ دکاندار کو ضبطگی کی وجہ سے آگاہ کر دیا گیا ہے اور مزید ضروری کاروائیوں سے بھی آگاہ کر دیا گیا ہے۔

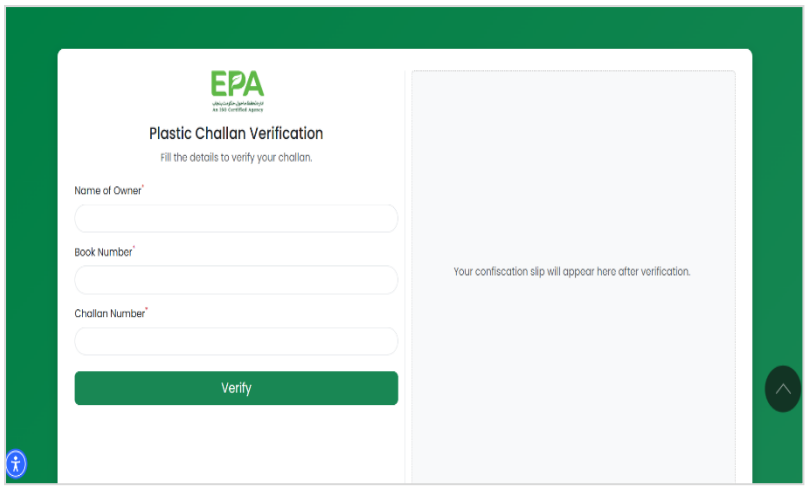
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مجاز آفیسر کے دستخط اور مہر:

تاریخ:

Figure 13.26: Plastic Confiscation QR coded book

This initiative has introduced a new dimension of public empowerment by allowing citizens to verify confiscation actions in real time. By scanning the QR code, the public can access detailed information pertaining to the violation and its associated evidence, thereby ensuring that enforcement activities are conducted transparently and with credibility. Moreover, a dedicated helpline (1373) has been integrated into the system to facilitate complaints, feedback, and verification, further strengthening citizen engagement.



As a result of this intervention, EPA Punjab has established a structured and reliable digital record of plastic confiscation activities for the first time. This data-driven repository enables the Agency to analyse enforcement trends, monitor field performance, and identify policy gaps. Consequently, more informed and targeted policy decisions have been implemented to strengthen plastic regulation across the province. This initiative complements the broader Eco Watch framework by enhancing transparency, bolstering accountability, and advancing the transition towards a fully digital, citizen-centric environmental governance system.

Figure 13.27: Plastic Verification System – EPA Punjab

13.4.3 Revamping of the 1373 Helpline

The digitisation of EPA Punjab's operational ecosystem through the Eco Watch Application necessitated the enhancement of public interaction and engagement mechanisms. While the 1373 helpline initially functioned as a basic complaint registration service, it lacked alignment with modern digital systems and real-time, data-driven capabilities. To address these shortcomings, the helpline was transformed into a Customer Relationship Management (CRM)-based intelligent complaint management and public facilitation system, fully integrated into EPA Punjab's digital infrastructure.

Under this revamped system, the 1373 helpline serves as a centralised platform for complaint handling and public engagement. Complaints concerning smoke emissions, illegal industrial activities, and other environmental violations are digitally logged, categorised, and automatically routed to relevant departments for prompt action, thereby improving efficiency and accountability.

The system has been further augmented with advanced features such as automated compliance follow-up calls to industrial units and integration with the QR-coded plastic confiscation system. This enables citizens to verify challans and enforcement records directly through the helpline, enhancing transparency and accessibility.

To ensure service quality, all helpline agents received structured refresher training aligned with EPA Punjab's digital systems, operational protocols, and communication standards. The helpline has also been leveraged for awareness campaigns, including over 13,000 automated robo-calls to educators on crop residue burning awareness.

This transformation has significantly improved service delivery, reducing the volume of physical office visits by approximately 30% and strengthening public trust through timely responses and a more transparent system. In 2025, a total of 62,502 inquiries were recorded via the 1373 helpline, reflecting strong public engagement. The majority of complaints—44,959—pertained to the Emission Testing System, followed by smoke-related incidents (7,151), encroachments (2,441), and fire incidents (2,303). Other categories included general complaints (1,143), dust (1,111), odours (723), illegal petrol machines (662), green lockdown violations (518), school timing violations (511), plastic violations (279), Punjab Green School Certificate issues (236), and animal abuse reports (157).

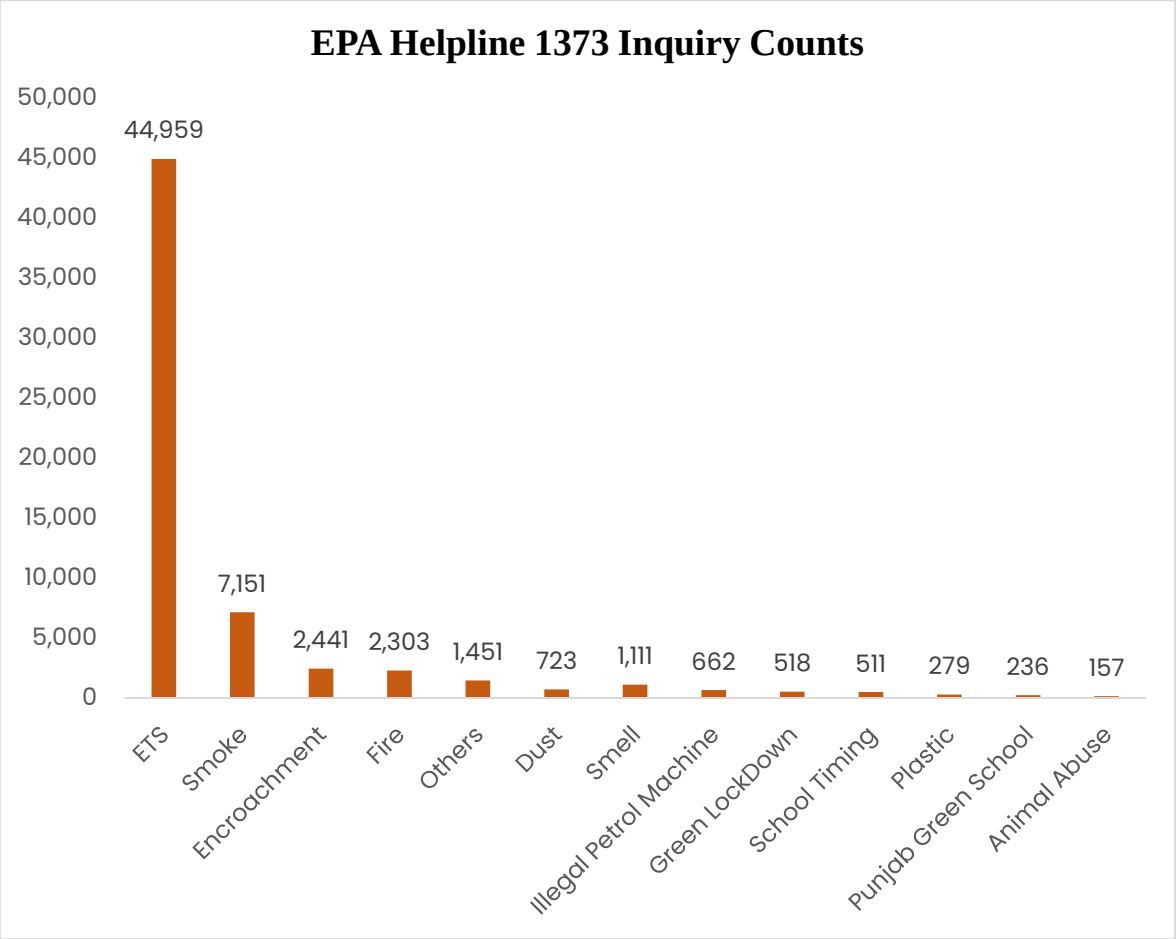


Figure 13.28: Environmental Enquiry Statics

13.4.4 Revamping of the Green Punjab Application

The Green Punjab Application, initially launched as EPA Punjab's inaugural citizen-facing digital platform, was conceived to centralise public complaints and create a direct linkage with the 1373 helpline for streamlined grievance redressal. However, in response to the Agency's broader digital transformation, it became imperative to overhaul the application's functionality. The revamp expanded its capabilities beyond complaint registration, transforming it into a comprehensive platform for citizen engagement and environmental monitoring. This redevelopment



Figure 13.29: Green Punjab App

established the application as a critical interface between the public and EPA Punjab, facilitating real-time reporting, enhancing transparency, and promoting active citizen participation in environmental governance.

A significant enhancement within the revamped Green Punjab App was the direct integration of EPA Punjab's flagship Emission Testing System. Through this system, Light Transport Vehicles (LTVs) undergo digital inspection using gas analysers, with emission readings, live vehicle photographs, and supporting evidence recorded and uploaded in real time. Each inspection is conducted using uniquely assigned, geo-fenced identifiers linked to specific testing booths, ensuring location authenticity and preventing fraudulent entries. The verification process is further reinforced by linking the system to the official Environment Protection Department (EPD) Punjab website, enabling public validation of testing records.

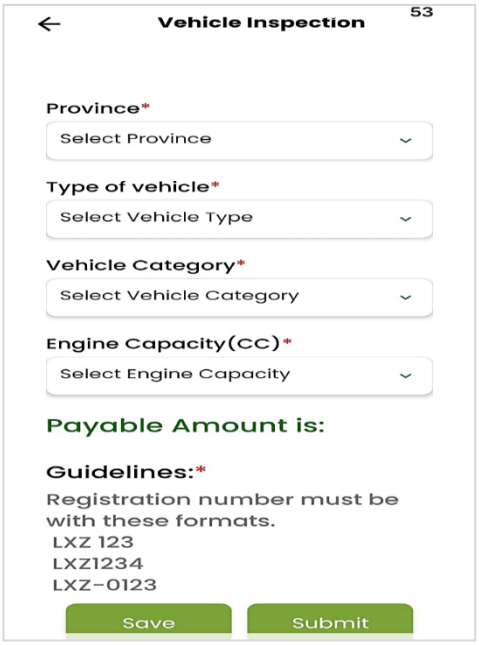


Figure 13.30: Vehicle Inspection form

To ensure financial transparency and eliminate manual handling of fees, the Green Punjab App has been integrated with the ePay system, enabling emission testing charges to be paid digitally via system-generated Payment System Identification Numbers (PSIDs). This integration has established a fully cashless, transparent, and auditable mechanism for service delivery. Beyond its operational function, the Green Punjab App has significantly contributed to research and policy development. As part of a province-wide study, over 250 automobile workshops were registered through the platform to facilitate correlation analysis of various emission testing technologies available in the market, offering valuable insights to support regulatory standardisation.



Figure 13.31: Vehicle Inspection – Green Punjab App



Figure 13.32: Green Sticker – Vehicle Inspection

The robustness of the system is further demonstrated by its institutional integrations, including linkages with the Safe City authorities and the Transport Department, facilitating real-time data sharing and interdepartmental coordination. To date, over 300,000 vehicle inspections have been conducted through the platform, with comprehensive digital records—encompassing emission results, photographic evidence, and payment details—readily accessible. This extensive digitisation has effectively replaced the traditional manual inspection process and significantly enhanced public trust by promoting transparency, reliability, and ease of access.

Overall, the revamped Green Punjab Application has matured into a powerful instrument for participatory governance, integrating citizen reporting, digital enforcement, financial transparency, and inter-agency collaboration within a unified digital platform.

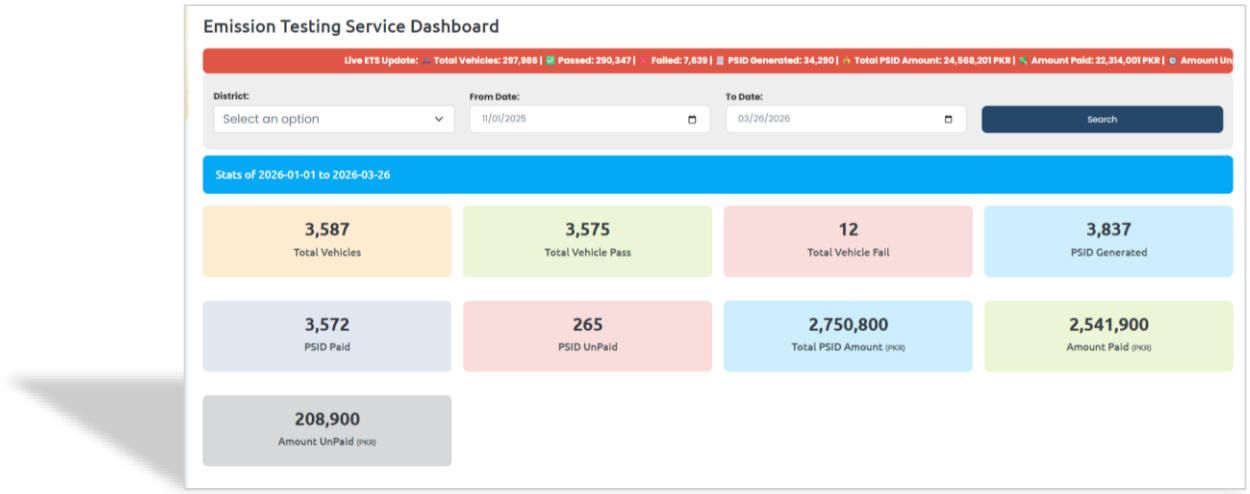


Figure 13.33: ETS Dashboard – EPA Punjab

13.5 Digital Institutional Reforms

The digital transformation of EPA Punjab represents a comprehensive institutional reform programme that transcends the mere introduction of standalone applications. It has fundamentally reshaped governance, accountability, and service delivery by replacing fragmented, paper-based procedures with integrated digital systems. Through the digitisation of human resource management, office automation, digital compliance monitoring, and technology-enhanced enforcement mechanisms, the Agency has improved procedural efficiency, reduced operational delays, and established a more traceable record of administrative and regulatory actions.

These reforms have bolstered internal oversight by standardising workflows and enabling real-time performance monitoring. Digital platforms allow senior management to review inspection activities, track pending cases, monitor staff performance, and evaluate regulatory actions using structured data. This has facilitated more consistent decision-making and mitigated risks associated with manual reporting, missing documentation, and delayed approvals. In this manner, EPA Punjab's digital reforms have contributed significantly to creating a transparent and accountable institutional framework.

However, the increased reliance on digital systems introduces new governance risks that demand proactive management. Cybersecurity, data privacy, and

information security have become central to the sustainability of EPA Punjab's digital reform agenda. The Agency's platforms process sensitive information—including inspection records, industrial compliance data, enforcement decisions, geotagged evidence, personnel records, and public complaints. Without robust protection measures such as stringent access controls, encryption, audit trails, and regular security assessments, the risk of data breaches, unauthorised access, record manipulation, or misuse of confidential information escalates.

System resilience is another crucial institutional consideration. As EPA Punjab increasingly depends on dashboards, mobile applications, and real-time monitoring tools, any technical failure, cyberattack, or data loss could disrupt inspections, complaint processing, and enforcement activities. Thus, the Agency should establish well-defined disaster recovery and business continuity plans encompassing regular data backups, secure cloud or server infrastructure, prescribed recovery timelines, incident response protocols, and routine drills to verify recovery preparedness.

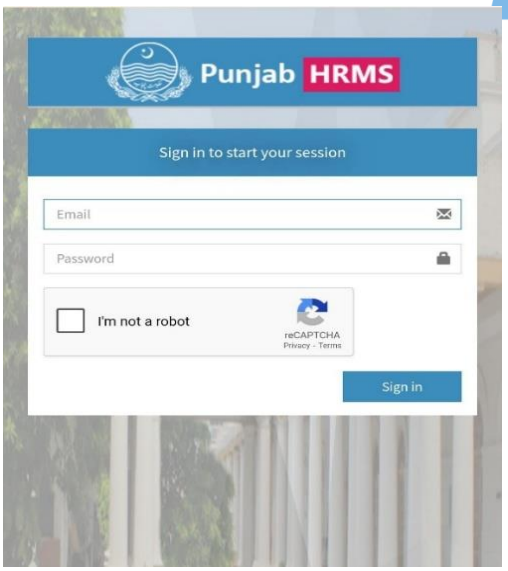
In summary, EPA Punjab's digital institutional reforms have fostered a more efficient, transparent, and forward-looking governance framework. Nevertheless, the long-term success of these reforms hinges not only on technological adoption but equally on robust digital risk management. To maintain credibility and continuity, EPA Punjab should systematically integrate cybersecurity safeguards, data protection standards, resilience planning, and disaster recovery mechanisms into its institutional reform strategy. Such integration will ensure that the digital governance model remains secure, reliable, and capable of underpinning environmental regulation amid evolving administrative and technological landscapes.

13.5.1 Human Resource Management Information System (HRMIS)

Figure 13.34: PUNJAB HRMS

Following the successful implementation of multiple digital initiatives, including the Environmental Approval Management System (EAMS), the Unique Identification (UID) system, and smart monitoring technologies, the imperative to strengthen internal human resource

management became increasingly apparent. It was essential to transition away from outdated manual record-keeping practices, eliminate bureaucratic delays, and instil greater transparency and efficiency within HR processes.



In this context, EPA Punjab leveraged the Government of Punjab's Human Resource Management Information System (HRMIS) to digitally transform its entire human resource framework. The Agency executed a comprehensive digitisation of employee records—including service histories, leave management, and other HR-related processes—successfully transitioning from conventional archive-based systems to a fully integrated digital platform.

A notable milestone achieved under this initiative was the digitisation of pension cases, positioning EPA Punjab as the first attached department in the province to manage pension-related matters through the Human Resource Management Information System (HRMIS). This advancement not only streamlined the pension processing workflow but also reduced delays and enhanced transparency for employees approaching retirement.

Building on this progress, EPA Punjab further enhanced transparency and accountability by integrating Performance Evaluation Reports (PERs) into the Human Resource Management Information System (HRMIS). Supervisors are now mandated to enter employee evaluations directly into the system, ensuring timely completion, accurate documentation, and real-time monitoring of performance assessments.

This transition has yielded significant improvements in employee confidence and morale. Enhanced transparency, clear evaluation procedures, and the reduction of procedural delays have fostered a greater sense of security and motivation among staff. As a result, notable increases in productivity, ownership, and overall organisational performance have been observed.

By fully adopting the Human Resource Management Information System (HRMIS), EPA Punjab has modernised its internal operations and reinforced a culture of accountability, efficiency, and merit-based evaluation, thereby aligning its workforce management practices with contemporary governance standards.



Figure 13.35: Punjab HRMIS Platform

13.5.2 Electronic Filing and Office Automation System (e-FOAS)

The Punjab Environmental Protection Agency (EPA) has fully transitioned its internal administration to the Government of Punjab's Electronic Filing and Office Automation System (e-FOAS), marking a significant modernisation of its operational workflows. This comprehensive digital migration automates file movements, internal communications, document drafting, and formal approvals, replacing cumbersome, paper-intensive processes with a secure and efficient digital environment. By streamlining these functions, the Agency has accelerated internal response

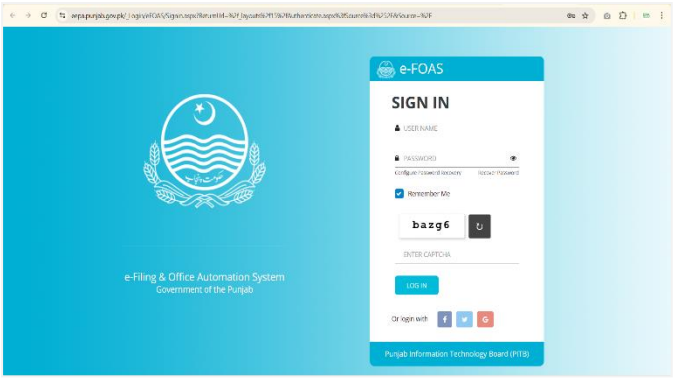


Figure 13.36: e-FOAS

times, minimised administrative delays, and virtually eliminated the risk of lost documentation.

A key innovation within this system is the introduction of QR-coded No Objection Certificates (NOCs), which facilitate instant digital verification of environmental approvals. This feature enhances transparency, guarantees secure authentication, and prevents the circulation of fraudulent permits, allowing stakeholders to verify the authenticity of any EPA-issued certificate with a simple scan. Through the integration of e-FOAS and QR-coded NOCs, EPA Punjab demonstrates its commitment to digital innovation, efficient service delivery, and accountable regulatory practices, establishing a new benchmark for internal governance and operational efficiency across the province.

13.5.3 Digital Compliance Verification System

The Digital Compliance Verification System, developed in close collaboration with the Online Adjudication Hub, constitutes a significant reform in EPA Punjab's enforcement mechanisms, particularly under the regulatory framework governing smog and environmental protection. Traditionally, while enforcement actions were pursued against violators, there was no structured, transparent, and time-bound process to ensure a formal hearing or to digitally verify compliance prior to finalising enforcement measures. Recognising the imperative to balance regulatory authority with procedural fairness, EPA Punjab institutionalised a system wherein every alleged violator is afforded an opportunity to be heard before a conclusive decision is rendered.

Under this system, upon initiation of enforcement action against any industrial unit or facility, the violator is required to apply for a hearing via the EPD Punjab website. Once the application is submitted, a verification email is automatically generated, triggering the digital compliance verification workflow. Within 24 hours, the system schedules and notifies the applicant of an online hearing, ensuring prompt and legally structured resolution. During the hearing, both the regulatory perspective and the violator's response are considered, guaranteeing that decisions are made with transparency, fairness, and in strict accordance with environmental legislation and due process.

Following the hearing, compliance verification is conducted digitally within a stipulated timeframe, facilitating efficient finalisation of cases. Once compliance is confirmed, the system enables timely closure of enforcement proceedings and, where appropriate, authorises the controlled and lawful reopening of industrial operations. This approach has substantially reduced unnecessary operational downtime for industries while upholding stringent environmental safeguards.

Action initiated on this form: epd.punjab.gov.pk/application-for-compliance-of-standards



Figure 13.37: Digital Compliance Verification System

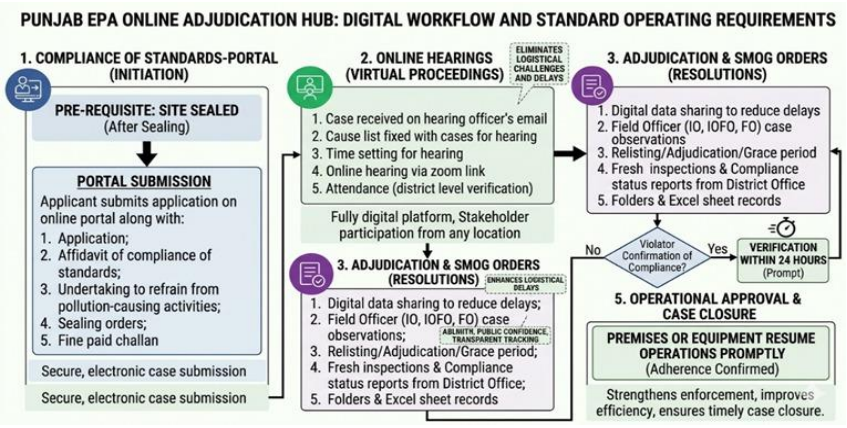
The introduction of this digital compliance verification system has been widely welcomed by stakeholders, particularly within the industrial community, as it offers a transparent and accessible alternative to protracted legal proceedings. Instead of directly approaching the courts, stakeholders increasingly prefer to present their cases before the competent authority via this digital platform, confident in its fairness and accountability. The system has also bolstered institutional credibility, as EPA Punjab ensures that no arbitrary or unjustified enforcement actions are taken against any industrial unit.

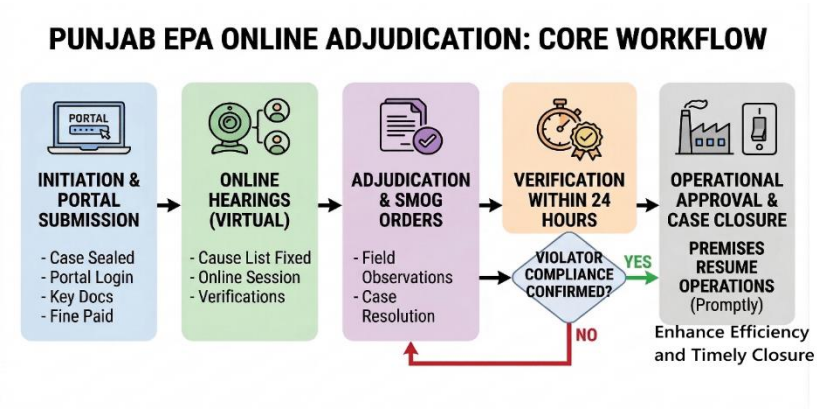
To date, over 1,000 compliance cases have been processed through the system, with most resolved and finalised within one week, significantly enhancing the efficiency of enforcement proceedings. Crucially, the system has established a structured digital record of compliance across districts, enabling EPA Punjab to

monitor compliance ratios and trends. This data is now employed as a key performance indicator (KPI) in assessing district-level regulatory performance, thereby strengthening internal accountability and fostering a results-oriented regulatory culture.

13.5.4 Online Adjudication Hub

Previously, EPA Punjab maintained an online hearing mechanism; however, it operated in isolation without integration into a structured compliance verification system. This disconnect limited the mechanism's effectiveness, as hearings could be conducted, but there was no cohesive, time-bound digital process to verify compliance and expedite case finalisation. To address this limitation, the online hearing platform was fully integrated into the Online Adjudication Hub, establishing a seamless end-to-end digital workflow.





This integration has markedly enhanced accessibility, enabling applicants from remote areas to participate in hearings at their respective district offices rather than necessitating travel to EPA Headquarters in Lahore, where attendance is verified locally. The resulting system is more inclusive, efficient, and user-friendly. The entire process is designed to uphold transparency, with every procedural step digitally recorded, traceable, and subject to audit.

The Punjab EPA Online Adjudication Hub now operates via a fully digitised and structured workflow designed to ensure transparency, efficiency, and timely resolution of environmental cases. The process is initiated when a site is sealed due to a violation, at which point the applicant submits a case through the online portal, providing all requisite documentation—including the application form, affidavit of compliance with environmental standards, undertaking to desist from pollution-causing activities, sealing orders, and proof of fine payment. This comprehensive electronic submission ensures secure and complete case documentation, forming the foundation for subsequent proceedings.

Following submission, the case progresses to the online hearing phase, where virtual proceedings are conducted to obviate logistical delays and enhance accessibility. The case is received by the designated hearing officer, docketed for a hearing, and scheduled within a prescribed timeframe. Hearings are conducted digitally via video conferencing, with verified attendance by relevant district authorities, enabling stakeholder participation from any location while maintaining facilitation at the district level.



Figure 13.38: Online Adjudication Hub Workflow - Digital Hearing Platform

Subsequently, the adjudication and decision-making phase is conducted through integrated digital data sharing. Field officers submit inspection reports, observations, and compliance updates, which are assessed alongside fresh inspections and district-level compliance status reports. The system also facilitates case relisting, adjudication decisions, and the provision of grace

periods where applicable, with all actions meticulously documented through structured digital records.

A crucial element of this workflow is the compliance confirmation stage. When a violator meets the prescribed environmental standards, the system ensures verification within 24 hours, enabling timely action. In instances where compliance is not confirmed, the case advances to further enforcement proceedings. Upon verification of compliance, the system progresses toward operational approval and case closure, allowing premises or equipment to promptly resume operations.

13.5.5 Internal Accountability Dashboard

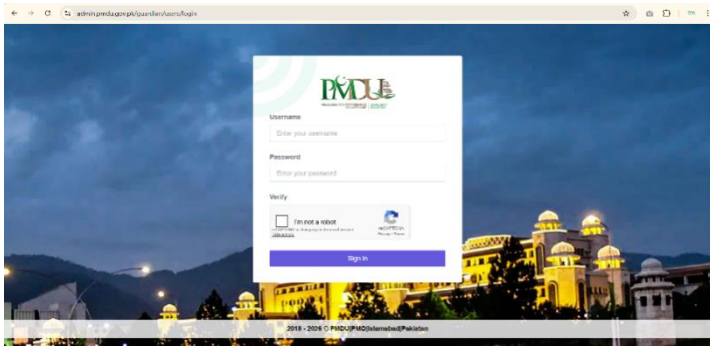


Figure 13.39: IAD Dashboard

For the first time, EPA Punjab has taken a significant step towards transparency by bringing its internal accountability system into the public domain. While the Internal Accountability Dashboard (IAD) is utilised across various departments of the Government of Punjab, it has traditionally functioned as an internal monitoring tool inaccessible to the public. Demonstrating institutional confidence and a commitment to transparency, EPA Punjab integrated its IAD with the Prime Minister's Delivery Unit (PMDU), thereby rendering officer performance and complaint handling visible to a wider audience.

This transformation has converted internal performance tracking into a citizen-facing accountability mechanism, fostering public trust and reinforcing principles of responsible governance.

As illustrated in the workflow, the process begins with complaint intake from multiple sources, including Safe Cities, Drones, Hawk Eye, Labs-SMR reports and direct public complaints.

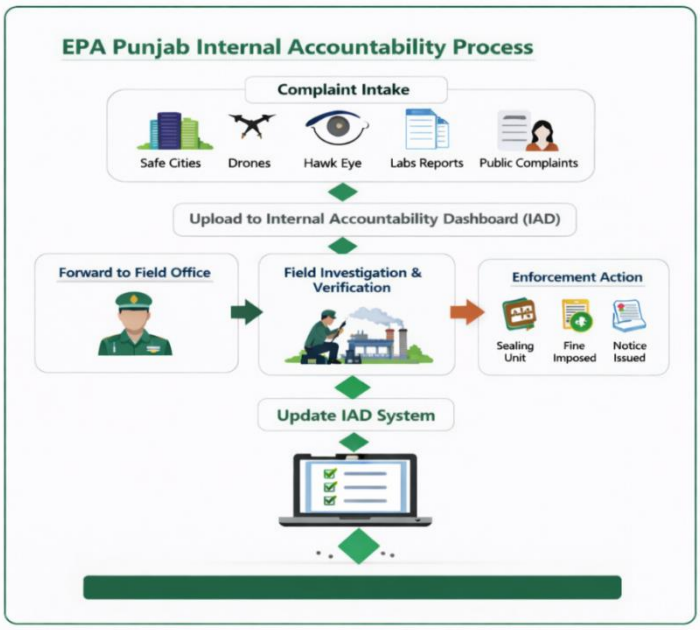


Figure 13.40: Internal Accountability Process

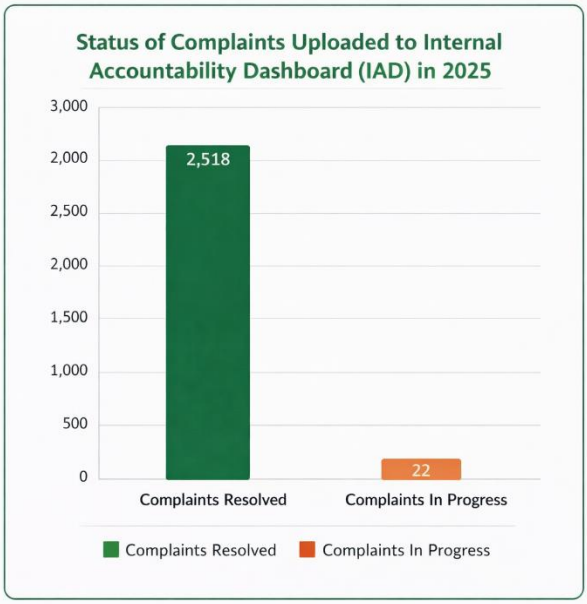


Figure 13.41: IAD Complaints graph 2025

This multi-source integration ensures that environmental violations are captured both through citizen reports and advanced surveillance systems developed by EPA Punjab, significantly enhancing the Agency's monitoring capacity. In 2025, a total of 2,540 complaints were uploaded to the Internal Accountability Dashboard (IAD) from these sources. Of these, 2,518 complaints were resolved, while 22 remained in progress, demonstrating the system's effectiveness in managing, tracking, and ensuring accountability for environmental compliance issues.

Upon receipt, each complaint is uploaded to the central IAD system and immediately forwarded to the relevant field office, ensuring that no complaint is left unattended or delayed. The subsequent stage involves field officer investigation, where on-site verification assesses the validity and severity of the complaint. This step guarantees that all enforcement actions are evidence-

based and grounded in actual field conditions. Following verification, appropriate legal or administrative measures are initiated, which may include sealing of facilities, imposition of fines, or issuance of notices, depending on the violation's nature.

After enforcement actions are undertaken, the responsible officer is required to update the IAD system with comprehensive details, including observations and outcomes. This real-time updating ensures that every procedural step is documented, traceable, and transparent within the system. Once all necessary actions are completed, the complaint is formally closed.

This end-to-end digital workflow establishes a clear chain of responsibility and accountability, tracking each complaint from initiation to resolution. By linking the system with the Prime Minister's Delivery Unit (PMDU) and enhancing the transparency of performance data, EPA Punjab has not only improved operational efficiency but also set a new benchmark for public sector accountability and citizen-centric governance.

13.5.6 Establishment of the IT Support Unit

The establishment of the IT Support Unit within the Punjab Environmental Protection Agency (EPA Punjab) represented a pivotal and timely intervention aimed at safeguarding, sustaining, and streamlining the Agency's rapidly expanding digital infrastructure. As EPA Punjab transitioned towards a fully digitised operational model, it became apparent that, without a centralised technical framework, the burgeoning number of digital systems would face challenges related to maintenance, coordination, duplication, and long-term sustainability. To address this paradigm shift and ensure the continuity of digital reforms, a dedicated in-house IT Support Unit was created to serve as the backbone for all existing and future technological initiatives, guaranteeing institutional control, consistency, and enduring sustainability.

The primary objective of the Unit is to centralise and coordinate all digital initiatives, ensuring that systems are developed, managed, and scaled in a cohesive and standardised manner. This approach minimises duplication of effort, optimises resource utilisation, and ensures interoperability among

applications and platforms, in alignment with the Agency's strategic goals. The Unit also provides a structured framework for managing digital infrastructure, transforming previously fragmented systems into an integrated, efficient ecosystem that underpins effective governance and regulatory functions.

According to its Terms of Reference (TORs), the IT Support Unit acts as the focal point for coordination with the Punjab Information Technology Board (PITB) concerning the development, implementation, and maintenance of digital platforms, including mobile applications and dashboards. It is tasked with establishing and managing a centralised data repository to facilitate planning, monitoring, reporting, and evidence-based decision-making at the highest institutional levels. The Unit offers continuous technical support and advisory services across all wings, field formations, and directorates, while proactively identifying emerging needs in information technology, artificial intelligence, and data analytics. Additionally, it ensures secure administrative management of all digital systems, prepares periodic performance reports for the Director General, and collaborates closely with strategic units such as the Strategic and Analysis Wing (SAW).

Operationally, the IT Support Unit functions as the central technical hub responsible for the smooth operation, maintenance, and ongoing enhancement of all digital systems utilised by EPA Punjab. Beyond system oversight and issue resolution, it plays a critical role in capacity building and digital empowerment of staff by providing training on digital tools, workflows, and systems. Serving as a single point of contact for technical assistance, the Unit delivers real-time support, manages problem resolution, and offers guidance to both field personnel and office staff. Moreover, it actively promotes advanced digital competencies, including AI-driven awareness and skill development, ensuring that EPA Punjab remains adaptive to emerging technological innovations. Through this structured and integrated approach, the IT Support Unit has significantly fortified the resilience, efficiency, coordination, and responsiveness of EPA Punjab's digital systems, thereby enabling transparent, accountable, and data-driven environmental governance.

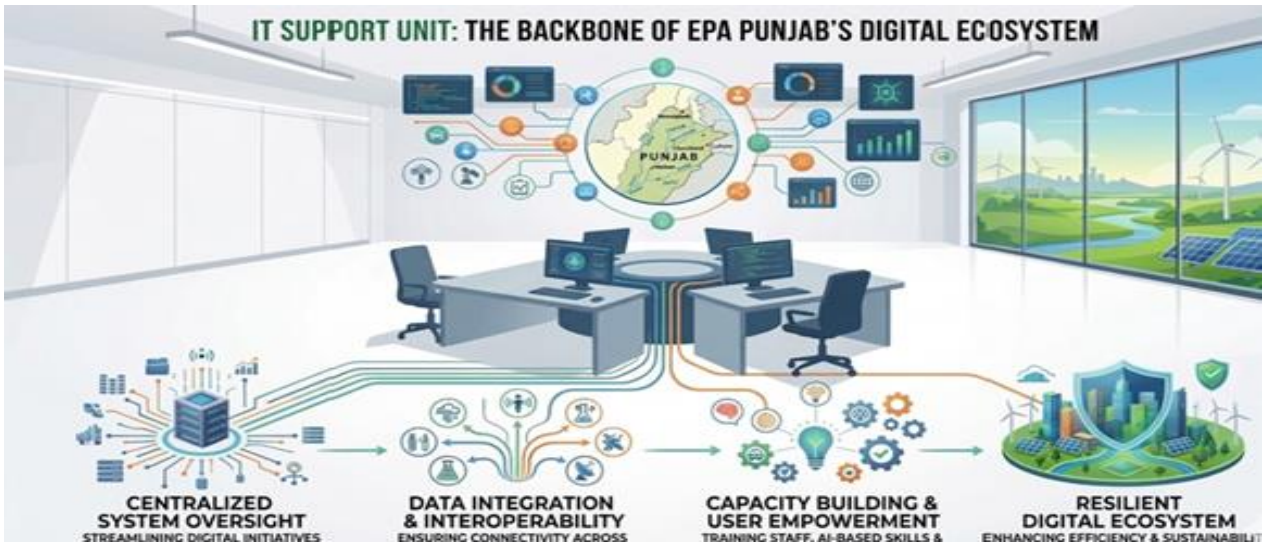


Figure 13.42: IT Support Unit Responsibilities – EPA Punjab

13.6 Conclusion

The digital transformation of EPA Punjab represents a significant advancement towards more transparent, accountable, and data-driven environmental governance. Through the deployment of digital platforms such as the ECO Watch Dashboard, Internal Accountability Dashboard, Industrial Directory Dashboard, Green Punjab App, and ECO Watch App, the Agency has established a robust digital footprint spanning monitoring, inspection, enforcement, and public engagement functions. These systems have enhanced the availability of real-time information and created a structured foundation for evidence-based decision-making.

However, the success of this transformation should not be measured solely by the existence of dashboards and applications. Its true value lies in whether these systems have yielded measurable improvements in governance performance. Consequently, EPA Punjab's digital transformation should be evaluated using indicators such as reduced response times to complaints and violations, increased numbers of digitally documented inspections, higher compliance rates among industries, decreased backlogs of pending cases, improved traceability of enforcement actions, and enhanced public access to environmental information.

Moreover, the transformation has strengthened institutional accountability by integrating centralised oversight with decentralised, field-level implementation. Real-time inspection uploads, geotagged evidence, automated monitoring, and internal review processes permit senior authorities to monitor field performance more effectively. This mitigates risks associated with manual reporting, delayed verification, and inconsistent enforcement. Simultaneously, citizen-centric platforms have made environmental governance more participatory by enabling the public to report environmental issues and monitor the Agency's responsiveness.

Overall, EPA Punjab's digital governance framework has laid a strong foundation for modern environmental regulation. It holds the potential to improve transparency, operational efficiency, regulatory fairness, and public trust. To maintain effectiveness and credibility, however, EPA Punjab should consistently publish performance results, incorporating baseline data, annual targets, and progress indicators. Such reporting will ensure that digital transformation transcends technological advancement to deliver tangible environmental, administrative, and governance benefits.

CHAPTER 14

Inter-departmental & International Coordination



14.1. Introduction

Environmental governance today demands engagement that transcends conventional regulation, requiring dynamic global connectivity, robust local institutional anchoring, and sustained investment in cultivating future environmental stewards. For EPA Punjab, this understanding has shaped a governance philosophy that integrates international representation, institutional collaboration, and youth-centred academic engagement into a coherent framework of environmental action.

Through its growing involvement in international environmental forums, EPA Punjab has emerged as a visible and credible subnational voice within the global environmental architecture. Participation in multilateral platforms, technical working groups, and regional cooperation mechanisms under Multilateral Environmental Agreements (MEAs) has enabled Punjab not only to align its regulatory and policy instruments with evolving global standards but also to project provincial experiences, challenges, and innovations onto the international stage. In so doing, the province has contributed meaningfully to global dialogues on climate change, air quality, hazardous chemicals, and waste governance, while ensuring that international commitments are translated into practical, science-based actions on the ground.

This outward engagement is complemented by a deliberate strengthening of Punjab's internal institutional ecosystem. EPA Punjab has progressively established partnerships with public sector bodies, regulatory authorities, technological institutions, chambers of commerce, and civil society organisations, facilitating the integration of environmental considerations into governance, commerce, and urban development. These collaborations have expanded the reach of environmental regulation, fostered interagency ownership of sustainability goals, and enabled environmental priorities to influence decision-making across transportation, industry, infrastructure, and public services. Thus, environmental protection has evolved from a specialised regulatory function into a shared provincial responsibility.

Nevertheless, the most enduring investment of this integrated model lies in its engagement with young people and academia. Recognising that environmental resilience ultimately depends on informed and empowered citizens, EPA Punjab has forged enduring partnerships with universities, research centres, and student communities across the province. Through Memoranda of Understanding, structured internship programmes, policy dialogues, climate simulations, and knowledge-generation initiatives, students are actively integrated into the environmental governance process. They are not mere recipients of awareness campaigns but active participants in data collection, policy analysis, fieldwork, innovation, and advocacy—learning by doing while shaping the environmental future of Punjab as they prepare to inherit it.

This chapter traces how international representation, institutional partnerships, and youth-driven academic engagement converge to form a distinctive and forward-looking model of environmental leadership in Punjab. Collectively, these elements embody a governance approach that is globally connected yet locally rooted, scientifically rigorous yet socially responsive, and firmly committed to securing a sustainable and resilient future for the province and its inhabitants.

14.2. International Engagements by EPA Punjab

In 2025, EPA Punjab broadened its international engagements via global platforms and technical collaborations, thereby strengthening institutional capacity in air quality monitoring, climate resilience, and the formulation of sustainable policies.

14.2.1 World Economic Forum 2025

The World Economic Forum (WEF) Annual Meeting serves as a premier global platform where governments, international organisations, and private sector leaders convene to shape policy dialogue on economic development, environmental sustainability, and climate resilience. Punjab's participation in the



Figure 14. 1: Participation of DG EPA Punjab Imran Hamid Sheikh in Pakistan Business Summit 2025

WEF Annual Meeting 2025, held in Davos from 20 to 25 January 2025, marked a significant milestone in positioning the province within the international climate and sustainability framework.

Building upon the momentum garnered at COP29 in Baku, where EPA Punjab showcased its regulatory and technological innovations, the Environment Protection & Climate Change Department (EP&CCD), Government of Punjab, was invited to represent the province at the Pakistan Business Summit convened alongside the World Economic Forum (WEF) Annual Meeting. During the session titled "Environment & Climate Change," EPA Punjab presented the province's

reforms in air quality management, industrial decarbonisation initiatives, waste management systems, and climate resilience strategies. Dr Imran Hamid, Director General of EPA Punjab, articulated Punjab's long-term vision for a Green Punjab, emphasising institutional strengthening and alignment with global climate objectives.

Punjab's engagement attracted considerable interest from expatriates, academia, and international stakeholders, facilitating opportunities for research collaboration and technical cooperation. EPA Punjab officers also contributed to thematic WEF sessions on sustainable and climate-resilient urban development, reinforcing the pertinence of international best practices to Punjab's policy priorities. Punjab's participation at WEF 2025 exemplified its active role as a sub-national entity, enhancing provincial credibility and expanding partnership prospects for climate-resilient development.

14.2.2. Second High-Level World Health Organization (WHO) Conference

In March 2025, the Environment Protection & Climate Change Department (EP&CCD) Punjab marked a significant milestone in its international engagement by participating in a high-level global forum on air quality and public health held in Cartagena, Colombia. Raja Jahangir Anwar, Secretary of EP&CCD; Dr Imran Hamid Sheikh, Director General of EPA Punjab; and Dr Wajid Ijaz, Deputy Director of Monitoring and Evaluation, represented the province at the conference titled "Clean Air for All: Addressing Pollution in South Asia for a Healthier Future." Organised by the World Bank and held concurrently with the Second High-Level WHO Conference from 21 to 26 March 2025, the event provided a global platform to advance policy dialogue on air pollution, public health, and climate-responsive environmental governance.

