EPA

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An ISO Certified Agency

WHOLE OF GOVERNMENT APPROACH

REPORT 2025

PUNJAB STATE OF ENVIRONMENT

Table of Contents

Part I: Environmental Governance Framework & Provincial Context 26
Chapter No. 1: Introduction 27
1.1 Background 27
1.2 Purpose 27
1.3 Objective 28
1.4 Structure 29
1.5 Scope 30
1.5.1 Significance for Environmental Governance 30
1.5.2 Public Value and Policy Relevance 30
1.5.3 Instrument of Transparency and Accountability 31
1.6 Practical Applications of the Report 31
1.7 2025 at a Glance 32
1.8 Limitations and Implementation Challenges 33
Chapter No. 2: Regulatory Framework & Governance Paradigm 34
2.1 Statutory Mandate & Core Functional Framework 34
2.2 Key Legal Provisions 34
2.2.1 Establishment of Environmental Governance Bodies (Sections 3 & 5) 34
2.2.2 Administrative and Standard Setting Provisions (Section 6 & 7) 35
2.2.3. Core Functional Sections (Sections 12, 14, 15 & 16) 35
2.2.4. Delegation and Rule Making Authority (Sections 31–33) 36
2.3. Rules and Regulations Notified under PEPA, 1997 38
2.3.1. Punjab Environmental Protection (Smog Prevention and Control) Rules 2023 38
2.3.2 The Punjab Hospital Waste Management Rules, 2014 39
2.3.3. The Punjab Environmental Protection (Motor Vehicles) Rules, 2013 40
2.3.4 The Punjab Bio-Safety Rules, 2014 41
2.3.5 The Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Product) Regulations, 2023 42

DRAFT SOE 2025

2.3.6. The Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations 2022 43
2.3.7. Punjab Environmental Quality Standards: Legislative Overview 44
2.4 Environmental Adjudication and Tribunal Framework in Punjab 46
2.4.1 Punjab Environmental Tribunal 46
2.5 Specialised Units.... 47
2.6 Governance Shift Observed by 2025 51
2.7 Conclusion 52
Chapter No. 3: Judicial Interventions and Institutional Support in Environmental Governance 53
3.1 Judicial Water and Environmental Commission 53
3.2 Smog Control and Anti-Smog Measures 54
3.2.1 Declaration of Smog as Calamity and Crisis Management....54
3.2.2 Closure of Schools, Colleges and Educational Institutions during Smog Season 55
3.2.3 Closure of Markets, Restaurants, Hotels and Commercial Activities 55
3.2.4 Installation of Catalytic Converters and Emission Control Devices 56
3.2.5 Working Hours for Markets and Business....56
3.2.6 EPA Appreciation and Support during Smog Season 2025 56
3.3 Control of Environmental Stressors.... 57
3.3.1 EPA Operations against Industrial Units 57
3.3.2 Brick kilns 58
3.3.3 Stubble Burning — Enforcement and Imposition of Fines 58
3.3.4 Vehicular Emissions and Transport Sector Reforms 59
3.3.5 Water Conservation and Groundwater Protection....60
3.4 Tree Plantation, Miyawaki Forests and Protection of Green Areas 62
3.4.1 Miyawaki Forests....62
3.4.2 Tree Plantation in Public Schools and Colleges....62
3.5 Agriculture Sector — Super Seeders and Mechanised Farming.... 62
3.6 Environmental Compliance of Development Projects.... 63
3.6.1 No Conversion of Agricultural Land 63
3.6.2 Green Standards in Building Regulations 63
3.7 Waste Management and Plastic Pollution.... 63