The forum convened policymakers, public health experts, environmental regulators, and development partners worldwide to address the interrelated challenges of air pollution, climate change, and human health, with a particular focus on South Asia. EP&CCD Punjab's participation signified growing international recognition of the province's institutional capacity in air quality

management, emissions regulation, and environmental governance. At this platform, EPA Punjab showcased its experience in regulatory reforms, real-time monitoring systems, and enforcement frameworks, while engaging with global best practices in pollution control, health-based air quality standards, and climate-responsive policy design.

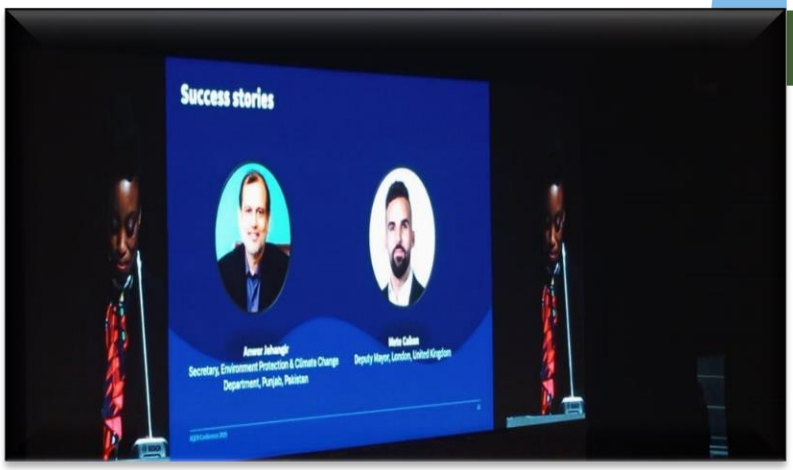


Figure 14.2: Secretary EP&CCD as panelist

Beyond technical exchange, the engagement in Cartagena strengthened institutional linkages with the World Bank and the World Health Organization, opening new avenues for cooperation in air quality management. This participation marked a significant consolidation of Punjab's stature as a proactive and credible sub-national actor within the global environmental and public health community.

14.2.3. Technical Committee of the Science Policy and Finance Dialogue (SPFD) on Air Quality Management in the Indo-Gangetic Plain and Himalayan Foothills (IGP-HF)

In March 2025, Mr Faisal Maqsood, Deputy Director (Laboratories) at EPA Rawalpindi, represented EPA Punjab at the Technical Committee meeting of the Science, Policy and Finance Dialogue (SPFD) on Air Quality Management held in Kathmandu, Nepal. This high-level regional engagement was convened under the joint auspices of the International Centre for Integrated Mountain Development (ICIMOD) and the World Bank, aiming to operationalise the outcomes of the Thimphu Declaration (June 2024). Through this declaration, Bangladesh, Bhutan, India, Nepal, and Pakistan collectively recognised the transboundary nature of air pollution across the Indo-Gangetic Plain and Himalayan Foothills (IGP-HF) and pledged to address it through a structured regional cooperation framework.

The deliberations resulted in the establishment of a comprehensive regional institutional architecture comprising an Executive Body, an Advisory Committee, and three Thematic Working Groups focused on air quality monitoring and emissions, pollution mitigation solutions, and air quality finance. A Secretariat, to be hosted by ICIMOD with technical support from the World Bank, will coordinate these efforts. EPA Punjab provided technical expertise during the Science–Policy Dialogue under the IGP-HF initiative, contributing to regional discussions on transboundary air quality management and fostering collaborative approaches to improve air quality across the Indo-Gangetic Plain.

14.2.4. Regional Training Workshop on Air Quality Data Analysis, 30 June-04 July 2025, Kathmandu, Nepal.

In June–July 2025, Mr Fahad Ahmed, Data Analyst from the Strategy and Analysis Wing of EPA Punjab, represented the Agency at the Regional Training Workshop on Air Quality Data Analysis held from 30 June to 4 July 2025 at the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu, Nepal. The programme aimed to strengthen the capacity of subnational partners to monitor air quality, analyse air quality datasets, and understand the social and gender dimensions linked to air pollution, with a particular focus on programming tools such as Python and R to support evidence-based analysis.

This engagement enhanced EPA Punjab's capacity for data-driven air quality management. The training improved the Agency's proficiency in applying modern analytical and programming techniques to convert raw monitoring data into actionable intelligence for smog control, health risk assessment, and climate-responsive environmental planning, aligning with international best practices for regional air quality governance.

14.2.5. Regional Representation of EPA Punjab AT SACEP–AIT Programme (Bangkok, September 2025)

In September 2025, Dr Imran Hamid Sheikh, Director General of the Environmental Protection Agency (EPA) Punjab, represented the Environment Protection & Climate Change Department, Punjab, at a high-level regional engagement under the South Asia Cooperative Environment Programme (SACEP). The event

was held at the Asian Institute of Technology (AIT) in Bangkok from 2 to 5 September 2025. This participation formed part of Pakistan's official representation at the Second Review Workshop of the SACEP Articles of Association and the Strategic Planning Workshop, convened to strengthen regional environmental governance in South Asia.

The Federal Government, through the Ministry of Climate Change and Environmental Coordination (MoCC&EC), constituted an official national delegation to represent Pakistan in the consecutive SACEP sessions. The delegation comprised Mr Imran Hamid Sheikh, Director General of EPA Punjab; Mr Khalid Mehmood, Director of the Pakistan EPA; and Mr Salman Mehmood, Section Officer (IC), MoCC&EC. In recognition of Punjab's robust performance in environmental governance, institutional strengthening, and regional cooperation, Mr Imran Hamid Sheikh was appointed Team Lead of the Pakistani delegation—a nomination formally conveyed to the SACEP Secretariat on 21 August 2025.



Figure 14.3: Pakistan's Delegation

The first component of the engagement centred on the review and finalisation of the revised Articles of Association (AoA) of the South Asia Cooperative Environment Programme (SACEP). The workshop reviewed and validated the revised draft, incorporating feedback from the inaugural review workshop and subsequent written submissions, sought consensus on unresolved matters among member states, and ensured that the revised AoA encapsulated the shared vision, priorities, and aspirations of the region. The process also aimed to strengthen SACEP's institutional framework to augment its effectiveness in fulfilling its regional mandate and to finalise the AoA for submission to the Governing Council for formal adoption.

The discussions underscored the increasing significance of sub-national environmental regulators, such as EPA Punjab, in fulfilling regional and global environmental commitments. A notable outcome of Punjab's active participation in the AoA review was the successful advocacy for clauses formally recognising sub-national units and provinces within SACEP's governance structure.



Figure 14.4: Director General EPA at Strategic Planning workshop

The second component, the Strategic Planning Workshop, was dedicated to formulating a five-year roadmap and a ten-year regional vision (2025–2035) for SACEP. Participants critically examined emerging environmental risks, governance gaps, and opportunities for collective action across key areas including air pollution, plastic waste, biodiversity conservation, digital environmental governance, and climate resilience.

Under the leadership of the Director General of EPA Punjab as Team Lead, Pakistan showcased practical and field-tested institutional models, highlighting



Figure 14.5: Participants of Strategic Planning Workshop Organized by SACEP

Punjab's experience in environmental enforcement, plastic regulation, air quality management, and digital monitoring systems. This engagement reinforced Punjab's position as a leading sub-national environmental authority within South Asia and bolstered Pakistan's contribution to the development of the regional architecture for environmental cooperation, sustainability, and climate action.

14.2.6. Transformative Action to End Open Burning of Waste in South Asia

In September 2025, Mr Farooq Alam, Director of Multilateral Environmental Agreements at EPA Punjab, represented the Agency at the Regional Dialogue on "Transformative Action to End Open Burning of Waste in South Asia," held from 4 to 7 September 2025 at the Malla Hotel in Kathmandu, Nepal. The dialogue was



Figure 14.6: Representation of EPA Punjab at the Regional Dialogue

organised under the IGES–UNEP Climate and Clean Air Coalition (CCAC) initiative, in collaboration with Nepal's Ministry of Forest and Environment, GAIA, and HECAF360. The event sought to address the escalating crisis of open waste burning, recognised as a major contributor to air pollution, black carbon emissions, and climate change across South Asia.

The dialogue convened governments, international organisations, and regional experts to review and refine the draft Regional Roadmap for Asia to End Open Burning of Waste, focusing on policy enforcement, institutional coordination and regional collaboration, financing mechanisms, and data-driven monitoring and inspection systems. Through this engagement, EPA Punjab contributed

significantly to shaping a South Asian framework for integrated solid waste management, climate mitigation, and air quality improvement, reinforcing Punjab's role in regional environmental diplomacy and cooperative action against transboundary pollution.

14.2.7. Conference Of Parties (COP-30) under UNFCCC

In November 2025, the Government of Punjab stepped onto the global climate stage at the 30th UN Climate Change Conference (COP-30), held in Belém, Brazil, from 10 to 21 November 2025. Led by the Honourable Chief Minister of Punjab, Ms Maryam Nawaz Sharif, the provincial delegation united senior political leadership and technical expertise from across government. Punjab's presence at COP-30 was strategic rather than symbolic, aimed at establishing the province as a credible sub-national climate actor capable of delivering large-scale, implementable solutions aligned with global climate goals.

Punjab entered COP-30 with clearly articulated strategic objectives: to demonstrate the province's transformation in environmental governance; showcase flagship initiatives, particularly Suthra Punjab, as globally relevant models; deepen partnerships with international organisations, donors, and research institutions; enhance institutional capacity for climate diplomacy and negotiations; and position Punjab as a sub-national leader contributing substantively to global climate solutions. This represented a shift from passive participation to active climate diplomacy, with Punjab seeking to substantively influence discussions, presenting evidence, demonstrable outcomes, and a credible track record as a sub-national government.

The scale and visibility of Punjab's presence at COP-30 reflected these ambitions. The Chief Minister's engagements at the Pakistan Pavilion within the UNFCCC Blue Zone positioned Punjab at the forefront of international climate discourse. Through a series of high-profile events, programme launches, and bilateral meetings, Punjab's leadership articulated the province's reform trajectory in air quality, waste management, climate resilience, sustainable mobility, and digital governance. These diplomatic efforts underscored the transformative potential of sub-national governments, demonstrating that, when equipped with political

will and institutional capacity, they can play pivotal roles in driving global climate action.

One of the prominent engagements was a meeting with the former Prime Minister of New Zealand, Rt. Hon. Jacinda Ardern, held on 10 November 2025. During this interaction, Punjab's eco-friendly governance reforms, digital monitoring systems, smog control strategies, and extensive community engagement initiatives were recognised as a "unique sub-national example from the Global South."



Figure14. 7: CM Punjab Meeting with Former PM of New Zealand at COP-30

A defining moment of Punjab's presence at COP-30 was the international launch of Suthra Punjab, the province's flagship waste governance initiative, held on 10 November 2025 at the Pakistan Pavilion. Suthra Punjab represents one of the world's largest integrated waste management systems, processing tens of thousands of tonnes of municipal waste daily through a province-wide, AI-enabled



Figure 14.8: International launch of Suthra Punjab at COP-30

operational framework supported by over 150,000 sanitation workers and 30,000 vehicles. Its launch at COP-30 showcased Punjab's capacity to translate political commitment into effective service delivery, rigorous environmental enforcement, and digital transparency. The initiative aligns with global priorities related to the circular economy, pollution reduction, and urban resilience. Presenting this scalable, implementation-ready model at COP-30 enabled Punjab to share its experiences and foster partnerships with stakeholders worldwide.

Beyond symbolic and political milestones, EPA Punjab played a substantive technical and diplomatic role throughout COP-30. Under the leadership of Dr Imran Hamid Sheikh, Director General of EPA Punjab, the Agency represented the Government of Punjab in nine major panel discussions, thematic dialogues, and expert-level sessions convened by international organisations, research institutions, and multilateral entities. These platforms enabled Punjab to present its environmental reforms not as abstract policy aspirations but as operational systems underpinned by data, enforcement capacity, and digital infrastructure.

EPA Punjab showcased the province's expansion of its air quality monitoring network from three stations to forty-one, with plans to grow to one hundred monitoring sites, alongside the deployment of AI-enabled Air Quality Index (AQI) forecasting systems that enhance seasonal preparedness. The establishment of Pakistan's first Environmental Protection Force by Punjab was highlighted as a landmark innovation in regulatory enforcement, supported by thermal drone surveillance, digital inspection tools, and real-time reporting platforms. The province's Emission Testing System (ETS), transition to electric mobility, and stringent fuel quality enforcement further illustrate the shift from paper-based compliance towards technology-enabled governance.

Punjab's engagement extended into the realm of climate finance and institutional planning. The delegation presented the Climate Resilient Punjab Vision & Action Plan 2024, highlighted increased climate budget allocations, and detailed the integration of climate objectives into infrastructure, waste management, and urban planning sectors. Through these presentations, Punjab positioned itself not merely as a project implementer but as a province adept at

managing climate finance, monitoring outcomes, and delivering bankable, scalable climate investments.

A historic institutional milestone at COP-30 was EPA Punjab's inaugural formal entry as observers into the UNFCCC negotiation rooms. Participation in contact groups and technical negotiation sessions afforded EPA Punjab officers first-hand exposure to the processes by which international climate positions are negotiated, shaped, and finalised. This experience laid the foundation for institutionalising negotiation preparedness within EPA Punjab, enabling the province to contribute evidence-based inputs to Pakistan's national positions in forthcoming climate discussions. It marked a pivotal transition from external advocacy to procedural participation in global climate governance.

Punjab's rising profile was further highlighted through its engagement at the China Pavilion during COP-30. Invited to deliver a keynote address on "Low-Carbon Technology Innovation and Industrial Practice," the Director General of EPA Punjab presented the province's alignment with scalable Chinese technologies in renewable energy, electric mobility, digital monitoring, reporting, and verification (MRV) systems, and green industrialisation. The discussion emphasised the importance of technology transfer, bilateral cooperation, and the critical role of transparent and participatory governance in accelerating low-carbon transitions at the sub-national level.



Figure 14.9: DG EPA, Punjab Presenting at China Pavilion during COP-30's Participation

Equally significant was Punjab's role in discussions on Loss and Damage, where the province highlighted its acute vulnerability to climate shocks, drawing upon the devastating floods of 2022 and 2025. By presenting institutional reforms, augmented budgetary allocations, and community-level verification systems, Punjab emphasised that Loss and Damage finance must directly support resilience-building and livelihood restoration for frontline communities.



Punjab's youth-focused climate engagement garnered significant international recognition. Through sessions held at the GAUC Pavilion and collaborations with the Yale School of the Environment, Punjab showcased its youth-centric climate governance model. This model encompasses digital platforms, university partnerships, climate internships, and community-based monitoring initiatives. These engagements positioned Punjab as a leader in integrating young people into evidence-driven climate action.



Figure 14.10: Panelist at Youth and Climate Action organized by Yale School of Environment and MoCC & EC

The Government of Punjab was represented by the Director General of EPA Punjab in the panel discussion titled “Unlocking the Local Benefits of Renewable Energy,” organised by the University of Oxford and the Smith School of Enterprise & Environment at the WWF Pavilion. Punjab emphasised the importance of equitable benefit-sharing in renewable energy development, drawing on examples of community-driven micro-hydro projects and international best practices.



Figure 14.11: Unlocking the Local Benefits of Renewable Energy,” organized by the University of Oxford and the Smith School of

Key initiatives included the deployment of 1,500 electric buses, the establishment of Pakistan’s first Vehicle Emission Testing System for light-duty vehicles, digital enforcement mechanisms for traffic and emissions control, expansion of the air quality monitoring network to 41 stations, strengthened regulation of fuel quality, and the launch of the Chief Minister’s Green Credit programme to accelerate electric vehicle adoption. Collectively, these measures constitute an integrated clean transport system that synergises regulatory oversight, technological innovation, and market incentives to achieve measurable reductions in pollution and emissions.

Building on these reforms, the Director General of EPA Punjab was invited to present Punjab's experience at the United Nations Department of Economic and Social Affairs (UN DESA) session held at the Sustainable Development Goals (SDGs) Pavilion. Additionally, he represented the Government of Punjab in the UN Decade of Sustainable Transport (2026–2035) dialogue, where Punjab's Climate Resilient Vision & Action Plan 2024 was showcased as a practical framework for implementing global transport objectives across the province.



Figure 14.12: Panelist at UN Decade of Sustainable Transport (2026-2035) at SDGs Pavillion

Collectively, COP-30 yielded significant dividends: Punjab was recognised as an emerging climate leader in South Asia, particularly in the domains of waste governance, air quality management, and digital enforcement. Furthermore, the province's stature as a technically credible sub-national actor was affirmed across multiple United Nations and international platforms.

By the conclusion of COP-30, Punjab had undergone a decisive transformation—from a provincial environmental regulator to an acknowledged participant in global climate diplomacy. Its reforms, institutions, and leadership transcended domestic considerations, securing a role within the evolving architecture of international climate action. Punjab's presence at COP-30 thus symbolises not merely participation but a structural repositioning within the global climate governance framework, laying the groundwork for enduring global partnerships, enhanced negotiation capabilities, and sustained climate-related investment.

14.2.8. Strengthening Regional Capacity for Wastewater and Environmental Surveillance (WES) in Public Health Systems of IsDB Member Countries

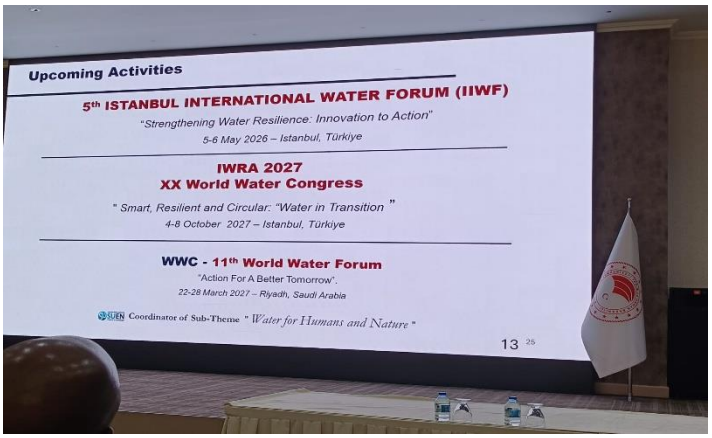


Figure 14.13: International Workshop on "Strengthening Regional Capacity for Wastewater and Environmental

In November 2025, Mr Anjum Riaz, Director (Planning & Coordination) and Head of the Specialized Water Sector, represented EPA Punjab at the International Workshop on "Strengthening Regional Capacity for Wastewater and Environmental Surveillance (WES) in Public Health Systems of IsDB Member Countries," held on 18–19 November 2025 in Istanbul, Türkiye. The workshop was jointly organised by the Islamic Development Bank (IsDB) in collaboration with the Bill & Melinda Gates Foundation, the European Commission's Health Emergency Preparedness and Response Authority (HERA), and the Turkish Water Institute (SUEN). Attended by the World Health Organization (WHO) and other international partners, the forum aimed to promote the institutionalisation of wastewater and environmental surveillance as an integral component of public health and environmental monitoring systems.

The programme combined high-level policy dialogue with practical exposure to operational surveillance systems. Plenary sessions and country showcases highlighted international experiences in integrating wastewater surveillance into public health decision-making, mobilising sustainable financing, and translating environmental data into early warning systems for disease outbreaks. Field visits to the Tuzla Advanced Wastewater Treatment Plant and the Veterinary Control Institute in Pendik offered firsthand insights into sampling protocols, pathogen detection methods, laboratory workflows, biosafety practices, and inter-institutional coordination mechanisms linking wastewater treatment infrastructure with public health surveillance functions.

Through this international engagement, EPA Punjab enhanced its understanding of embedding wastewater and environmental monitoring within provincial

surveillance and regulatory frameworks. This reinforced the strategic alignment between environmental protection, public health preparedness, and data-driven risk management, in accordance with emerging global best practices in One Health and climate-resilient environmental governance.

14.2.9. Clean Air Week 2025

In November 2025, Mr Usman Azhar, Deputy Director of EPA Punjab, represented the Agency as a panelist in an International Centre for Integrated Mountain Development (ICIMOD) organised session during Clean Air Week 2025, convened by the United Nations Environment Programme (UNEP) from 24 to 28 November 2025 in Bangkok, Thailand. The session, titled "From National Action to Regional Cooperation: Advancing Clean Air through Science, Policy and Finance," was held on 25 November 2025. It focused on enhancing regional harmonisation in air quality management through robust sub-national clean air strategies linked to regional cooperation frameworks. The session promoted South-South learning, peer-to-peer exchange, and the adoption of standardised regional approaches.



Figure 14.14: Clean Air Week 2025 session organized by ICIMOD in Bangkok Thailand

Through his participation as a panelist, EPA Punjab contributed its provincial experience and institutional perspectives to a multilateral dialogue aimed at harmonising country-level clean air initiatives with emerging regional

cooperation frameworks across South Asia and the broader Himalayan and Indo-Gangetic region.

14.2.10. International Technical Partnerships and Bilateral Cooperation Initiatives (In Pipeline)

A defining outcome of EPA Punjab's sustained international engagement in 2025 is the development of a robust pipeline of technical partnerships, Memoranda of Understanding (MoUs), and bilateral cooperation frameworks initiated as a direct result of these efforts. These prospective institutional arrangements, currently at various stages of finalisation, reflect EPA Punjab's growing credibility and will transform its international presence into structured, long-term collaborations in environmental science, technology transfer, capacity building, and joint governance.

(i) Memorandum of Understanding with ICIMOD (In Pipeline)

EPA Punjab is in the process of formalising a Memorandum of Understanding with the International Centre for Integrated Mountain Development (ICIMOD), the premier intergovernmental knowledge and learning centre serving the Hindu Kush Himalayan region. The prospective MoU aims to institutionalise collaboration in air quality monitoring, regional data sharing, scientific capacity building, and policy-relevant research within the Indo-Gangetic Plain and Himalayan Foothills (IGP-HF) framework. Given ICIMOD's convening role in the Science, Policy and Finance Dialogue (SPFD) platform and its technical support to the IGP-HF airshed governance mechanism, this partnership is expected to become foundational to Punjab's regional environmental science architecture.

(ii) Technical Partnership with CRAES and MoU (In Pipeline)

EPA Punjab has established an active technical collaboration with the Chinese Research Academy of Environmental Sciences (CRAES), China's foremost national environmental research institution under the Ministry of Ecology and Environment. CRAES currently provides technical assistance to ongoing projects of EPA Punjab and the Environment Protection & Climate Change Department (EP&CCD), covering knowledge transfer in advanced air quality monitoring

methodologies, pollution source apportionment, industrial emission control technologies, and digital environmental governance systems. A formal Memorandum of Understanding to institutionalise this collaboration is under development. CRAES's engagement grants direct access to the scientific underpinnings of China's transformative air quality improvements—a 35–45% reduction in $PM_{2.5}$ across major cities from 2013 to 2023 (Ministry of Ecology and Environment, China, 2023)—offering Punjab proven, scalable, and cost-effective solutions for its industrial and urban pollution challenges.

(iii) Cooperation Framework with the University of São Paulo (USP), Brazil (In Pipeline)

During EPA Punjab's COP-30 engagement in Belém, the University of São Paulo (USP), one of South America's leading academic and research institutions and ranked among the top 100 universities globally, expressed a strong interest in establishing a structured cooperation with EPA Punjab. This prospective partnership aims to facilitate collaborative research on air quality, climate adaptation, urban environmental governance, and the circular economy, linking Punjab's environmental practitioners with cutting-edge research ecosystems. USP's expertise in tropical and subtropical environmental systems, industrial ecology, and community-based resilience is directly pertinent to Punjab's environmental challenges.

(iv) MoU with the Department of Forestry, Fisheries and the Environment, Republic of South Africa (Under Process)

A Memorandum of Understanding between EPA Punjab and the Department of Forestry, Fisheries and the Environment (DFFE) of South Africa is currently under negotiation. South Africa's DFFE serves as the principal environmental regulatory authority responsible for biodiversity conservation, pollution and waste management, climate change adaptation, and environmental impact assessment—all functions similar to EPA Punjab's mandate. Once formalised, this MoU will establish a bilateral platform for regulatory peer exchange, joint capacity development, shared monitoring methodologies, and cooperative engagement in multilateral fora.

14.3. Local Partnership & Coordination Mechanism

EPA Punjab amplifies its environmental impact through strategic partnerships with government institutions, academic organisations, the private sector, and civil society. These collaborations foster shared responsibility and community-driven solutions, extending the reach of environmental regulation while encouraging innovation, public awareness, and long-term environmental stewardship.

14.3.1. Memorandums of Understanding with Local Authorities

EPA Punjab has adopted a whole-of-government and whole-of-society approach to environmental governance by forging strategic collaborations with key provincial institutions, the private sector, and academic entities. A central pillar of this strategy is its partnership with the Punjab Safe Cities Authority (PSCA), which leverages advanced surveillance systems, command and control infrastructure, and real-time data feeds to enhance environmental enforcement, regulate traffic-related emissions, and support compliance monitoring within major urban centres. Concurrently, EPA Punjab collaborates with the Ravi Urban Development Authority (RUDA) to ensure that large-scale urban development projects integrate robust environmental safeguards and adhere to regulatory compliance requirements.



Figure 14.15: EPA & PSCA MOU Signing Ceremony

Concurrently, EPA Punjab has established dedicated facilitation and compliance desks at the Chambers of Commerce and Industry in Lahore, Faisalabad, Gujranwala, Sialkot, and other major cities, thereby creating a direct institutional interface with the industrial and business communities. These desks are designed not only to streamline regulatory guidance and approval processes but also to promote voluntary compliance, encourage cleaner production practices, and raise awareness of evolving environmental standards.



Figure 14.16: EPA & PITB MOU Signing Ceremony

Complementing its outreach and enforcement mechanisms, EPA Punjab has strengthened its partnership with the Punjab Information Technology Board (PITB) to institutionalise digital environmental governance. This collaboration supports the development and operation of critical digital platforms, including e-FOAS, Eco-Watch, digital inspection and laboratory management systems, and integrates environmental complaint management via the Punjab Government's 1373 Helpline under a formal agreement. Collectively, these initiatives have enhanced regulatory efficiency, improved public access to environmental grievance redressal, and enabled technology-driven environmental monitoring and enforcement across the province.

These institutional partnerships have yielded tangible improvements in collaborative enforcement and real-time environmental monitoring throughout Punjab. Under the Safe City Alliance, EPA Punjab operates continuously across five key domains, with dedicated focal persons at five major provincial facilities, enabling sustained surveillance and enforcement at unprecedented scale and intensity. The deployment of Safe City cameras has introduced a significant additional layer of monitoring and enforcement capacity province-wide.

Collaboration with the Ravi Urban Development Authority (RUDA) in northern Lahore has likewise produced measurable improvements in industrial compliance, with smart camera monitoring facilitating round-the-clock oversight previously unavailable. This capability has been particularly effective in curbing late-night and off-hours industrial emissions—a persistent enforcement challenge—by extending regulatory visibility into historically high-violation periods.

Through its Memorandum of Understanding (MoU) with PITB, EPA Punjab has integrated the 1373 platform into its core operations, transforming it into more than a conventional call centre or public helpline. The platform now facilitates comprehensive institutional interactions and underpins efficient implementation of enforcement actions. For example, under the CCTV camera initiative, communications with industrial proponents are routed exclusively through the platform, reducing the risk of personal bias and enhancing transparency. This system-mediated, third-party communication model has added measurable efficiency and accountability to EPA Punjab's enforcement efforts. Furthermore, the 1373 platform supports the generation of automated alerts and the coordination of multi-stakeholder responses, enabling EPA Punjab to perform monitoring, enforcement, and stakeholder engagement functions through a single integrated digital system.

EPA Punjab, in collaboration with Coca-Cola Pakistan, implemented the Waste Wise Management Process to promote modern waste segregation practices in



Figure 14.17: EPA Punjab with Coca-Cola Pakistan for Waste Wise Management Process

educational institutions across the province. Under this initiative, ten model schools were equipped with five-stream, colour-coded bin systems to facilitate effective recycling and environmentally responsible waste disposal. Supported by comprehensive environmental education materials, the programme enhances waste literacy among students and fosters a culture of sustainability, positioning youth as active participants in Punjab's transition towards a cleaner and more resilient future.

Another significant initiative was the Conference of Directors General of Environmental Protection Agencies, convened by EPA Punjab in collaboration with UNICEF. This event marked an important institutional milestone in strengthening inter-provincial environmental governance in Pakistan. By bringing together the heads of all federal and provincial Environmental Protection Agencies on a common platform, the conference created a rare opportunity for strategic dialogue, peer learning, and collective problem-solving at the highest level of

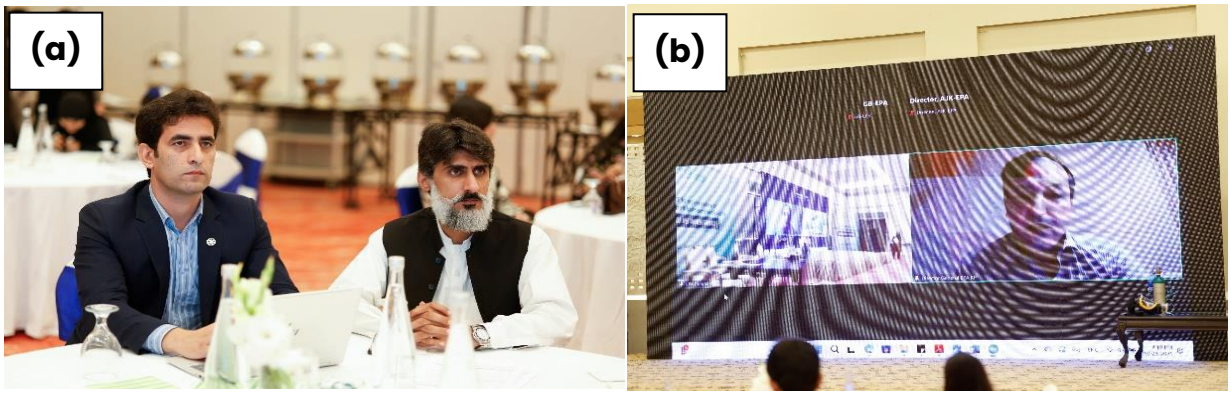


Figure 14. 18: (a) Participants from Baluchistan EPA (b) Online Participation from AJK EPA

environmental administration.

Through structured presentations by each Director General followed by plenary discussions, the forum facilitated the exchange of operational experiences, regulatory innovations, and policy challenges across provinces. The proceedings culminated in the formulation of joint recommendations and the establishment of a structured mechanism for sustained coordination, thereby laying the foundation for a more coherent, cooperative, and harmonised national environmental governance framework.

The Conference yielded tangible inter-provincial coordination outcomes that extended well beyond the event itself. All provinces expressed appreciation for the efforts of EPA Punjab and concurred on the development of a formal coordination mechanism to facilitate ongoing knowledge exchange.



Figure 14. 19: Participants of DG's Conference in Lahore

14.3.2. Youth Engagement and Academic Partnerships for Environmental Action:

EPA Punjab has deliberately positioned youth at the heart of its environmental governance and climate action framework, recognising young people as both custodians of the future and active agents in the present. This vision was formalised through the signing of a Memorandum of Understanding (MoU) with the Lahore University of Management Sciences (LUMS), establishing a structured platform for collaboration encompassing environmental awareness, academic exchange, research engagement, and policy dialogue. The MoU represents a strategic shift from sporadic outreach activities towards sustained institutional partnerships with academia, ensuring that environmental governance in Punjab is continually enhanced by intellectual inquiry, innovation, and youth participation.

Building on this foundation, EPA Punjab launched the "COP in My City" programme, a flagship youth engagement and climate simulation initiative. This platform immerses students in the complexities of international climate

negotiations by involving them in simulated Conference of the Parties (COP) processes, policy role-plays, negotiation exercises, and evidence-based climate dialogues. Through this experiential learning approach, young participants develop an active understanding of climate diplomacy and the reconciliation of scientific evidence with climate justice concerns within global frameworks.

Under this initiative, COP-style simulations and youth engagement sessions were held at LUMS, Government College University, the College of Earth and Environmental Sciences at the University of the Punjab, and other institutions. These events enabled students to assume the roles of negotiators, scientists, policymakers, and civil society actors, gaining practical insights into the workings of the United Nations Framework Convention on Climate Change (UNFCCC) process and the multifaceted nature of climate governance. By linking global climate negotiations to Punjab's specific environmental challenges, the programme helped young participants contextualise international commitments within local realities, fostering informed engagement with climate policy implementation.



Figure 14.20: COP in my City at GCU Lahore

EPA Punjab's "COP in My City" series thus represents not merely an outreach initiative but a structured investment in cultivating the next generation of climate-conscious citizens and environmental professionals in Punjab.

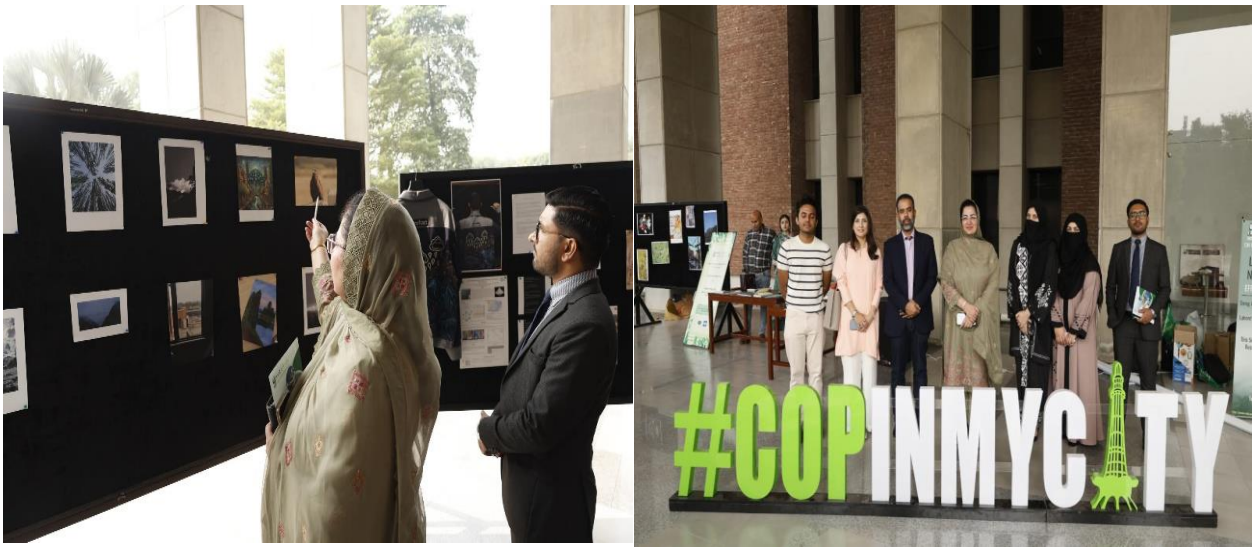


Figure 14.21: COP in my City at LUMS



Figure 11. 22: COP in my City at CEES PU

To complement awareness initiatives with practical experience, EPA Punjab simultaneously expanded a province-wide internship and youth placement programme, opening its institutional framework to students from universities and colleges across Punjab. During 2025, over 100 students completed structured internships within the Agency, gaining hands-on exposure to air quality management, environmental monitoring, regulatory compliance, data analysis, and public communication. This engagement provided young scholars with first-hand experience of environmental governance in action, fostering a generation well-equipped with both academic insight and practical operational understanding.

Complementing these initiatives, EPA Punjab also invested in the development of enduring educational resources designed for young audiences. In this context, the Agency produced and published its inaugural youth-focused environmental book, **Our Earth, Our Responsibility**. This publication presents environmental challenges, climate risks, and sustainability principles in a clear and engaging manner, inspiring young readers to view themselves as custodians of the environment and active participants in climate action.

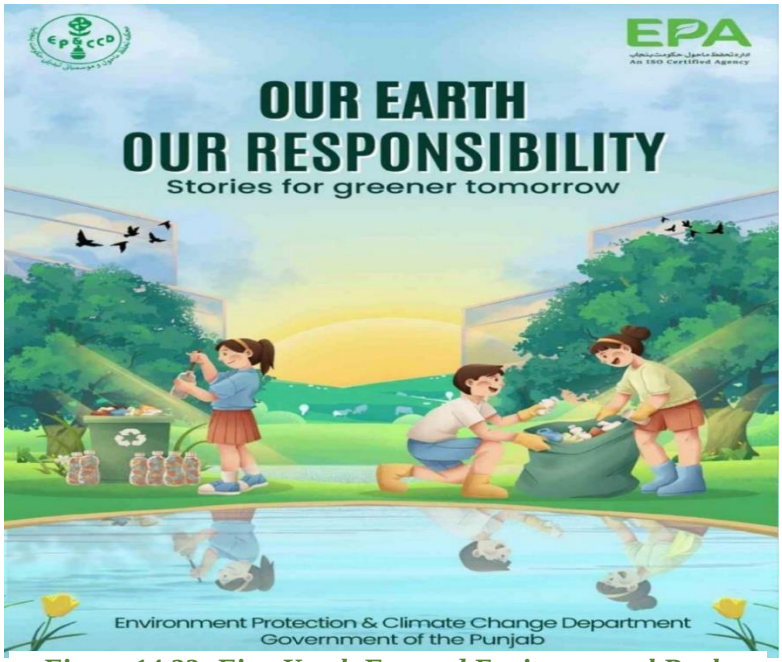


Figure 14.23: First Youth Focused Environmental Book, "Our Earth, Our Responsibility"

14.4 Conclusion: From Engagement to Endurance

EPA Punjab's work in 2025 represents a significant advancement in the Agency's operational approach, both internationally and domestically. Rather than treating global engagements as isolated events, EPA Punjab has leveraged each

platform to build practical capacity, establish enduring partnerships, and bring tangible knowledge back to the province.

On the international stage, participation in COP-30 in Belém marked EPA Punjab officers' first direct exposure to the intricacies of climate negotiations, spanning technical discussions through to clause drafting sessions. This experience is invaluable in equipping the Agency to engage substantively in future negotiations rather than remaining peripheral observers. Concurrently, new technical partnerships with institutions such as the Chinese Research Academy of Environmental Sciences (CRAES), the International Centre for Integrated Mountain Development (ICIMOD), the University of São Paulo, and South Africa's Department of Environment, together with strengthened collaborations with global entities like the World Bank and World Health Organization (WHO), provide EPA Punjab with enhanced access to expertise, data, and tools to advance air quality management, environmental monitoring, and policy development.

Domestically, formalising a Memorandum of Understanding with Lahore University of Management Sciences (LUMS), expanding the internship programme integrating students within EPA Punjab, and implementing the "COP in My City" simulations at various universities are strategic investments in cultivating the next generation of environmental stewards. The publication of Punjab's first youth-focused environmental book further extends this effort by fostering awareness among a broader audience. Nationally, the Conference of Directors General of Environmental Protection Agencies yielded a pivotal outcome: all provinces committed to developing a shared coordination mechanism, laying the foundation for coherent environmental governance across Pakistan.

Collectively, these initiatives demonstrate EPA Punjab's commitment to building a resilient institution that learns from international experience, applies insights locally, and develops the institutional and human capacities necessary for sustained improvement.

The priorities moving forward are unequivocal: transforming Memoranda of Understanding from documents to actionable collaborations, translating training

into policy instruments, and nurturing the young professionals engaged in 2025 into the environmental leaders Punjab requires. With a solid foundation laid, the imperative now is to build upon it.

CHAPTER 15

Punjab Climate Observatory

Institutionalizing Climate Intelligence for a Resilient Punjab



1. From Climate Risk to Institutional Response: The Case for the Punjab Climate Observatory

Pakistan is consistently listed among the countries most vulnerable to climate change in Germanwatch's Global Climate Risk Index. This makes localized, evidence-based climate governance a necessity rather than a choice. The World Bank's Country Climate and Development Report (2022) shows how the threat is growing. By the end of the 21st century, the number of days each year with a heat index above 35 °C is projected to rise by 9–13 days under the SSP1-1.9 scenario. Under SSP2-4.5 the rise is 16–30 days, and under SSP3-7.0 it is 21–39 days[104].

Punjab is Pakistan's agricultural and economic powerhouse, and it carries a large share of this exposure. The province is already living with extreme and unpredictable weather, including prolonged droughts, off-season rainfall, recurring heatwaves, floods and water stress, urban expansion, agricultural vulnerability and increasing demands for climate-compatible public investment. The 2022 floods showed how limited its capacity is to forecast climate events, anticipate risks and coordinate a response[105]. The relevant information is generated by some of the institutions in different formats, spatial scales and reporting cycles. The resulting fragmentation constrains the ability of decision-makers to connect environmental state and trends with their underlying drivers, projected risks and the likely effect of policy choices. Also, without reliable real-time climate data, predictive modelling and impact analytics, Punjab will find it hard to build the evidence base that international climate finance mechanisms require. These include the Green Climate Fund (GCF), the Adaptation Fund and the Fund for responding to Loss and Damage. It is this gap that the Punjab Climate Observatory (PCO) is designed to close.

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[104] World Bank Group (2022). *Pakistan Country Climate and Development Report.* Washington, DC: World Bank. DOI: 10.1596/38277. https://hdl.handle.net/10986/38277

[105] Government of Pakistan, Ministry of Planning, Development and Special Initiatives, with ADB, EU, UN agencies and the World Bank (2022). *Pakistan Floods 2022: Post-Disaster Needs Assessment (Main Report).* https://www.ilo.org/publications/pakistan-floods-2022-post-disaster-needs-assessment-main-report

2. Learning from Global Precedents

The concept of PCO is drawn from a growing global body of practice in which governments and institutions use climate observatories to turn data into decisions. Examples range from site-based facilities such as the Ponmudi Climate Observatory (India) and the XIANCHE Atmospheric Observatory (China) to national platforms such as ONACC and the China Meteorological Data Service, and from city and sub-national initiatives such as the Resilient Sydney Platform and the State Climate Data Observatory to regional and global networks such as CEON, the European Climate Neutrality Observatory (ECNO), the Group on Earth Observations (GEO) and Space for Climate Observatories (SCO).

Mandates differ, but the lesson is common: the most effective observatories combine sustained observation, interoperable data systems, scientific modelling, institutional partnerships, accessible decision products and access to international climate finance, and they link data directly to planning and decision-making. The PCO adapts these principles to Punjab's administrative, environmental and development-planning context, as the sections that follow describe.



Figure 1. Examples of global climate observatories

3. The Punjab Climate Observatory: A Provincial Flagship Initiative

The Government of the Punjab is establishing the Punjab Climate Observatory (PCO) as a first-of-its-kind provincial climate-intelligence, research and decision-support platform designed to convert fragmented environmental and

climate data into credible, timely and actionable intelligence. Conceived at the intersection of science, technology and public policy, the Observatory is intended to provide year-round monitoring, advanced modelling and forecasting, integrated data management, climate-risk analysis, decision-support services and a common coordination platform for provincial and federal institutions. It represents a shift from episodic, sector-specific environmental information towards a continuous, integrated and anticipatory system for climate-resilient development.

The vision of the PCO is:

> *"A dynamic and innovative year-round integrated center for real-time monitoring, forecasting, data sharing, and proactive decision-making to institutionalize evidence-based policy planning enabling Punjab to move towards resilience and sustainability."*

The PCO is being established in Lahore, on a 64-kanal site, at a cost of Rs. 12,988.323 million and is planned for implementation over three fiscal years, from FY 2025-26 to FY 2027-28.

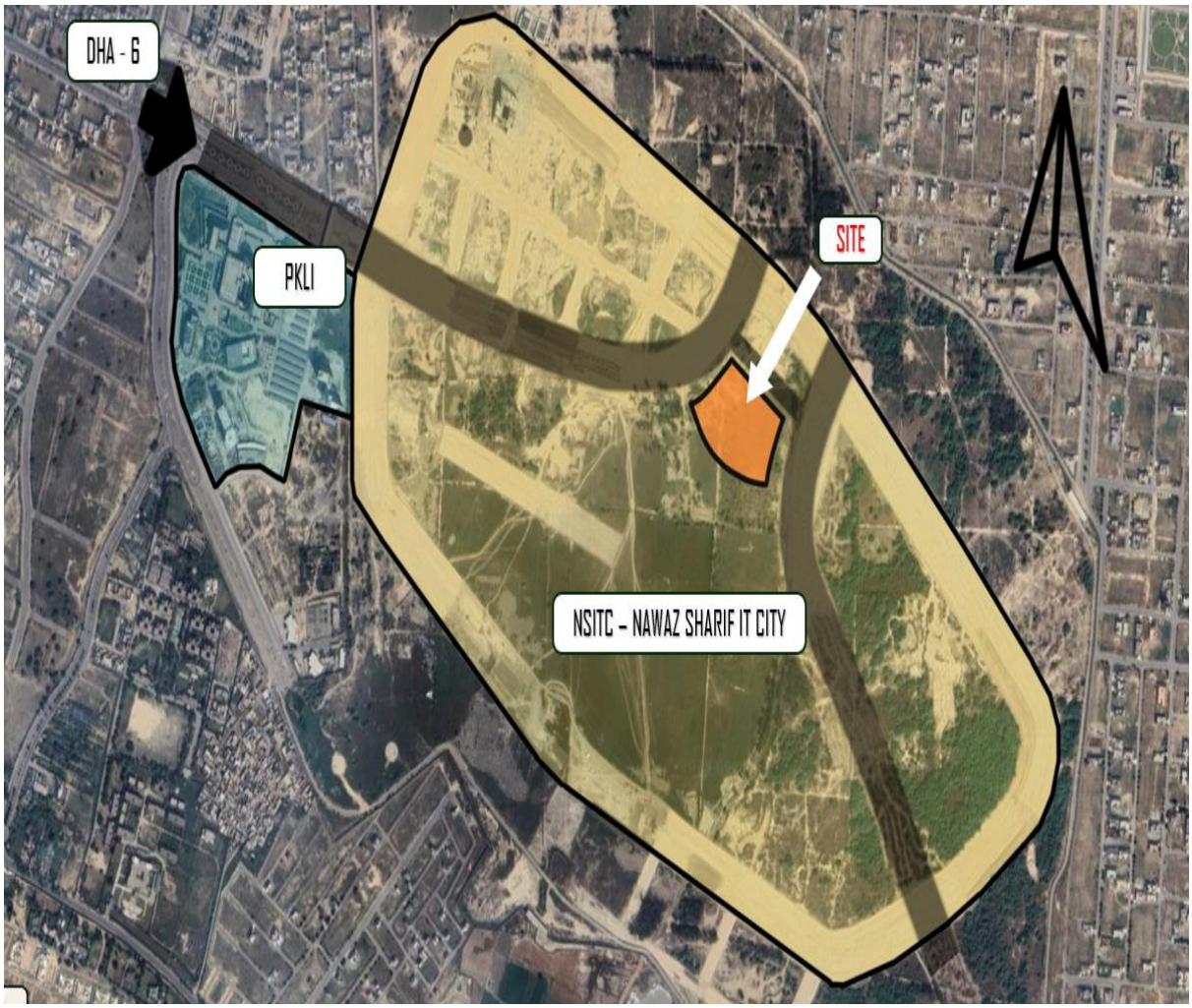


Figure 2: Site for PCO in Lahore

It is sponsored by the Environment Protection & Climate Change Department (EP&CCD), and execution is shared among six institutions, described in Section 7. Together, these entities pool their mandates and capabilities, from planning and policy to regulation, technology and spatial analysis, so that climate intelligence is built on a shared foundation across Government.

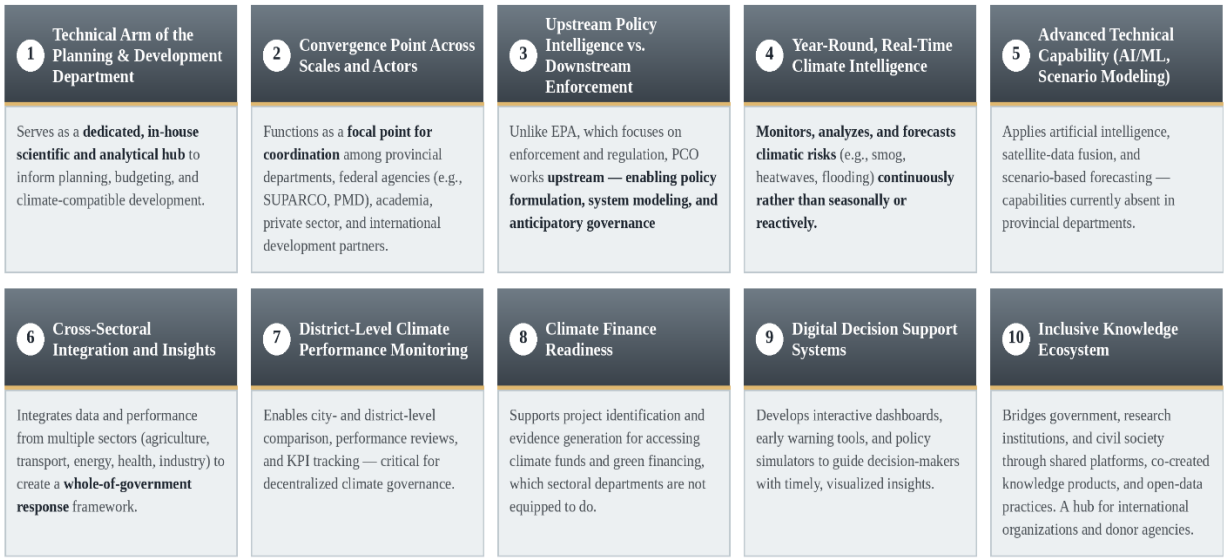


Figure 3: Distinctive features envisaged for the Punjab Climate Observatory

Considering the scale, technical complexity, and multi-component nature of the project, a dedicated Project Management Unit (PMU) in EPCCD will be responsible for overall project execution, procurement processes, human resource management, inter-departmental coordination, supervision of project activities, contract management, and monitoring and reporting of implementation progress.

4. How PCO Works: From data to Decisions

The defining concept of PCO is not simply a data centre or a repository of environmental statistics. It is envisaged as a climate intelligence hub: an institutional capability that continuously brings together observations, administrative records, satellite and geospatial information, models, scientific knowledge and policy objectives, and transforms them into decision-ready products. The core value of the Observatory therefore lies in the chain from data acquisition to interpretation, prediction, scenario testing and policy action.

The Observatory is expected to ingest and integrate information from EPA/EMC air-quality monitoring systems, water-quality monitoring, treatment plants and laboratories; district EPA offices; industrial and factory monitoring systems, including live or periodic video/sensor feeds; agricultural and municipal monitoring relating to crops, soil, water, stubble burning and waste burning; meteorological and hydrological feeds; satellite and remote-sensing products;

disaster information; and datasets from provincial departments, PMD, SUPARCO, PDMA, The Urban Unit, academia, private platforms and open online sources.

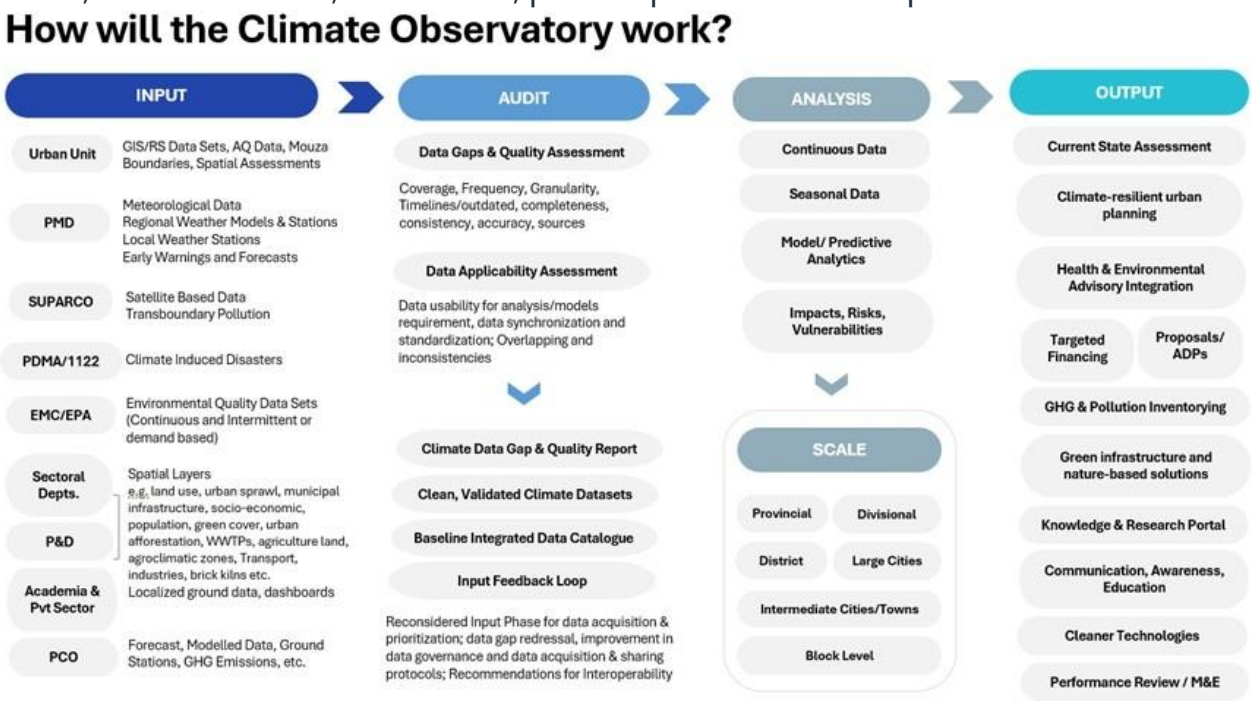


Figure 4: Conceptual data-to-intelligence workflow for the PCO

The Climate Intelligence Cycle

- Observe and integrate: collect live, near-real-time and periodic environmental, meteorological, geospatial, socioeconomic and sectoral information from multiple trusted sources.
- Standardize and validate: apply common metadata, data-quality, governance, lineage and interoperability standards so that heterogeneous datasets can be compared and combined.
- Analyze and model: use statistical analysis, GIS/remote sensing, physical climate and environmental models, AI/ML, forecasting, risk models and simulation to understand conditions and anticipate change.
- Translate into decisions: generate dashboards, early warnings, policy briefs, sectoral scorecards, climate-risk assessments, project appraisal inputs, MRV products and climate-finance evidence.
- Learn and improve: validate forecasts and interventions against observed outcomes, refine models and update assumptions as new evidence becomes available.

A convergence point for Government

PCO is intended to complement not duplicate the mandates of existing institutions. PMD remains the national meteorological authority; SUPARCO contributes satellite and remote-sensing capability; EPA/EMC provides regulatory and environmental-monitoring data; PDMA contributes disaster information; The Urban Unit provides spatial and analytical support; and sector departments supply domain-specific data. PCO's niche is to integrate these inputs, perform cross-sector analysis and convert them into a common climate-intelligence layer for Government decision-making.

5. Core Functions and Service Portfolio of PCO

The PCO is structured around adaptation, mitigation and cross-cutting climate functions, with an emphasis on converting science into usable public policy. Its anticipated service portfolio spans the following mutually reinforcing functions.



Figure 5: Adaptation, mitigation and cross-cutting thematic areas informing PCO operations

i. **Integrated environmental and climate monitoring.** Continuous synthesis of air, water, weather, hydrology, land, vegetation, emissions, industrial, agriculture, waste and other environmental indicators at provincial, divisional, district, city and site scales.

ii. **Forecasting, nowcasting and early warning.** Localized intelligence on smog, extreme heat, heavy rainfall, floods, drought, water stress and other climate-related hazards, with links to appropriate alert and communication mechanisms.

iii. **Climate-risk and vulnerability assessment.** Hazard mapping, exposure and vulnerability analysis, compound-risk assessment, infrastructure and urban resilience analysis, and identification of priority adaptation measures.

iv. **Mitigation, emissions and decarbonization analytics.** GHG inventories and MRV, emissions baselines, sectoral pathways for transport, energy, industry, agriculture, waste and land use, and assessment of technology and policy options for emission reduction.

v. **GIS, Earth observation and spatial intelligence.** Fusion of satellite, drone, field and administrative data for land-use change, urban growth, crop and vegetation monitoring, pollution tracking, hazard mapping and district-level climate intelligence.

vi. **Climate finance and carbon-market readiness.** Evidence for bankable climate projects, financing proposals, carbon-crediting and Article 6/carbon-market analysis, project monitoring, economic and financial appraisal, and climate-finance prioritization.

vii. **Climate-compatible planning and performance management.** Climate impact scoring, scenario testing, city/district performance dashboards, sectoral KPIs, project appraisal inputs, cost-benefit evidence and monitoring of climate-aligned public investment.

viii. **Knowledge, research and public decision support.** Research partnerships, policy briefs, advisories, data products, dashboards, training, climate diplomacy, knowledge exchange and collaborative R&D with national and international institutions.

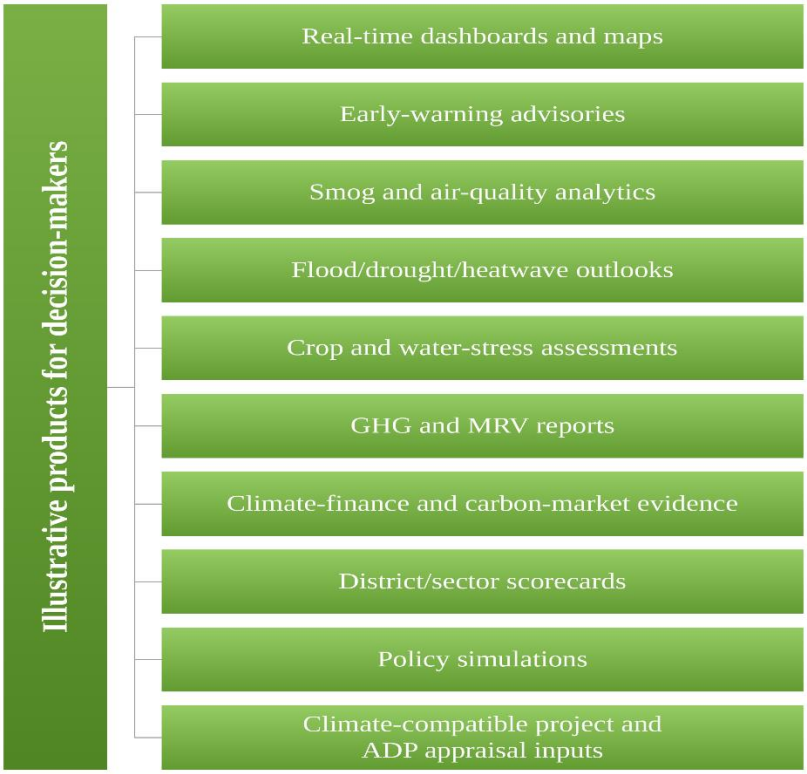


Figure 6: Illustrative decision-support products of the Punjab Climate Observatory

6. Analytics, Modelling and Digital Architecture

PCO's technical architecture is being conceived from the analytical problem backwards. The sequence is deliberate: first define the climate-intelligence questions and modelling framework; then determine the software stack, data platforms and AI/model requirements; and only then size the supporting computing and data-centre infrastructure. This avoids technology lock-in and allows the final configuration to reflect current scientific methods, available datasets, system advances and evolving operational requirements.

A Multi-Method Analytical Environment

The analytical environment is expected to support descriptive and diagnostic analysis of what is happening and why; inferential analysis of relationships and drivers; predictive forecasting of likely future conditions; prescriptive analysis of response options; and scenario simulation of alternative policy, investment and climate pathways. Depending on the application, this may combine statistics and econometrics; time-series forecasting; GIS and remote sensing; hydrological, atmospheric, air-quality and crop models; machine learning and

deep learning; computer vision; optimization and reinforcement learning; risk models; digital twins or scenario sandboxes; and carbon/MRV and ESG-related analytics.

Software and Compute Should Follow the Analytical Need

The resulting software stack may include data-ingestion and streaming services, APIs and ETL/ELT pipelines, geospatial and time-series databases, a data lake/warehouse, metadata and quality-control services, model development and MLOps environments, GIS/remote-sensing tools, climate and atmospheric modelling stacks, dashboards, reporting and alerting services, and cybersecurity/data-governance controls. The associated hardware should then be sized to actual workload requirements, with a balanced combination of normal enterprise compute and specialized advanced compute, including GPU-enabled systems and HPC where justified for large physical models, AI/deep-learning training, high-resolution Earth-observation processing and high-throughput simulation.

7. Institutional Architecture, Governance and Collaboration

PCO is inherently cross-sectoral and multi-institutional. EP&CCD is the sponsoring department, whereas, the P&D Board, EP&CCD, EPA, CPTC, IDAP and The Urban Unit are among the executing entities. Upon completion, the Observatory is envisaged to leading climate intelligence embedded within province-wide planning and investment decisions rather than confining it to a single sector.

Institution / arrangement	Principal role in the PCO ecosystem
EP&CCD / PMU	Sponsorship and establishment-phase execution: procurement, HR, contracts, coordination, monitoring and follow-up
P&D Board	Strategic planning linkage and post-completion institutional home and O&M platform
EPA / EMC and CPTC	Environmental monitoring, regulatory and domain inputs, policy and technology support
IDAP	Physical infrastructure: civil, MEP and data-centre building
The Urban Unit	GIS, spatial and climate-assessment deliverables and implementation support

Institution / arrangement	Principal role in the PCO ecosystem
PMD, SUPARCO, PDMA and sector departments	Authoritative weather, satellite, disaster and sectoral datasets and joint analytics
Technical / Steering Committees	Technical coordination and decision support, with policy oversight and escalation

A Steering Committee headed by Chairman P&D Board will provide strategic oversight, policy guidance and high-level decision support for the establishment and operationalization of the PCO. Its membership reflects the cross-sectoral character of the Observatory: the Secretary P&D Board; the Secretaries of Finance, EP&CCD, Agriculture, Livestock & Dairy Development, Irrigation, Energy, Industries, Commerce & Investment, Transport & Mass Transit, Housing, Urban Development & Public Health Engineering, Forest & Wildlife, Fisheries & Aquaculture, and Local Government & Community Development; the Director Generals of EPA, PDMA and CPTC; the CEOs of IDAP and The Urban Unit; and the Chief Technical Advisor of the PCO, who serves as Member/Secretary. The Committee will review progress against the PC-I and acts as the principal decision-making forum for scheme-related matters.

8. PCO Organization and Staffing

The PCO is designed to run under a multi-tiered governance framework that separates technical oversight, policy coordination and operational execution. The Chief Technical Advisor (CTA) will head the Observatory and provide strategic leadership in climate modelling, earth observation, AI-driven analytics, high-performance computing, climate finance, and national and international coordination. Beneath the CTA, the work will be organised in following two groups (a total staffing of 124 individuals):

- **Specialized units:** the Directorates of Adaptation and Mitigation and a meteorology and early-warning team, which will cover urban resilience, agriculture, water, disaster management, public health, transport, energy, industry, waste, GHG inventories, forecasting and early warning.
- **Functional units:** the Directorates of Spatial and Data Systems, Development & IT, Communication, Policy & Finance, and Admin & Coordination, which will cover GIS and data science, AI, software, HPC and

cybersecurity, outreach, climate finance and carbon markets, M&E, coordination and administration.

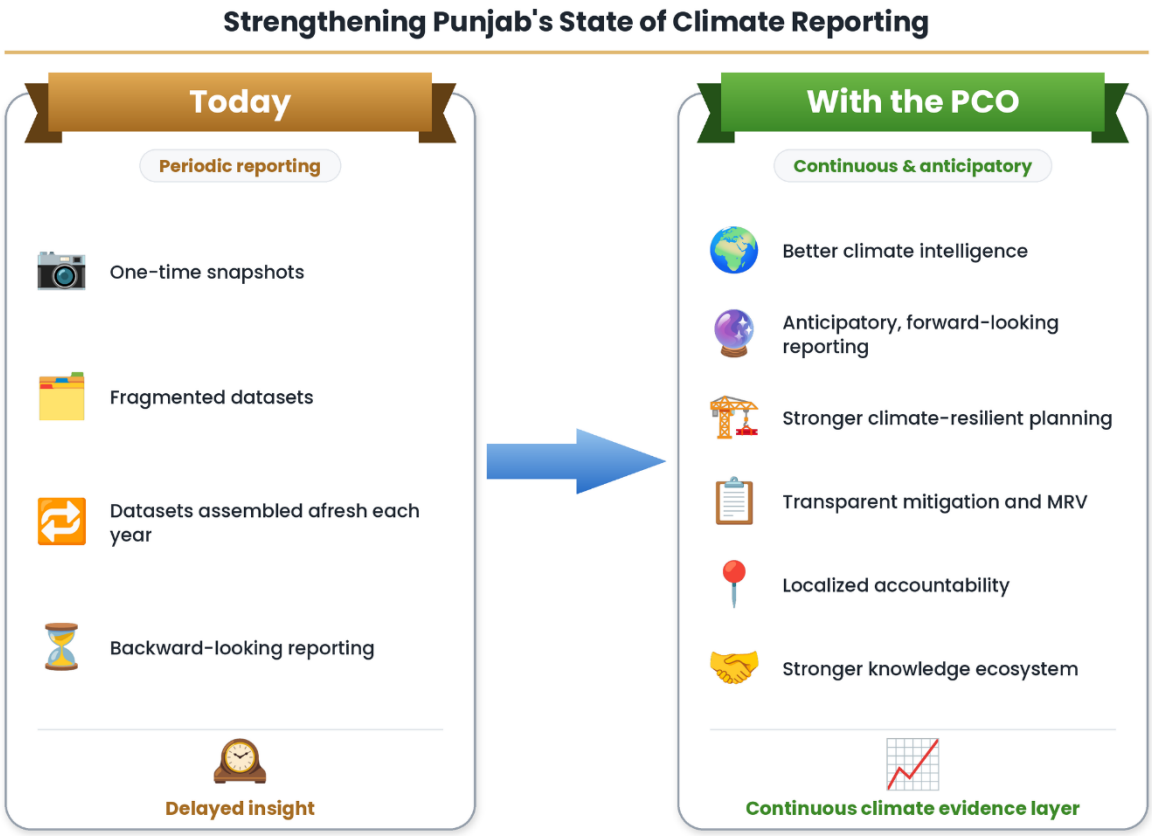
9. Building Infrastructure

The PCO will be housed in a purpose-built, unconventional yet sustainable structure designed & executed by IDAP, specifically to reflect its environmental mandate. Featuring eco-friendly design elements and aiming for LEED certification, the building will not only provide functional space for data integration, analysis, and collaboration, but also serve as a physical model of climate-conscious infrastructure, reinforcing the Observatory's role in promoting sustainability and innovation across the province. The key features of the PCO Building Design Include:

- **Command & Control Center:** A fully equipped central hub for real-time monitoring of environmental and climate indicators, continuous data analysis, visualization, and reporting.
- **Observation Deck / Elevated Watchpoint:** A viewing platform on the first floor, allowing visitors and officials to observe live operations of the Command Center from above.
- **Dedicated Office Floor:** Includes workspaces for PCO staff, with separate units, meeting rooms, and a conference hall to support internal coordination and external stakeholder engagement.
- **Communication & Knowledge Floor:** A dedicated level for public engagement, featuring a media studio, auditorium, and interactive awareness exhibits, serving both educational and outreach functions. This space may also evolve into a tourist or scientific attraction, similar in spirit to a planetarium.
- **Research & Partnership Floor:** Designed to accommodate cabin spaces for researchers, donor agencies, academic partners, and think tanks, with capacity for 80–100 individuals, enabling co-working and integrated research efforts.
- **Support Facilities:** A digital library for reference and learning; a cafeteria to serve staff and guests; a server room and IT control space to ensure secure, uninterrupted data management and digital operations.

10. A Continuous Evidence Base for State of Climate Reporting

The PCO has the potential to change the nature of climate reporting in Punjab. A periodic State of Climate Report can only give a snapshot of climate risks, impacts and responses at a point in time. A fully operational PCO will add a continuous evidence layer beneath that reporting cycle: standardized high-frequency climate data, district and city trends, model-based attribution, forward projections, early-warning indicators and measured policy-performance information. In practical terms, future State of Climate reports will be able to draw on a single, validated and analytics-ready evidence base instead of assembling fragmented datasets afresh each year.



11. Implementation Path and Way Forward

The project is in its establishment phase and is being advanced through coordinated institutional, physical-infrastructure, human-resource, consultancy and ICT/digital-system workstreams. The most important implementation principle is sequencing:

(i) finalize the climate-intelligence and analytics/modelling framework;

(ii) translate the framework into software, model, data-governance and integration requirements;

(iii) derive the required standard and advanced/GPU-enabled compute architecture;

(iv) procure and integrate systems through vendor-neutral, performance-based packages;

(v) validate models, data pipelines, cybersecurity, dashboards and operational workflows; and

(vi) transition progressively to routine PCO operations with trained staff, SOPs, O&M arrangements and measurable service standards.

Closing Perspective

The Punjab Climate Observatory is conceived as more than a project or a technology platform. It is a new public-sector capability for turning environmental observation into foresight, and foresight into better policy, investment and risk management. By institutionalizing climate intelligence at the provincial level, PCO can become a hallmark of Punjab's transition towards cleaner growth, climate resilience, evidence-based governance and transparent environmental performance.

PART 04

Integrated Sustainability, Public Engagement & Future Outlook

CHAPTER 16

Inter-departmental & International Coordination



16.1 Introduction

As Pakistan's most populous province, Punjab carries a large share of the country's economic, demographic, agricultural, industrial and urban pressures. This concentration places heavy demands on both natural and man-made resources, and the resulting pressures reinforce one another. Emissions from brick kilns aggravate respiratory illness, agricultural runoff pollutes the water bodies on which people depend for drinking and irrigation, and unregulated urban sprawl breaks up the green spaces that protect cities from heat and flooding. Human activity and climate-related stress have together accelerated environmental degradation across the province. These challenges therefore lie beyond the reach of any single department and call for coordinated action by the environment, health, agriculture, transport, industry, energy, local government, urban development, planning and disaster management sectors.

In recognition of this, the Government of Punjab has adopted an integrated, whole-of-government approach that places environmental considerations at the heart of policy, development planning, public investment, monitoring and enforcement. The Environment Protection & Climate Change Department (EP&CCD) and the Environmental Protection Agency (EPA) Punjab act as the principal coordinating bodies, ensuring that sectoral initiatives support environmental protection and climate resilience. Through digital monitoring systems, regulatory reform, Annual Development Programme (ADP) initiatives, climate finance mechanisms and interdepartmental coordination, the province is steadily building a system of evidence-based environmental governance.

This chapter presents the development outlook of EP&CCD and the Government of Punjab for environmental sustainability and pollution management. It explains how environmental priorities have been mainstreamed into sectoral planning, regulatory reform and public investment under ADP 2025–26, reviews the results achieved and the constraints that remain, and sets out the way forward.

16.2 Sectoral Integration of Environmental Governance in Development Projects

To strengthen environmental governance and improve policy coherence, the Government of Punjab has organised its development initiatives and ADP projects around the core themes of environmental sustainability, within a framework of green governance. Green governance rests on deliberative and collaborative policymaking aimed at preventing environmental degradation. As environmental threats have grown, governments have been prompted to adopt more transformative and coherent regulatory measures in pursuit of the Sustainable Development Goals (SDGs). Figure 15.1 illustrates how interdisciplinary approaches contribute to sustainability and green governance.

Organising investment by sector has improved coordination among departments, made better use of available resources and ensured that environmental considerations shape both the planning and the execution of development projects. This thematic approach reflects the Government's commitment to tackling environmental challenges through targeted action in climate resilience, clean energy, sustainable transport, urban infrastructure, agriculture and waste management. The sections that follow describe the major initiatives undertaken by EP&CCD and other departments to promote sustainable development, reduce environmental degradation and strengthen climate resilience.



Figure 16.1: Illustration of integration of green environmental governance model[1].

16.3 Green Public Investment Framework

Through the ADP, the Government of Punjab has progressively built environmental considerations into public investment planning, marking a clear transition towards a Green Public Investment Framework. Sectoral plans are increasingly aligned with climate mitigation, adaptation and sustainability goals, both through the climate-tagging of development expenditure and through environmental safeguards incorporated in project design. EP&CCD has played a central role in mainstreaming these priorities, and its own development allocation has grown threefold, from Rs. 5 billion in 2023–24 to Rs. 15 billion in 2025–26.

In the 2025–26 budget, approximately Rs. 795 billion of ADP expenditure, equivalent to 64% of total development allocations, was formally climate-tagged. Of this amount, Rs. 371.7 billion was allocated to climate mitigation, Rs. 277.4 billion to climate adaptation and Rs. 146.0 billion to other supporting sectors. This pattern of allocation shows the province's growing alignment with the SDGs, the Paris Agreement and international climate finance frameworks.

16.4 EP&CCD Development interventions under ADP

EP&CCD is the central coordinating authority for environmental governance in Punjab. It integrates environmental safeguards across agriculture, transport, industry, energy and urban development through regulatory frameworks, real-time monitoring, enforcement and close coordination with the Planning & Development Board and district administrations. By combining digital governance tools, institutional capacity building and substantial ADP investment, the Department is embedding environmental considerations in planning, implementation and monitoring throughout the province and building an evidence-based, technology-enabled system of environmental governance. Its key ADP interventions are described below.[106]

i. Enhanced Air & Water Quality Monitoring Networks (ADP 2025–26; World Bank PCAP)

This intervention aims to strengthen real-time environmental monitoring, improve enforcement and support evidence-based policy. A network of 42 Air Quality Monitoring Stations, 37 fixed and 5 mobile, now reports to a centralised dashboard (https://aqi.punjab.gov.pk/), while the AQI mobile app and ECO Chatbot make this information directly available to the public. Fifteen Water Quality Monitoring Stations have also been installed. To understand where pollution comes from, a source apportionment study is being carried out with SUPARCO, and an integrated emissions inventory covering greenhouse gases, air pollutants and Short-Lived Climate Pollutants (SLCPs) has been developed for five major districts. On the enforcement side, drones, GIS systems and multi-gas analysers support anti-smog operations, and vehicular emission scanning and fog/smog cannons are deployed at pollution hotspots.

[106] Environment Protection & Climate Change Department| Government of Punjab.

ii. Establishment of Environmental Monitoring Centre (PERL Upgradation)

The upgradation of the Punjab Environmental Reference Laboratory (PERL) is designed to enhance the province's laboratory-based diagnostic and analytical capacity. The laboratory has been made operational and equipped with an ICP-OES for advanced chemical analysis. Its systems are being upgraded and accredited, and an integrated data management system is being developed to enable real-time reporting of results.

iii. CM Punjab Green Credit Program (ADP 2025–26)

The Green Credit Program seeks to create market-based incentives for environmental action and to prepare the ground for an Emissions Trading System (ETS). The programme has registered 116,586 users and issued 4,059 green credits, with PKR 40.585 million disbursed to participants. Applications are verified through an online MRV-based dashboard (https://greencredit.punjab.gov.pk/), and credits reward actions such as adopting electric vehicles, planting trees and other citizen-led climate initiatives. The programme is also being prepared for integration with carbon markets under Article 6 mechanisms.

iv. CM Punjab Climate Leadership Development Internship Program (Phase-II; Rs. 325.8 million)

This programme aims to build a climate-literate young workforce to support environmental governance. During 2025–27, five batches of 250 interns each will be trained in environmental governance, field work and policy implementation, following a curriculum developed in collaboration with SDPI. An internship monitoring dashboard tracks the performance of participants throughout the programme.

v. Plastic Management & Single-Use Plastics

To promote a circular economy and reduce plastic pollution, EP&CCD has made the Plastic Management Information System (PMIS) operational and established 40,000 environmental clubs in schools. Guidelines on Extended Producer Responsibility (EPR), together with eco-labelling and green procurement

frameworks, are being finalised, and public awareness campaigns and plastic clean-up drives are being conducted across the province.

vi. Establishment of Environment Protection Force in 10 Zones of Punjab

The Environment Protection Force has been created to strengthen enforcement and on-ground compliance monitoring. It has been deployed in ten pollution hotspot zones and is supported by an AI-based surveillance system of 8,500 CCTV cameras and by smart digital monitoring platforms. Quick Response Centres have also been established to control stubble burning.

vii. Climate Policy & Technology Centre (CPTC)

The CPTC brings climate policy, research and technology transfer together on a single institutional platform. Formed by merging the Department's policy and technology institutions, the Centre concentrates on climate policy formulation, research and capacity building, and supports the adoption of clean technologies and the alignment of climate governance across government.

viii. Punjab Climate Observatory (PCO)

The PCO is intended to serve as a centralised hub for climate intelligence and data. Its PC-I has been approved for construction in Lahore IT City. Once established, the Observatory will integrate climate and environmental data from multiple sectors and provide the evidence base for adaptive climate governance.

ix. Strategic Communication & Awareness Initiatives (IM4Climate & SCC)

These initiatives aim to raise public awareness of climate change and encourage behavioural change. The IM4Climate campaign has attracted more than 1,800 registrations, and a green coins reward system and citizen engagement programmes encourage active participation. More than 800 creative awareness products have been developed, and the Department reaches the public regularly through climate bulletins, social media campaigns and public events.

x. Construction & Operationalisation of Divisional Environmental Complexes:

Divisional Environmental Complexes are being built to decentralise environmental governance and bring services closer to the public. Three complexes are now operational in Sahiwal, Dera Ghazi Khan and Rawalpindi, while the remaining complexes are under construction or in planning. Work is also under way to integrate IT and laboratory infrastructure into these facilities.

xi. Establishment of Environmental Endowment Fund Management Unit:

To mobilise green financing for environmental projects, the Punjab Environment & Climate Change Endowment Fund Company has been incorporated, and its governance structure and operational framework are now being put in place.

xii. Implementation of Environmental and Social Safeguard Requirements and Pollution Impact Studies:

This intervention strengthens compliance with environmental and social safeguards in development projects. More than 350 stakeholders have been trained on safeguard requirements and compliance, and pollution impact studies are informing the revision of the province's environmental standards described under item xvi.

xiii. Low-Cost Wastewater Treatment Projects

This project seeks to provide affordable and sustainable wastewater treatment in rural areas. Following the completion of a pilot study in three villages in Chiniot, Pakpattan and Chakwal, construction of three treatment plants is now under way.

xiv. Revamping of Biodiversity Park, Murree

Executed by the Directorate General (Wildlife), Punjab, and sponsored by EP&CCD, this project aims to restore biodiversity and promote eco-tourism. It includes the development of trails, bridges and visitor facilities, alongside habitat restoration and the promotion of sustainable tourism.

xv. Piloting the Solutions for Environmentally Sound Management of Crop Residues in Punjab

This pilot aims to reduce stubble burning and encourage sustainable agricultural practices. Awareness campaigns, including docudrama screenings in 80 villages, have been used to promote environmentally sound techniques for managing crop residues.

xvi. Development of Missing Environmental Quality Standards and Revision of Existing Standards (PGDP):

This intervention aims to update, rationalise and strengthen the Punjab Environmental Quality Standards (PEQS) so that they support effective regulation, monitoring and compliance. The existing standards have been comprehensively reviewed and rationalised to improve their relevance, and new standards have been developed to address emerging environmental challenges and pollution sources. A multi-stakeholder expert panel drawn from government, industry, academia, laboratories and NGOs reviewed and refined the drafts, and the finalised PEQS are now being submitted to the Punjab Environmental Protection Council for formal approval.

16.5 Institutional Environmental Governance Reforms

Alongside these investments, Punjab has undertaken far-reaching institutional reforms to strengthen the architecture of environmental governance. Under the Punjab Environmental Protection Act, 1997, EP&CCD and its attached EPA have evolved into a multi-sectoral regulatory authority. The reforms span five areas, each building on the ADP interventions described in Section 15.4.

i. Monitoring and Digital Governance Systems

The province now operates 42 Air Quality Monitoring Stations, 37 fixed and 5 mobile, and 15 Water Quality Monitoring Stations, with results made public through the AQI Punjab mobile application and dashboard. These are complemented by the Environmental Assessment Management System (EAMS), the Emission Testing System, Eco Watch and the Green Punjab App, which together support digital approvals, emissions testing and citizen reporting.

ii. Environmental Enforcement Capacity

Enforcement capacity has been strengthened through the Environment Protection Force, which operates across ten zones with the support of drones and an AI-based CCTV surveillance network of 8,500 cameras. Quick Response Centres have also been formed to control stubble burning.

iii. Regulatory and Analytical Strengthening

The Punjab Environmental Reference Laboratory (PERL) has been upgraded, and an integrated emissions inventory system has been established in accordance with the IPCC 2006 Guidelines. ISO certification and accreditation of the monitoring systems are also under way.

iv. Climate Policy Institutions

Two new institutions anchor climate policy in the province: the Climate Policy & Technology Centre (CPTC), and the Punjab Climate Observatory (PCO), which is being developed as a centralised climate intelligence hub.

v. Climate Finance & International Alignment

Punjab's environmental governance framework is increasingly aligned with global climate finance mechanisms and international agreements. The CM Punjab Green Credit Program represents a major shift towards market-based environmental governance. It has registered 116,586 users, 42% of whom are women, processed more than 9,000 MRV applications, issued 4,059 green credits and disbursed PKR 40.585 million.

The programme is now being developed into a structured Emissions Trading System (ETS), linked to Article 6 carbon markets and voluntary carbon mechanisms, and fifteen public sector projects have been identified for carbon market registration. These initiatives are consistent with the Paris Agreement and the SDGs and will help deliver measurable emission reductions and mobilise climate finance. Taken together, the reforms have strengthened the province's institutional capacity for monitoring, enforcement and climate governance.

16.6 Sectoral Environmental Investment Analysis

To embed green governance across the province, environmental considerations are being integrated into key economic sectors, including energy, transport, urban development, agriculture, solid waste management and disaster management. Each sector faces distinct environmental challenges and follows its own investment pattern, which together illustrate the breadth of the whole-of-government approach. Environmental outcomes are therefore no longer the responsibility of EP&CCD alone; they are increasingly shared by line departments through targeted ADP allocations, regulatory compliance and cross-sectoral coordination.

i. Energy Sector

The energy sector remains a pivotal driver of environmental outcomes in Punjab. Long reliant on fossil fuels, the province has begun a transition towards renewable and cleaner energy. Energy consumption has risen markedly, with around 68–70% of electricity demand met through the grid in 2024–25, and the environmental pressures arising from fossil fuel dependence remain substantial. In response, the Government is solarising public infrastructure, deploying distributed renewable energy systems and implementing energy efficiency programmes.

As a result, the share of renewable energy in Punjab's energy mix has risen from 2% in 2017–18 to approximately 13% by 2025, signalling a gradual but significant structural shift. Under the 2025–26 ADP, PKR 4,718.3 million has been allocated to 11 ongoing energy schemes (Figure 15.2) and PKR 2,781.7 million to 18 new schemes, the largest share of which is directed to solar energy (Figure 15.3).

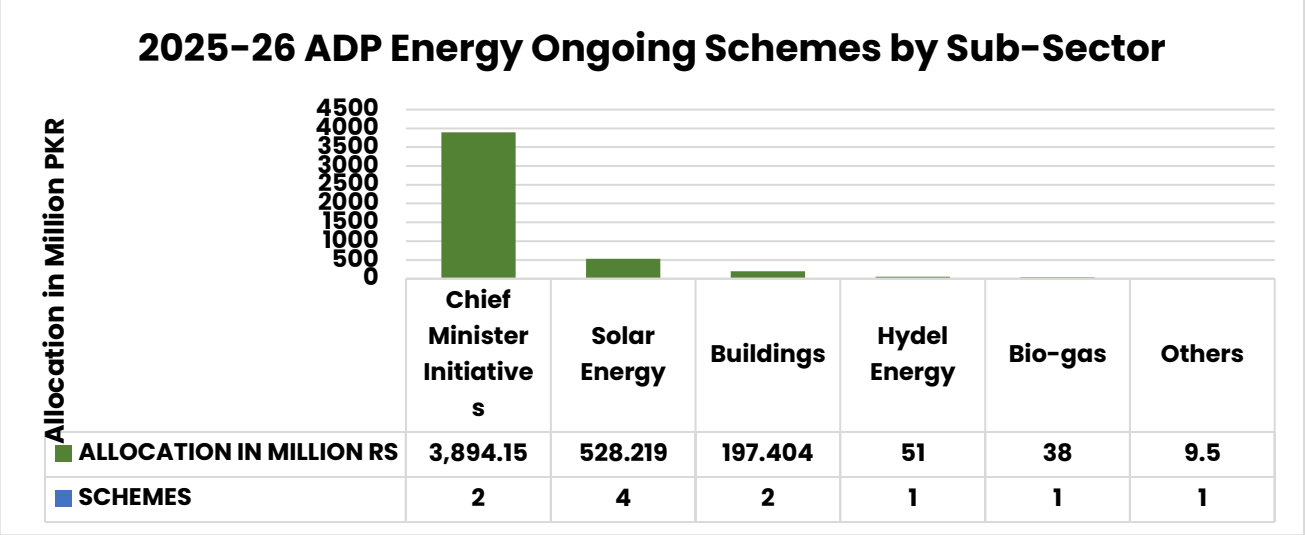


Figure 16.2 ADP Allocation for Ongoing Schemes, FY 2025-26

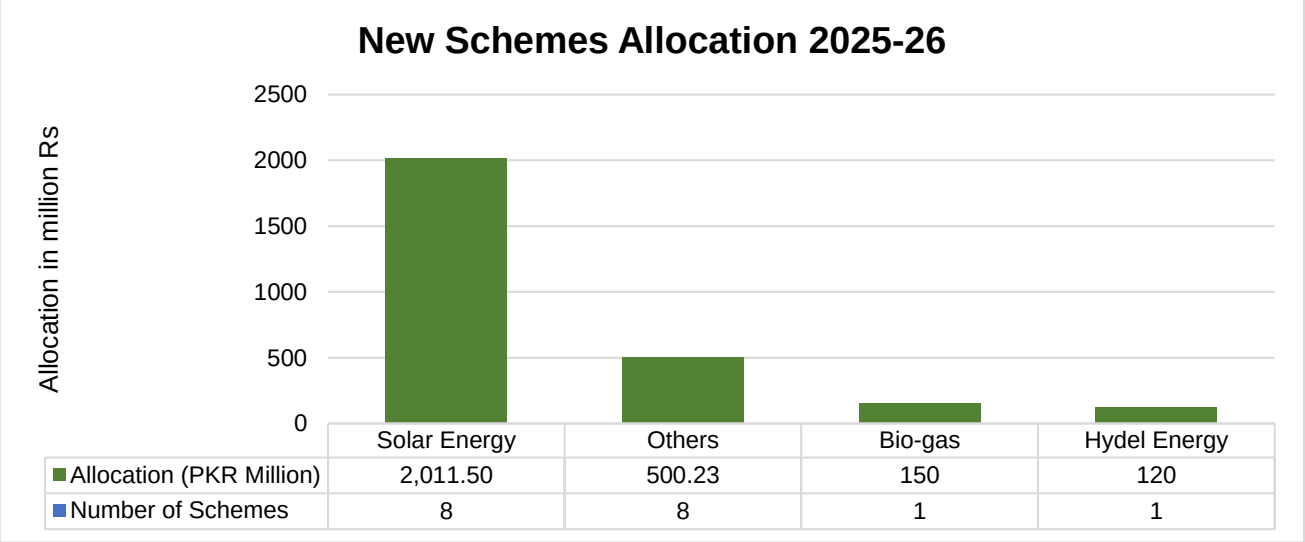


Figure 16.3 Allocation for New Schemes, FY 2025-26

ii. Transport and Mass Transit Sector

Transport is a major source of urban air pollution, accounting for approximately 40–50% of $PM_{2.5}$ emissions in major cities according to EPA Punjab monitoring data. Rapid growth in the vehicle fleet, estimated by the Punjab Transport Department at 8–10% a year, has intensified these pressures.

The 2025–26 transport ADP comprises 54 schemes with a total allocation of PKR 85,000 million. Of these, 20 ongoing schemes account for PKR 4,569.908 million

and 34 new schemes for PKR 80,430.092 million. Chief Minister's Initiative (CMI) schemes make up PKR 80,014.092 million, or 94.1% of the total. The main interventions include eco-friendly bus systems, vehicle emission inspection and certification programmes, and digital vehicle monitoring frameworks. The financial profile of the sector is summarised in Table 15.1.

Table 16.1: ADP 2025-26 Transport Sector Financial Summary (PKR Million)

Category	No. of Schemes	Capital (PKR M)	Revenue (PKR M)	G. Total (PKR M)	Projection 2026-27 (PKR M)
On-Going: Regular	8	7	367	374	1,023.08
On-Going: CM Initiative	11	2,800.00	1,345.91	4,145.91	18,825.40
On-Going: Liability	1	0	50	50	150
Total Ongoing Schemes	20	2,807.00	1,762.91	4,569.91	19,998.48
New: Regular	6	300	116	416	19,082.46
New: CM Initiative	28	33,920.00	46,094.09	80,014.09	673,678.50
Grand Total	**54**	**37,027.00**	**47,973.00**	**85,000.00**	**712,759.43**

16.7 Urban Development Sector

Urban development investment totals PKR 145,000 million across 185 schemes, of which approximately PKR 97,500 million (67%) is linked to environmental protection through wastewater treatment, sewerage, stormwater drainage and green urban spaces.

Wastewater treatment is a major focus. Key projects include the Babu Sabu and Kattar Bund Wastewater Treatment Plants and the DANIDA-assisted Eastern Wastewater Treatment Plant in Lahore, the Faisalabad Water and Wastewater Management Project, and the Surface Water Treatment Plant on the BRBD Canal. Access to clean water is being expanded in parallel through the Saaf Pani

Program, the AFD-supported Faisalabad Water Project Phase II, water supply schemes in Rawalpindi and a feasibility study for the Dadhocha Dam. Together, these interventions significantly reduce the discharge of untreated effluent and improve environmental health in urban areas.