DRAFT SOE 2025

3.7.1 LWMC — Prohibition on Garbage Burning 64
3.7.2 Recycling of Solid Waste and Reuse of Plastic 64
3.7.3 Ban on Polythene Bags 64
3.7.4 Land Fill Gas Collection — Environmental Concern 65
3.8 Public Awareness, Technology-Based Monitoring and PEMRA 65
3.8.1 PITB Application 65
3.8.2 PEMRA — Smog Awareness Campaign 66
3.9 Inter-Departmental Coordination 66
3.10 Institutional Strengthening and Enforcement Support to EPA 66
3.11 Conclusion 67
Chapter No. 4: Punjab's Environmental Profile 68
4.1 Introduction 68
4.2 Population, Urbanisation and Industrial Density 68
4.2.1 Population & Demographic Overview 68
4.2.2. Urbanisation 69
4.2.3 Industrial Density 70
4.3. Climate Stressors 74
4.3.1 Natural Stressors 74
4.3.2. Anthropogenic Climate Stressor 78
4.4. Environmental Pressure Points 82
4.4.1 Air Quality Pressure 82
4.4.2. Water Resources Pressure 83
4.4.3. Soil and Land Pressure 84
4.4.4. Biodiversity Pressure 84
4.4.5. Climate and Atmospheric Pressure 85
4.4.6. Waste and Resource Pressure 86
4.4.7. Human Health Pressure 87
4.5. Conclusion 88
Part II Environmental Quality Assessment & Pollution Management 89
Chapter No. 5 Air Quality of Punjab 90
5.1 Situational Analysis of Air Quality: 90

DRAFT SOE 2025

5.2 Pollution Index of Punjab 91
5.2.1 Pollution Index of hotspot districts: 92
5.2.2 Comparison of AQI level of hotspot districts during winter season: 94
5.3 Major Sources of Air Pollution in Punjab: 96
5.3.1 Anthropogenic Sources of air pollution in Punjab: 97
5.3.2 Natural Sources of air pollution in Punjab: 98
5.4 Pollution Hotspot Assessment through E-Maps 99
5.4.1 Industrial Contribution to Pollution 100
5.4.2 Air Pollution assessment in Central Punjab Districts: 100
5.4.3 Air Pollution Assessment in Southern Punjab Districts: 104
5.4.4 Air Pollution Assessment in Northern Punjab Districts: 106
5.5 Assimilation Capacity of Punjab's Industrial Districts 107
5.6 EPA Punjab's Air Quality Management Regime 109
5.6.1 Air Quality Management Cycle 110
5.6.2 Integrated Air Quality Governance and Monitoring: 111
5.6.3 AQMS in Lahore: 112
5.6.4 AQI Dissemination Dashboard 113
5.6.5 AQI Forecasting and Early Warning System 114
5.7 Environmental Monitoring and Scientific Surveillance 114
5.7.1 Industrial monitoring through Unique ID Allotment: 114
5.7.2 GIS-Based E-Mapping for Strengthened Environmental Monitoring: 115
5.7.3 Drone-Based Environmental Surveillance 115
5.7.4 Hawkeye Monitoring Vehicle: 117
5.7.5 CCTV Monitoring of Industrial Emissions: A pathway towards inspector less Regime: 120
5.7.6 Scientific Surveillance 120
5.7.7 Stack Emission Monitoring: 121
5.8 Enforcement Actions: 122
5.8.1 Brick Kiln Inspections: 122
5.8.2 Industrial Inspections: 123
5.8.3 Anti - Stubble Burning Enforcement: 125
5.8.4 Fugitive Dust Management: 127
5.8.5 Emission Testing of Vehicles: 128