16.8 Agriculture Sector

Agriculture is both a driver and a victim of environmental degradation. The 2025–26 ADP for the sector provides PKR 80,000 million for 37 schemes, comprising 16 ongoing schemes worth PKR 32,401.605 million and 21 new schemes worth PKR 47,598.395 million. Programmes such as PRIAT and the Indus Basin initiatives focus on climate-smart agriculture, efficient water use, soil health and basin-scale resilience planning. Table 15.2 lists the CMI schemes with the clearest environmental benefits, which together promote climate resilience and the sustainable use of resources.

Table 16.2: Chief Minister Initiative Schemes in Agriculture Sector

GS	Scheme Name	2025-26 Provision (PKR M)	Environmental Governance Benefit
2544	Solarisation of Agri. Tubewells	8,756.300	Reduces diesel emissions
2546	Sesame, Soybean & Canola Promotion	409.226	Crop diversification
2568	Water Efficient Agriculture Program	2,000.000	Water conservation
2571	Transformation of Agri. in Pothohar	1,000.000	Climate adaptation

16.9 Waste Management Sector (Suthra Punjab Program)

Punjab generates approximately 50,000 tonnes of municipal waste every day. Launched in 2024, the Suthra Punjab Programme represents a significant institutional reform, replacing fragmented waste management practices with an integrated, province-wide system that covers 41 districts and 141 tehsils. The programme is run through public-private partnerships under KPI-based

contracts, supported by a digital governance system, a multi-tiered audit framework and centralised regulatory oversight. In addition, the Lakhodair Landfill Gas Project links waste management with carbon finance under Article 6 of the Paris Agreement.

16.10 Disaster Management Sector

The Provincial Disaster Management Authority (PDMA) coordinates preparedness, emergency response, mitigation and recovery within the provincial disaster management framework. Its work prioritises early warning, real-time monitoring, inter-agency coordination and gender-responsive disaster management. The events of 2025, a drought followed by severe floods, showed how quickly the province can swing between climate extremes.

a. Monsoon Flood 2025

The 2025 monsoon was driven by a north-westward-moving system, reinforced by westerly troughs and heavy moisture inflows from the Bay of Bengal and the Arabian Sea. Above-average rainfall was recorded at 64% of weather observatories across Punjab; Sialkot Cantt received 209 mm and Sialkot Airport recorded a 24-hour peak of 101 mm. The Chenab, Ravi and Sutlej rivers all reached historic peaks (Figure 15.4).

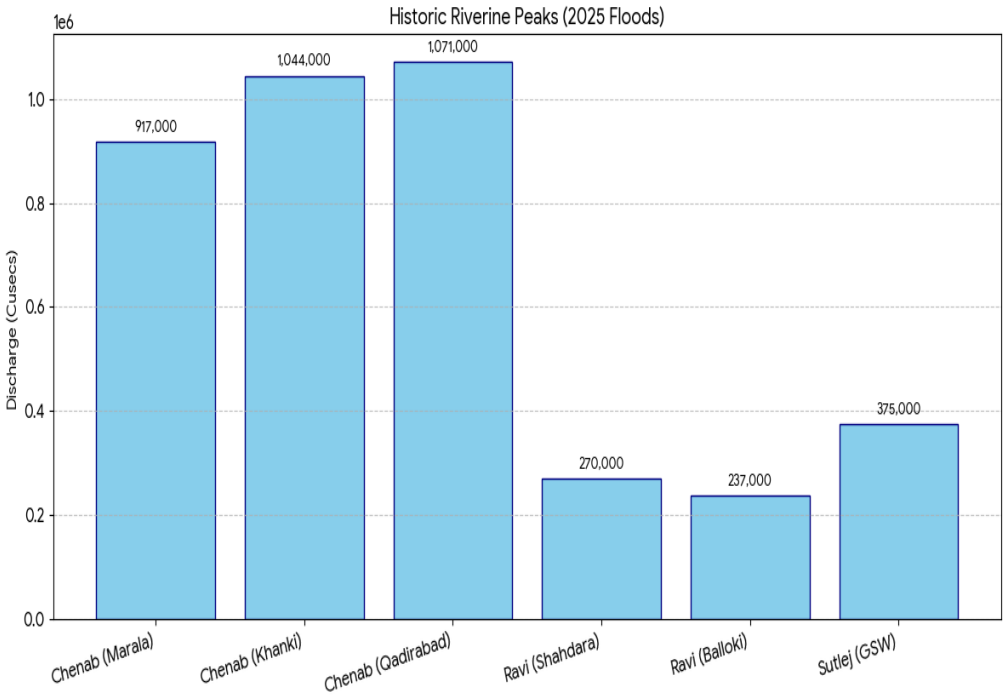


Figure 16.4: Historic Riverine Peaks for Punjab

The floods impacted approximately 4.7 million people and resulted in 145 fatalities. The Chenab River basin was the most severely affected, accounting for 111 of these deaths. Agricultural losses were substantial, with an estimated 2.4 million acres of crops damaged.

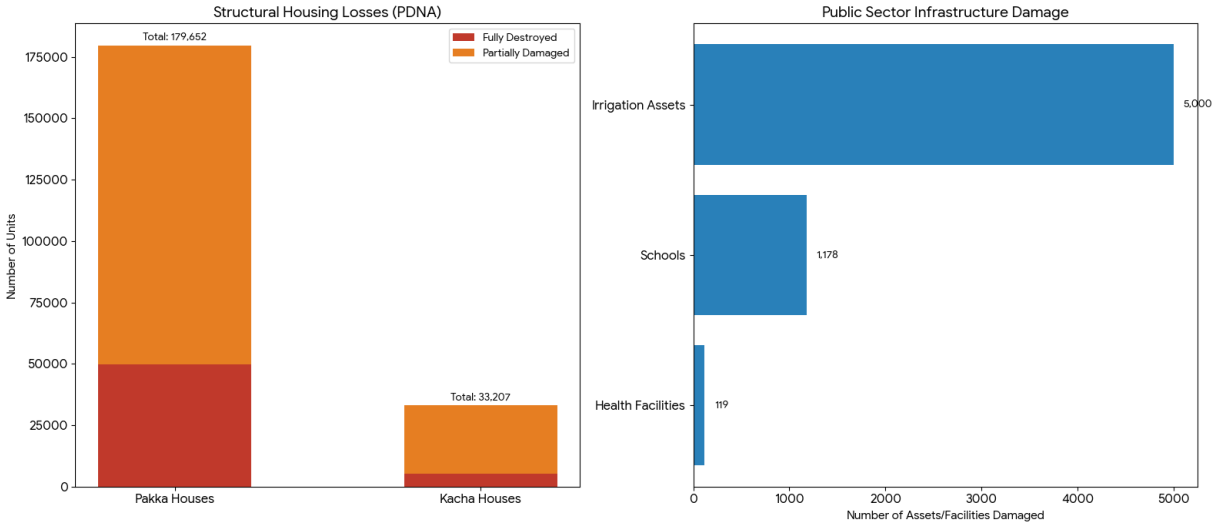


Figure 16.5: Structural and public infrastructure damage summary

The floods affected approximately 4.7 million people and claimed 145 lives, 111 of them in the Chenab River basin. Some 2.4 million acres of crops were damaged, along with more than 212,000 houses and a substantial amount of public infrastructure (Figure 15.5).

b. Drought and Heat Conditions 2025

By March 2025, rainfall had fallen by 40% nationally and by 38% in Punjab, while temperatures remained 2–3°C above average during prolonged dry spells. District administrations responded by activating emergency operation centres, setting up heatstroke treatment facilities and issuing public advisories on heat protection and hydration.

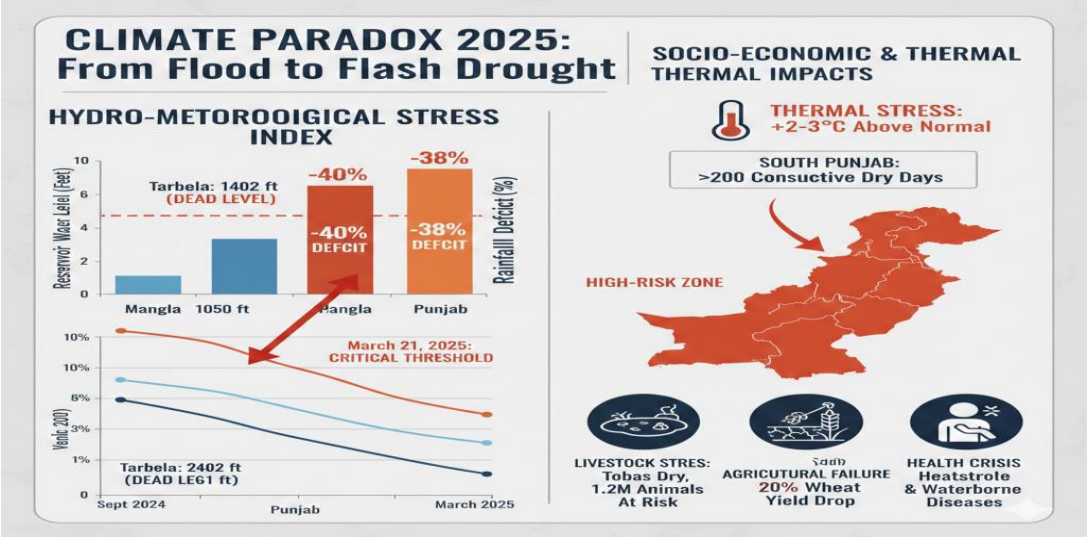


Figure 16.6: Socio-economic & thermal impacts

16.11 Environmental Co-benefits of ADP Investments

Environmental investments under ADP 2025–26 are producing benefits that reach well beyond the environment sector. Reforms in transport and energy are helping to reduce urban air pollution, while new wastewater treatment infrastructure is improving water quality. Lower exposure to pollutants is translating into better public health outcomes, and water and soil management programmes are making agriculture more resilient to climate change. Reduced smog-related productivity losses also contribute to economic stability.

The wastewater treatment plants in Lahore and Faisalabad offer a clear example: by reducing the discharge of untreated effluent into the Ravi River system, they are improving ecosystem health and lowering risks to public health. Such co-benefits demonstrate that environmental governance is an enabler of sustainable development rather than a constraint on it.

16.12 Governance Performance & Monitoring

A major shift in governance has been the development of performance-based environmental monitoring. Real-time dashboards, compliance-tracking systems and KPI-based enforcement mark a transition towards evidence-based decision-making. Under EP&CCD initiatives, digital platforms such as AQI dashboards, emissions monitoring systems, Green Credit platforms and the 24/7 public complaint helpline 1373

have improved transparency and citizen engagement. The integration of AI-based surveillance, geographic information systems (GIS) and digital enforcement tools further strengthens compliance monitoring and supports data-driven decisions across sectors.

Benefits of Green Investment and Development Projects

The implementation of Punjab's green development framework across sectors has been accompanied by measurable improvements. Daily $PM_{2.5}$ peaks in Lahore during the critical winter months fell by 56%, from 539 µg/m³ to 237 µg/m³. This coincided with a 65% reduction in crop residue burning incidents, supported by an agricultural mechanisation programme that distributed thousands of subsidised Super Seeders to farmers. Beyond easing the seasonal smog crisis, ending open-field burning preserves topsoil organic carbon and nutrients, strengthening climate resilience and food security, and wheat productivity gains of up to 15% have been reported.

Punjab has also strengthened fiscal accountability through a Climate Budget Tagging System, which aligns approximately 64% of the provincial ADP, about Rs. 795 billion, with climate mitigation and adaptation. Complementary measures, including the deployment of 50,000 electric bikes and the Waste Wise plastic recycling initiative in 5,112 schools, are laying the foundation for long-term economic, energy and environmental restoration across the province.

16.13 Challenges & Implementation Constraints

Despite these advances, Punjab's environmental governance system continues to face systemic constraints. Institutional capacity remains fragmented across departments, enforcement is uneven from one district to another, and technical expertise in emerging environmental technologies is limited. Ensuring the long-term financial sustainability of new infrastructure and monitoring systems, particularly their operation and maintenance, is a further concern.

Historically, environmental services such as waste management and pollution control have been concentrated in urban centres, leaving rural areas with limited

coverage and inconsistent monitoring. Despite recent reforms, achieving uniform compliance across all sectors remains a persistent and critical challenge.

16.14 Conclusion

Punjab's environmental governance is evolving from a limited regulatory framework into an integrated and modernised system. ADP 2025–26 reflects this shift, with environmental protection prioritised across energy, transport, urban development, agriculture, waste management and disaster management. Through climate-tagged investment, digital monitoring platforms and stronger enforcement, the Government is improving environmental management and fostering sustainable development across the province.

EP&CCD and EPA Punjab are at the centre of this transition, coordinating, monitoring and implementing critical environmental initiatives. The Air Quality Monitoring System (AQMS), the Water Quality Monitoring System (WQMS), the Punjab Environmental Reference Laboratory (PERL), the Green Credit Program, digital dashboards and the Environment Protection Force have substantially strengthened environmental surveillance and public engagement.

Challenges nevertheless remain, including the impacts of climate change, persistent air pollution, limited institutional capacity and gaps in enforcement. Upcoming initiatives, notably the Punjab Climate Observatory, the Lahore Air Improvement Framework and expanded digital governance systems, are expected to advance environmental governance and climate resilience across Punjab still further.

CHAPTER 17

Behavioural Change through Community Engagement



17.1 Introduction

Principle 10 of the Rio Declaration on Environment and Development (1992) states: "Environmental issues are best handled with the participation of all concerned citizens at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided."

Embracing the spirit of Principle 10, environmental governance must extend beyond conventional regulatory measures. While laws, inspections, notices, penalties, and enforcement actions remain vital for environmental protection, EPA Punjab recognises that sustainable progress requires addressing the behaviours of citizens, communities, and various sectors of society. Issues such as smog, waste burning, stubble burning, vehicular emissions, plastic pollution, inadequate waste disposal, and limited civic ownership are not solely technical or legal challenges but are deeply intertwined with daily habits, social practices, and behavioural patterns.

Continuing its regulatory mandate, EPA Punjab has examined the root causes of recurring environmental problems and identified behavioural change as a critical missing component. In many instances, environmental degradation stems not simply from the absence of law but from entrenched practices, lack of awareness, weak community ownership, and insufficient public participation. Accordingly, the Agency acknowledges that enforcement alone may temporarily curtail violations; however, long-term improvement demands a broader societal shift in how people understand, engage with, and take responsibility for environmental protection.

In response, EPA Punjab adopted a strategy that links behavioural change with community engagement, aiming to reframe environmental protection from a

solely department-led regulatory function into a shared public responsibility. This approach involves identifying diverse behavioural patterns across various societal groups and engaging them through targeted awareness campaigns, education, communication, and participatory initiatives. Children, students, youth, academia, farmers, communities, transporters, industries, and the general public are regarded as vital stakeholders in this governance model.

Through this dual-track approach—maintaining conventional enforcement alongside promoting behavioural transformation—EPA Punjab has connected public awareness with practical action, encouraged environmentally conscientious practices, and strengthened community roles in supporting environmental protection across the province.

17.2 Understanding Behavioural Patterns in Environmental Governance

Behavioural patterns refer to the habitual actions, choices, and practices through which individuals, communities, and sectors interact with the environment. In the context of environmental governance, these patterns hold significant importance because pollution and environmental degradation arise not solely from machines, industries, or vehicles, but also from the collective behaviours associated with how people live, consume, dispose of waste, travel, cultivate land, report, and respond to environmental concerns. Thus, environmental governance is influenced not only by laws and enforcement but also by societal behaviours.

A behavioural pattern can either support or undermine environmental protection. For instance, when citizens refrain from open burning, report pollution incidents, plant and conserve trees, reduce plastic usage, or maintain vehicles properly, their actions contribute positively to environmental governance. Conversely, behaviours such as open waste burning, crop residue burning, operation of smoke-emitting vehicles, irresponsible plastic use, neglect of industrial emissions, or community silence in the face of violations lead to adverse environmental outcomes. Consequently, public behaviour directly impacts the effectiveness of environmental regulations.

Environmental behavioural patterns may be broadly categorised into two types: positive behavioural patterns and negative behavioural patterns.

16.2.1 Positive Behavioural Patterns

Positive behavioural patterns encompass habits and practices that support environmental protection and alleviate pressure on natural resources. These include planting and nurturing trees, proper waste disposal, reducing plastic consumption, avoiding open burning, maintaining vehicles regularly, reporting environmental violations, adopting cleaner technologies, participating in awareness initiatives, and fostering community ownership of public spaces. Such behaviours contribute to reframing environmental stewardship as a collective civic responsibility rather than solely a governmental obligation.

17.2.2 Negative Behavioural Patterns

Negative behavioural patterns consist of recurring practices that exacerbate pollution, environmental degradation, and non-compliance. These include waste burning, stubble burning, littering, excessive use of single-use plastics, operation of smoke-emitting vehicles, non-compliance by industrial and commercial entities, inadequate waste management, weak civic engagement, and insufficient public reporting. These actions contribute significantly to air pollution, intensify smog, impair public health, and undermine the effectiveness of regulatory interventions.

EPA Punjab has observed that many of the province's environmental challenges are linked to these negative behavioural patterns. Consequently, while maintaining its conventional legal and regulatory frameworks, the Agency acknowledges that enforcement alone is insufficient. Meaningful and sustained improvement requires behavioural change among citizens, farmers, students, industries, transporters, and communities. This insight has become the foundation for EPA Punjab's community engagement and behavioural transformation strategy.

17.3 EPA Punjab's Integrated Behavioural Transformation Model

EPA Punjab's community-based environmental initiatives can be understood as an integrated behavioural transformation framework that connects awareness, participation, and environmental responsibility across diverse social groups. However, behavioural transformation should not be presumed solely on the basis of campaign activities; it must be assessed through measurable outcomes, community responses, and independent evaluations. Accordingly, this section presents EPA Punjab's model not as definitive evidence of behavioural change, but as a structured methodology through which behavioural change can be promoted, monitored, and evaluated.

16.3.1 The Green Behaviour Transformation Model

Under this model, EPA Punjab engaged children, rural communities, and urban citizens around a shared environmental objective: fostering environmental ownership across the province. The model's distinctiveness lies in its segmentation of society into specific target groups based on their roles, behaviours, and environmental impacts, moving beyond generalised awareness campaigns.

Children were involved through school-based activities such as tree plantation drives, cleanliness campaigns, and climate awareness sessions. Rural communities and farmers were reached via targeted awareness programmes focused on crop residue burning, stubble burning control, and sustainable agricultural practices. Urban residents were engaged through media campaigns, digital platforms, Air Quality Index (AQI) advisories, complaint systems, and public outreach initiatives aimed at promoting responsible waste disposal, traffic emission reduction, plastic use minimisation, and civic responsibility.

The model's practical strength stems from recognising that different societal groups contribute to environmental challenges in differing ways. The environmental responsibilities of a farmer, school student, shopkeeper, vehicle owner, industrial operator, and urban household are inherently distinct.

Consequently, EPA Punjab's approach tailored communication methods to each group while maintaining a unified environmental protection goal.

To substantiate behavioural transformation, the model necessitates support via measurable indicators. For instance, changes at the school level can be evaluated through metrics such as the number of participating schools, student engagement in plantation activities, adoption of cleanliness practices, and ongoing monitoring of environmental clubs. In rural contexts, behavioural shifts may be assessed by reductions in reported stubble burning incidents, farmer participation in awareness initiatives, and adoption rates of alternative residue management practices. Urban progress can be measured by complaint registration data, public responsiveness to AQI advisories, reductions in plastic consumption, waste reporting, vehicle emission compliance, and active citizen involvement in environmental campaigns.

Stream	Target Group	Behavioral Focus	Possible Measurable Indicators
Green Schools Stream	Children and students	Plantation, cleanliness, climate awareness and early-age environmental responsibility	Number of participating schools, student participation rates, plantation survival rate, school cleanliness activities and environmental club records
Green Communities Stream	Rural communities and farmers	Stubble burning control, waste management, local participation and sustainable practices	Reduction in reported stubble burning cases, farmer attendance in awareness sessions, adoption of alternative crop residue practices and community feedback
Green Cities Stream	Urban citizens, transporters, commercial units and general public	Waste reduction, emission control, plastic reduction, reporting of violations and civic responsibility	Number of public complaints, AQI advisory engagement, emission-check compliance, plastic reduction activities and violation reporting trends

In addition to internal reporting, independent assessment is crucial to ascertain whether awareness activities have translated into genuine behavioural change. Such evaluations may involve third-party surveys, school audits, farmer interviews, field monitoring, satellite-based detection of crop burning, comparative analysis of air quality data, and examination of trends in public

complaints. These methodologies facilitate determination of whether EPA Punjab's initiatives have resulted merely in short-term awareness or actual long-term behavioural improvements.

Accordingly, EPA Punjab's Green Behaviours Transformation Model should be regarded as a participatory environmental governance framework with the potential to influence behaviours across schools, rural communities, and urban areas. Its ultimate effectiveness hinges on the capacity to correlate awareness activities with quantifiable behavioural outcomes. When reinforced by reliable data and independent evaluation, this model can illustrate how environmental governance may evolve beyond regulation to embrace active public engagement and shared responsibility.

17.4 Building Environmental Behaviour from Childhood

Following the Green Behaviour Transformation Model, EPA Punjab introduced school-based interventions aimed at fostering environmental awareness among children as a foundation for enduring behavioural change. This approach rests on the premise that early exposure to environmental practices can shape lifelong attitudes; however, such claims require empirical validation rather than mere assumption.

The Agency targeted under-matriculation students to cultivate environmental habits at formative developmental stages. Within this framework, EPA Punjab launched the "Mera Poda Mera Class Fellow" initiative to engage students in tree planting and basic environmental activities within educational settings.

While these initiatives demonstrate active engagement, they primarily represent programme activities rather than confirmed behavioural transformations. Currently, there is limited evidence demonstrating that these interventions lead to sustained environmental literacy, prolonged pro-environmental behaviour, or influence extending beyond the school environment.

To bolster evaluation, impact assessments should incorporate indicators such as pre- and post-intervention knowledge assessments, longitudinal tracking of student behaviour in domestic contexts, continued involvement in environmental

actions, and teacher-reported observations of behavioural change. The long-term efficacy of these programmes also depends on whether the inculcated environmental habits persist once the intervention concludes.

Therefore, although school-based interventions constitute an essential component in raising environmental awareness, their true behavioural impact remains uncertain without systematic and longitudinal evaluation.

17.4.1 Mera Pouda Mera Class fellow

The "Mera Pouda Mera Class Fellow" initiative, launched by the Environmental Protection Agency Punjab, is a distinctive and innovative environmental awareness campaign aimed at fostering a lifelong connection between students and nature. Under this initiative, an entire class of eighth-grade students collectively plants a sapling, adopting it as their "class fellow." This plant remains affiliated with the class throughout their educational journey until the tenth grade, symbolising friendship, responsibility, care, and environmental stewardship. Students regularly nurture the plant by watering, protecting, and monitoring its growth, thereby cultivating a strong sense of ownership and emotional attachment to environmental conservation from an early age.

A distinctive feature of this initiative is the continuity and legacy it creates within educational institutions. As cohorts graduate from the tenth grade, their respective plants remain within the school grounds as "senior class fellows" for succeeding classes. Each new intake of students plants its own sapling, thereby perpetuating the lineage of greenery, with earlier plantings acting as senior companions and living memorials to former students. Through this cyclical process, schools progressively develop a comprehensive green heritage, where every plant represents a particular class and cohort. This ongoing tradition not only enhances tree plantation and greenery within educational premises but also reinforces the emotional bond between students, schools, and the natural environment.

The initiative seeks to promote tree planting, environmental awareness, and climate responsibility among students, contributing to a cleaner and greener Punjab. It provides educational opportunities to understand the vital role of trees

in pollution control, air quality improvement, climate change mitigation, and ecosystem stability. Through this campaign, educational institutions become proactive partners in environmental protection, while students learn values of teamwork, responsibility, continuity, and sustainability. The "Mera Pouda Mera Class Fellow" initiative epitomises EPA Punjab's vision to engage future generations in practical environmental action and to cultivate a lasting culture of greening across schools throughout the province.

17.4.2 Green School Certification Program

As part of the Green Schools Stream under the Green Behaviour Transformation Model, the Environment Protection & Climate Change Department (EP&CCD) Punjab introduced the Punjab Green School Certification Program to institutionalise environmental responsibility within educational institutions. The programme is designed as a structured certification framework encouraging schools to integrate sustainability into daily operations, student engagement, and campus management, rather than restricting it solely to classroom awareness.

Schools are evaluated across six thematic areas: Save Energy, Waste Wise, Environmental Action, Plant for Pakistan, Air for Life, and Every Drop Counts (Water Management). Within these categories, schools accumulate certification points based on documented activities such as plantation drives, waste segregation systems, recycling initiatives, AQI awareness sessions, energy conservation measures, and water-saving practices.

The certification operates on a star-rating system, with schools awarded levels corresponding to points accrued across the six domains. However, the programme's transparency hinges upon clearly defined verification protocols, including the methods for validating activities, the authorities responsible for inspections, and the inclusion of independent monitoring. Absent such robust verification and audit procedures, the reliability of self-reported compliance may be limited.

Monitoring arrangements typically consist of periodic self-reporting by schools and departmental review; however, documentation on external evaluation or

third-party validation remains sparse, creating a gap between reported participation and independently substantiated environmental outcomes.

The programme's ultimate aim is to foster sustainable behavioural change by embedding environmental practices within school systems and promoting student involvement in sustainability initiatives. Nevertheless, measurable indicators of environmental impact—such as reductions in waste production, energy consumption, or enhancements in environmental literacy—are not consistently recorded.

Consequently, while the certification framework establishes a structured incentive system to encourage environmental engagement in schools, its effectiveness depends on enhanced transparency in verification methods, consistent monitoring, and rigorous incorporation of measurable environmental impact indicators.

17.4.3 Environmental Council

The Environmental Council Initiative, launched by the Environmental Protection Agency (EPA) Punjab, is an organised platform established within educational institutions to promote environmental awareness, leadership, and active participation among students in environmental protection activities. The primary objective of this initiative is to engage students, teachers, and school administrators in collaborative efforts aimed at fostering environmentally responsible educational institutions and communities. Under this initiative, Environmental Councils are formed in schools and colleges, comprising students, teachers, and designated focal persons who jointly plan, organise, and monitor various environmental activities throughout the academic year.

These Environmental Councils act as student-led bodies responsible for raising awareness of pressing environmental issues such as air pollution, climate change, water conservation, waste management, plastic pollution, and afforestation. The Councils encourage students to become environmental ambassadors within their institutions by organising campaigns, seminars, speech competitions, cleanliness drives, tree-planting activities, and eco-friendly projects.

A key feature of the initiative is the cultivation of environmental leadership and responsibility among students. Members of the Environmental Council are assigned specific responsibilities, including monitoring cleanliness, promoting waste segregation, ensuring proper care of plantations, reducing plastic use, and encouraging environmentally sustainable behaviour among peers. Through regular meetings and activities, students acquire practical knowledge and develop a strong sense of ownership towards conservation efforts. The initiative also enhances coordination between educational institutions and EPA Punjab, facilitating the implementation of sustainable environmental practices at the grassroots level.

The Environmental Council Initiative strives to foster long-term behavioural change by embedding environmental responsibility within the culture of educational institutions across Punjab. By directly involving students in governance, awareness campaigns, and experiential activities, the programme contributes to the development of a cleaner, greener, and healthier society. It exemplifies EPA Punjab's commitment to equipping future generations with the environmental knowledge, practical skills, and leadership qualities necessary to address emerging environmental and climate challenges.

Building upon these school-level interventions and youth engagement, EPA Punjab has subsequently expanded its focus to encompass broader youth outreach. Recognising the expanding influence of digital platforms, social media, and youth-driven communication, the department launched a new phase of environmental awareness targeting young citizens, influencers, digital content creators, and online communities through its programme, Im4Climate.

17.4.4 Im4Climate Campaign

The Im4Climate campaign was launched under the Punjab Clean Air Program (PCAP) by the Environment Protection & Climate Change Department (EP&CCD), Government of Punjab. Conceived as a citizen-centred behavioural change initiative, the campaign aims to harness the extensive outreach capabilities of social media to promote environmental awareness, advocacy for clean air, and climate-responsive behaviours, with a particular focus on engaging young people. Through collaborations with social media influencers, online campaigns, public participation, and digital engagement activities, Im4Climate strives to transform environmental protection into a widespread social movement driven by awareness, participation, and collective responsibility. The campaign targets a broad audience comprising individual social media users, emerging digital content creators, and registered digital media organisations. Participants are encouraged to develop and disseminate creative, solution-oriented content across major platforms including Instagram, Facebook, TikTok, YouTube, Snapchat, X (formerly Twitter), and LinkedIn. The content is expected to address real environmental challenges, with a particular emphasis on reducing air pollution and promoting sustainable lifestyles throughout Punjab.



What distinguishes Im4Climate from conventional awareness campaigns is its structured support for content creators. The programme organises dedicated boot camps, storytelling workshops, and university-based outreach activities designed to equip participants with the skills necessary to craft high-quality,

responsible environmental narratives. These sessions enable creators to effectively communicate complex climate issues, transforming scientific data into relatable, compelling stories that resonate with everyday audiences.

Operating under a clear set of content guidelines established by the Environment Protection & Climate Change Department (EP&CCD), the campaign encourages creativity while strictly prohibiting hate speech, political messaging, and misinformation. The focus remains firmly on fostering positive behavioural change, inspiring communities to adopt eco-friendly habits rather than inciting division or panic.

Beyond promoting individual content creation, Im4Climate aims to cultivate a broader community of climate-conscious digital advocates. By encouraging informed dialogue regarding air quality challenges and fostering collective action through evidence-based storytelling, the campaign seeks to generate a ripple effect in which one person's post motivates others to change habits—ultimately multiplying this impact across neighbourhoods, cities, and throughout Punjab.

Ultimately, the initiative signifies a paradigm shift in environmental policy communication. Rather than relying solely on traditional public awareness methods, EP&CCD invests in the creativity and connectivity of Punjab's youth to drive cultural transformation that government notices alone cannot effect. Im4Climate is more than a campaign; it is an endeavour to establish a lasting culture of sustainability, shared responsibility, and civic pride centered on the issue of clean air.

However, despite these awareness efforts and youth-centred initiatives, EPA Punjab observed the persistence of certain environmental challenges—particularly stubble burning and unsustainable agricultural practices—in rural areas. These continuities are attributed to entrenched behavioural patterns, limited outreach mechanisms, and restricted access to environmental education resources. The Department recognised that conventional communication channels and digital campaigns alone are insufficient to effectively engage many farming communities and remote rural populations.

In response to this challenge, EP&CCD adopted a more direct community engagement strategy by initiating the Docudrama Initiative, which brings environmental awareness physically into villages, farming communities, and local public spaces. Instead of relying on citizens' proactive access to awareness platforms, the Department directly reaches communities through dramatized field presentations, mobile awareness activities, and visual storytelling campaigns conducted at the grassroots level.

17.4.5 Docudrama

The Docudrama Initiative is an innovative environmental awareness campaign designed to educate the public through visual storytelling, dramatised presentations, and community engagement activities. Its primary aim is to raise awareness of critical environmental challenges such as smog, air pollution, stubble burning, climate change, improper waste disposal, deforestation, and the associated public health impacts of environmental degradation. By combining documentary-style information with dramatic enactments and real-life scenarios, the initiative communicates these issues in a manner that is both informative and emotionally resonant for students, farmers, and the wider public.

A central feature and cornerstone of the campaign is a purpose-built docudrama focusing on the environmental and health consequences of stubble burning. The film elucidates how crop residue burning significantly contributes to smog formation, degrades air quality, impairs soil fertility, and instigates severe respiratory and cardiovascular conditions among the populace. Visually depicting the harmful effects of smoke emissions—especially particulate matter such as $PM_{2.5}$ and PM_{10}, which pose substantial health and environmental risks—the docudrama was screened in over 100 villages within high cultivation areas of Punjab where stubble burning is prevalent. These screenings formed part of broader community awareness sessions aimed at promoting environmentally responsible agricultural practices.

The initiative also integrated interactive dialogue sessions following each screening. Here, agricultural experts, environmental specialists, and local stakeholders engaged directly with farmers and community members,

facilitating the exchange of experiences, discussion of field-level challenges, and dissemination of practical alternatives to crop residue burning. These included sustainable residue management methods and environmentally friendly farming practices. Through such engagements, farmers were encouraged to adopt non-burning techniques that support cleaner air, improved soil health, and long-term agricultural sustainability.



Figure 17.1: (a) Community members attending docudrama screening session

Prior to the launch of the Docudrama Initiative, EPA Punjab had already embarked on environmental awareness efforts through cultural and theatrical engagement with the production titled ***Dharti Maa***. This initiative took the form of an environmental theatre performance designed to evoke an emotional connection between the public and the imperative of environmental protection through dramatised storytelling. The play portrayed nature as a nurturing mother figure, suffering from pollution, deforestation, smog, waste, and irresponsible human activities, while emphasising citizens' responsibilities toward environmental preservation.

The success of ***Dharti Maa*** demonstrated that environmental communication via cultural expression and live performance can engender stronger public

engagement and emotional impact compared to conventional awareness strategies alone. Building upon this experience, EPA Punjab subsequently expanded the concept into a broader, field-based outreach endeavour through the Docudrama Initiative. This programme took environmental awareness activities directly into communities, rural settings, and public spaces to address entrenched harmful behavioural patterns at the grassroots level.

17.4.6 Public Awareness Play "Dharti Maa" at Alhamra Art Council

The Punjab Environment Protection Department (EPA) has innovatively incorporated theatre into its environmental awareness campaigns by staging Dharti Maa at the Alhamra Arts Council. Departing from conventional, didactic seminars, the department has embraced the performing arts to engage audiences more profoundly. By commissioning the theatrical production Dharti Maa (Mother Earth), EPA Punjab acknowledges that while data and statistics inform the intellect, it is art and storytelling that move the heart. This 100-minute performance vividly portrays the devastating effects of smog and environmental degradation, allowing audiences to perceive the "personality" of the planet and transforming the abstract concept of climate change into an immediate, personal, and compelling narrative.


DAWN

E-PAPER | JANUARY 06, 2025

HOME LATEST BREATHE GAZA SIEGE PAKISTAN 0

Punjab environment dept presents Dharti Maa at Alhamra

The Newspaper's Staff Reporter | Published January 6, 2025 | Updated about 4 hours ago

A scene from the play Dharti Maa.

Traditional awareness sessions often suffer from "information overload," wherein complex scientific jargon may alienate the general public. By adopting a theatrical format, EPA Punjab utilises sensory learning to engage audiences more effectively. The integration of specially composed music, folk traditions, and live performance creates an immersive environment, allowing the audience not merely to be informed about

environmental issues but to viscerally experience their gravity. This "edutainment" methodology bridges the divide between official policy discourse and public emotion, ensuring that conservation messages resonate long after the final curtain.

The casting of renowned actors such as Samia Mumtaz, who personifies "Mother Earth," represents a masterstroke in psychological communication. Through this personification, the environment transcends the abstraction of ecosystems or legal statutes to become a maternal, living entity with whom the audience can identify through the universal themes of love and protection. The depiction of environmental harm as "unknowing betrayal" provokes a more profound sense of individual responsibility than conventional pamphlets or lectures.

By dedicating specific performance days to targeted groups—including students, office workers, and families—EPA Punjab effectively tailors a collective social experience that fosters communal dialogue. The theatrical production at Alhamra functions as a cultural town square, offering diverse segments of society an opportunity to witness a shared environmental struggle simultaneously. The planned provincial tour promises to extend this impact beyond Lahore's urban centres to divisional levels across Punjab. This strategic utilisation of the stage transforms environmentalism from a specialized administrative concern into a vibrant, community-rooted cultural movement.


THE NEWS

Lahore

'Dharti Maa' play from 10th to highlight climate issues

By Our Correspondent January 06, 2025

LAHORE : A theatrical play titled 'Dharti Maa' will be enacted at Alhamra Arts Council.


Punjab environment dept presents *Dharti Maa* at Alhamra





Figure 17.1: EPA Public Awareness Campaign "Dharti Maa"

In response to this evolving behavioural landscape, EPA Punjab expanded its outreach strategy to encompass digital environmental engagement. The objective extended beyond mere awareness-raising to fostering continuous public interaction, active citizen participation, and real-time communication of environmental issues through social media, digital campaigns, influential personalities, and online engagement platforms.

17.5 Digital Media Engagement

In the contemporary digital era, social media and real-time communication platforms have become vital tools for fostering environmental awareness and public engagement. Recognising this paradigm shift, EPA Punjab has integrated digital media into its environmental governance strategy by utilising social media platforms, digital dashboards, mobile applications, and real-time information systems to disseminate Air Quality Index (AQI) updates, anti-smog advisories, enforcement actions, and environmental awareness content.

This evolution transformed environmental communication from traditional one-way messaging into an interactive system, enabling citizens not only to access information but also, in certain cases, to report environmental concerns. While these activities demonstrate a robust digital presence and outreach capacity, they do not, in isolation, provide concrete evidence of behavioural change or communication effectiveness.

To assess impact, digital engagement should be evaluated through objective metrics such as audience reach, engagement rates (including likes, shares, and comments), frequency of citizen interactions with AQI dashboards, response times to public complaints, and levels of user participation in reporting systems. Without such analytical frameworks, it remains difficult to ascertain whether digital communications translate into heightened environmental awareness or sustained behavioural modification.

Moreover, behavioural outcomes could be gauged through indicators of public compliance behaviour changes, including reduced incidents of waste burning, increased utilisation of air quality alerts for informed decision-making, and enhanced participation in environmental campaigns. At present, however, such outcome-based evidence is not consistently documented or reported alongside digital outreach efforts.

Consequently, while EPA Punjab's digital media strategy significantly improves the visibility and accessibility of environmental information, its overall effectiveness warrants assessment through structured engagement analytics and behavioural outcome metrics rather than communication activity alone.

17.5.1 Social Media Platforms & Digital Outreach

EPA Punjab's social media presence, led by the Strategic Communication Cell (SCC), evolved into a high-impact digital platform for environmental governance, public awareness, and citizen engagement throughout 2025. The Agency strategically utilised its digital platforms to promote major environmental campaigns and awareness initiatives, including World Environment Day activities, anti-smog awareness drives, and public health advisories issued during peak pollution periods. Simultaneously, social media channels were extensively employed to disseminate real-time Air Quality Index (AQI) updates and forecasts, environmental alerts, and messages encouraging pollution prevention and environmentally responsible behaviours.

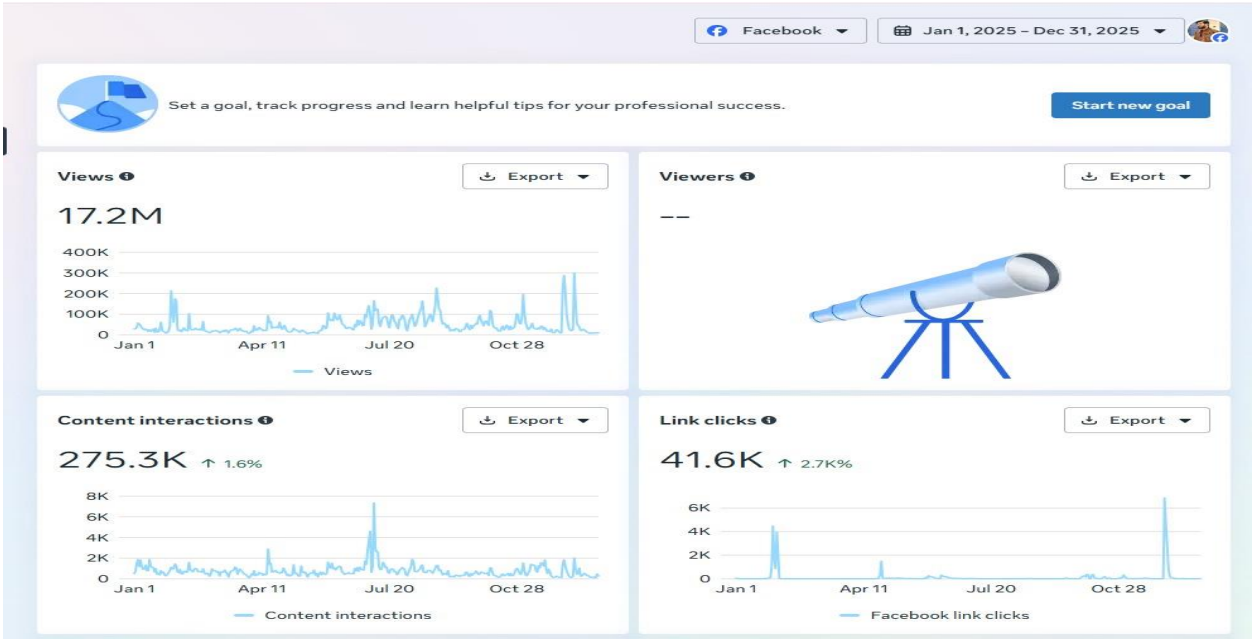
To enhance transparency and institutional visibility, EPA Punjab publicly showcased enforcement actions such as the demolition and sealing of non-compliant units, confiscations, vehicle emission testing drives, and field surveillance operations. The Agency regularly highlighted progress on key initiatives, including the Punjab Climate Watch, the Chief Minister Punjab Green Credit Program, and the adoption of the Zig-Zag kiln technology. The integration of citizen engagement tools, such as the Green Punjab App, further transformed these platforms into interactive mechanisms for public participation, facilitating crowdsourced reporting and direct dialogue with the community.

Through this structured digital communication strategy, EPA Punjab successfully positioned itself as a proactive, transparent, and digitally connected environmental institution.

17.5.1.1 Engagements through Facebook

EPA Punjab's Facebook platform emerged as one of the Agency's most effective digital communication channels in 2025, significantly enhancing public outreach, environmental awareness, and citizen engagement across Punjab. The platform amassed approximately 17.2 million total views over the year, evidencing the extensive reach and visibility of EPA Punjab's environmental campaigns, enforcement activities, and public advisories. Public engagement remained consistently robust throughout the year, with notable spikes observed in October and November, coinciding with the peak smog season, intensified anti-smog enforcement efforts, and heightened public concern regarding air quality and health.

The platform generated approximately 275,300 content interactions, demonstrating active public engagement through likes, comments, shares, and discussions on environmental issues. Concurrently, page followers increased to approximately 34,600, reflecting a substantial growth of nearly 58%, indicating rising public reliance on EPA Punjab's digital platforms as a trusted source of environmental information and updates. Additionally, the page recorded nearly 624,200 visits, underscoring robust direct audience engagement and sustained public interest in environmental governance and regulatory developments.



17.5.1.2. Engagements through Instagram

EPA Punjab's Instagram platform experienced substantial growth during 2025, emerging as an effective medium for visual storytelling, environmental awareness, and digital public engagement. The platform garnered approximately 2.6 million total views over the year, with overall reach exceeding 1.1 million, reflecting a significant expansion in audience visibility and public interaction. Engagement levels were notably high during the latter half of the year, particularly throughout the smog season, when environmental issues received heightened public attention across Punjab. The platform generated approximately 68,200 content interactions through likes, comments, and shares,

Figure 17.2: Insights for Facebook Platform for year 2025

indicating strong audience responsiveness to EPA Punjab's environmental messaging and awareness campaigns. Additionally, link clicks increased substantially, demonstrating growing public interest in accessing detailed environmental information, advisories, and official updates beyond social media

posts. Through visually driven communication strategies—including short awareness videos, enforcement highlights, environmental campaigns, and real-time public advisories—Instagram enabled EPA Punjab to connect effectively with younger, digitally active audiences.

Beyond audience growth, the platform played an important role in strengthening environmental communication by making complex environmental issues more accessible, engaging and publicly understandable.

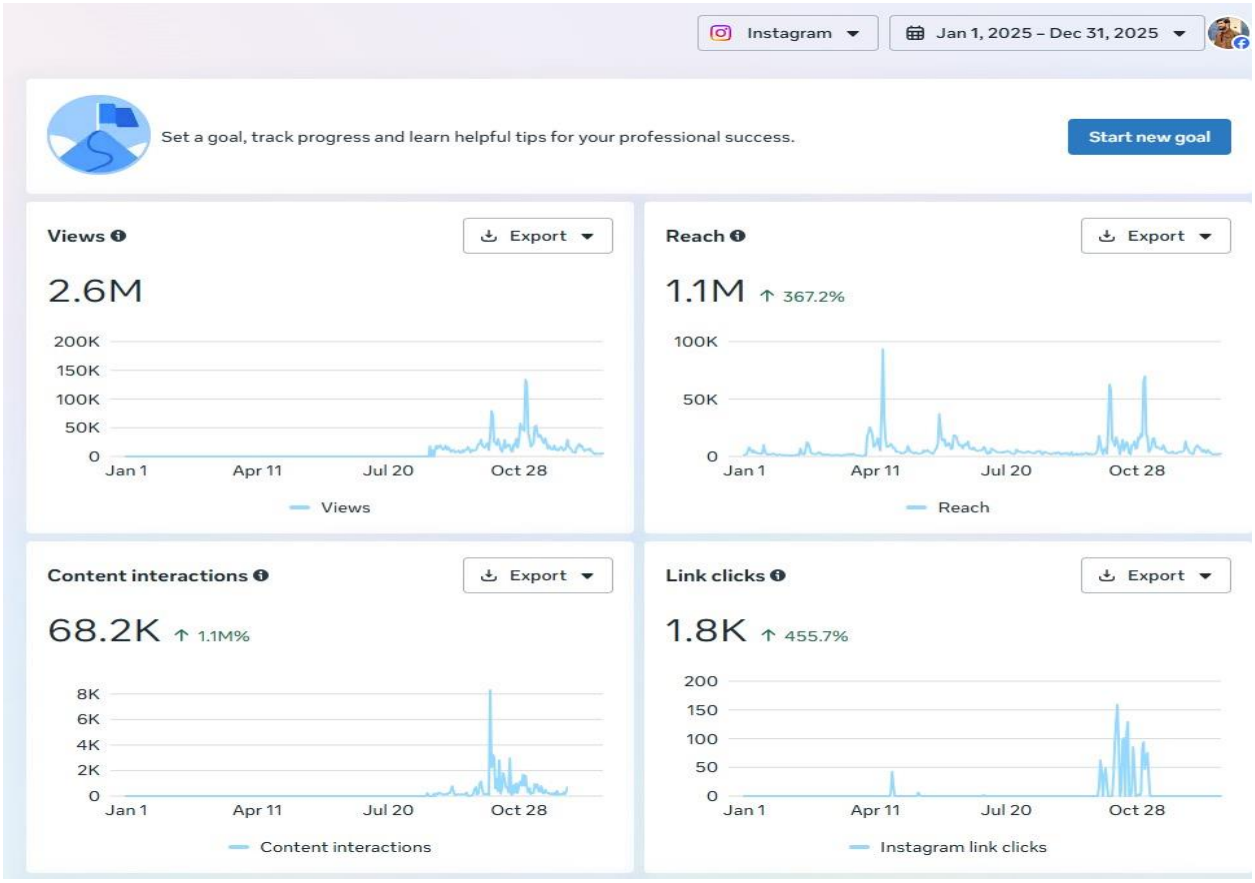


Figure 17.3: Insights for Instagram Platform for year 2025

17.5.1.3 Engagement through YouTube

EPA Punjab enhanced its digital outreach in 2025 through its official YouTube channel, Climate Corner, which became a vital platform for environmental communication, public awareness, and institutional visibility. Unlike the brief formats typical of social media, this channel enabled the Agency to deliver comprehensive visual content covering environmental challenges,

governmental interventions, and public awareness initiatives in an accessible and informative manner. The channel featured diverse content, including Air Quality Index (AQI) forecasts, anti-smog campaigns, environmental education videos, updates on Air Quality Monitoring Stations (AQMS), activities related to the Green Credit Program, departmental training sessions, enforcement operations, and public messages from senior officials on environmental protection and climate risks.

The platform played a crucial role in elucidating complex environmental issues through visual storytelling and explanatory narratives, thereby facilitating greater public understanding of air pollution dynamics, smog risks, environmental technologies, and governmental response strategies. By continuously uploading educational materials, operational footage, and real-time environmental updates, Climate Corner has bolstered public access to verified environmental information and enhanced transparency and confidence in EPA Punjab's governance initiatives.

17.5.2 AI-enabled Citizen EngagementBottom of Form

17.5.2.1 ECO Chatbot

The Punjab Environment Protection and Climate Change Department (EPCCD) has taken a significant step towards digital transformation and climate action by introducing EcoBot, an AI-powered WhatsApp chatbot. This innovative tool facilitates citizen engagement by enabling users to interact with the department in simple, conversational language, thereby improving access to environmental information. Users can activate EcoBot by scanning a QR code available on the department's website and social media pages, initiating an interactive dialogue with the chatbot.

Figure 17.4: EPA Introduces First WhatsApp AI ECO Bot

EcoBot is integrated with live environmental monitoring data from the department's air quality monitoring stations, ensuring delivery of accurate, up-to-date information. The chatbot provides real-time hourly pollution levels, educational tips, and guidance on protecting oneself from smog and air pollution. Designed to support inputs in both English and Urdu, EcoBot is accessible to a broad demographic. The department plans to enhance EcoBot's functionalities in the future by incorporating features such as noise pollution data, waste management information, and mechanisms for reporting environmental violations.



This initiative is expected to strengthen public engagement and contribute to a promotion of the cleaner and healthier environment in Punjab.



Figure 17.4: EPA Introduces First WhatsApp AI ECO Bot

Beyond delivering real-time environmental information and facilitating citizen interaction through tools such as EcoBot, EPA Punjab progressively expanded its

digital communication strategy to encompass broader public participation and behavioural transformation. Recognising that effective environmental protection necessitates active societal engagement rather than passive receipt of information, the Agency intensified efforts to involve youth, digital communities, and the general public through participatory digital campaigns and citizen-driven environmental advocacy initiatives.

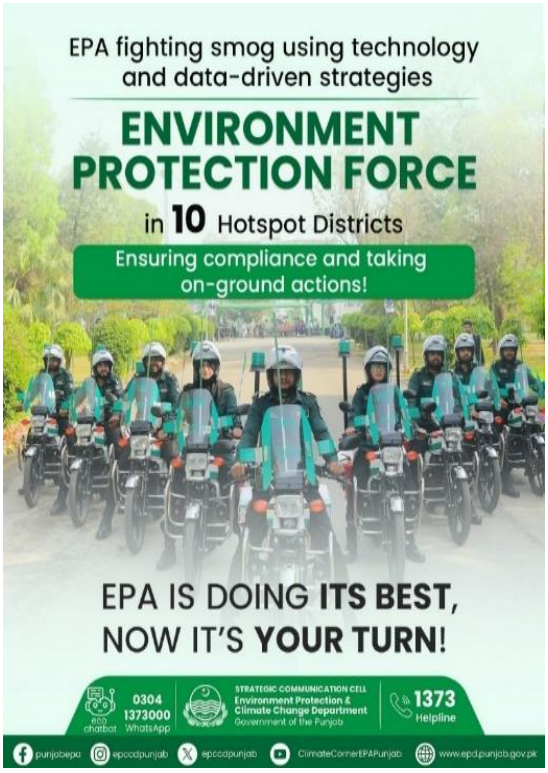


Figure 17.5: Environmental Protection Force

17.6 Technology-Driven Environmental Communication & Enforcement Visibility

While initiatives such as Im4Climate focused on transforming citizens into active participants in environmental awareness and behavioural change, EPA Punjab concurrently enhanced the digital visibility of its on-ground enforcement and environmental interventions. Recognising that public trust and behavioural transformation depend not only on awareness campaigns but also on demonstrable institutional action, the Agency increasingly leveraged technology-driven communication and digital storytelling to bring environmental governance into the public sphere. Through visual documentation, digital outreach, and technology-enabled monitoring systems, EPA Punjab transformed environmental enforcement from a conventional regulatory process into a transparent, publicly visible, and digitally connected governance framework.

17.6.1 Environmental Protection Force & Enforcement Visibility

The Environmental Protection Force (EPF) has emerged as a visible and proactive enforcement mechanism, strengthening field operations and enhancing

regulatory compliance across Punjab. Enforcement activities—including inspections, anti-smog operations, industrial monitoring, and field crackdowns—were actively publicised through digital platforms and media coverage to increase public visibility and institutional transparency. By bringing enforcement actions into the public domain, EPA Punjab has bolstered deterrence against environmental violations while simultaneously raising public awareness of environmental laws, compliance obligations, and government interventions.

17.6.2 Drone Surveillance & Smart Environmental Monitoring

In 2025, EPA Punjab further modernised environmental monitoring through the introduction of drone surveillance and technology-enhanced field monitoring systems. The deployment of aerial surveillance substantially augmented the Agency's operational capacity, facilitating the monitoring of industrial zones, illegal dumping sites, smoke emissions, and hard-to-access areas with improved efficiency and precision. Beyond reinforcing enforcement capabilities, drone-based monitoring enhanced the digital visibility of environmental governance by providing real-time visual documentation of field operations and environmental violations.

This technology-driven approach has improved institutional responsiveness, strengthened evidence-based enforcement, and positioned EPA Punjab as a modern and technologically adaptive environmental regulator.



Figure 17.6: EPA Drone Surveillance & Vigilant Aerial Enforcement

17.6.3 Liquid Tree & Innovative Environmental Communication

The "Liquid Tree" initiative exemplified EPA Punjab's commitment to innovative, technology-driven environmental solutions aimed at enhancing urban sustainability and public awareness. Through structured digital campaigns and compelling visual communications, the initiative introduced alternative environmental technologies to the public in an accessible and engaging manner.

Beyond its environmental importance, the project fostered public discourse on innovation-led sustainability solutions and reinforced EPA Punjab's reputation as a forward-looking institution actively championing modern approaches to environmental protection and climate resilience.

17.6.4 AQI Forecasting & Public Environmental Advisory System

The Air Quality Index (AQI) Forecasting initiative represented a significant evolution in EPA Punjab's environmental communication strategy by converting complex air quality data into a real-time public advisory and decision-support tool. Moving beyond technical reporting, EPA Punjab leveraged digital platforms and social media to disseminate simplified, colour-coded AQI forecasts that are easily understood by the general public. This empowerment enabled citizens to make informed decisions concerning outdoor exposure, health precautions, and daily activities during periods of elevated pollution.

Through the continuous dissemination of real-time forecasts, smog alerts, and public health advisories, environmental information became deeply integrated into daily public discourse, akin to weather and traffic updates. This persistent visibility not only bolstered public awareness of air pollution risks but also encouraged precautionary behaviours, increased responsiveness to advisory messages, and established air



Figure 17.7: Liquid Tree

quality forecasting as an indispensable public service across Punjab.

The 2025 AQI Forecast Campaign transformed environmental data from an abstract scientific concept into a practical daily utility for Punjab's residents. By distilling complex parameters such as $PM_{2.5}$ concentrations into accessible, colour-coded bulletins and digital dashboards, EPA Punjab effectively democratized air quality information. This paradigm shift advanced environmental engagement from passive observation to actionable intelligence, enabling families, schools, and communities to make timely, informed decisions to safeguard health during periods of poor air quality.

The campaign's success was grounded in its multi-channel dissemination strategy. By leveraging social media and real-time digital displays, EPA Punjab ensured that "smog levels" became as accessible and routine as the daily weather report. This consistent flow of data facilitated a gradual yet significant behavioural shift province-wide, reducing exposure during peak pollution hours and promoting the adoption of protective measures. For the media, it provided a reliable daily reference point for environmental reporting, transforming public discourse from seasonal panic towards a sustained, data-driven conversation centred on public health and individual responsibility.

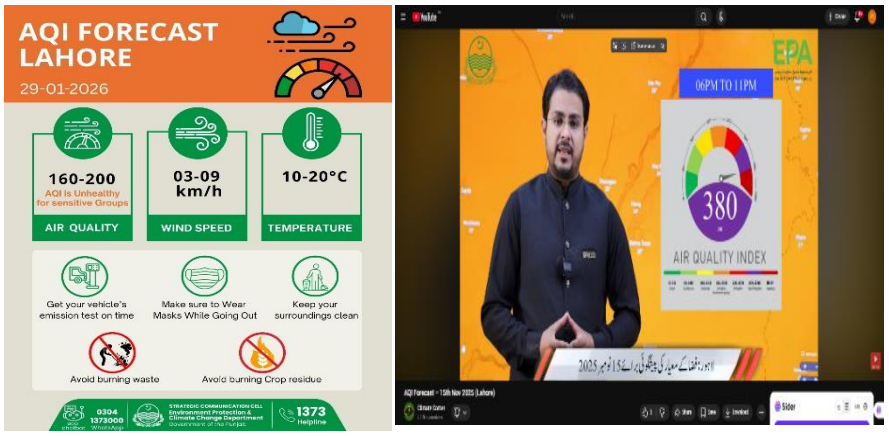


Figure 17.8: AQI Forecast through social media

While digital media significantly enhanced EPA Punjab's real-time outreach and citizen engagement capabilities, the Agency concurrently leveraged

conventional electronic media platforms to broaden the reach of environmental messaging across diverse audiences in Punjab. Recognising the enduring influence of television broadcasting and mainstream news networks in shaping public discourse and opinion, EPA Punjab strategically incorporated electronic media engagement into its wider communication framework. This integration has served to bolster environmental awareness, elevate institutional visibility, and strengthen public confidence in government-led environmental initiatives.

17.7 Electronic Media Engagement

Recognising the extensive reach and influence of electronic media across diverse societal segments, EPA Punjab strategically employed television networks, broadcast media, and mainstream news platforms as integral components of its environmental communication framework throughout 2025. Given the broad audience base and significant public influence of electronic media—particularly among households, urban populations, transport sectors, commercial stakeholders, and rural communities—the Agency adopted a targeted communication approach designed to ensure that environmental messaging remained accessible, highly visible, and socially impactful.

This electronic media engagement encompassed five principal domains: leadership-initiated environmental communication, public awareness and behavioural change campaigns, visibility of environmental enforcement operations, technology-driven environmental monitoring, and sector-specific regulatory compliance reporting. Through this structured communication strategy, EPA Punjab transformed environmental governance from a primarily administrative function into a publicly visible and continuously communicated societal concern. This shift has enhanced public awareness, institutional transparency, and citizen participation across the province.

17.7.1 Strategic Media Communication & Leadership Outreach

EPA Punjab adopted a leadership-driven communication strategy whereby senior departmental officials engaged directly with the public through television interviews, morning shows, live discussions, and current affairs programmes on

mainstream media channels. In this context, both the Secretary of the Environment Protection & Climate Change Department (EP&CCD) and the Director General of EPA Punjab frequently appeared on electronic media platforms to elucidate environmental challenges, communicate anti-smog measures, disseminate public health advisories, and showcase ongoing environmental initiatives across the province. This direct engagement empowered the Agency to shape environmental discourse at the national level, while ensuring that environmental governance remained publicly visible and institutionally accountable at the highest echelons of leadership. Through the strategic use of mainstream television platforms, EPA Punjab successfully recast environmental protection as a collective public responsibility rather than solely a governmental regulatory obligation.

17.7.2 Public Awareness Campaigns & Environmental Narrative Building

Electronic media was extensively utilised to enhance public awareness of air pollution, smog risks, fuel quality, groundwater depletion, and environmentally responsible behaviour. Through televised awareness campaigns, news coverage, public advisories, and continuous environmental messaging, EPA Punjab ensured that environmental issues remained integral to mainstream public discourse throughout the year. Particular emphasis was placed on anti-smog awareness, communication of Air Quality Index (AQI) updates, and precautionary public health messaging during peak pollution periods. This sustained media engagement significantly improved environmental literacy among citizens, fostering precautionary behaviours, heightened public responsiveness, and broader societal participation in environmental protection efforts.

17.7.3 Media Visibility of Environmental Enforcement & Field Operations

EPA Punjab strategically leveraged electronic media to amplify the visibility of its environmental enforcement operations and field interventions conducted throughout the province. Major enforcement activities—including Anti-Smog Gun operations, vehicle emission testing campaigns, anti-stubble burning initiatives,

fuel quality inspections, and actions against smoke-emitting vehicles—received extensive coverage across electronic and digital media platforms. By bringing field operations into the public domain, the Agency transformed environmental enforcement into a transparent and observable governance process, thereby enhancing institutional accountability, bolstering public confidence, and reinforcing deterrence against environmental violations. Continuous visual documentation of enforcement efforts also helped citizens gain a clearer understanding of the scale, seriousness, and operational intensity of government actions targeting pollution and smog.

17.7.4 Technology-Driven Environmental Monitoring & Smart Enforcement

EPA Punjab further enhanced its electronic media strategy in 2025 by showcasing technology-driven environmental governance and smart monitoring initiatives. The deployment of drone surveillance systems, advanced monitoring mechanisms, and collaboration with the Punjab Safe Cities Authority (PSCA) injected a modern, technology-oriented dimension into environmental regulation and enforcement. Similarly, environmental infrastructure projects such as Smog Towers received considerable electronic media coverage, positioning EPA Punjab as a forward-looking and technologically adaptive environmental institution. Through strategic dissemination of information on these initiatives, the Agency bolstered public confidence in modern environmental governance tools while raising awareness about technology-based pollution monitoring and environmental management systems.

17.7.5 Sectoral Environmental Compliance & Regulatory Reporting

Electronic media platforms were further leveraged to enhance the visibility of sector-specific environmental compliance initiatives and enforcement actions across industrial and commercial sectors. Regulatory measures against illegal pyrolysis plants, mandatory suction hood compliance in restaurants, and various other sectoral interventions received prominent media coverage, including televised reports. This heightened public visibility strengthened regulatory

accountability and simultaneously informed businesses, industries, and commercial operators of their environmental compliance obligations and pollution control requirements. Through this structured media engagement, EPA Punjab effectively extended environmental accountability into sectors traditionally considered peripheral to mainstream public environmental discourse, thereby fostering broader acceptance of environmental regulation and sustainable operational practices throughout the province.








BREAKING NEWS
بریکنگ نیوز
لاہور: ٹریفک پولیس فوری کریک ڈاؤن کرے، ڈی جی ماحولیات ڈاکٹر عمران حامد شیخ
گرفتار ملزم نشے کا عادی ہے، تین ساتھیوں کے ساتھ مل کر وارداتیں کرتا تھا، پولیس

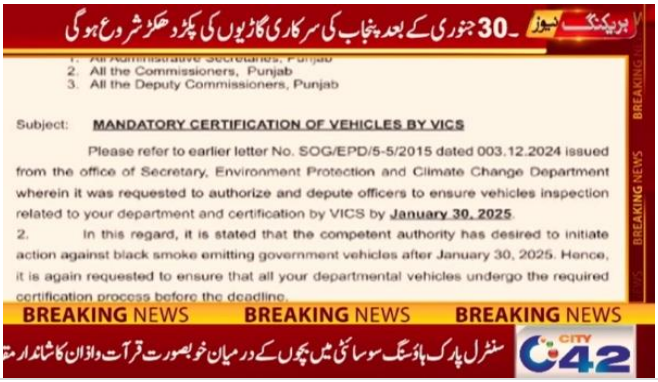

BREAKING NEWS
بریکنگ نیوز
لاہور: بغیر فٹنس اور سرٹیفکیٹ والی گاڑیوں کو فوراً بند کیا جائے، ڈی جی ماحولیات
کراچی: ملزم کو تین ساتھیوں سمیت گرفتار کیا گیا، تفتیش جاری ہے، پولیس


ایم خبر
لاہور میں رات کو چلنے والے پرانے ٹائروں کے کارخانے بند
PAKISTAN POPULATION COUNTER
256,126,088
DAWN
11:14 AM
پی ڈی ایم اے پنجاب کے افسر عبدالرحمان دوران ڈیوٹی دل کا دورہ پڑنے سے جاں بحق


express NEWS
9:08 AM
لاہور کو پائرولائزر پلانٹس کی ماحولیاتی آلودگی سے نجات دلانے پر ای پی اے کو خراج تحسین
ڈرون اسکواڈ دن رات آپریشن میں مصروف رہا، کوئی پلانٹ فعال نہ ہوا، ترجمان
اسموگ رولز کے تحت تمام پائرولائزر پلانٹس غیر قانونی قرار، ایکشن کی ہدایت، ترجمان
ڈپٹی ڈائریکٹر فیلڈ لاہور کو سخت ہدایات، دوبارہ کسی مقام پر پلانٹ چلنے نہ پائے، ادارہ ماحولیات
اگست تک تمام پلانٹس غیر فعال قرار، ستمبر میں زیادہ تر مسمار، ترجمان ادارہ ماحولیات
غیر قانونی کاربن اور پائروآئل کی فراہمی روک دی گئی، ترجمان ادارہ ماحولیات
لاہور میں تمام پائرولائزر پلانٹس کا صفایا، ترجمان ادارہ ماحولیات پنجاب


GOVERNMENT OF THE PUNJAB
ENVIRONMENTAL PROTECTION AGENCY
EPA
Schedule-I
Rule-2(E)
Punjab Environmental Protection (Motor Vehicle) Rules, 2013
(Directions Slip)
(Action under Section15 of the Punjab Environmental Protection Act-1997 (as amended in 2012))
Vehicle No: LE-10-2274
1.Book No. EPA/PSCA/LTV/1 Issue No. 364000938904259
2.Concerned Police Station N/A Tehsil N/A District
3.Date/ time & site of inspection 2025-11-17
URTAZA, C/O 10-G BILAL CENTRE NICHOLSON ROAD
عبدالقادر
4 روز میں 2000 چالان جاری کیے گئے، ترجمان ادارہ تحفظ ماحول
موٹروے پر ٹھوکر نیاز بیگ سے ہیوی ٹرانسپورٹ کی انٹری بند کر دی گئی، ترجمان
لاہور NEWS
3 40 PM
lahorenews.tv


10 روز میں 391 گاڑیوں کو وارننگ سلپس بھیجی گئیں، ڈی جی ماحولیات
لاہور NEWS
3:12 PM
WEDNESDAY

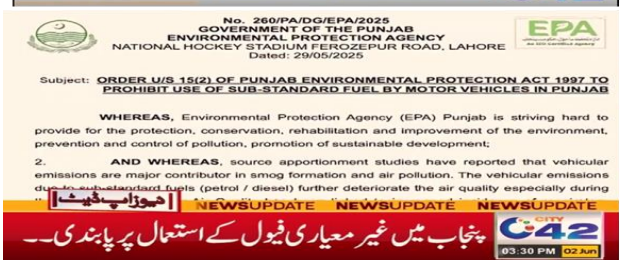

بریکنگ نیوز
30 جنوری کے بعد پنجاب کی سرکاری گاڑیوں کی پکڑ دھکڑ شروع ہو گی
2. All the Commissioners, Punjab
3. All the Deputy Commissioners, Punjab
Subject: MANDATORY CERTIFICATION OF VEHICLES BY VICS
Please refer to earlier letter No. SOG/EPD/5-5/2015 dated 003.12.2024 issued from the office of Secretary, Environment Protection and Climate Change Department wherein it was requested to authorize and depute officers to ensure vehicles inspection related to your department and certification by VICS by January 30, 2025.
2. In this regard, it is stated that the competent authority has desired to initiate action against black smoke emitting government vehicles after January 30, 2025. Hence, it is again requested to ensure that all your departmental vehicles undergo the required certification process before the deadline.
BREAKING NEWS BREAKING NEWS BREAKING NEWS
سنٹرل پارک ہاؤسنگ سوسائٹی میں بچوں کے درمیان خوبصورت قرآت واذان کا شاندار مقا
CITY 42


وقاص احمد، نمائندہ اسلام آباد
express NEWS
11 12 AM
لاہور میں 60 ایکسیمشن ٹیسٹنگ بوتھس قائم کر دیے، ڈی جی ماحولیات


وقاص احمد، نمائندہ اسلام آباد
express شیوز
11 12 AM
گرین اسٹیکرز جاری کرنے والے بوتھس کے اوقات 5 تا 9 ہوں گے، سیکریٹری ماحولیات


NEWS
ماحولیاتی ادارے کی جانب
سے پٹرول اور ڈیزل کے
معیار کی جانچ کا عمل جاری
/C42.LAHORE
/CITY42
/CITY42.LAHORE
CITY 42

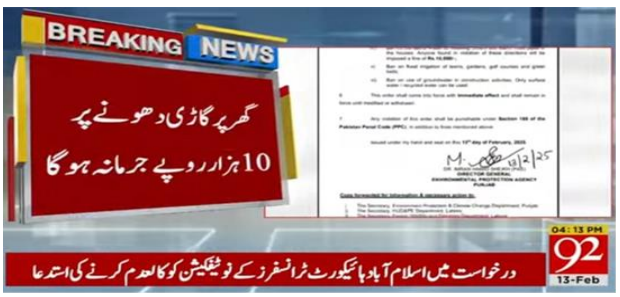



No. 260/PA/DG/EPA/2025
GOVERNMENT OF THE PUNJAB
ENVIRONMENTAL PROTECTION AGENCY
NATIONAL HOCKEY STADIUM FEROZEPUR ROAD, LAHORE
Dated: 29/05/2025
EPA
Subject: ORDER U/S 15(2) OF PUNJAB ENVIRONMENTAL PROTECTION ACT 1997 TO PROHIBIT USE OF SUB-STANDARD FUEL BY MOTOR VEHICLES IN PUNJAB
WHEREAS, Environmental Protection Agency (EPA) Punjab is striving hard to provide for the protection, conservation, rehabilitation and improvement of the environment, prevention and control of pollution, promotion of sustainable development;
2. AND WHEREAS, source apportionment studies have reported that vehicular emissions are major contributor in smog formation and air pollution. The vehicular emissions due to sub-standard fuels (petrol / diesel) further deteriorate the air quality especially during
اہم خبر
NEWSUPDATE NEWSUPDATE NEWSUPDATE
پنجاب میں غیر معیاری فیول کے استعمال پر پابندی۔۔
CITY 42
03:30 PM 02 Jun


بریکنگ نیوز
لاہور سمیت صوبہ بھر میں غیر معیاری
فیول کے استعمال پر پابندی عائد
پرچیز کمیٹی نے مارکیٹ ریٹ اور دیگر ہسپتالوں میں کٹس کے نرخ کو بھی نظرانداز کیا
3:32 PM
MONDAY


بریکنگ نیوز
کوئلہ، لکڑی یا چارکول استعمال کرنے
والے تمام ریسٹورنٹس پر پابندیاں عائد
بریکنگ نیوز
لاہور NEWS
6:35 PM
OCTOBER 15


اہم خبر
محکمہ ماحولیات پنجاب کی جانب
سے کوئلہ، لکڑی یا چارکول استعمال
کرنیوالے ریسٹورنٹس پر پابندیاں عائد
تفصیلات کچھ دیر بعد نیوز@7 میں ہم نیوز پر۔۔۔۔
HUM news
06:54 PM


BREAKING NEWS
گھر پر گاڑی دھونے پر
10 ہزار روپے جرمانہ ہوگا
درخواست میں اسلام آباد بائیکورٹ ٹرانسفرز کے نوٹیفکیشن کو کالعدم کرنے کی استدعا
04:13 PM
92
13-Feb


بریکنگ نیوز
پانی ری سائیکل کرنے کے سسٹم
کے بغیر سروس اسٹیشن پر
ایک لاکھ جرمانہ عائد ہوگا،
نوٹی فکیشن
ام فروا
نمائندہ جیو نیوز، لاہور
سرمایہ کاری اور معاشی ترقی کو فروغ مل رہا ہے، مریم نواز
15 44


until modified or withdrawn.
Any violation of this order shall be punishable under Section
stan Penal Code (PPC).
Issued under my hand and seal on this 7th day of April, 2
DR. IMRAN HAMID SHEIKH (PA
DIRECTOR GENERAL
ENVIRONMENTAL PROTECTION A
PUNJAB
information & necessary action to:
LIVE
بول
09 Apr, 2025
اہم خبر
سرکاری دفاتر، کمرشل عمارتوں
میں بھی ہوز پائپ استعمال
نہیں ہوگا
جعفر بن یار
نمائندہ لاہور
بریکنگ نیوز
سندھ کے تحفظات جائز ہیں، موٹروے کی تعمیر جلد شروع ہوگی، شہباز شریف


90 سروس سٹیشنز پر واٹر ری سائیکلر نصب، ڈی جی ماحولیات عمران حامد شیخ
CITY 42
29
430 سروس سٹیشنز کا معائنہ، 138 کو سیل کر دیا گیا، ڈی جی عمران حامد شیخ
CITY 42
SUNNY 33°

Collectively, EPA Punjab's electronic media engagement strategy has been instrumental in transforming environmental governance into a publicly visible, continuously communicated, and socially relevant discourse across the province. By strategically leveraging leadership outreach, public awareness campaigns, enforcement transparency, and technology-driven communication, the Agency has successfully broadened environmental conversations beyond administrative and technical realms into the mainstream public domain. This integrated media approach has enhanced institutional transparency and bolstered public trust, while promoting heightened environmental awareness, behavioural change, and citizen participation in environmental protection initiatives. While electronic media has facilitated real-time public communication and extensive audience reach, print media has complemented these efforts by providing in-depth reporting, analytical perspectives, and comprehensive documentation of environmental policies, interventions, and governance challenges throughout Punjab.

17.8 National & International Print Media Coverage

EPA Punjab's environmental initiatives, anti-smog interventions, and regulatory actions received extensive coverage in both national and international print media during 2025, significantly enhancing the visibility of Punjab's environmental governance efforts domestically and globally. Prominent international media outlets—including Reuters, Associated Press, The Washington Post, Gulf News, BBC Urdu, and Voice of America—highlighted


THE EXPRESS TRIBUNE
TODAY'S PAPER| DECEMBER 20, 2025
HOME LATEST NEWS PAKISTAN WORLD OPI
Ad
Lahore air quality improves as AQI falls to 215
Authorities credit stricter industrial and vehicular checks for recent air quality gains
Web Desk | December 19, 2025


DAWN
TODAY'S PAPER | DECEMBER 04, 2025
HOME LATEST PAKISTAN BUSINESS OPINION
ICRC
Fostering disability inclusive societies for advancing social progress
International Day of Persons with Disabilities 2025
Updated 04 Dec, 2025 09:50am
Lahore sees significant reprieve from extreme smog

Punjab's environmental challenges, anti-smog operations, and government response mechanisms, drawing considerable international attention to regional environmental and air quality concerns. Simultaneously, major national Urdu and English newspapers—including Dawn, The News International, Express Tribune, Jang, Nawa-i-Waqt, The Nation, Minute Mirror, Nukta, and Express News—provided continuous coverage of environmental enforcement actions, policy interventions, smog mitigation measures, and public health concerns throughout the year. This sustained engagement by the print media considerably enhanced the public visibility of environmental governance while reinforcing

transparency, raising public awareness, and bolstering institutional credibility both nationally and internationally.

17.8.1 EPA Post-Smog Appraisal & Institutional Learning

Following the conclusion of the smog season, EPA Punjab conducted a comprehensive post-smog appraisal to evaluate the effectiveness, operational impact, and implementation challenges of the anti-smog interventions undertaken in 2025. The review process encompassed environmental data analysis, assessment of enforcement operations, interdepartmental consultations, and the identification of policy and operational gaps requiring future improvement. Moving beyond a solely enforcement-centric role, the appraisal underscored EPA Punjab's transition towards evidence-based and adaptive environmental governance, emphasising continuous institutional learning and policy refinement. This exercise contributed to the development of enhanced mitigation strategies, operational recommendations, and future response mechanisms for subsequent smog seasons. Through analytical reporting and policy-oriented media coverage, the appraisal further reinforced institutional transparency and demonstrated the Agency's commitment to evaluating, improving, and strengthening long-term environmental management and anti-smog governance frameworks throughout Punjab.

17.9 Outcomes and Societal Impact of Media & Community Engagement

EPA Punjab's media and community engagement initiatives are reported to have enhanced public awareness of environmental issues, increased citizen participation, and elevated the visibility of environmental governance across the province. These positive outcomes are primarily attributed to awareness campaigns, school and community programmes, and digital media outreach efforts.

However, many of these reported impacts remain largely descriptive and lack systematic empirical validation. In the absence of structured surveys, perception

studies, or longitudinal behavioural assessments, it is challenging to ascertain whether heightened awareness has translated into sustained behavioural change at the societal level.

To rigorously evaluate societal impact, evidence-based assessment mechanisms are necessary, including public perception surveys, pre- and post-intervention studies, analysis of citizen feedback, and independent monitoring of behavioural indicators such as waste disposal practices, adherence to environmental advisories, and engagement in reporting systems. Furthermore, third-party evaluations and academic research could enhance the credibility of reported outcomes by mitigating the reliance on institutional self-reporting.

Without such empirical verification, conclusions regarding societal transformation remain provisional rather than definitive. Consequently, while EPA Punjab's media and community engagement efforts demonstrate considerable outreach capacity and public visibility, their broader social impact should be interpreted with caution until substantiated by robust and independently verified evidence.

17.9.1 Environment as Mainstream Public Discourse

One of the most transformative outcomes of EPA Punjab's communication strategy in 2025 was the integration of environmental issues into mainstream public discourse across the province. Concerns relating to smog, pollution, climate change, and public health risks increasingly permeated everyday conversations within households, educational institutions, workplaces, media outlets, and digital communities. What was once predominantly regarded as a technical and regulatory matter evolved into a widely acknowledged social issue, sustaining heightened public attention and active engagement.

16.9.2 Transformation of Environmental Governance into Publicly Visible Governance

EPA Punjab's integrated communication strategy significantly bridged the traditional gap between government operations and public visibility. Through continuous dissemination of environmental information, proactive leadership

engagement, and transparent showcasing of institutional actions, environmental governance became increasingly transparent, publicly observable, and socially connected. Citizens, once distanced from environmental decision-making and governmental interventions, now experienced enhanced accessibility, comprehension, and visibility of environmental governance within public discourse and media narratives.

17.9.3 Strengthening Public Trust, Responsiveness & Environmental Awareness

The continuous dissemination of environmental communication via electronic, digital, and print media has strengthened public confidence in institutional responsiveness and enhanced environmental literacy among citizens. Real-time advisories, public awareness campaigns, and accessible environmental information have empowered citizens to better comprehend pollution risks, adopt precautionary measures, and appreciate the broader societal implications of environmental degradation. This sustained engagement has fostered increased public responsiveness and heightened awareness of individual and collective responsibilities toward environmental protection.

17.9.4 Emergence of Participatory Environmental Culture

The communication and outreach initiatives implemented in 2025 contributed to fostering a more participatory environmental culture throughout Punjab. Citizens, youth, educational institutions, digital communities, and businesses increasingly assumed active roles as stakeholders in environmental protection, moving beyond passive spectatorship of government policies. This gradual societal transformation reinforced the notion that environmental sustainability is a collective social responsibility necessitating widespread participation, behavioural change, and engagement at the community level.

16.9.5 Enhancing Institutional Credibility & Global Visibility

The scale and consistency of EPA Punjab's communication efforts significantly enhanced the institution's credibility at both national and international levels.

Through continuous media visibility, structured public engagement, and technology-driven communication initiatives, EPA Punjab established itself as a modern, proactive, and publicly engaged environmental authority. Extensive coverage across national and international media platforms further elevated the profile of Punjab's environmental governance framework, positioning it as a pioneering example of integrated environmental communication and public engagement within the region.

Following the successful implementation of school engagement programmes, community outreach campaigns, theatrical awareness initiatives, docudramas, and extensive digital, electronic, and print media campaigns, EPA Punjab gradually attained institutional recognition and post-appraisal maturity in environmental communication and public engagement. However, the Department also recognised that sustainable environmental governance cannot rely solely on awareness campaigns and enforcement mechanisms. An increasing need has emerged for an institutional platform dedicated to preserving environmental knowledge, fostering policy dialogue, developing technical expertise, and promoting focused stakeholder engagement on critical environmental issues.

17.10 Centre for Knowledge Exchange and Policy Dialogue (CKE&PD)

In response to this need, EPA Punjab established the Centre for Knowledge Exchange and Policy Dialogue (CKE&PD) as its inaugural organised centre for training, research, and policy dialogue. The creation of the Centre reflects EPA Punjab's evolution from a conventional regulatory body towards a knowledge-driven and collaborative governance model centred on institutional learning, research facilitation, and evidence-based policymaking.

The primary objective of the Centre is to conduct structured capacity-building programmes for all levels of EPA Punjab personnel, including promotion-linked training for officials from grades BS-01 to BS-15. Additionally, the Centre functions as a platform for organising national and international workshops, seminars, and

policy dialogues aimed at enhancing stakeholder engagement and promoting environmental knowledge exchange across multiple sectors.

The Centre also seeks to cultivate collaborations with universities, academic institutions, training academies, and research organisations to support research, innovation, and environmental policy development. It serves as a centralised repository for environmental data, research studies, case analyses, and best practices, thereby aiding policymakers, researchers, and public awareness initiatives in alignment with applicable legal frameworks.

Beyond its institutional training mandate, the Centre is envisioned as a policy support and research facilitation hub, where researchers and technical experts can disseminate findings and convert research outcomes into actionable policy recommendations for decision-makers. Through this initiative, EPA Punjab strives to institutionalise environmental learning, policy innovation, and stakeholder collaboration, while developing an internal think tank equipped to address future environmental governance challenges in the province.

17.11 Conclusion

The media and community engagement framework employed in 2025 demonstrated that modern environmental governance extends beyond regulatory actions and administrative interventions; it increasingly relies on the capacity to shape public perception, maintain sustained public attention, and cultivate collective social responsibility regarding environmental issues. The growing incorporation of environmental concerns into mainstream media discourse signifies a critical societal transition, wherein pollution, smog, climate risks, and environmental sustainability have emerged not merely as technical matters but as salient issues of public interest, health, and everyday social relevance.

The extensive deployment of digital, electronic, and print media highlights the transformative role of communication in influencing behavioural patterns, enhancing public responsiveness, and fostering a culture of participatory environmental stewardship. Environmental information has become more accessible, visible, and comprehensible to the general populace, with media

platforms evolving into powerful tools for raising awareness, mobilising communities, and enhancing institutional transparency. This shift reinforces the recognition that effective environmental governance is intrinsically linked to informed citizenry, active participation, and sustained public engagement.

The overall communication landscape of 2025 further indicates that environmental media engagement has transcended mere information dissemination; it has evolved into a strategic governance instrument capable of shaping societal attitudes, influencing policy discourse, and nurturing enduring environmental consciousness at both national and community levels.

CHAPTER 18

Future Direction



18.1 Environmental Governance Maturity

The Environmental Protection Agency Punjab is progressively transitioning from a conventional regulatory body to a modern, technology-enabled, and data-driven authority in environmental governance. This transformation embodies a broader shift towards proactive environmental management grounded in scientific evidence, digital monitoring systems, institutional coordination, and informed decision-making.

The evolving governance model emphasises prevention over reactive enforcement, empowering the Agency to identify environmental risks at earlier stages, enhance regulatory efficiency, and bolster public trust. By integrating advanced technologies, environmental intelligence systems, and transparent governance structures, EPA Punjab aspires to elevate environmental protection while concurrently fostering sustainable economic development across the province.

This transition also signifies Punjab's growing recognition that effective environmental governance extends beyond mere regulatory compliance. It now necessitates integrated planning, predictive analytics, digital governance, public participation, and interdepartmental collaboration to effectively navigate the multifaceted environmental and climate challenges confronting the region.

18.1.1 Progress Achieved in 2025

The year 2025 marked a pivotal phase in the strengthening of environmental governance and institutional modernisation in Punjab. Throughout the year, EPA Punjab implemented a series of reforms and initiatives aimed at enhancing environmental monitoring, regulatory enforcement, pollution management, and public engagement.

These efforts were prompted by escalating environmental pressures, including worsening air pollution, industrial emissions, water stress, plastic waste, climate vulnerability, and rapid urban expansion. In response, the Agency adopted a technology-oriented and evidence-based approach to environmental management by integrating digital platforms, augmenting monitoring infrastructure, and improving institutional coordination.

Several key governance enhancements introduced during 2025 include the expansion of environmental monitoring networks, development of digital complaint management systems, reinforcement of enforcement mechanisms, promotion of sustainable development practices, and enhancement of public access to environmental information.

The cumulative impact of these initiatives signifies a notable institutional transformation in Punjab's environmental governance, characterised by:

- A shift from reactive to proactive environmental management
- An increased reliance on data-driven decision-making
- Greater utilisation of digital monitoring and analytical technologies
- Improved environmental transparency and public participation
- Strengthened culture of enforcement and compliance
- Integration of scientific and technological insights into policymaking
- Enhanced institutional coordination and operational capacity
- Promotion of sustainable development alongside facilitation of ease of doing business

Collectively, these advances position EPA Punjab among Pakistan's foremost environmental regulatory institutions, with an expanding focus on modern, adaptive, and technology-enabled governance.

18.1.2 Focus Areas for 2026

Building on the institutional advancements achieved in 2025, EPA Punjab will further enhance environmental governance through a suite of strategic interventions and targeted reforms in 2026. The Agency's future priorities will include bolstering environmental monitoring systems, advancing climate resilience, upgrading digital governance infrastructure, expanding predictive environmental management capabilities, and promoting sustainable resource management throughout the province.

18.1.2.1 Targeted Enforcement in Pollution Hotspot Districts

EPA Punjab will establish dedicated environmental enforcement infrastructure in identified pollution hotspot districts across the province. These districts will

benefit from targeted monitoring, rapid response interventions, and reinforced field enforcement aimed at controlling industrial emissions, open burning, waste-related pollution, and other significant environmental violations. The initiative seeks to enhance on-ground regulatory presence, facilitate expedited environmental responses, and improve compliance monitoring in these high-risk areas.

18.1.2.2 Strengthening AQI Forecasting and Monitoring Systems

EPA Punjab will further expand and enhance the provincial Air Quality Index (AQI) monitoring and forecasting network. The Agency plans to increase the number of monitoring stations throughout Punjab while integrating real-time environmental data, meteorological information, satellite observations, and AI-based predictive models.

The upgraded forecasting system is intended to improve early warning capabilities, strengthen pollution response planning, and support informed policy interventions during smog events and periods of elevated pollution.

18.1.2.3 Climate Resilient Water Management Initiatives

Recognising the escalating risks posed by water scarcity and climate change, EPA Punjab will prioritise climate-resilient environmental planning with a particular emphasis on sustainable water management practices. The Agency intends to promote rainwater harvesting systems, groundwater recharge initiatives, wastewater reuse, and integrated stormwater management across residential, commercial, and industrial sectors. These efforts aim to bolster long-term water security while enhancing climate resilience in urban and semi-urban areas.

18.1.2.4 Capacity Building and Institutional Development

EPA Punjab will continue to strengthen institutional capacity through specialised training programmes, technical collaborations, and professional development initiatives. The Agency will seek to forge national and international partnerships to enhance technical expertise in environmental monitoring, climate governance, data analytics, and digital environmental management. Plans are also underway to establish a dedicated Environmental Training Centre to support

continuous professional learning, operational efficiency, and the adoption of international best practices.

18.1.2.5 Strengthening Digital and IT Infrastructure

EPA Punjab will further modernise its digital governance infrastructure by integrating smart monitoring technologies, Internet of Things (IoT)-based systems, environmental data analytics, and centralised digital platforms. The objective is to enhance environmental data collection, improve regulatory coordination and monitoring efficiency, and increase public accessibility to environmental information. Upgraded digital infrastructure will also facilitate faster reporting, promote transparent governance, and underpin evidence-based policymaking.

18.2 Strategic Outlook for 2026

Building on the institutional progress achieved in 2025, EPA Punjab's strategic direction in 2026 aims to consolidate environmental governance through technological modernisation, sustainable development initiatives, and climate-responsive policymaking. The Agency envisions a governance framework that synergistically combines regulatory oversight, digital innovation, scientific planning, and community participation to effectively confront emerging environmental and climate-related challenges.

18.2.1 Key Strategic Priorities for 2026

The strategic priorities for 2026 will focus on:

- Reducing air, water and soil pollution
- Strengthening environmental compliance and enforcement
- Promoting renewable energy and cleaner production technologies
- Enhancing climate resilience in urban and agricultural systems
- Expanding digital environmental governance mechanisms
- Improving environmental forecasting and predictive analysis

- Encouraging public participation and environmental awareness
- Strengthening partnerships with national and international stakeholders

Collectively, these priorities aim to establish EPA Punjab as a modern, adaptive, and globally aligned institution of environmental governance, capable of addressing future environmental challenges through proactive, technology-driven solutions. To ensure the effective realisation of these strategic objectives, EPA Punjab will implement a comprehensive framework characterised by measurable performance targets, clearly defined institutional responsibilities, specified implementation timelines, and sustainable financing mechanisms.

Regular monitoring and evaluation, conducted through key performance indicators (KPIs), will facilitate systematic progress tracking, evidence-based decision-making, and timely corrective actions as necessary. The framework will also enable adaptive management by incorporating periodic reviews, stakeholder feedback, and responsiveness to emerging environmental challenges, thereby ensuring that strategic interventions remain effective, accountable, and aligned with long-term environmental governance goals.

18.2.1.1 Sustainable Development and Circular Economy

EPA Punjab will advocate for sustainable development principles by facilitating a gradual shift from a traditional linear economic model towards a circular economy framework centred on waste reduction, enhanced resource efficiency, and the promotion of recycling and recovery practices.