DRAFT SOE 2025

5.8.6 Fuel Quality Inspections: 131
5.8.7 Installation of Suction Hood at commercial restaurants: 132
5.8.8 Fog Cannons Deployment: 134
5.8.9 Mist Sprinkles Installation at Under Construction Sites: 137
5.9 Nature Based Solution 138
5.9.1 Miyawaki Forest Initiative 138
5.10 Policy Reforms: 141
5.10.1 Punjab Clean Air Program (P-CAP) 141
5.10.2 Punjab Green Credit Program and Air Quality Initiative: 141
5.10.3 Driving Clean Futures: Electric Vehicles as Catalysts for Smog Reduction and Climate Resilience: 142
5.11 Outcomes of Air Pollution Abatement Measures EPA Punjab (2025) 143
5.11.1 Net pollution shift in 2025 143
5.11.2 Air Quality Improvement in Punjab: 144
5.11.3 Particulate Matter reduction in Hot spot districts: 145
5.11.4 Lahore air quality improvement: 146
5.11.5 Improvement in Air Quality and Reduction in Pollutants 147
5.12 Conclusion 148
Part 2: Emission Inventory of Major Industrial Sectors of Punjab 149
5.13 Sector wise emission load of Punjab 149
5.13.1 Sectoral Contributors and Key Pollutants 152
5.13.2 Dominant Sources of Industrial Air Pollution in Punjab 156
5.14. Actions and Policy Reforms 158
5.14.1 Actions & Reforms by EPA Punjab (Already Implemented) 158
5.14.2 Policy & Regulatory Reforms (Institutional) 159
5.14.3 Recommended Reforms 160
5.14.4 Multi-Departmental Coordination Required 161
5.15 Limitations of the Report 162
Chapter No. 6: Water Resources and Waste Water Management in Punjab 163
6.1 Introduction 163
6.2 Punjab's Water Resources Profile: Overview 164
6.3 Freshwater Resources: Current Condition, Stressors and Future Projections 165

DRAFT SOE 2025

6.3.1 Current Freshwater Condition in Punjab 165
6.3.2 Major Freshwater Stressors in Punjab 167
6.3.3 Stressor Projections and Emerging Freshwater Risks 168
6.4. Conservation Approach by EPA Punjab 169
6.4.1 Installation of Recycling Plants at Service Stations 169
6.4.2 Mandating Rainwater Harvesting in Urban Development (2025) 172
6.5. Freshwater Contamination and Wastewater Challenges 173
6.5.1. Wastewater Profile of Punjab 173
6.5.2. Punjab's Industrial Waste Water: Overview 174
6.6. Pollution Status of Industrial Sites of Province: GIS Analysis 176
6.7. Stressors Associated with Wastewater Pollution 178
6.7.1 Degradation of Freshwater Quality 178
6.7.2 Soil Fertility and Land Degradation 178
6.7.3 Food Security Risks 178
6.7.4 Groundwater Contamination 178
6.7.5 Public Health Burden 179
6.7.6 Aquatic Ecosystem Degradation 179
6.7.8 Livestock and Rural Livelihood Impacts 179
6.7.9 Urban Environmental Stress 179
6.7.10 Industrial and Regulatory Pressure 179
6.7.11 Climate and Resilience Concerns 179
6.8. Priority Sector Intervention by EPA Punjab 179
Tannery Wastewater Management 179
6.8.1 Transforming the Kasur Tannery Cluster toward Environmental Sustainability 180
6.8.2 Environmental Management Plan for Decontamination of Tannery Sites in Sialkot 184
6.9. Site-Specific Assessment of Polluted Drains 187
6.9.1. Water Quality Assessment of Hudiara Drain 187
6.10. Institutional Response: Dedicated Wastewater Governance Framework 192
6.10.1. District-Level Enforcement: Specialized Water Unit & Surveillance Network 192
6.11. Conclusion 196
Chapter No. 7: Environmental Approvals and Development Oversight 198
7.1 Introduction 198