Industries will be encouraged to embrace cleaner production technologies, optimise energy and water utilisation, and implement environmentally sustainable operational practices. Additionally, integrated waste management systems will be reinforced through improved waste segregation protocols, the expansion of recycling infrastructure, and the adoption of responsible disposal mechanisms.

Particular emphasis will be placed on mitigating plastic pollution through phased restrictions on single-use plastics, the promotion of environmentally friendly

alternatives, and the enforcement of Extended Producer Responsibility (EPR) mechanisms.

18.2.1.2 Pollution Reduction and Environmental Protection

EPA Punjab will further enhance pollution control efforts by expanding environmental monitoring infrastructure, improving regulatory enforcement, and strengthening industrial compliance systems. Networks for air quality monitoring, water quality surveillance, and environmental inspections will continue to be extended across urban and industrial zones. The Agency will increasingly leverage real-time environmental data, predictive analytics, and targeted interventions to identify pollution hotspots and proactively mitigate environmental risks.

Enhanced industrial emissions monitoring through Continuous Emission Monitoring Systems (CEMS), coupled with stricter enforcement of Punjab Environmental Quality Standards (PEQS) and more robust field enforcement mechanisms, will serve to reinforce regulatory compliance and institutional accountability.

18.2.1.3 Climate Resilience and Clean Energy Integration

Climate resilience will continue to be a central pillar of EPA Punjab's future environmental strategy. The Agency will promote the adoption of renewable energy, energy efficiency initiatives, and the development of sustainable infrastructure throughout Punjab. Emphasis will be placed on advancing solar energy systems, waste-to-energy initiatives, biogas generation projects, and environmentally sustainable industrial technologies, all aimed at reducing pollution while supporting low-carbon economic growth.

Simultaneously, EPA Punjab will promote climate adaptation measures—including climate-smart agriculture, flood resilience planning, heat mitigation strategies, and sustainable urban infrastructure—to enhance environmental resilience across vulnerable sectors.

18.2.1.4 Technology Driven Environmental Governance

EPA Punjab will persist in advancing a technology-enabled environmental governance framework anchored in digital monitoring systems, artificial intelligence-assisted environmental analysis, and geographic information system (GIS)-based decision support tools. The integration of these environmental intelligence systems is expected to enhance institutional responsiveness, bolster forecasting capabilities, and facilitate proactive environmental management. Furthermore, public access to environmental information will be expanded to promote greater transparency, foster citizen participation, and enhance institutional accountability.

18.2.1.5 Partnerships and Community Participation

Environmental protection necessitates collective responsibility and institutional collaboration. EPA Punjab will maintain close partnerships with government departments, international organisations, research institutions, non-governmental organisations (NGOs), and private sector stakeholders to bolster environmental sustainability initiatives across the province.

Community participation will continue to be a vital element of environmental governance, fostered through awareness campaigns, participatory monitoring programmes, and public engagement mechanisms designed to promote environmentally responsible behaviours.

18.2.1.6 Predictive Environmental Governance through Artificial Intelligence

EPA Punjab aims to progressively transition towards predictive environmental governance by integrating artificial intelligence (AI) and advanced environmental analytics into its monitoring and regulatory frameworks. AI-based models, trained on historical environmental data, industrial emissions, meteorological patterns, and satellite observations, will underpin pollution forecasting, environmental risk identification, and dynamic regulatory planning. These systems are designed to enhance early warning capabilities, improve the efficacy of environmental response mechanisms, and facilitate evidence-based inspection scheduling and enforcement prioritisation.

18.2.1.7 Provincial Environmental Data Exchange Platform

EPA Punjab plans to develop a centralised Environmental Data Exchange Platform (EDEP) aimed at enhancing interdepartmental environmental coordination and data interoperability. This platform will enable the integration of environmental datasets from diverse sectors, including health, transport, agriculture, urban development, and industry. Such an integrated approach is expected to improve environmental planning, strengthen policy coherence, and facilitate more comprehensive environmental analysis across Punjab.

18.2.1.8 Expansion of IoT Based Environmental Monitoring

EPA Punjab will continue the expansion of Internet of Things (IoT)-based environmental monitoring systems across urban centres, industrial clusters, and environmentally sensitive areas. The deployment of low-cost sensor networks will enhance real-time environmental surveillance, broaden spatial monitoring coverage, and facilitate swift regulatory response mechanisms. Furthermore, integrating IoT systems with centralised dashboards and analytical tools will improve the overall efficiency of environmental governance.

18.2.1.9 Climate Intelligence and Decision Support Systems

The Agency aims to strengthen climate intelligence systems capable of integrating environmental monitoring, climate modelling, and risk assessment within environmental planning and policymaking frameworks. These systems will support climate risk mapping, forecasting of extreme weather events, and the development of adaptive environmental management strategies to enhance resilience against floods, droughts, and heatwaves.

The implementation of such advanced environmental intelligence systems will necessitate robust data governance structures, interoperable information platforms, institutional ownership mechanisms, cybersecurity safeguards, reliable technical infrastructure, and specialised human resources. The successful integration of these systems into planning, regulatory decision-making, environmental monitoring, and disaster preparedness processes will be vital to achieving their intended benefits.

18.2.1.10 Institutional Transformation and Digital Capacity Building

EPA Punjab recognises that successful digital governance hinges not only on technological infrastructure but also on institutional capacity and specialised technical expertise. Accordingly, continuous training programmes in environmental data analysis, geographic information systems (GIS), AI-assisted monitoring, and digital governance systems will remain a strategic priority. Furthermore, specialised technical units dedicated to environmental intelligence, digital systems, and advanced analytics may be established to bolster institutional innovation and enhance operational effectiveness.

18.2.1.11 Water Conservation and Sustainable Resource Management

EPA Punjab will persist in advancing water conservation initiatives, including the enforcement of restrictions on excessive water use, promotion of wastewater recycling, and expansion of rainwater harvesting systems. Furthermore, the Agency intends to advocate for sustainable water management practices across residential, commercial, and industrial sectors to address the growing challenges of groundwater depletion and climate-induced water stress.

18.2.1.12 Floating Wetlands and Nature Based Solutions

EPA Punjab plans to expand the utilisation of floating wetland technology as a sustainable, nature-based solution for wastewater treatment and ecological restoration. This initiative aims to improve water quality in drains, canals, ponds, and other polluted water bodies, while simultaneously enhancing biodiversity and promoting environmental rehabilitation.

18.2.1.13 Advanced Air Quality Management and Source Apportionment

EPA Punjab will conduct detailed source apportionment studies to scientifically identify and quantify the principal contributors to $PM_{2.5}$ and urban air pollution across the province. Advanced analytical techniques, including receptor modeling, satellite data analysis, trajectory modeling, and Positive Matrix Factorization (PMF), will underpin evidence-based policymaking and enable targeted pollution control interventions.

18.2.1.14 Automated Air Quality Forecasting and GIS Based AQI Zoning

EPA Punjab aims to operationalise an integrated air quality forecasting system capable of predicting pollution trends 24 to 72 hours in advance by integrating data from Air Quality Monitoring Stations (AQMS), meteorological information, and AI-assisted forecasting models. Concurrently, geographic information system (GIS)-based Air Quality Index (AQI) mapping and zoning systems will be developed to identify district-specific pollution hotspots, enhance environmental planning, and facilitate targeted, localized pollution mitigation strategies.

18.3 Conclusion

The future trajectory of EPA Punjab reflects a broader evolution in environmental governance throughout the province. The Agency is progressively transitioning from traditional regulatory roles towards a more integrated, technology-driven, and predictive governance framework, equipped to address increasingly complex environmental and climate-related challenges.

Through the expansion of environmental monitoring networks, enhancement of digital governance infrastructure, advancement of climate resilience initiatives, and the development of scientific decision support systems, EPA Punjab aims to fortify environmental protection while fostering sustainable economic development and public well-being.

The strategic direction outlined for 2026 underscores EPA Punjab's commitment to establishing a transparent, responsive, and adaptive environmental governance system, aligned with emergent national imperatives and global environmental sustainability objectives.



ACKNOWLEDGEMENTS

Conferring of Sitara e Imtiaz



The Government of Pakistan recognised the outstanding contributions of Dr Imran Hamid Sheikh, Director General of the Environmental Protection Agency (EPA) Punjab, the operational arm of the Environment Protection & Climate Change Department. In acknowledgement of his visionary leadership, he was nominated for the prestigious Sitara-e-Imtiaz, with the Cabinet Division formally announcing his nomination on 14 August 2025. Since assuming office in March 2024, Dr Sheikh has spearheaded significant advancements in environmental governance and public service delivery across Punjab. He established Pakistan's first Environmental Protection Force (EPF), marking a milestone in the country's environmental history. Under his direction, unprecedented anti-smog operations were conducted, resulting in the sealing of over 3,000 polluting units and imposition of fines exceeding Rs. 300 million. These efforts contributed to a reduction of 22 unhealthy air days in 2024 compared to the previous year. Additionally, more than 720 emission control systems were installed, leading to a 41.25% reduction in $PM_{2.5}$ levels and a marked decline in industrial pollution.

Dr Sheikh's Anti-Plastic Campaign led to the seizure of over 200 tonnes of illegal plastic and the filing of 252 cases before magistrates. He championed the digital transformation of EPA Punjab by initiating the Smog War Room, the Green Punjab App, and the Environment Management System (EMS). For the first time in Pakistan's history, a vehicular emission testing regime was introduced in Punjab. His commitment to public engagement and environmental restoration is

reflected in the planting of over 400,000 trees surrounding brick kilns and the establishment of a Miyawaki forest at Hiran Minar.

Dr Sheikh's achievements have been recognised by the Lahore High Court, the National Assembly Committee, the International Centre for Integrated Mountain Development (ICIMOD), the World Economic Forum 2025, and the US Congressional Pakistan Caucus. Public satisfaction with EPA Punjab's smog mitigation efforts reached 63%, underscoring his impactful leadership. His dedication to positioning Punjab as a leading environmental actor at the national and international levels is widely commended.

On 13 May 2026, Dr Imran Hamid Sheikh was conferred the Sitara-e-Imtiaz by the Governor of Punjab, Sardar Saleem Haider Khan, in recognition of his meritorious services to environmental protection. This prestigious civil award stands as a testament to his unwavering commitment and the enduring impact of his work on Punjab's environment and its people.

US Congressional Pakistan Caucus Acknowledges Punjab's Brick Kiln Reforms

The United States Congressional Pakistan Caucus has formally acknowledged the Punjab government's efforts to promote cleaner brick kiln technologies. This significant endorsement from a foreign legislative body affirms the global recognition accruing to Punjab's environmental reform agenda.

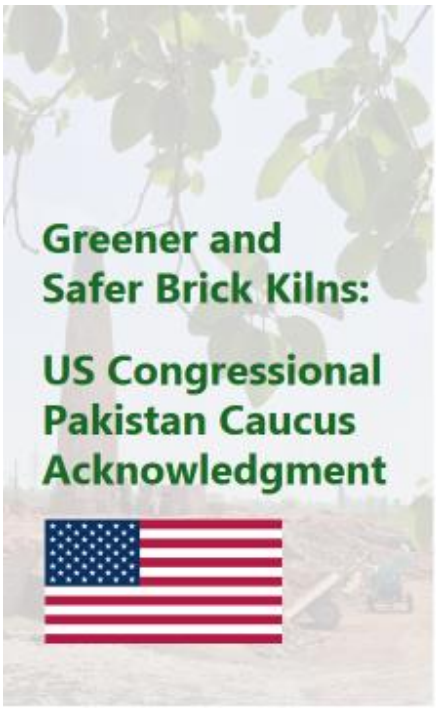
Air pollution remains a critical concern in Punjab, with brick kilns representing a substantial source of particulate matter (PM) pollution that degrades air quality and adversely impacts public health. To address this, the Environment Protection and Climate Change Department (EP&CCD) launched a sustained campaign to transition brick kilns from traditional, highly polluting firing methods to the more efficient and environmentally friendly zig-zag firing technology.

The zig-zag technology reduces fuel consumption and significantly lowers $PM_{2.5}$ emissions. Punjab's strategy combined regulatory enforcement, technical assistance, and on-ground compliance actions to facilitate this large-scale transition.

The recognition by the US Congressional Pakistan Caucus underscores the importance and success of this initiative and serves as a message to other

provinces and countries that substantial emission reductions in the brick kiln sector are achievable when supported by an effective policy mix.

ICIMOD Nepal Commends Punjab's Zig-Zag Technology Campaign





Congress of the United States
Washington, DC 20515

November 12, 2025

The Honorable Maryam Nawaz Sharif
Chief Minister of Punjab
Office of the Chief Minister
8 Club Road, GOR-I,
Lahore, Pakistan

Dear Chief Minister Sharif,

On behalf of the Congressional Pakistan Caucus, we extend our sincere appreciation for your government's visionary efforts to modernize Punjab's brick kiln industry as a means to address environmental challenges and eliminate bonded labor.

According to the United States Department of State's "2022 Trafficking in Persons Report: Pakistan," more than 4.5million people remain trapped in the peshgi system — … an unjust labor practice which that has endured for centuries throughout South Asia."

We were briefed by Mr. Mike Brickley, President of Families Set Free, and Dr. Rubina Feroze Bhatti, International Leadership Scholar, on your administration's strong commitment to this transformative initiative. The mechanization and modernization of this critical sector will not only support Pakistan in fulfilling its international obligations to end bonded labor but also position Punjab as a more attractive destination for foreign direct investment, particularly from American businesses committed to ethical and sustainable engagement.

This progress is vital to enhancing bilateral economic relations and strengthening the overall Pakistan– U.S. partnership, fostering long-term growth and cooperation. Punjab is well-positioned to serve as a pilot province for this initiative, setting a benchmark for your nation. Modernizing brick kilns is a critical step that will not only advance human rights but will also make Pakistan more attractive to long term foreign investment.

The Pakistan Caucus wholeheartedly supports all efforts to end bonded labor. Please do not hesitate to reach out if there is any way the Caucus can be helpful in this endeavor. Thank you for your attention to this matter.

Thomas R. Suozzi
Member of Congress

Jack Bergman
Member of Congress

The International Centre for Integrated Mountain Development (ICIMOD), Nepal, has formally endorsed the Environmental Protection Agency (EPA) Punjab's efforts to address emissions from brick kilns. ICIMOD is a respected intergovernmental regional organisation with jurisdiction over the Hindu Kush Himalayan region.

"The stringent measures taken by the Environmental Protection Agency (EPA) Punjab to promote zig-zag technology in brick kilns has not only contributed reduced PM2.5 emissions but also has set the stage for other provinces to follow suit." Said; ICIMOD Nepal

This statement highlights two significant outcomes. Firstly, it validates the efforts of the campaign in Punjab by confirming a measurable reduction in the concentration of $PM_{2.5}$, one of the most detrimental air pollutants to human

health. Secondly, it acknowledges that the Punjab model presents a replicable framework that other provinces can adopt.

ICIMOD's endorsement further solidifies Punjab's standing as a regional leader in industrial pollution control in South Asia. Moreover, it exemplifies the efficacy of combining robust regulatory measures with technological support to achieve tangible improvements in air quality.

ICIMOD

Pema Gyamtsho Ph.D.
Director General

5 December 2024

Honourable Marriyum Aurangzeb
Senior Minister for Environment, Climate Change, Forest, Wildlife and Planning and Development Board
Government of Punjab, Pakistan

Subject: Invitation to grace the inaugural session of a programme to capacitate the Sindh Brick Kiln Owners and scale zig-zag brick kiln operation and Social Code of Conduct (SCoC) based on learnings from Punjab-Pakistan and Nepal.

Your Excellency,

Greetings from ICIMOD!

Firstly, we would like to appreciate the Government of Punjab's visionary leadership and impactful interventions in addressing climate change and promoting environmental sustainability. The strides made by Punjab in adopting cleaner and more sustainable technologies are commendable and serve as a model for other provinces in Pakistan.

The International Centre for Integrated Mountain Development (ICIMOD) is an intergovernmental regional knowledge centre working across the Hindu Kush Himalaya. ICIMOD has worked with partners to introduce zig-zag brick kiln technology in Pakistan while simultaneously strengthening the capacity of stakeholders, including the brick kiln industry and government departments. These initiatives would not have succeeded in Punjab without the support of the Environment Protection Department (EPD) Punjab, the Ministry of Climate Change, and the Brick Kiln Owners Association of Pakistan (BKOAP). The stringent measures taken by the Environmental Protection Agency (EPA) Punjab to promote zig-zag technology in brick kilns has not only contributed to reduced PM2.5 emissions but has also set the stage for other provinces to follow suit.



"The stringent measures taken by the Environmental Protection Agency (EPA) Punjab to promote zig-zag technology in brick kilns has not only contributed reduced PM2.5 emissions but also has set the stage for other provinces to follow suit"

Recognition of Improved Air Quality in 2025

A Swiss-based air quality technology firm, recognised as a leading global air quality platform, has acknowledged Punjab's significant success in improving air quality in 2025. Various districts across the province—including Lahore, Multan, Gujranwala, and Rawalpindi—have demonstrated measurable reductions in $PM_{2.5}$ concentrations. These province-wide improvements reflect the cumulative impact of coordinated anti-smog campaigns, stringent vehicular emission controls, brick kiln regulations, and extensive industrial enforcement actions that have progressively fortified Punjab's air quality governance framework.

Among all districts, Lahore—the most populous city of Punjab and historically one of the most severely impacted by smog—recorded the most pronounced improvement, emerging as a symbol of the province's environmental recovery. In 2025, Lahore's annual average $PM_{2.5}$ concentration stood at 89 $\mu g/m^3$, marking a 13% decrease from the 102 $\mu g/m^3$ recorded in 2024, according to IQAir Insight data. This represents Lahore's cleanest year since the COVID-19 lockdown in 2020, when $PM_{2.5}$ levels temporarily declined to 79 $\mu g/m^3$.

This recognition underscores the sustained anti-smog efforts and environmental enforcement undertaken by the Environmental Protection Agency (EPA) Punjab. It serves not only as a testament to the progress made but also as a renewed



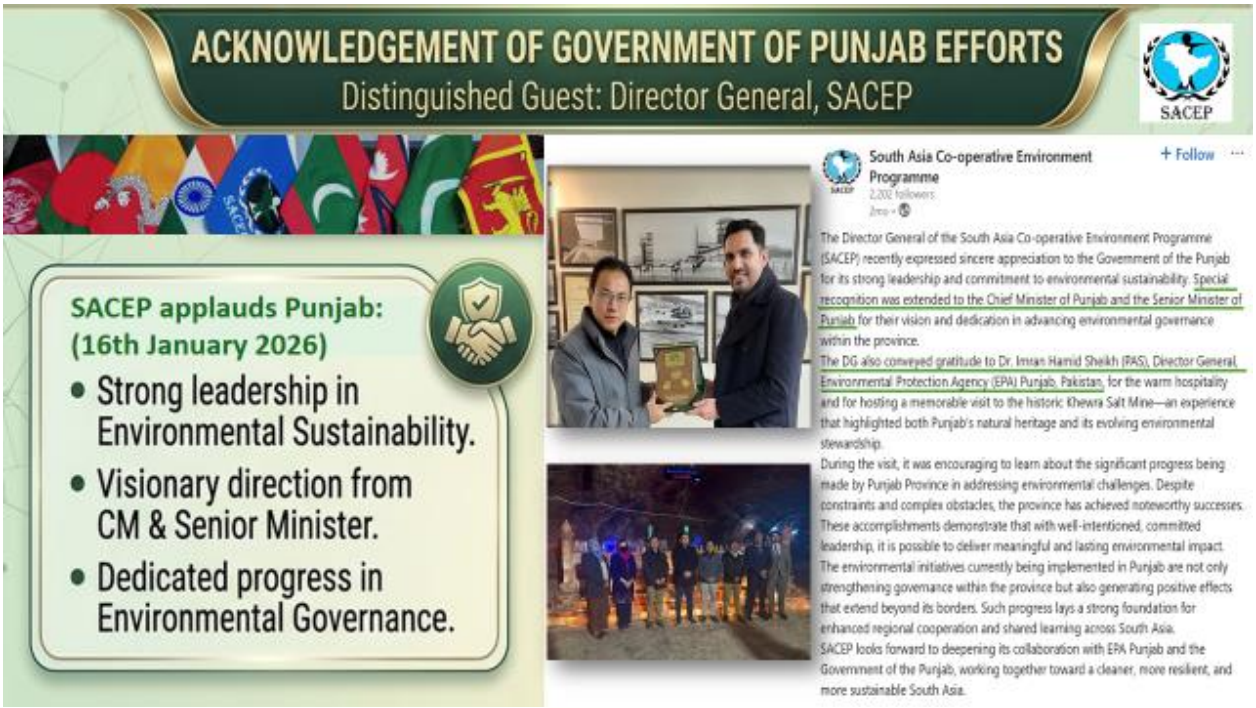
commitment to continue and intensify initiatives aimed at ensuring cleaner air for the people of Punjab.

SACEP Applauds Punjab's Environmental Leadership

On 16 January 2026, the South Asia Co-operative Environment Programme (SACEP) officially recognised Punjab for its exemplary role in environmental governance within South Asia. SACEP, an intergovernmental organisation established to support and promote the protection of the natural environment across the South Asian region, confers significant credibility on Punjab's environmental efforts. This acknowledgement signifies that Punjab's initiatives are not only acknowledged domestically but are also gaining prominence at the multilateral level.

This recognition places Punjab among the leading sub-national environmental governments in South Asia, highlighting the province's commitment to sustainable, evidence-based environmental management. EP&CCD Punjab's contributions through advanced monitoring systems, enforcement campaigns, and climate adaptation efforts have been central to this achievement.

While SACEP's commendation pays tribute to these past accomplishments, it also represents a clarion call to sustain and build upon the progress achieved.





EPA PUNJAB'S SUCCESS STORIES

Punjab Recognised at the World Economic Forum 2025, Davos

Punjab's environmental leadership was prominently acknowledged at the World Economic Forum (WEF) 2025, held in Davos, Switzerland. The WEF is one of the world's most influential gatherings of political leaders, business executives, and civil society representatives. Recognition on this global platform places Punjab among a select group of sub-national governments making significant contributions to climate action.

Davos serves as a crucible for setting global priorities, and Punjab's acknowledgement there underscores the importance of its environmental initiatives and their relevance to international climate and sustainable development discourse. This recognition validates the Government of Punjab's efforts across a range of environmental domains including brick kiln reform, smog control, international cooperation, and knowledge sharing. It affirms EP&CCD's long-term vision of institution-building, generation of credible environmental data, and the formulation of policies designed to deliver measurable outcomes.

The World Economic Forum's endorsement highlights Punjab not only as a province actively addressing its environmental challenges but also as a model demonstrating how sub-national governments can play a pivotal role in advancing global climate action.

WORLD ECONOMIC FORUM 2025
(DAVOS, SWITZERLAND)





EPA's Success Story Presented at International Air Quality Conference, Colombia

Punjab's Environmental Protection Agency (EPA) was invited to present its success story at an International Air Quality Conference held in Colombia in March 2025. This recognition positioned Punjab's EPA prominently on a global platform dedicated to addressing air pollution, one of the most pressing public health challenges worldwide.

Being invited to speak at such a prestigious conference affirms the EPA's practices, tools, and policies as exemplary models worthy of international sharing. The presentation likely focused on EPA Punjab's approach to managing air pollution in the form of smog and particulate matter—a pervasive issue affecting millions annually. By sharing its methodologies with peers across the globe, EPA Punjab has contributed meaningfully to the global knowledge base on urban and regional air quality management.

This recognition further underscores the importance of data-driven governance. Investments by the Government of Punjab in air quality monitoring and real-time environmental intelligence—exemplified by initiatives such as the Climate Watch facility—have provided robust evidence, enabling EPA Punjab to make credible contributions to international dialogues on air pollution.



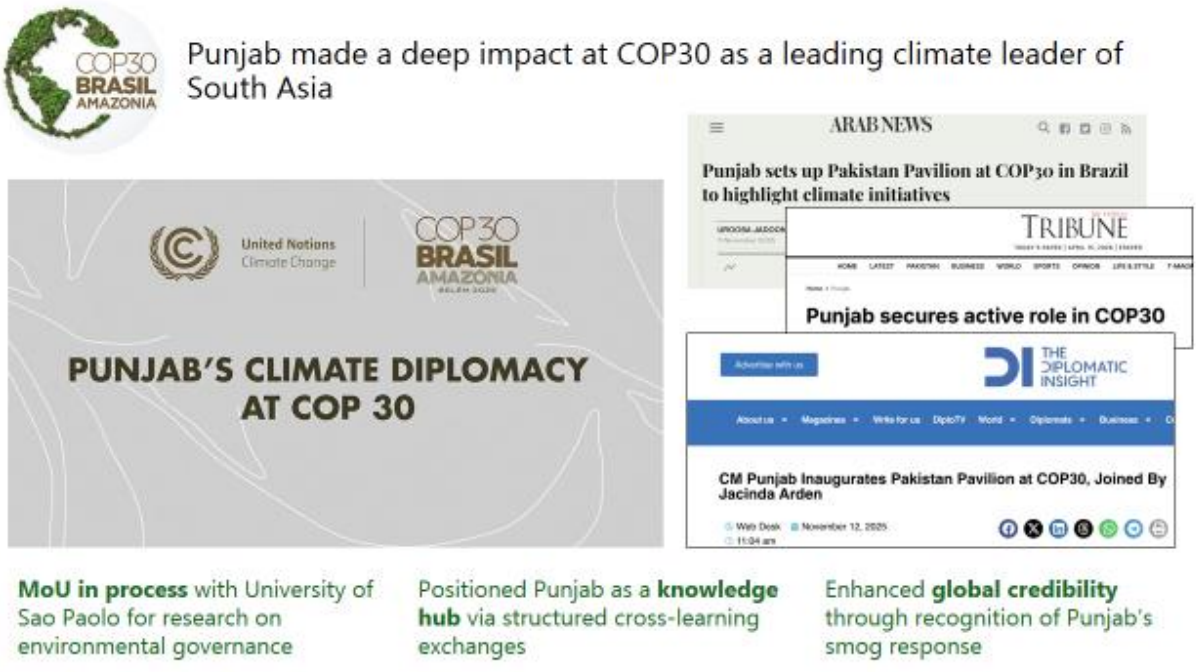
Punjab Emerges as a Leading Climate Voice at COP30

The 30th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP30) represented a significant milestone for Punjab. The province participated not only as an observer but emerged as a key climate actor within South Asia.

At COP30, Punjab achieved tangible outcomes: a Memorandum of Understanding (MoU) is nearing finalisation with the University of São Paulo, establishing a collaborative partnership focused on environmental governance and fostering institutional relationships between the Government of Punjab and one of Latin America's premier academic institutions.

Punjab has positioned itself as a hub of knowledge, facilitating cross-learning and the exchange of best practices in environmental management and climate adaptation across the region. The province's innovative approach to combating smog has earned international recognition, cited as a model exemplifying effective sub-national climate governance amid a persistent and complex challenge.

COP30 also provided Punjab with a platform to demonstrate its capacity for climate action at the provincial level. Its active participation and commendable performance at this global forum have enhanced its credibility and solidified its role as a proactive leader in climate governance.



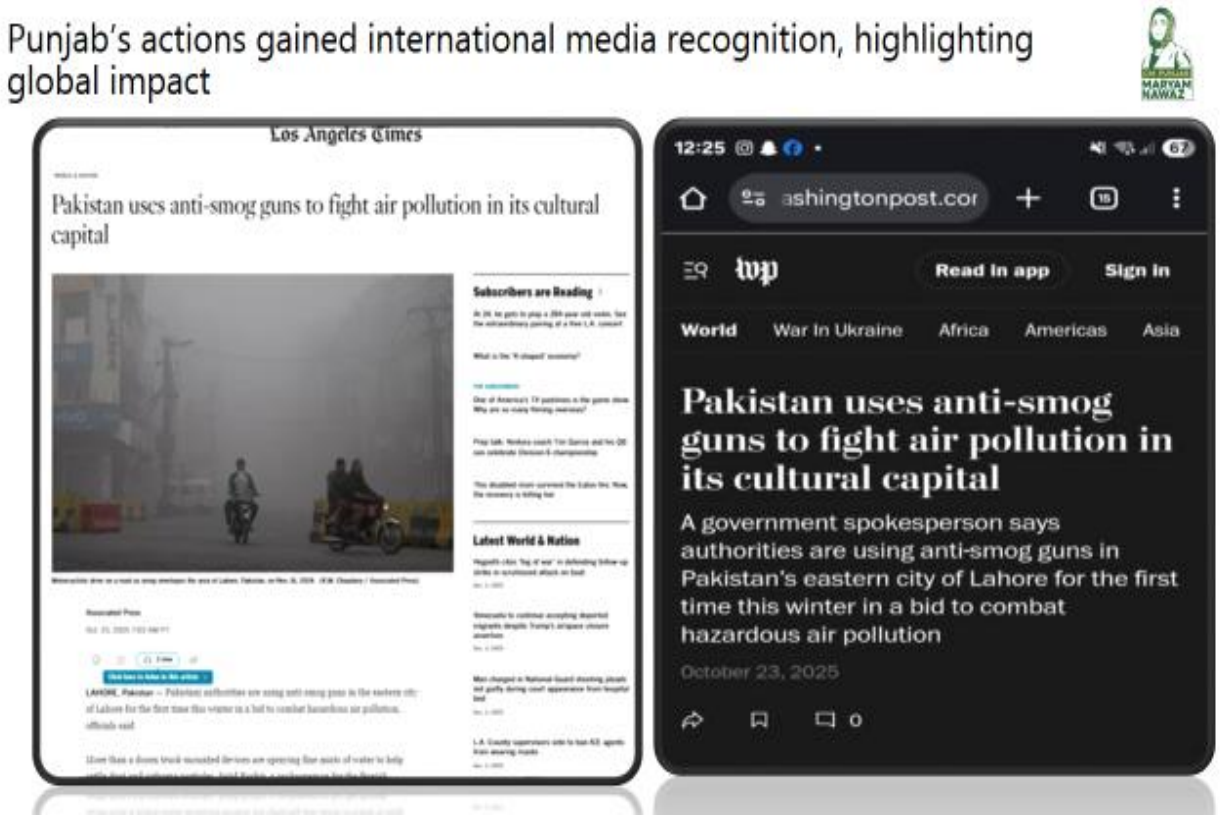


ACHIEVEMENTS

Punjab's Climate Actions Gain International Media Recognition

Punjab's environmental initiatives have garnered coverage from international media, signifying recognition that extends beyond institutional or diplomatic channels. Such global media attention underscores the credibility and significance of Punjab's environmental narrative, elevating the province's profile among researchers, policymakers, and civil society actors worldwide.

This international exposure highlights the broader impact of Punjab's climate actions, illustrating that efforts to address local challenges such as smog, air pollution, and environmental degradation contribute meaningfully to transnational environmental outcomes. Furthermore, international media scrutiny serves as a form of accountability, encouraging Punjab to pursue ambitious environmental objectives and uphold the standards it has established.



Public Endorsement: Survey Shows Support for Punjab's Smog Initiatives

A public survey conducted in smog-affected Punjab—reported by the Express Tribune—indicated strong public support for the measures implemented by Chief Minister Maryam Nawaz to mitigate the adverse effects of smog. This domestic endorsement complements the international recognition the province has garnered.

Public support serves as a critical measure of the success of any environmental programme. When citizens acknowledge and endorse government actions, it provides the authorities with the mandate to sustain and reinforce their efforts. Moreover, it reflects that environmental policies are resonating with the population, directly impacting their daily lives in meaningful and appreciable ways.

The survey findings also underscore a fundamental truth: environmental governance transcends technical or diplomatic procedures; it must earn the trust and backing of the communities it serves. The Punjab government's strategy—combining enforcement, awareness-raising, and tangible improvements in air quality—appears to have resonated effectively with the public.

These domestic accolades, alongside the international recognitions detailed in this section, paint an encouraging picture of Punjab's environmental progress. The province has secured both the trust of its citizens and the respect of the global community—an achievement that lays a firm foundation for addressing the environmental challenges ahead.

Punjab as a Global Model for Climate Action: International Delegations Seek Lessons from EP&CCD

In recognition of EPA Punjab's leadership in environmental protection and monitoring oversight, global leaders have increasingly visited Punjab Climate Watch to learn about the province's climate action strategies. This growing

international appreciation underscores the significance of Punjab's environmental policies and real-time monitoring systems.

In 2025, numerous high-level delegations—including representatives from the United States, the British High Commission, Turkey, the United Nations Population Fund (UNFPA), and the World Bank—visited Punjab Climate Watch or received detailed briefings on EP&CCD's environmental strategy, monitoring infrastructure, and institutional framework.

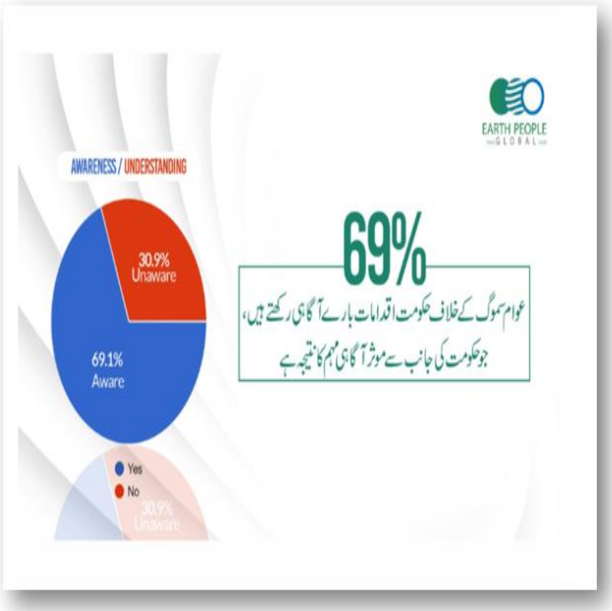
These visits reflect a sustained and expanding pattern of international interest, rather than isolated diplomatic interactions. Each engagement has contributed to the refinement of Punjab Climate Watch, enabling EPA Punjab to benchmark its systems against global best practices while simultaneously offering its model as a replicable framework for regions confronting analogous environmental challenges.

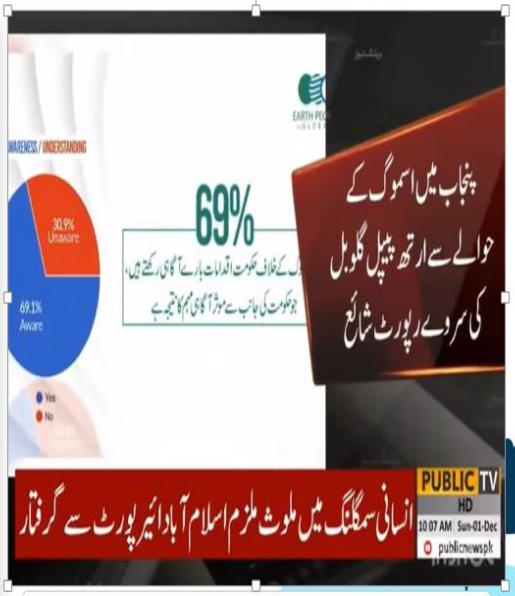
Most notably, Punjab has shifted from being a recipient of international guidance to serving as a global reference point—a province that has demonstrated its capacity to effectively address the climate crisis through institutional innovation, data-driven governance, and coordinated enforcement. As global engagement with Punjab Climate Watch continues to grow, this dynamic cycle of learning and enhancement positions the facility as an evolving hub for climate knowledge exchange on the world stage.

Punjab smog survey shows public support for Maryam Nawaz's steps

The majority of Lahore residents believe vehicle emissions are the top cause of smog.

News Desk | December 01, 2024





https://tribune.com.pk/story/2513041/punjab-smog-survey-shows-public-support-for-maryam-nawa

Global community leaders have started approaching Punjab to gather lessons on how to respond to a climate challenge



US Delegation Visited Punjab Climate Watch



Turkish Delegation briefed on EP&CCD strategy



World Bank delegation being briefed on EP&CCD strategy



British High Commission touring Punjab Climate Watch



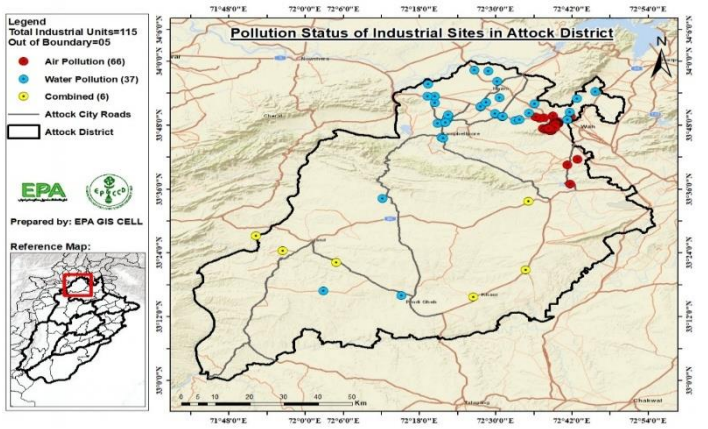
UNFPA Delegation touring Punjab Climate Watch

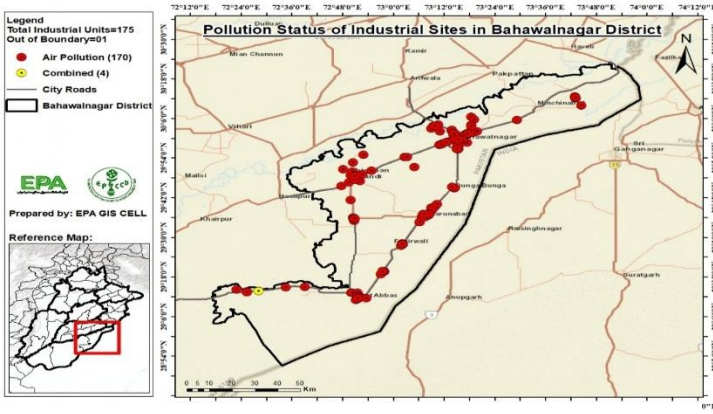


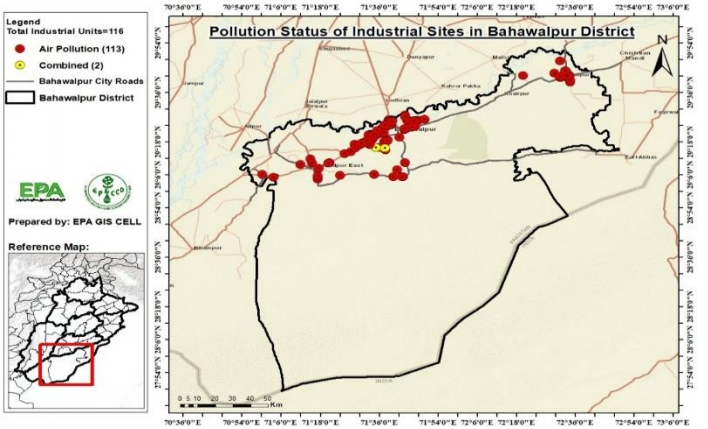
ANNEXURES

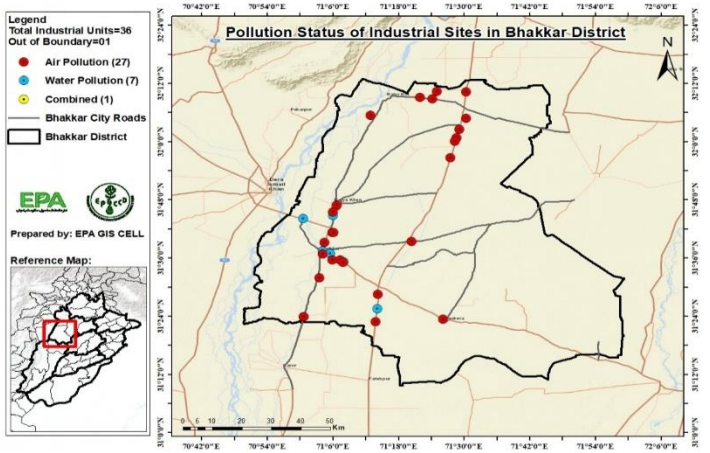
Annex-I

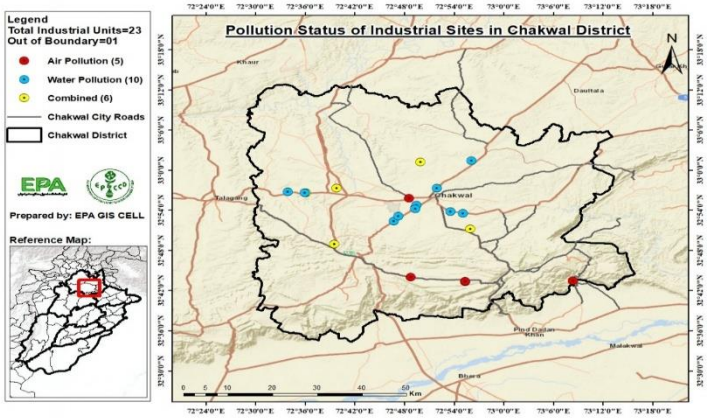
Pollution status maps of Punjab

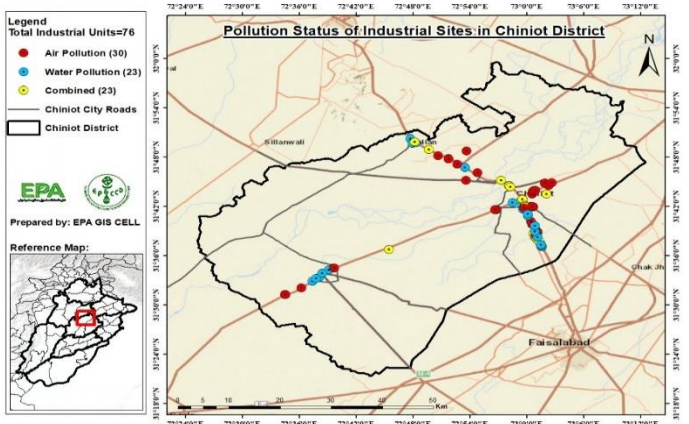


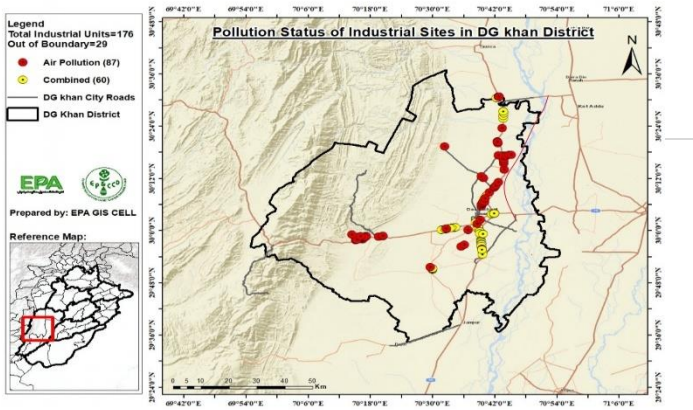


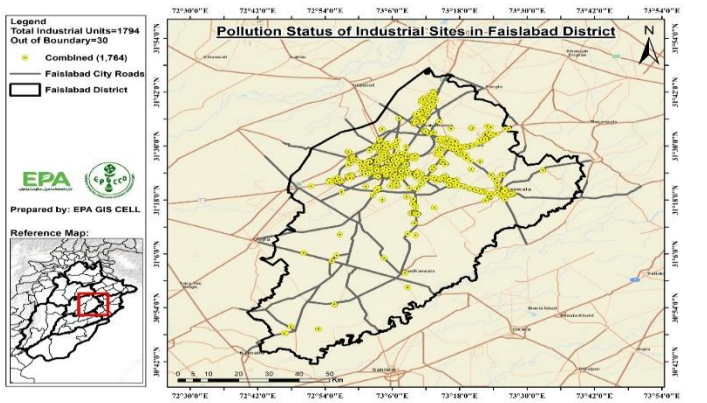


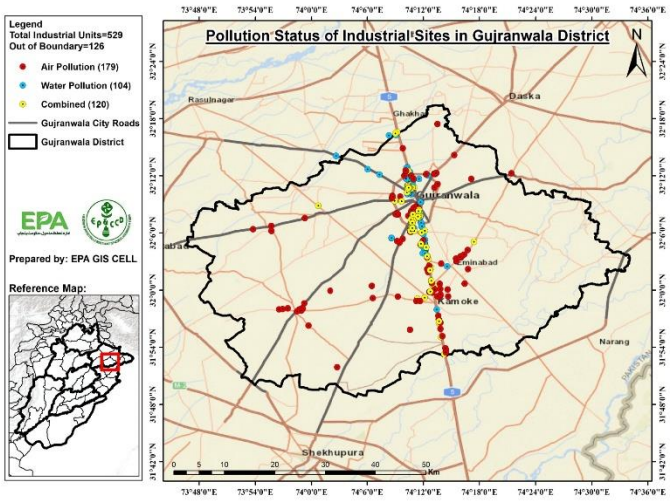


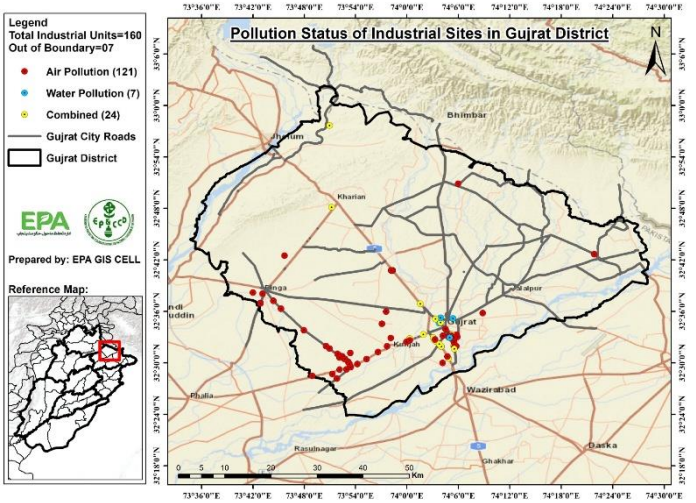


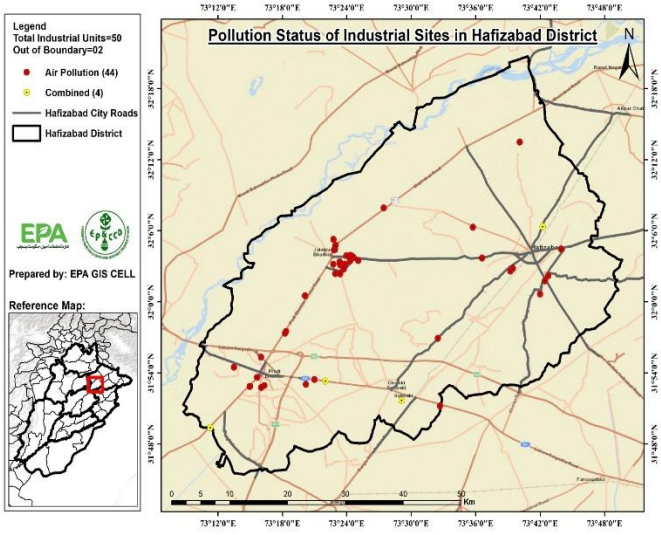


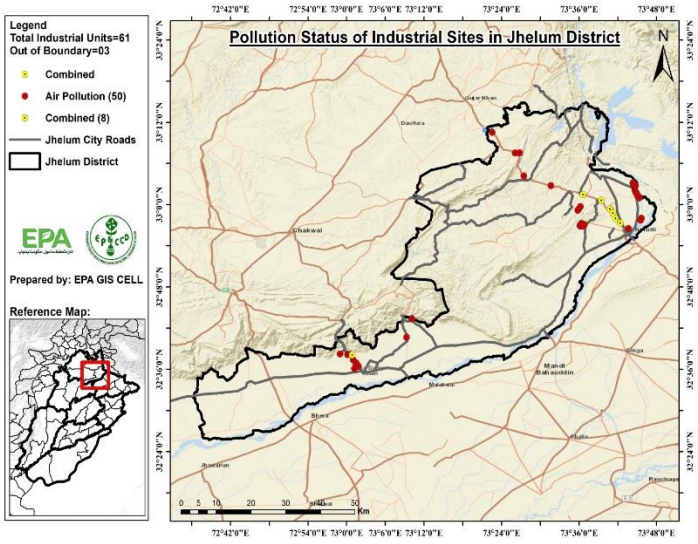


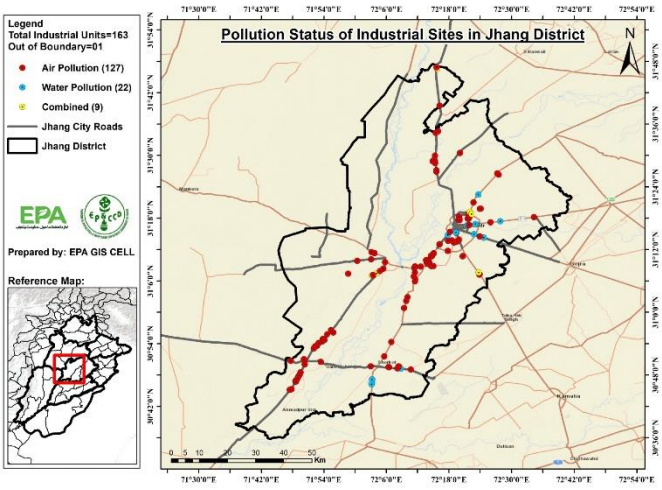


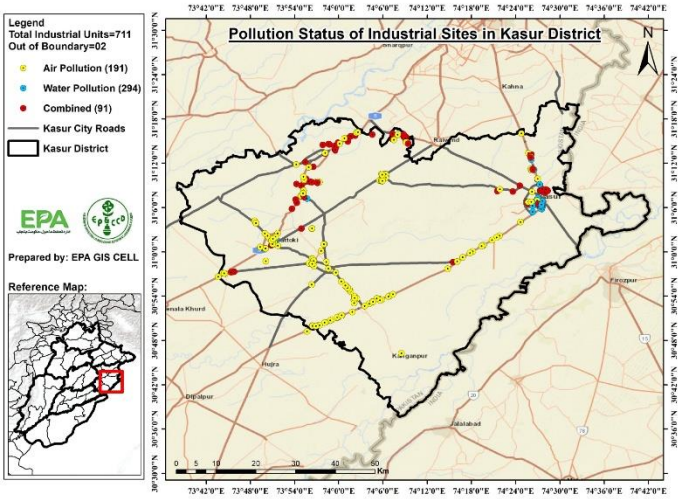

Pollution Status of Industrial Sites in Gujranwala District
Legend
Total Industrial Units=529
Out of Boundary=126
Air Pollution (179)
Water Pollution (104)
Combined (120)
Gujranwala City Roads
Gujranwala District
Prepared by: EPA GIS CELL
Reference Map:
Daska
Rasulnagar
Shakhar
Gujranwala
Eminabad
Kamoke
Narang
Shekhupura
N
Km

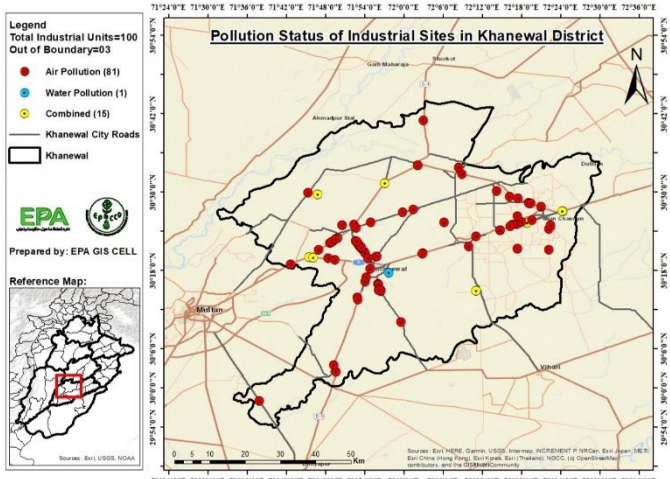

Pollution Status of Industrial Sites in Gujrat District
Legend
Total Industrial Units=160
Out of Boundary=07
Air Pollution (121)
Water Pollution (7)
Combined (24)
Gujrat City Roads
Gujrat District
Prepared by: EPA GIS CELL
Reference Map:
Bhimbar
Jhelum
Kharian
Gujrat
Kunjah
Phalia
Wazirabad
Rasulnagar
Daska
Ghakhar
N
Km

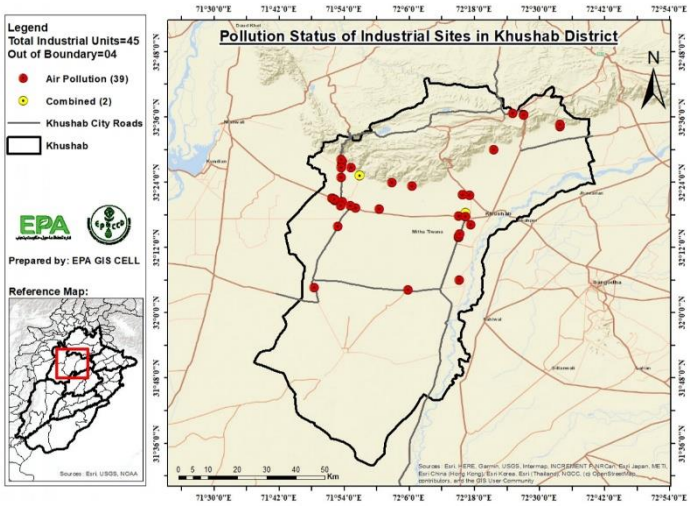

Pollution Status of Industrial Sites in Hafizabad District
Legend
Total Industrial Units=50
Out of Boundary=02
Air Pollution (44)
Combined (4)
Hafizabad City Roads
Hafizabad District
Prepared by: EPA GIS CELL
Reference Map:
N
Km

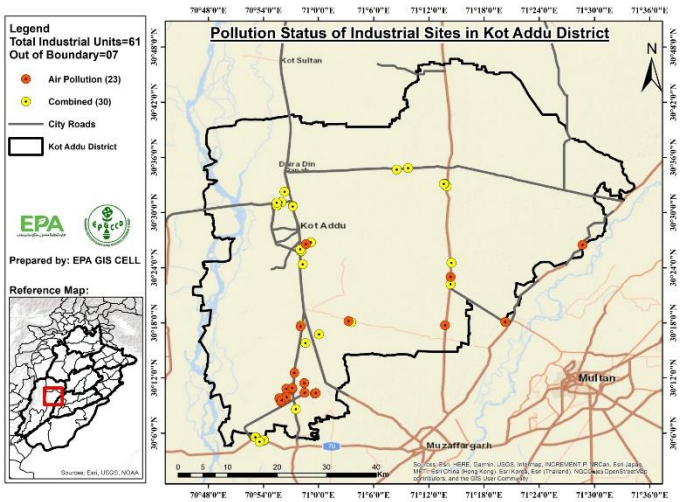

Pollution Status of Industrial Sites in Jhelum District
Legend
Total Industrial Units=61
Out of Boundary=03
Combined
Air Pollution (50)
Combined (8)
Jhelum City Roads
Jhelum District
Prepared by: EPA GIS CELL
Reference Map:
Chakwal
Mandi Bahauddin
Bhera
Phalia
N
Km

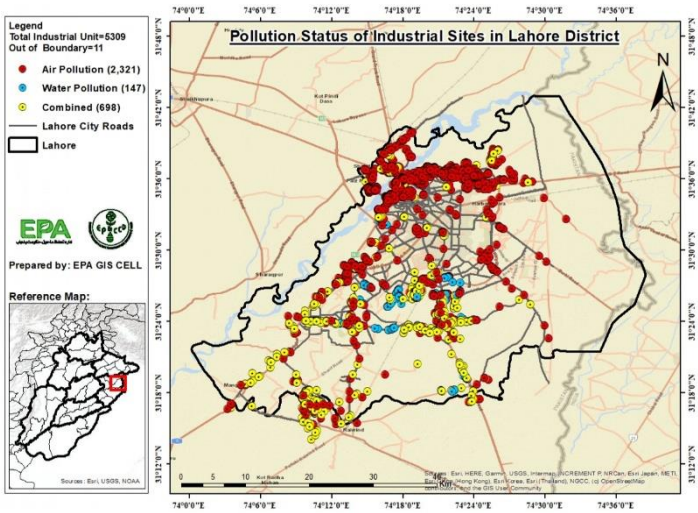

Pollution Status of Industrial Sites in Jhang District
Legend
Total Industrial Units=163
Out of Boundary=01
Air Pollution (127)
Water Pollution (22)
Combined (9)
Jhang City Roads
Jhang District
Prepared by: EPA GIS CELL
Reference Map:
N
Km

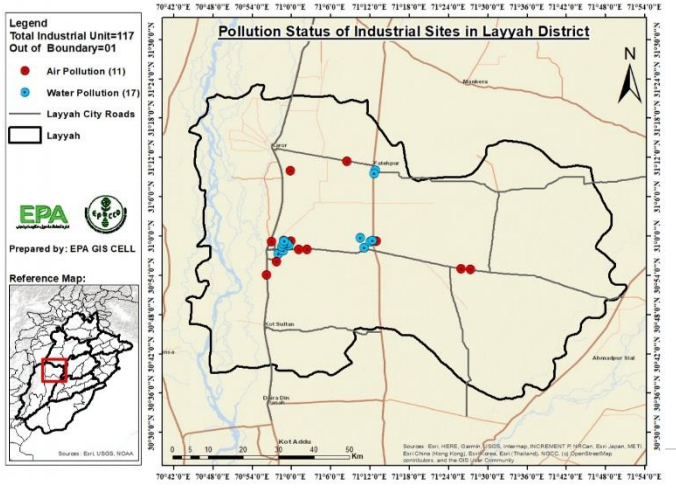

Pollution Status of Industrial Sites in Kasur District
Legend
Total Industrial Units=711
Out of Boundary=02
Air Pollution (191)
Water Pollution (294)
Combined (91)
Kasur City Roads
Kasur District
Prepared by: EPA GIS CELL
Reference Map:
Kasur
Pattoki
Firozpur
Raiwind
Jalalabad
N
Km

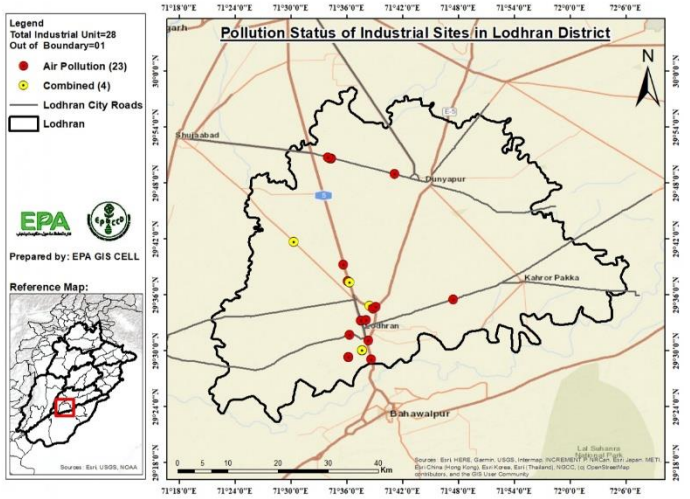

Pollution Status of Industrial Sites in Khanewal District
Legend
Total Industrial Units=100
Out of Boundary=03
Air Pollution (81)
Water Pollution (1)
Combined (15)
Khanewal City Roads
Khanewal
Prepared by: EPA GIS CELL
Reference Map:
Multan
Vihari
N

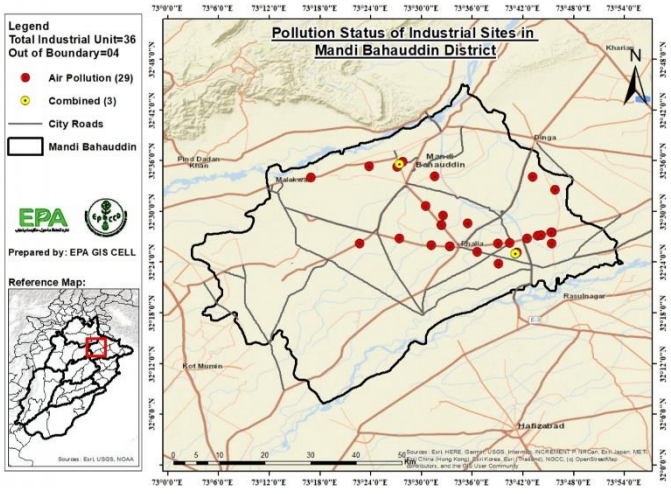

Pollution Status of Industrial Sites in Khushab District
Legend
Total Industrial Units=45
Out of Boundary=04
Air Pollution (39)
Combined (2)
Khushab City Roads
Khushab
Prepared by: EPA GIS CELL
Reference Map:
N

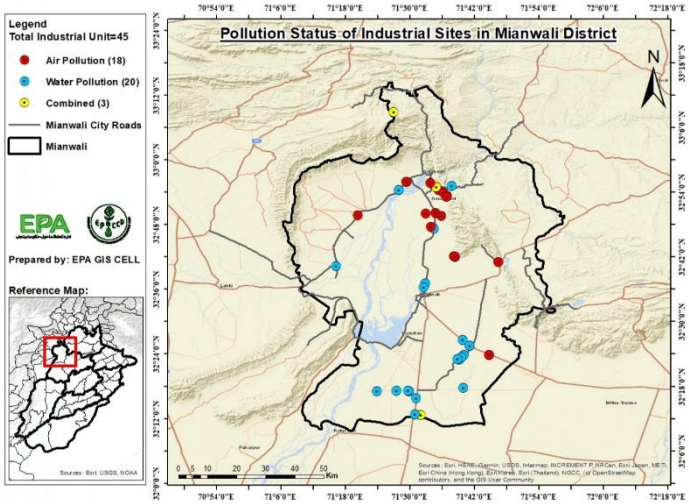

Pollution Status of Industrial Sites in Kot Addu District
Legend
Total Industrial Units=61
Out of Boundary=07
Air Pollution (23)
Combined (30)
City Roads
Kot Addu District
Prepared by: EPA GIS CELL
Reference Map:
Kot Sultan
Kot Addu
Multan
Muzaffargarh
N

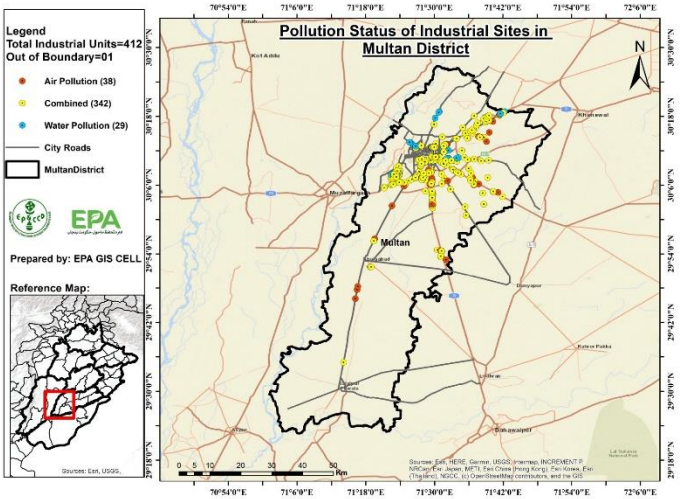

Pollution Status of Industrial Sites in Lahore District
Legend
Total Industrial Unit=5309
Out of Boundary=11
Air Pollution (2,321)
Water Pollution (147)
Combined (698)
Lahore City Roads
Lahore
Prepared by: EPA GIS CELL
Reference Map:
N

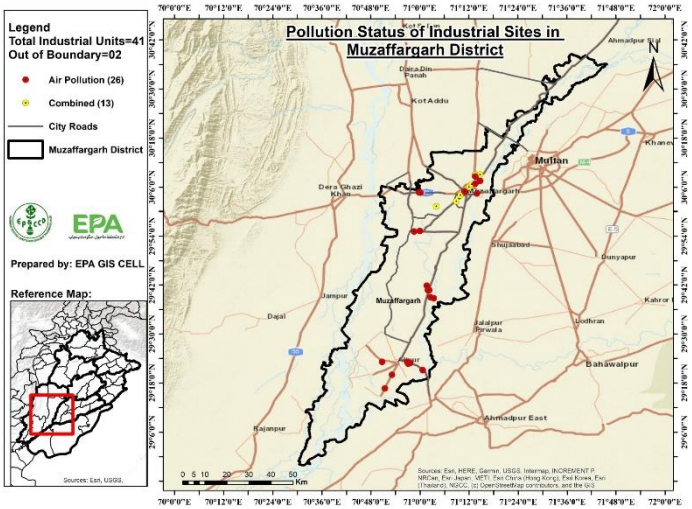

Pollution Status of Industrial Sites in Layyah District
Legend
Total Industrial Unit=117
Out of Boundary=01
Air Pollution (11)
Water Pollution (17)
Layyah City Roads
Layyah
Prepared by: EPA GIS CELL
Reference Map:
Kot Sultan
Kot Addu
N

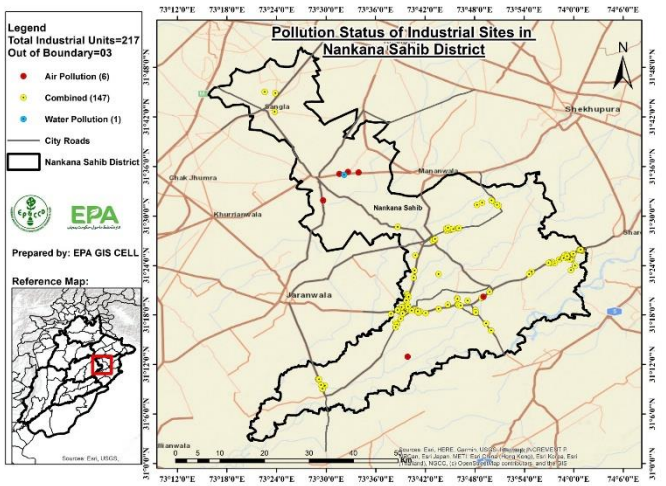

Pollution Status of Industrial Sites in Lodhran District
Legend
Total Industrial Unit=28
Out of Boundary=01
Air Pollution (23)
Combined (4)
Lodhran City Roads
Lodhran
Prepared by: EPA GIS CELL
Reference Map:
Shujabad
Dunyapur
Kahror Pakka
Lodhran
Bahawalpur
N

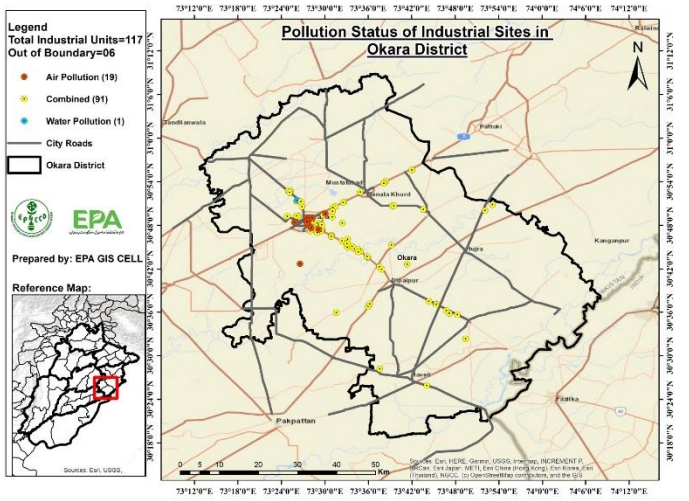

Pollution Status of Industrial Sites in Mandi Bahauddin District
Legend
Total Industrial Unit=36
Out of Boundary=04
Air Pollution (29)
Combined (3)
City Roads
Mandi Bahauddin
Prepared by: EPA GIS CELL
Reference Map:
Mandi Bahauddin
Malakwal
Phalia
Rasulnagar
Hafizabad
Khariala
Dinga
Pind Dadan Khan
Kot Momin
N

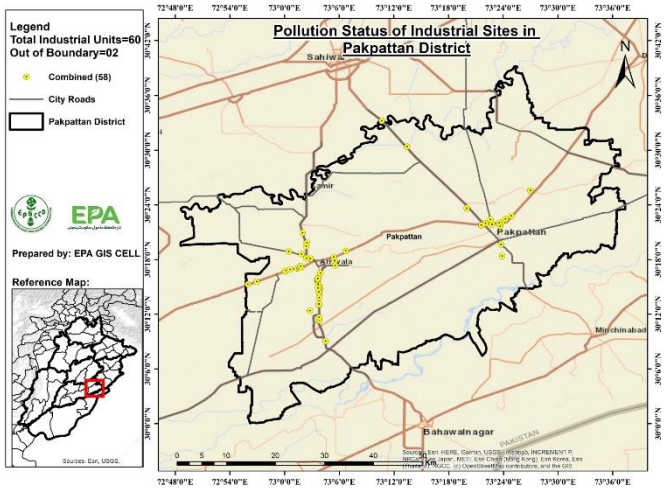

Pollution Status of Industrial Sites in Mianwali District
Legend
Total Industrial Unit=45
Air Pollution (18)
Water Pollution (20)
Combined (3)
Mianwali City Roads
Mianwali
Prepared by: EPA GIS CELL
Reference Map:
N

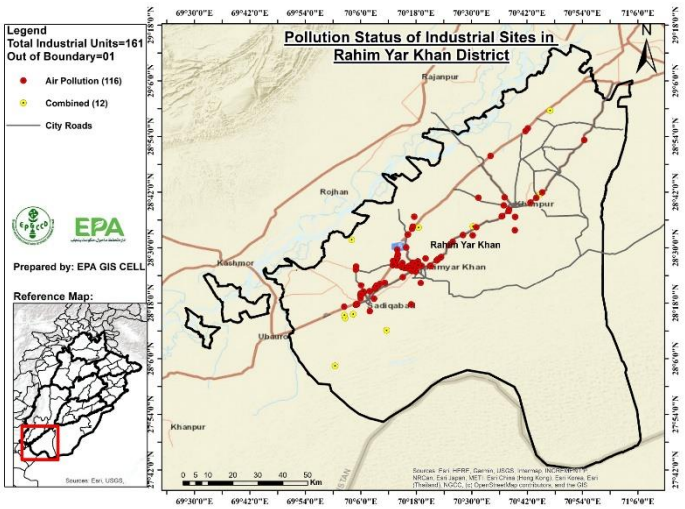

Pollution Status of Industrial Sites in Multan District
Legend
Total Industrial Units=412
Out of Boundary=01
Air Pollution (38)
Combined (342)
Water Pollution (29)
City Roads
MultanDistrict
Prepared by: EPA GIS CELL
Reference Map:
Multan
Shujabad
Jalalpur Pirwala
Bahawalpur
N

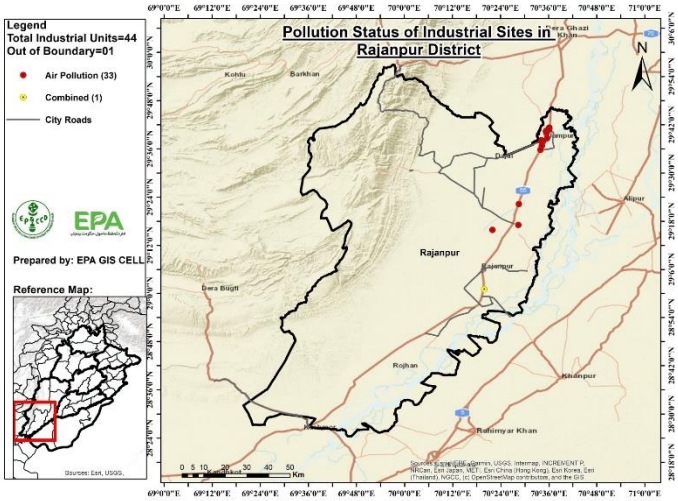

Pollution Status of Industrial Sites in Muzaffargarh District
Legend
Total Industrial Units=41
Out of Boundary=02
Air Pollution (26)
Combined (13)
City Roads
Muzaffargarh District
Prepared by: EPA GIS CELL
Reference Map:
Kot Addu
Multan
Shujabad
Dunyapur
Jampur
Muzaffargarh
Dajal
Jalalpur Pirwala
Lodhran
Bahawalpur
Rajanpur
Ahmadpur East
N

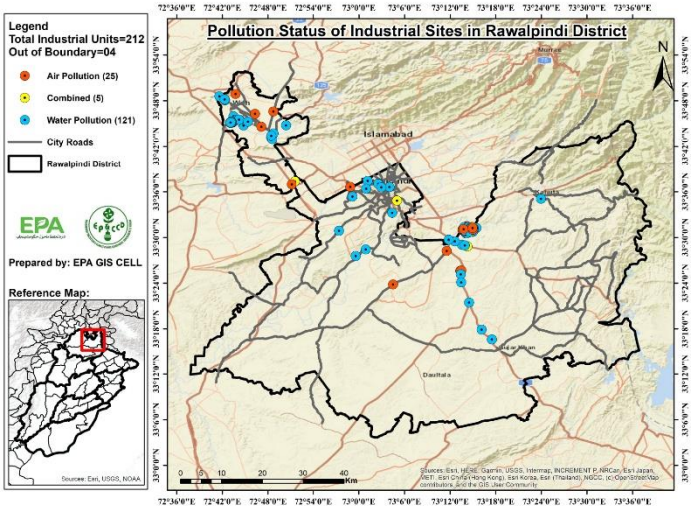

Pollution Status of Industrial Sites in Nankana Sahib District
Legend
Total Industrial Units=217
Out of Boundary=03
Air Pollution (6)
Combined (147)
Water Pollution (1)
City Roads
Nankana Sahib District
Prepared by: EPA GIS CELL
Reference Map:
Shekhupura
Chak Jhumra
Khurrianwala
Nankana Sahib
Jaranwala
N

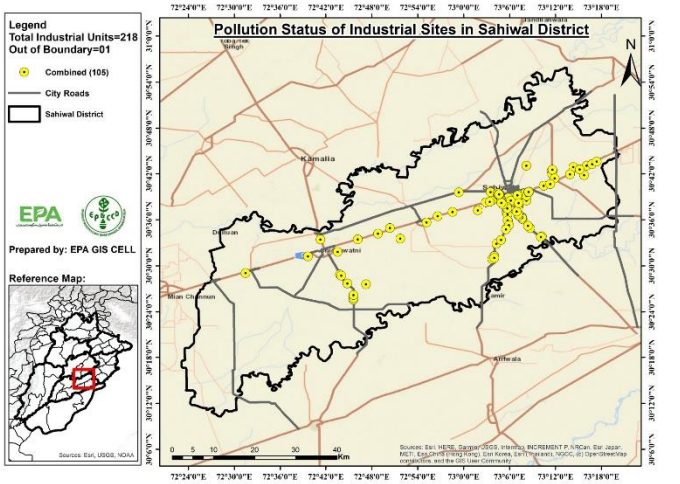

Pollution Status of Industrial Sites in Okara District
Legend
Total Industrial Units=117
Out of Boundary=06
Air Pollution (19)
Combined (91)
Water Pollution (1)
City Roads
Okara District
Prepared by: EPA GIS CELL
Reference Map:
Okara
Renala Khurd
Depalpur
Pakpattan
Pattoki
N

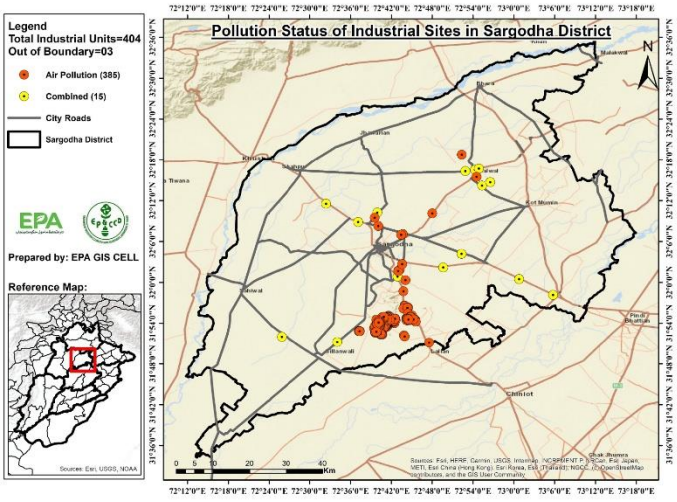

Legend
Total Industrial Units=60
Out of Boundary=02
Combined (58)
City Roads
Pakpattan District
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Pakpattan District
Sahiwal
Arifwala
Pakpattan
Pakpattan
Mirchinabad
Bahawalnagar
N

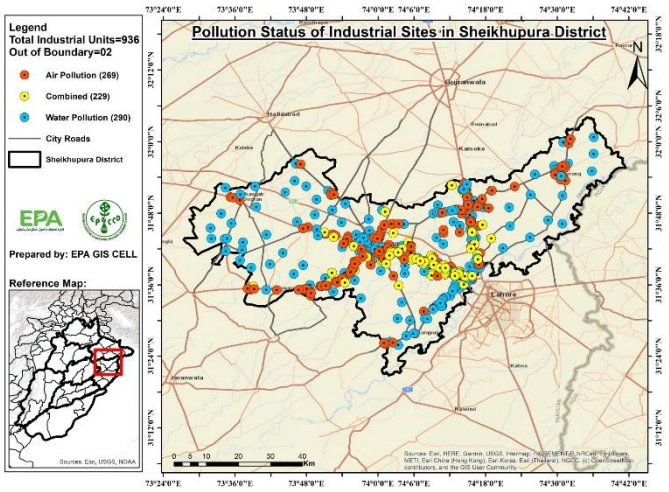

Legend
Total Industrial Units=161
Out of Boundary=01
Air Pollution (116)
Combined (12)
City Roads
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Rahim Yar Khan District
Rajanpur
Rojhan
Kashmor
Rahim Yar Khan
Sadiqabad
Ubauro
Khanpur
N

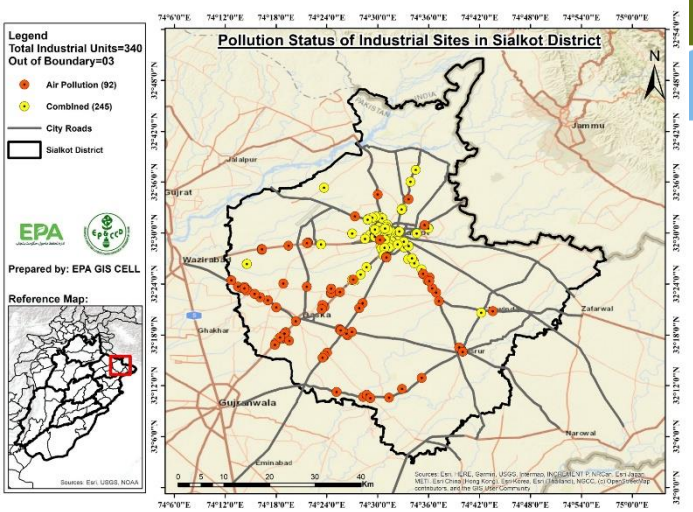

Legend
Total Industrial Units=44
Out of Boundary=01
Air Pollution (33)
Combined (1)
City Roads
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Rajanpur District
Kohlu
Barkhan
Dera Ghazi Khan
Dajal
Jampur
Rajanpur
Dera Bugti
Rojhan
Khanpur
Kashmor
Rahimyar Khan
N

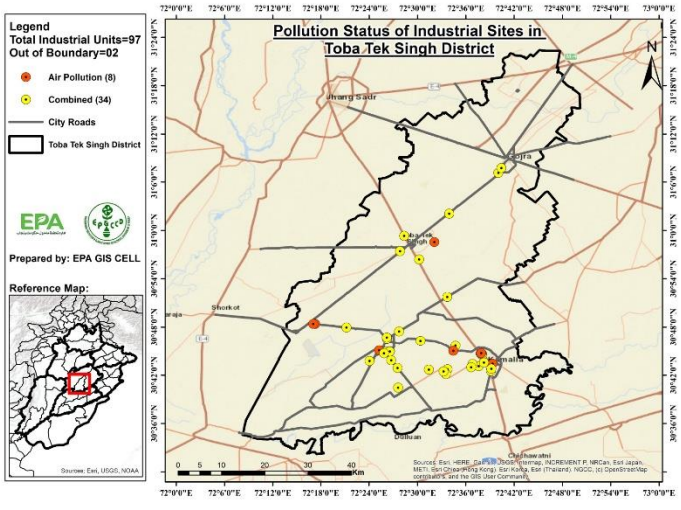

Legend
Total Industrial Units=212
Out of Boundary=04
Air Pollution (25)
Combined (5)
Water Pollution (121)
City Roads
Rawalpindi District
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Rawalpindi District
Murree
Islamabad
Attock
Daultala
N

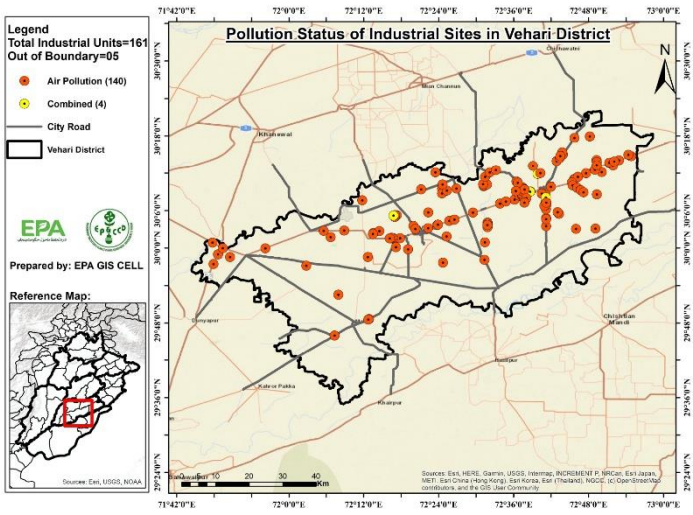

Legend
Total Industrial Units=218
Out of Boundary=01
Combined (105)
City Roads
Sahiwal District
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Sahiwal District
Kamalia
Sahiwal
Chichawatni
Mian Channun
Arifwala
N


Legend
Total Industrial Units=404
Out of Boundary=03
Air Pollution (385)
Combined (15)
City Roads
Sargodha District
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Sargodha District
Bhera
Shahpur
Khushab
Sargodha
Sillanwali
Bhalwal
Chiniot
N


Pollution Status of Industrial Sites in Sheikhupura District
Legend
Total Industrial Units=936
Out of Boundary=02
Air Pollution (269)
Combined (229)
Water Pollution (290)
City Roads
Sheikhupura District
Prepared by: EPA GIS CELL
Reference Map:
Lahore
Kasur
Gujranwala
Sheikhupura
Kamoke
Kala Shah Kaku
Pattoki
Kanganpur
Kalasa
Narowal
Sharqpur
Ferozewala
Halkabad
Kaleke
Sources: Esri, USGS, NOAA
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

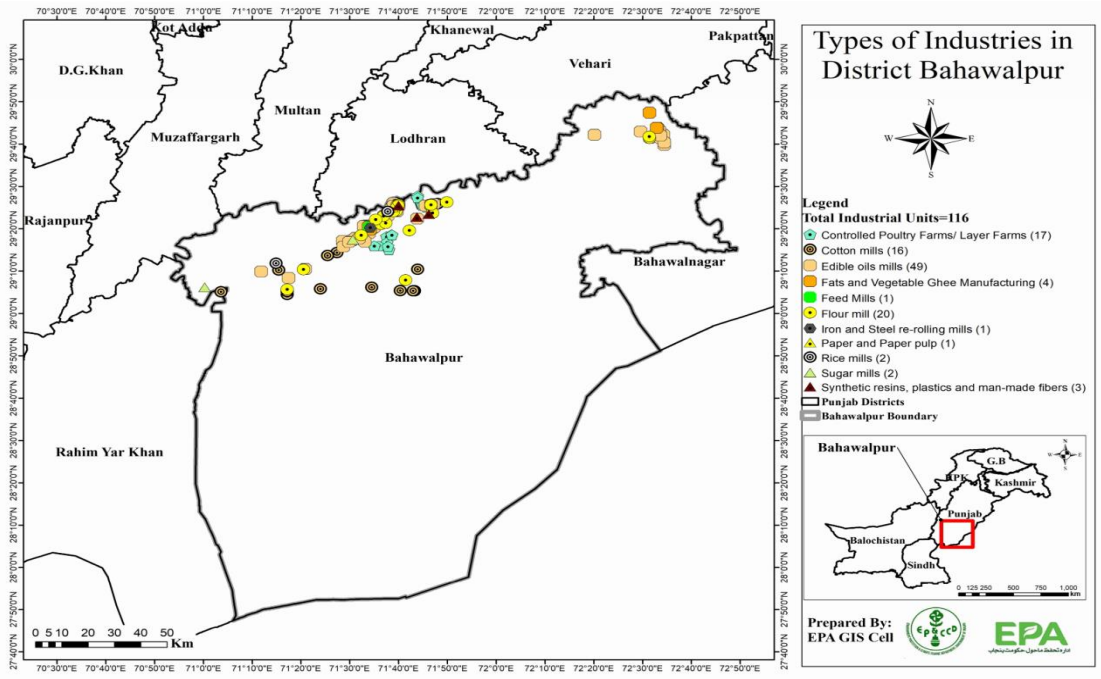

Pollution Status of Industrial Sites in Sialkot District
Legend
Total Industrial Units=340
Out of Boundary=03
Air Pollution (92)
Combined (245)
City Roads
Sialkot District
Prepared by: EPA GIS CELL
Reference Map:
Jammu
Jalalpur
Gujrat
Wazirabad
Daska
Ghakhar
Gujranwala
Zafarwal
Narowal
Eminabad
Sources: Esri, USGS, NOAA
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

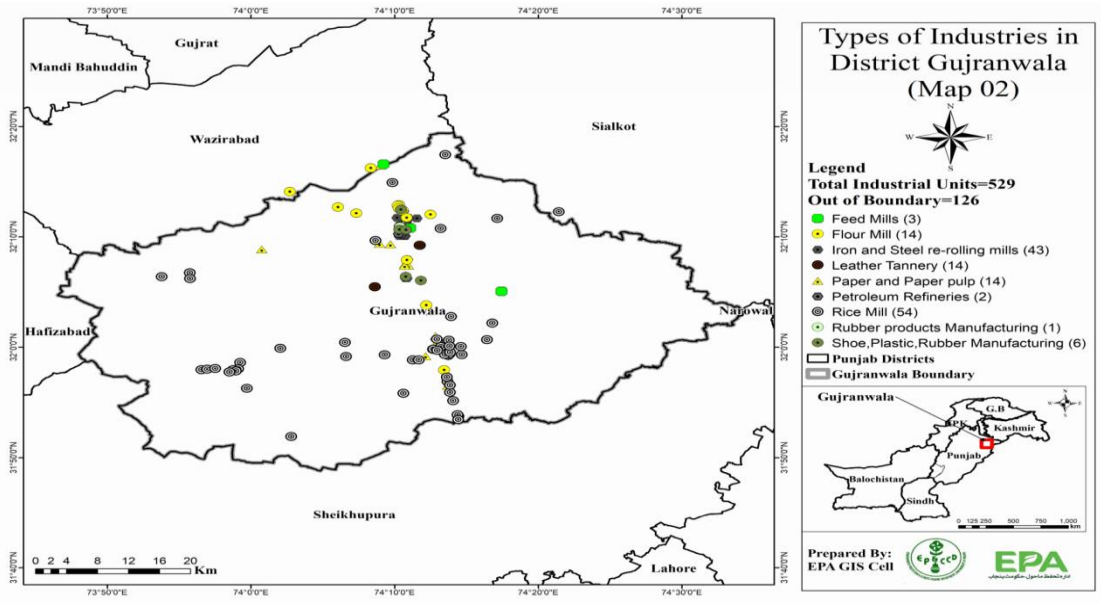

Pollution Status of Industrial Sites in Toba Tek Singh District
Legend
Total Industrial Units=97
Out of Boundary=02
Air Pollution (8)
Combined (34)
City Roads
Toba Tek Singh District
Prepared by: EPA GIS CELL
Reference Map:
Toba Tek Singh
Gojra
Shorkot
Kamalia
Chichawatni
Dijkot
Sources: Esri, USGS, NOAA
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

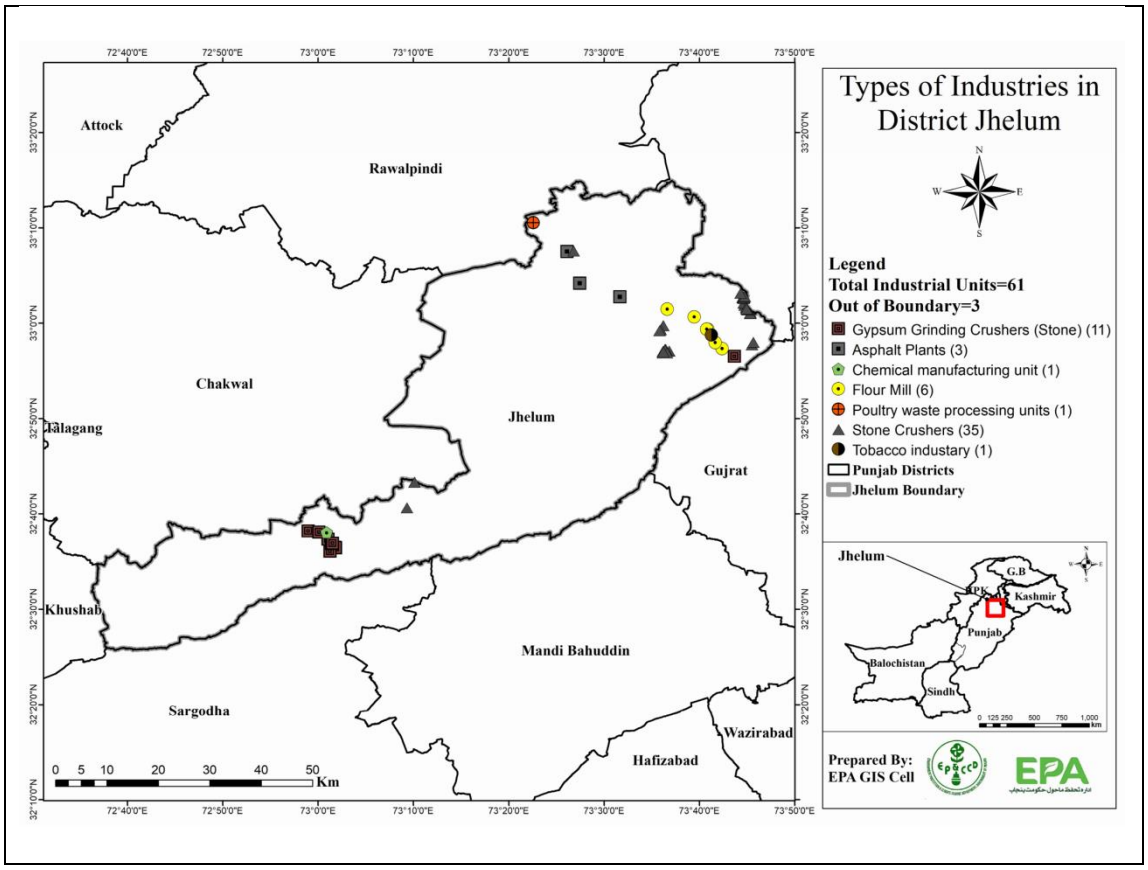

Pollution Status of Industrial Sites in Vehari District
Legend
Total Industrial Units=161
Out of Boundary=05
Air Pollution (140)
Combined (4)
City Road
Vehari District
Prepared by: EPA GIS CELL
Reference Map:
Vehari
Mian Channun
Khanewal
Burewala
Kabirwala
Kahror Pakka
Kot Qaisran
Chichian Mandi
Sources: Esri, USGS, NOAA
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

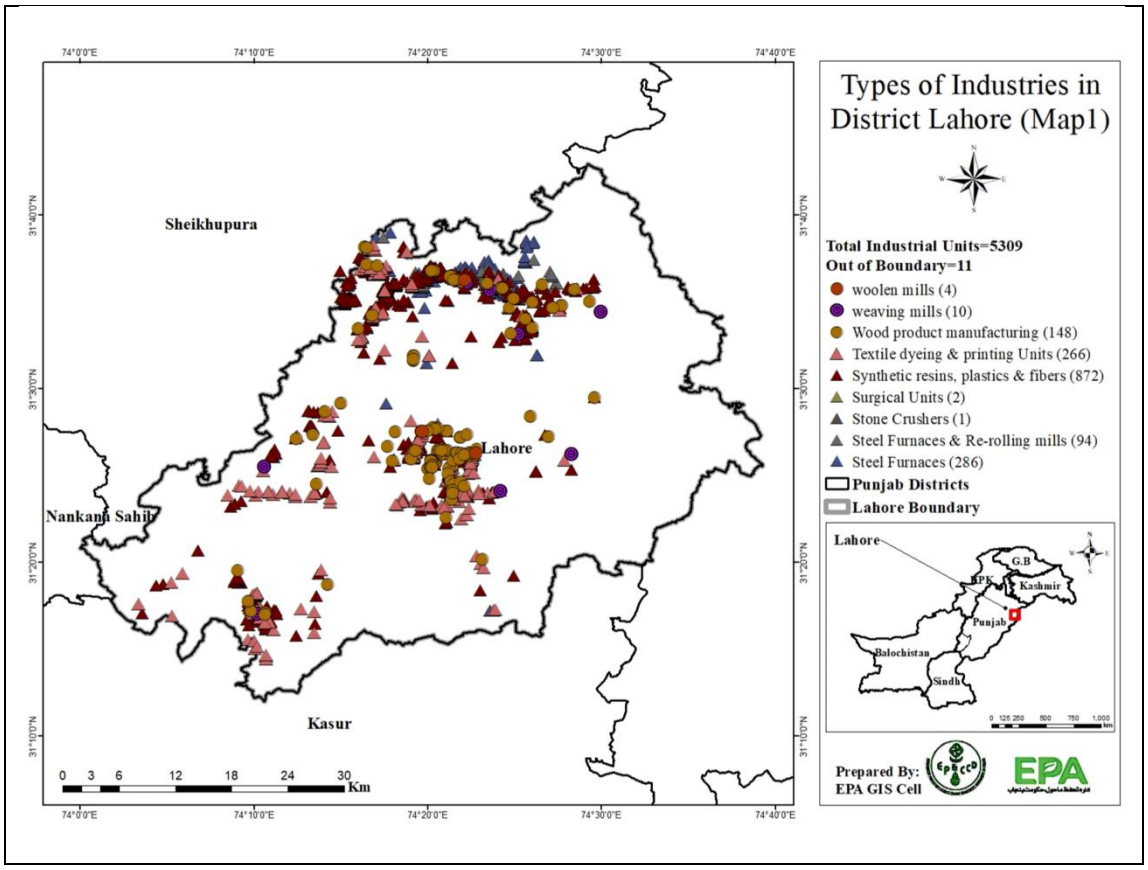
Annexure-II

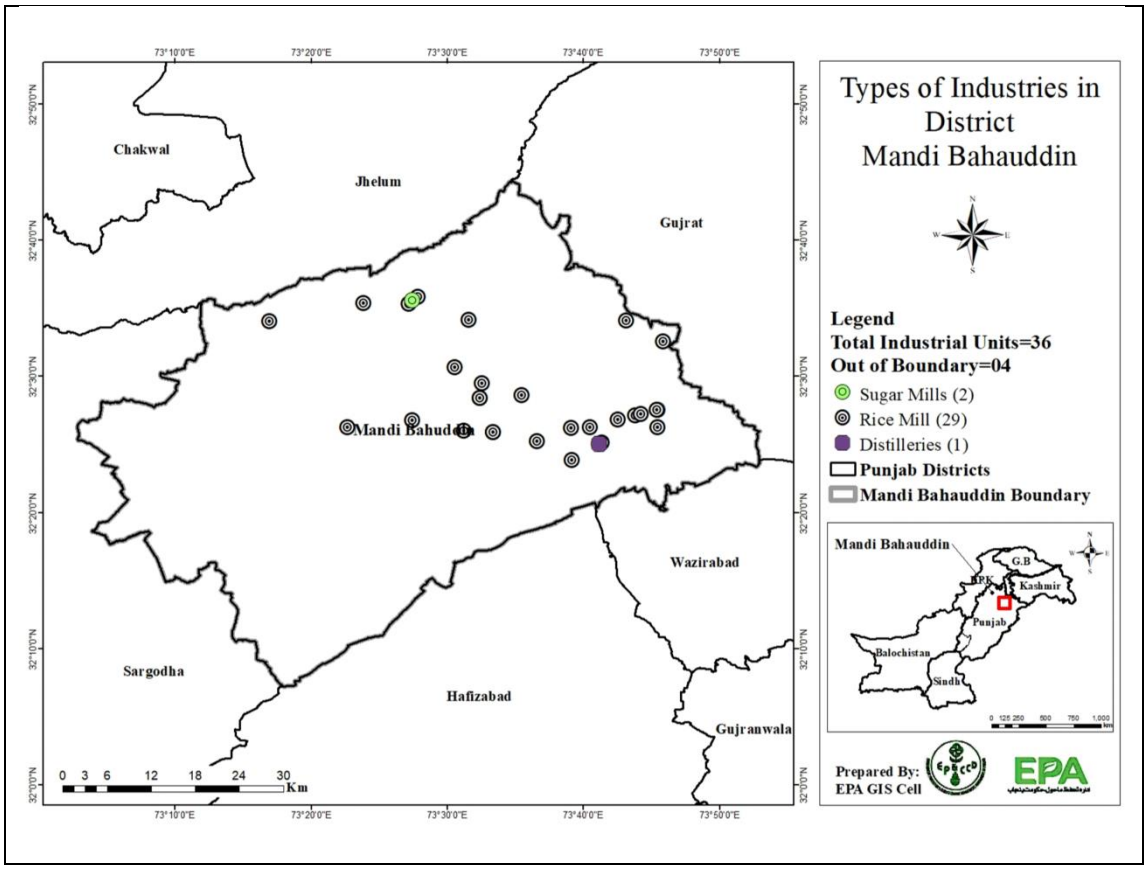
Industry types map of Punjab

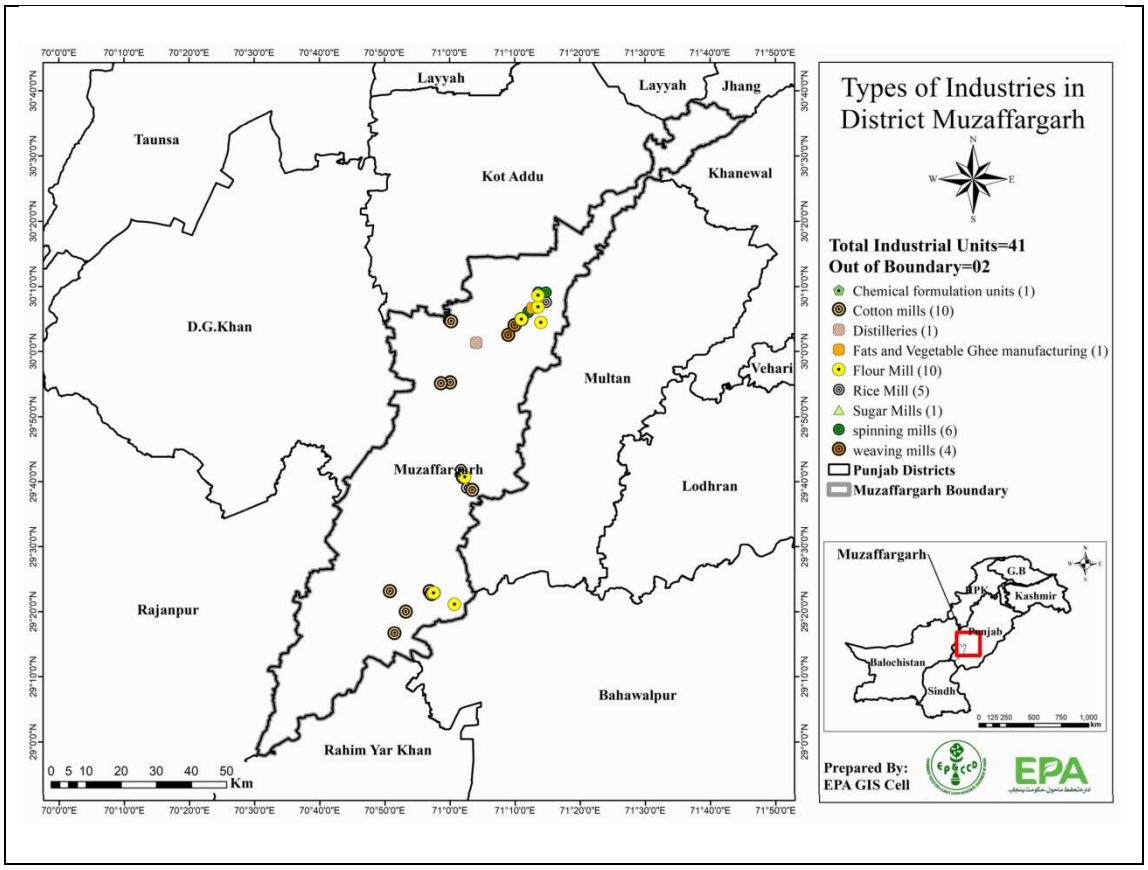


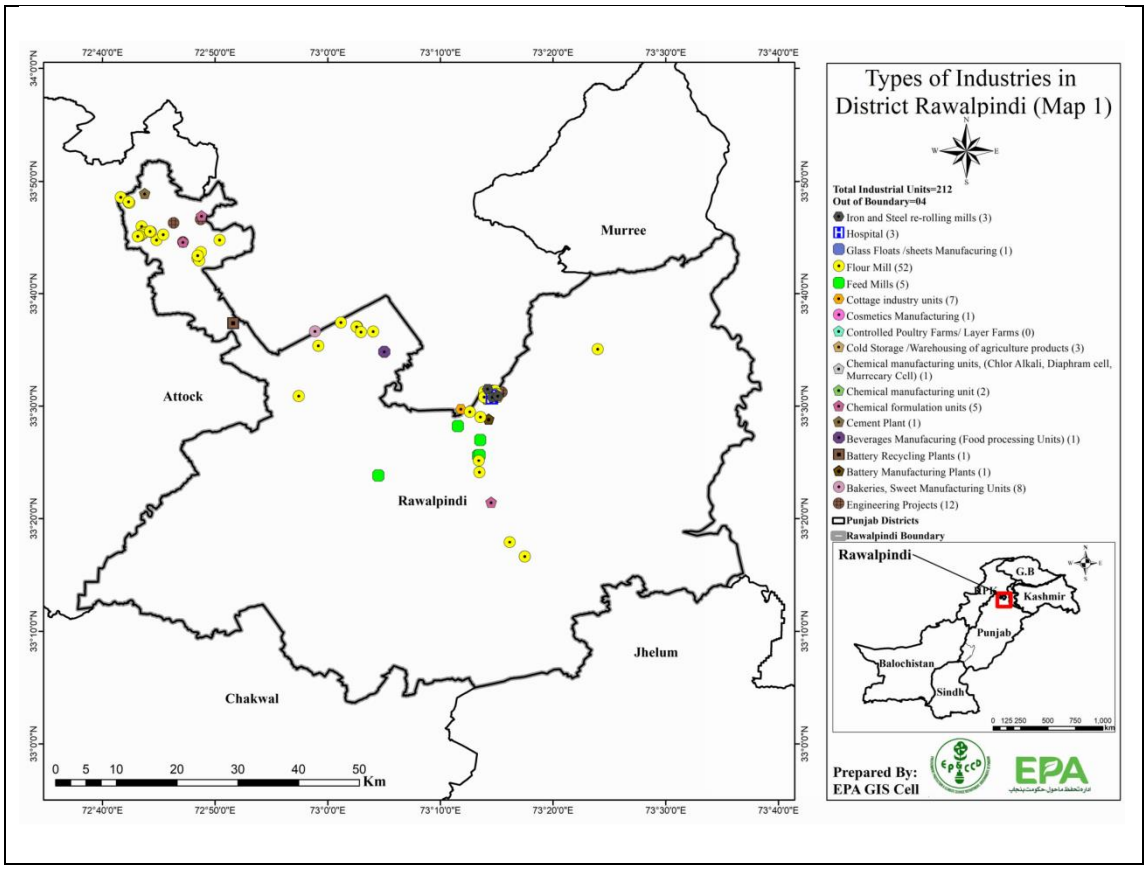


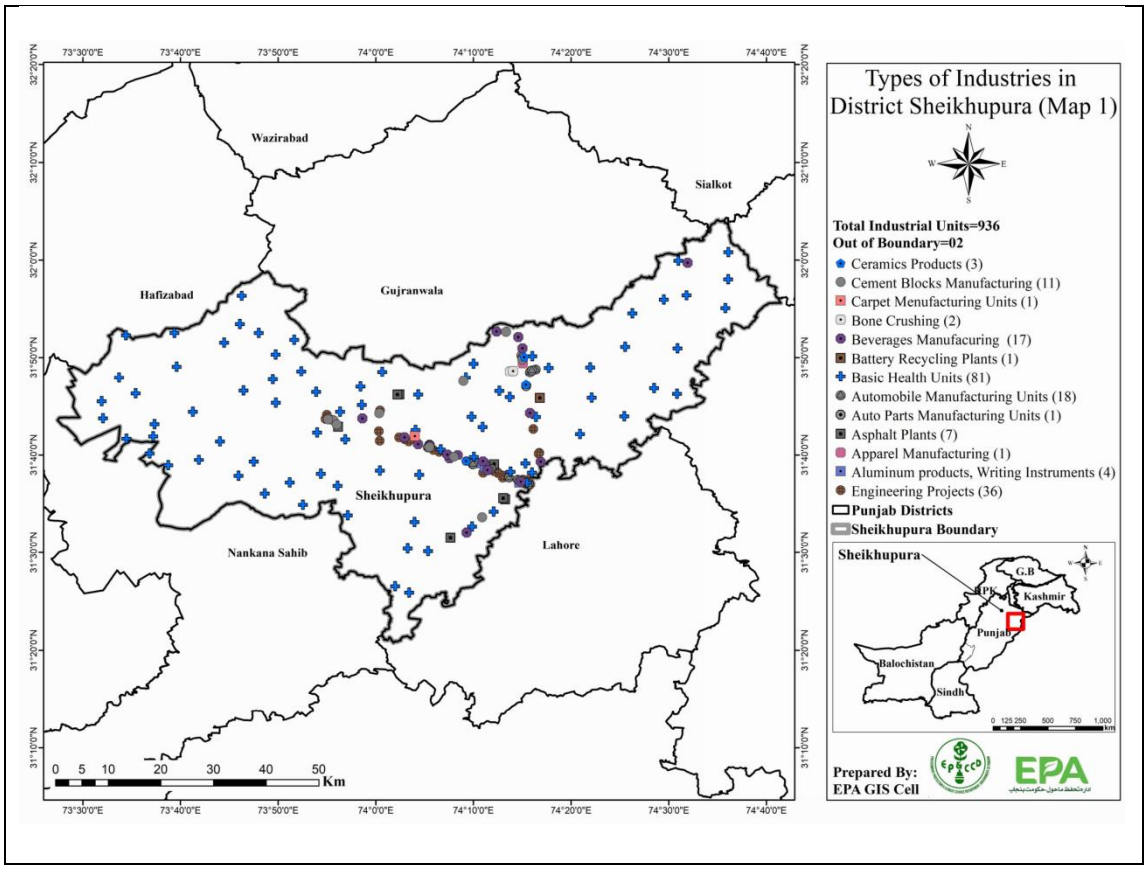

Types of Industries in District Jhelum
Legend
Total Industrial Units=61
Out of Boundary=3
Gypsum Grinding Crushers (Stone) (11)
Asphalt Plants (3)
Chemical manufacturing unit (1)
Flour Mill (6)
Poultry waste processing units (1)
Stone Crushers (35)
Tobacco industary (1)
Punjab Districts
Jhelum Boundary
Attock
Rawalpindi
Chakwal
Jhelum
Talagang
Gujrat
Khushab
Mandi Bahuddin
Sargodha
Wazirabad
Hafizabad
Km
Prepared By:
EPA GIS Cell
EPA


Types of Industries in District Lahore (Map1)
Total Industrial Units=5309
Out of Boundary=11
woolen mills (4)
weaving mills (10)
Wood product manufacturing (148)
Textile dyeing & printing Units (266)
Synthetic resins, plastics & fibers (872)
Surgical Units (2)
Stone Crushers (1)
Steel Furnaces & Re-rolling mills (94)
Steel Furnaces (286)
Punjab Districts
Lahore Boundary
Sheikhupura
Lahore
Nankana Sahib
Kasur
Km
Prepared By:
EPA GIS Cell
EPA
G.B
AJK
Kashmir
Punjab
Balochistan
Sindh


Types of Industries in District Mandi Bahauddin
Legend
Total Industrial Units=36
Out of Boundary=04
Sugar Mills (2)
Rice Mill (29)
Distilleries (1)
Punjab Districts
Mandi Bahauddin Boundary
Mandi Bahauddin
Chakwal
Jhelum
Gujrat
Wazirabad
Sargodha
Hafizabad
Gujranwala
Km
Prepared By:
EPA GIS Cell
G.B
AJK
Kashmir
Punjab
Balochistan
Sindh


Types of Industries in District Muzaffargarh
Total Industrial Units=41
Out of Boundary=02
Chemical formulation units (1)
Cotton mills (10)
Distilleries (1)
Fats and Vegetable Ghee manufacturing (1)
Flour Mill (10)
Rice Mill (5)
Sugar Mills (1)
spinning mills (6)
weaving mills (4)
Punjab Districts
Muzaffargarh Boundary
Layyah
Jhang
Taunsa
Kot Addu
Khanewal
D.G.Khan
Multan
Vehari
Muzaffargarh
Lodhran
Rajanpur
Bahawalpur
Rahim Yar Khan
0 5 10 20 30 40 50 Km
Muzaffargarh
G.B
KPK
Kashmir
Punjab
Balochistan
Sindh
Prepared By:
EPA GIS Cell
EPA

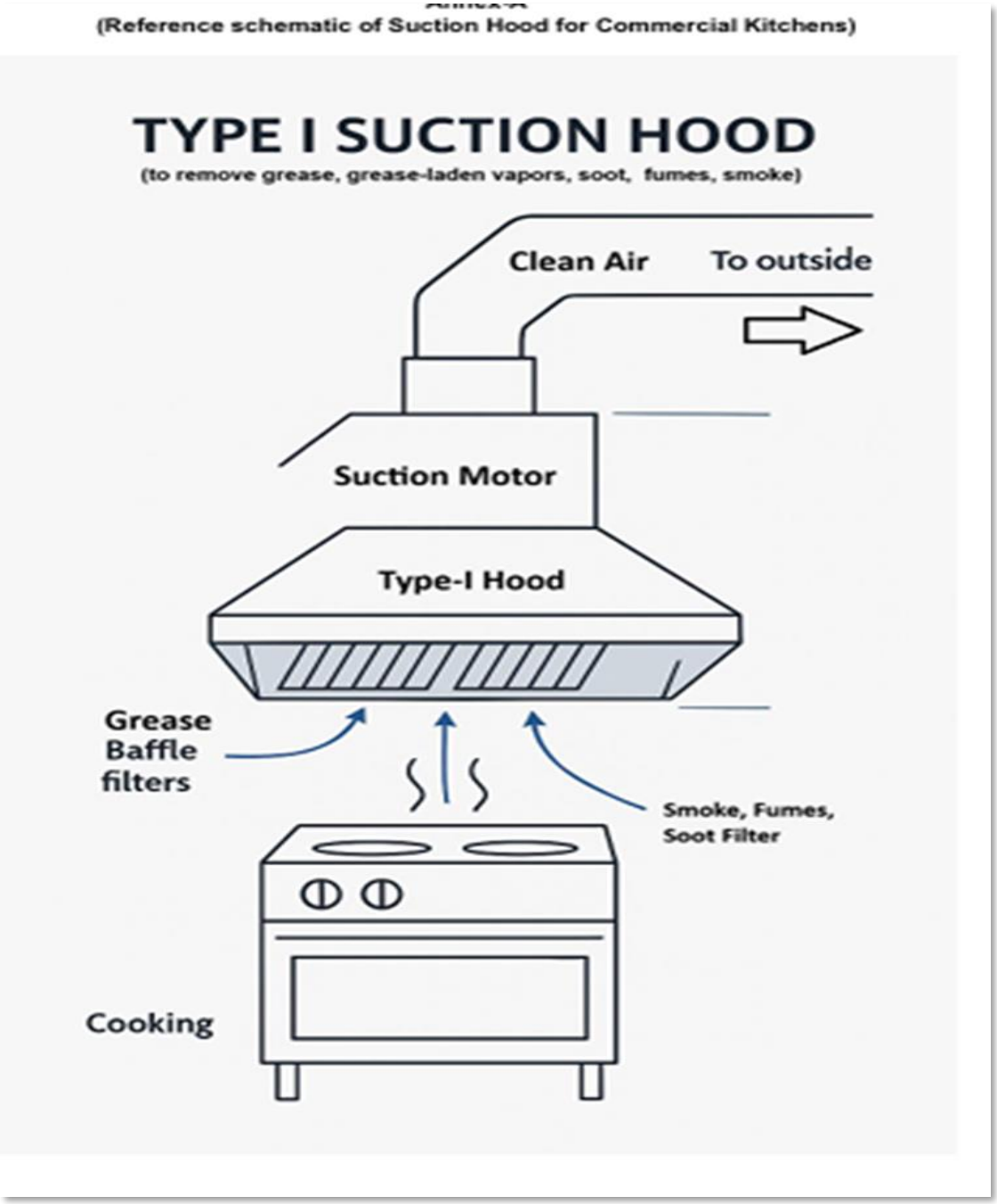

Types of Industries in District Rawalpindi (Map 1)
Total Industrial Units=212
Out of Boundary=04
Iron and Steel re-rolling mills (3)
Hospital (3)
Glass Floats /sheets Manufacuring (1)
Flour Mill (52)
Feed Mills (5)
Cottage industry units (7)
Cosmetics Manufacturing (1)
Controlled Poultry Farms/ Layer Farms (0)
Cold Storage /Warehousing of agriculture products (3)
Chemical manufacturing units, (Chlor Alkali, Diaphram cell, Murrecary Cell) (1)
Chemical manufacturing unit (2)
Chemical formulation units (5)
Cement Plant (1)
Beverages Manufacuring (Food processing Units) (1)
Battery Recycling Plants (1)
Battery Manufacturing Plants (1)
Bakeries, Sweet Manufacturing Units (8)
Engineering Projects (12)
Punjab Districts
Rawalpindi Boundary
Rawalpindi
G.B
AJK
Kashmir
Punjab
Balochistan
Sindh
Prepared By:
EPA GIS Cell
Murree
Attock
Rawalpindi
Jhelum
Chakwal
0 5 10 20 30 40 50 Km
72°40'0"E
72°50'0"E
73°0'0"E
73°10'0"E
73°20'0"E
73°30'0"E
73°40'0"E
34°0'0"N
33°50'0"N
33°40'0"N
33°30'0"N
33°20'0"N
33°10'0"N
33°0'0"N


Types of Industries in District Sheikhupura (Map 1)
Total Industrial Units=936
Out of Boundary=02
Ceramics Products (3)
Cement Blocks Manufacturing (11)
Carpet Menufacturing Units (1)
Bone Crushing (2)
Beverages Manufacuring (17)
Battery Recycling Plants (1)
Basic Health Units (81)
Automobile Manufacturing Units (18)
Auto Parts Manufacturing Units (1)
Asphalt Plants (7)
Apparel Manufacturing (1)
Aluminum products, Writing Instruments (4)
Engineering Projects (36)
Punjab Districts
Sheikhupura Boundary
Wazirabad
Sialkot
Hafizabad
Gujranwala
Sheikhupura
Nankana Sahib
Lahore
0 5 10 20 30 40 50 Km
Sheikhupura
G.B
AJK
Kashmir
Punjab
Balochistan
Sindh
Prepared By:
EPA GIS Cell

Annexure –III

Design and SOPs of Suction Hood

(Reference schematic of Suction Hood for Commercial Kitchens)



Annex-IV

Details of Energy Sector ADP Schemes 2025-26

GS No.	Scheme	Environmental focus area	Ongoing/New Scheme	Environmental Benefits
1680	Installation of Biogas Plant for Gujjar Colony, Lahore	Waste-to-Energy	Ongoing	Utilisation of organic waste and reduction of methane emissions. Introduction of circular resource management.
1681	Liaison Office for Energy Department	Institutional Infrastructure	Ongoing	Enabling energy governance and coordination for promotion of sustainable energy sources.
1682	Design and Construction of Net Zero Energy Building (ACEIP, DLI-8)	Sustainable building	Ongoing	Development of energy efficiency in public sector building construction with reduced emission footprint and sustainable design.
1683	Chief Minister Punjab Free Solar Panel Scheme	Renewable Technology Development	Ongoing	Decreasing domestic and household per capita emission footprint and increased energy off grid energy generation with decrease in fuel imports.
1684	Promotion of Renewable Energy Technologies (PC-II)	Renewable Technology Development	Ongoing	Adoption of research and systematic planning and adoption of clean energy systems.
1685	Renewable Energy Development Sector Investment Programme (REDSIP)	Hydel Energy	Ongoing	Providing clean energy generation with lower emission per unit of electricity generation.
1686	Project Management Unit (ACEIP, DLI-6)	Institutional Infrastructure	Ongoing	Better energy management and strengthening of environmental framework.

1687	Solarisation of Public Sector Buildings	Solar Energy	Ongoing	Reduction in electricity consumption for public sector buildings and reduction of financial pressure in terms of electricity payments.
1688	Solarisation of Tubewells for Water Supply Schemes (Okara)	Renewable Energy for Water Systems	Ongoing	Reducing fossil fuel dependence on agriculture tubewells and increasing the local produce.
1689	Energy Efficiency & Conservation Programme	Energy Efficiency	Ongoing	Introduction of energy conservation measures and energy efficiency recommendations.
1690	Solarisation of Public Sector Buildings in Punjab	Solar Energy Expansion	Ongoing	Utilisation of clean solar photovoltaic energy for affordable energy for public buildings.
1691	Installation of Biofertilizer Plant at Gujjar Colony Lahore	Waste-to-Energy / Circular Economy	New	Conversion of organic waste into useful biofertilizer for reducing solid waste and methane emissions
1692	Hydrokinetic Turbine Pilot Project	Renewable Energy Technology	New	Providing clean energy generation with lower emission per unit of electricity generation using flowing water on existing irrigation infrastructure.
1693	Up-gradation of PV Module Testing Laboratory (CERAD, UET Lahore)	Renewable Technology Research	New	Improves quality and reliability of solar technologies, supporting sustainable renewable energy deployment
1694	Automation of Business Regulations for Energy Sector	Digital Governance	New	Enhances regulatory efficiency and monitoring of energy systems, improving environmental oversight
1695	Feasibility Study for Vertical Axis Wind Turbines	Renewable Energy Exploration	New	Assessment of wind energy potential and diversification of renewable energy mix.

1696	Enhancement of Remote Monitoring System	Energy Monitoring	New	Better reporting, management and monitoring system for improved local environment.
1697	Punjab Endorsement Label (SAVE UP)	Energy Efficiency Standards	New	Encourages adoption of energy-efficient appliances and technologies, reducing electricity consumption
1698	Feasibility Study for Establishment of EPRA Punjab	Regulatory Governance	New	Improving regulatory framework for better energy management and environmental stewardship
1699	Clearance of Pending Liabilities for Un-Funded Schemes	Financial Management	New	Enables completion of earlier initiated projects, including renewable and efficiency initiatives introduced by the government
1700	Installation of AMI Smart Meters at MDI Connections in LESCO	Smart Energy Systems	New	Improves energy usage monitoring, reduces energy losses.
1701	Solarisation of Punjab Governor House	Solar Energy	New	Demonstrates renewable energy adoption in government buildings and reduces carbon emissions
1702	Solarisation of Government Higher Secondary Schools	Solar Energy in Education Sector	New	Reduces electricity costs and emissions while promoting environmental awareness among students
1703	Solarisation of THQ Hospitals in Punjab	Renewable Energy for Health Facilities	New	Ensures reliable clean energy for healthcare infrastructure while reducing fossil fuel electricity use
1704	Green Energy Projects (KfW Bank Germany)	International Renewable Energy Program	New	Supports development of large-scale renewable energy systems and promotes low-carbon energy infrastructure

1705	Solarisation of Public Buildings	Solar Energy	New	Reduction in electricity consumption for public sector buildings and reduction of financial pressure in terms of electricity payments.
1706	Solarisation of District and Sessions Courts and High Court Benches	Renewable Energy in Judicial Infrastructure	New	Reduction of energy consumption in judicial courts reducing the electricity load.
1707	Sustainable Energy Enablement Scheme	Clean Energy Promotion	New	Energy efficiency and adoption of energy systems and energy efficiency initiatives.
1708	Solarisation of Public Colleges in Punjab	Renewable Energy in Higher Education	New	Promoting solar energy in public sector educational sector reduces the load on national grid.

Annex-V

EPD ADP Schemes

Sr. No.	G.S. No.	Name of Scheme	Project Cost (PKR Million)	Revised Allocation (PKR Million)
On-going Schemes				
1	**2953**	Construction of Environment Complex in Sargodha (DLI-1 PGDP)	335.002	310.002
2	**2954**	Construction of Environment Complex in Faisalabad (DLI-1 PGDP)	392.358	342.122
4	**2956**	Strengthening of Strategic Planning and Implementation Unit (PGDP)	596.914	110.141
5	**2957**	Establishment of Environmental Monitoring Center (DLI-2, PGDP)	631.12	631
6	**2958**	Construction of Green Building for EMC, EPD and Allied New Entities Established under PGDP (DLI-2, PGDP)	3723.93	1338.6
7	**2959**	Establishment of Climate Policy and Technology Centre (DLI-I, PGDP)	150	150
8	**2960**	Strategic Communication Cell	315.38	87.289
9	**2961**	9th Divisional Laboratory of EPA In Sahiwal (DLI-I, PGDP)	164.665	69.972
10	**2962**	Construction of Environment Complex in Multan (DLI-1 PGDP)	602.221	30
11	**2963**	Establishment of Environmental Endowment Fund Management Unit (DLI-8, PGDP)	103.5	40
12	**2964**	Enhanced Air Quality Monitoring System in Punjab (DLI-2, PGDP)	5205.3	380
13	**2965**	Enhanced Water Quality Monitoring System in Punjab (DLI-2, PGDP)	2972.72	722
14	**2966**	Environmental Monitoring of Industrial Units (DLI 1-3, PGDP World Bank)	861	417.285

15	**2967**	Implementation of initiatives of Plastic Management Strategy and Single-Use Plastics Regulations (DLI 4, PGDP World Bank)	382	72
16	**2968**	Operationalization of Divisional Complexes	298	198
17	**2969**	Investigation of Sources of Particulate Matter for Informed Decision Making in Punjab.	560	160
18	**2970**	Construction of 03 Low-Cost Wastewater Treatment Plants (DLI-I, PGDP)	583.996	145.743
Chief Minister initiatives:				
19	**2971**	EPA; Up Gradation, Restructuring, Revamping and Automation	560	95
20	**2972**	CM Punjab Green Credit Program	1000	547
21	**2973**	Punjab Smog Mitigation and Response Initiative – Air Safe	5381	3381
Chief Minister Murree Development Programme				
22	**2974**	Revamping of Biodiversity Park, Murree	388.303	375.54
New Schemes				
23	**2975**	Establishment of Climate Observatory in Punjab	5000	1712.409
24	**2976**	Piloting The Solutions for Environmentally Sound Management of Crop Residues in Punjab	750	372.513
25	**2977**	Innovation Program for Brick Manufacturing in Punjab	300	25
26	**2978**	Enhancing Awareness to Combat Air Pollution Under the World Bank's PCAP	560	50
27	**2979**	Installation of 44 AQMS under the World Bank's PCAP	2900	50
28	**2980**	Establishment of Fuel Quality Testing Laboratories Fixed and Mobile Under the World Bank's PCAP	560	40
29	**2981**	Establishment of an Integrated Air Pollutant and GHG Inventory System for Punjab Under the World Bank's PCAP	558.4	42
30	**2982**	Establishment of Environment Protection Force in 10 Zones of Punjab	2948.02	2148
31	**5311**	CM Punjab Climate Leadership Development Internship Program (Phase-II)	325.8	81.576
Other On-going schemes				
32	**3317**	Construction of Environment Complex in DG Khan (DLI-1 PGDP)	290.938	6.671

33	**3318**	Construction of Environment Complex in Rawalpindi (DLI-1 PGDP)	290.938	7.067
34	**3320**	Disclosure of Environmental Information and Citizen Engagement (DLI-3, PGDP)	70	0.813
35	**3321**	Implementation of Environmental and Social Safeguard Requirements and Pollution Impact Studies	6.15	0.335
36	**3322**	Pilot of Low Cost Wastewater Treatment (Study) (PGDP)	24.5	1.7
37	**3323**	Development of Missing Environmental Quality Standards and Revision of Existing Standards (PGDP)	75	9.264
38	**3324**	Construction of Environment Complex in Sahiwal (DLI-1 PGDP)	286.002	38.638
39	**5283**	Construction of Environment Complex in Lahore (DLI-1 PGDP)	293.06	0
		Total	**40,768.114**	**14460.576**

Annex-VI

Scheme-Wise Details of Air Quality Monitoring Stations In Punjab

	30 AQMS installation under PGDP					
#	District Name	Station	Total in Districts	Location Name	Lat/Long	Current Status
1.	Lahore	Mobile	5	Raja Jang, Kasur	31.218759306227106, 74.2666869386518	Operational
2.				Lathe Pur	31.718128570652464, 74.38971820983542	Operational
3.				Wahga Border	31.60234175750565, 74.54494993681253	Operational
4.				Egerton Road	31.56103546968741, 74.33099891168348	Operational
5.				BHU Jandiala Kalasan	31.8499509234676, 74.51570708100425	Operational
6.	Faisalabad	Fixed	3	DC Office Faisalabad	31.43087645586924, 73.08828838650678	Operational
7.				GCU Faisalabad	31.416246064561182, 73.07000252883559	Operational
8.				NTU Faisalabad	31.462112827887097, 73.14854729999999	Operational
9.	Multan	Fixed	2	BZU Multan	30.262345863388603, 71.51253806752977	Operational
10				M. Nawaz Sharif University of Engineering & Technology Multan	30.16544152223379, 71.49690014417796	Operational

11	Bahawalpur	Fixed	2	IUB (Baghdad Campus) Bahawalpur	29.37898363382516, 71.76514932698643	Operational
12				IUB (Abbasia Campus) Bahawalpur	29.398270945549985, 71.6907959711644	Operational
13	DG Khan	Fixed	1	DC Office DG Khan	30.051789891839096, 70.62966112883561	Operational
14	Rawalpindi	Fixed	3	DC Office Rawalpindi	33.58462459856753, 73.06891569999999	Operational
15				ARID University Rawalpindi	33.65061773446243, 73.08067117116441	Operational
16				Drug Testing Laboratory Rawalpindi	33.54226391435295, 73.01392021534237	Operational
17	Sargodha	Fixed	2	DC Office Sargodha	32.074810651312184, 72.6756118504164	Operational
18				BISE Sargodha	32.03511524105685, 72.70053982883559	Operational
19	Gujranwala	Fixed	2	GCW Gujranwala	32.258158570304616, 74.15782782117046	Operational
20				DC Office Gujranwala	32.17467376769729, 74.19495271349322	Operational
21	Sialkot	Fixed	1	DC Office Sialkot	32.176368820677, 74.1949431423288	Operational
22	Lahore	Fixed	1	LWMC	31.46387200 , 74.22508900	Operational
23			1	Punjab University	31.47965600 , 74.26603400	Operational
24			1	UET	31.57763400 , 74.35739500	Operational
25			1	FMDRC	31.53573300 ,	Operational

					74.43563300	
26			1	PKLI	31.45396900 , 74.46317400	Operational
27			1	Kahna Hospital	31.37108300 , 74.36493100	Operational
28			1	Shahdara	31.63820600 , 74.28410800	Operational
29			1	Safari Park	31.38603600 , 74.21164100	Operational
30			1	Sheikhupura	31.71193800 , 73.97636700	Operational

08 AQMS installation Under Air-Safe					
#	**District Name**	**Total in Districts**	**Location Name**	**Lat/Long**	**Current Status**
31.	Gujrat	1	Deputy Commissioner Office, Gujrat	32°35'5.01"N/ 74° 4'44.18"E	Operational
32.	Hafizabad	1	Deputy Commissioner Office, Hafizabad	32° 4'3.36"N/ 73°42'40.81"E	Operational
33.	Chakwal	1	Deputy Commissioner Office, Chakwal	32°55'31.32"N/ 72°48'19.63"E	Operational
34.	Khanewal	1	Deputy Commissioner Office, Khanewal	30°18'6.45"N/ 71°55'44.77"E	Operational
35.	RY Khan	1	Deputy Commissioner Office, RY Khan	28°25'21.81"N/ 70°19'5.69"E	Operational
36.	Narowal	1	Deputy Commissioner Office, Narowal	32° 5'48.55"N/ 74°53'39.00"E	Operational

37.	Muzaffargarh	1	Deputy Commissioner Office, Muzaffargarh	30° 4'32.21"N/ 71°11'25.19"E	Operational
38.	Kasur	1	Deputy Commissioner Office, Kasur	31° 6'56.04"N/ 74°28'2.24"E	Operational
18 AQMS installation Under Air-Safe					
39.	Attock	1	Deputy Commissioner Office, Attock	33°46'22.86"N/ 72°21'42.13"E	Under Installation/ Procurement
40.	Jhelum	1	Deputy Commissioner Office, Jhelum	32°56'36.38"N/ 73°44'22.33"E	Under Installation/ Procurement
41.	Murree	1	Deputy Commissioner Office, Murree	33°54'16.74"N/ 73°24'7.68"E	Under Installation/ Procurement
42.	MB Din	1	Deputy Commissioner Office, MB Din	32°32'34.26"N/ 73°28'47.85"E	Under Installation/ Procurement
43.	Nankana Sahib	1	Deputy Commissioner Office, Nankana Sahib	31°26'52.94"N/ 73°41'51.06"E	Under Installation/ Procurement
44.	Okara	1	Deputy Commissioner Office, Okara	30°48'2.19"N/ 73°25'32.68"E	Under Installation/ Procurement
45.	Bahawalnagar	1	Deputy Commissioner Office, Bahawalnagar	30° 0'39.07"N/ 73°15'20.56"E	Under Installation/ Procurement
46.	Kot Addu	1	Deputy Commissioner Office, Kot Addu	30°30'9.38"N/ 70°57'22.67"E	Under Installation/ Procurement
47.	Mianwali	1	Deputy Commissioner Office, Mianwali	32°35'2.78"N/ 71°32'45.42"E	Under Installation/ Procurement

48.	Bhakkar	1	Deputy Commissioner Office, Bhakkar	31°37'0.39"N/ 71° 4'46.88"E	Under Installation/ Procurement
49.	Layyah	1	Deputy Commissioner Office, Layyah	30°59'1.63"N/ 70°57'50.63"E	Under Installation/ Procurement
50.	Lodhran	1	Deputy Commissioner Office, Lodhran	29°32'13.47"N/ 71°37'39.33"E	Under Installation/ Procurement
51.	Pakpattan	1	Deputy Commissioner Office, Pakpattan	30°21'43.52"N/ 73°22'55.00"E	Under Installation/ Procurement
52.	Wazirabad	1	Deputy Commissioner Office, Wazirabad	28°46'15.93"N/ 77°30'35.67"E	Under Installation/ Procurement
53.	Vehari	1	Deputy Commissioner Office, Vehari	30° 3'1.44"N/ 72°21'25.32"E	Under Installation/ Procurement
54.	Chiniot	1	Deputy Commissioner Office, Chiniot	31°43'13.04"N/ 72°59'19.97"E	Under Installation/ Procurement
55.	TT Singh	1	Deputy Commissioner Office, TT Singh	30°57'57.14"N/ 72°29'10.25"E	Under Installation/ Procurement
56.	Jhang	1	Deputy Commissioner Office, Jhang	31°16'16.61"N/ 72°19'26.76"E	Under Installation/ Procurement

Annex-VII

Location of Water Quality Monitoring Stations in Punjab

Sr. No.	District	GPS Coordinates	Location
1	Lahore	31.722547N 74.470786E	Entry Point of Ravi at Syphon
2	Okara	32.669157N 74.471087E	Entry Point of River Sutlej at Upstream of Sulemanki Headwork's
3	Sialkot	32.913703N 73.741381E	Entry Point of River Chenab at Upstream of Marala Headwork's
4	Jhelum	31.147596N 72.138733E	Entry Point of River Jhelum at Mangla Dam
5	Mianwali	29.823526N 72.550402E	Entry Point of Indus River at the Upstream of Kala Bagh Dam
6	Jhang	32.402833N 73.975684E	Upstream of Trimmu Headwork
7	Lahore	31.398515N 72.289045E	River Ravi at Downstream of Hudiara Drain
8	Toba Tek Singh	32.473989N 72.861959E	River Ravi at the Downstream of Samudri/Mudhwana Drain
9	Bahawalnagar	32.242613N 73.429630E	River Sutlej-Downstream of Kali Budhi Drain
10	Bahawalpur	29.344684N 71.026364E	River Sutlej Upstream of Islam Headworks
11	Wazirabad	31.403878N 74.051079E	River Chenab At the upstream of Khanki Barrage
12	Faisalabad	30.379735N 73.871867E	River Chenab- Faqiran Silanwali, Joining at Appx. 4 km of Chak Bandi/ Pharang Drain Downstream from right side of the River Chenab
13	Sargodha	32.921444N 71.516846N	River Jhelum- Downstream of Mona Bhaira Drain
14	Mandi Bahauddin	30.575576N 72.677531E	River Chenab- at downstream of Buddhi Drain
15	Muzaffargarh	30.07944722N 73.1549889E	Upstream of Punjnad Headwork's

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