DRAFT SOE 2025

7.2 Environmental Approvals Matrix 198
7.3 ISO-9000 Certification in Environmental Approval Regime 199
7.4 Provincial Level Environmental Approval Matrix 200
7.5 Divisional-Level Environmental Approvals Matrix 204
7.6 District-Level Environmental Approvals Matrix 206
7.7 Compliance status of environmental conditions 207
7.8 Spatio-Temporal Governance 210
7.8.1 Three-Year Trend at HQ Level - A Record-Breaking Performance 210
7.9 Tier-wise Development Volume 211
7.10 Enforcement Actions 211
7.11 Rejection Patterns 211
7.12 Pending Case Analysis 212
7.13 Pollution Risk Analysis 212
7.14 Pollution Load Balancing Through Approval Conditionalities 215
7.15 Socio Economic Benefit from the Environmental Approvals 216
7.16 Recent Developments 218
7.17 Conclusion 218
Chapter No. 8: Pollution Risk Analysis of Ecological Site 220
8.1 Introduction 220
8.2 Ecologically Sensitive Sites in Punjab 221
8.3 Criteria for Declaration as Ecological Sensitive Zones 221
8.4 Classification of Ecologically Sensitive Zones in Punjab 222
8.5 Significance of the Ecological Sensitive Zones 223
8.5.1 Ramsar Sites: Wetlands of International Importance 224
8.5.2 EPA Punjab's Initiative: Mapping Industrial Clusters around Ecologically Sensitive Zones 224
8.6 Proximity Assessment: Industrial Impact on Ecological Sensitive Zones 226
8.6.1. Lal Suhanra National Park, Bahawalpur 226
8.6.2. Changa Manga Plantation Forest, Kasur 226
8.6.3. Uchali Lake, Soon Valley (EPA-Notified Sensitive Area) 227
8.6.4. Kahuta Tehsil (EPA-Notified Sensitive Area) 228

DRAFT SOE 2025

8.6.5. Jahlar Lake, Soon Valley (EPA-Notified Sensitive Area) 229
8.6.6. River Ravi Corridor – Ravi Syphon to Village Maraka (50 km stretch) 230
8.6.7. Dharab Lake (EPA-Notified Sensitive Area) 231
8.7 Conclusion 232
Chapter No. 9: Plastic and Hazardous Waste Management 233
9.1. Introduction 233
9.1.1. Escalating Plastic Pollution and Its Environmental Consequences 234
9.1.2. Hazardous Waste and Industrial Vulnerability 235
9.2. The Regulatory Shift and Future Outlook 235
9.2.1. Plastic Reduction Commitments and Strategies 236
9.2.2 Producer Responsibility & Mandatory Registration 237
9.2.3 Transition from Plastic Waste to Circular Economy 240
9.2.4 Green Credit Program, 2025 240
9.3. Plastic Recycling in Punjab 243
9.3.1. Post-Confiscation Handling and Recovery 244
9.3.2 Plastic Pledges and Plastic-Free Zones 247
9.4. Plastic-Free Zones 248
9.4.1 Voluntary Environmental Commitments and Policy Integration 249
9.4.2 Plastic-Free Markets and Community Participation 250
9.4.3 Integrated Plastic and Waste Management Approach 251
9.5. Waste Wise School Campaign by EPA Punjab 251
9.5.1. Integrated Waste Wise Management Implementation across Schools 252
9.5.2. Operational and Environmental Benefits 253
9.5.3. Public Health and Community Linkages 254
9.5.4. Outcomes and Future Prospects 254
9.6. Hospital Waste Management and Compliance 255
9.6.1. Hospital Waste Generation in the Healthcare Sector 256
9.6.2. Regulatory Framework and Risk Waste Classification 257
9.6.3. Segregation and On-Site Handling 259
9.6.4. Storage, Transportation and Treatment 261
9.6.5. Authorisation of Certified Waste Management Firms 263
9.7. Hospital Waste Mitigation Infrastructure and Compliance 265

DRAFT SOE 2025

9.7.1. Monitoring, Inspection and Compliance Enforcement....266
9.7.2. Infrastructure Performance and Waste Generation Trends....266
9.7.3. Compliance Monitoring and Capacity Building....268
9.7.4. Future Perspective....268
9.8 Conclusion....269
Chapter No. 10: One Health and Environmental Risk Nexus in Punjab....270
10.1 Introduction and Background....270
10.2 Punjab's Disease Burden and Epidemiological Context....270
10.3 Conceptual Framework: Human, Animal, Ecosystem and Climate....271
10.3.1 The Animal-Human Interface:....272
10.3.2 Animal and Livestock Density:....272
10.3.3 Ecosystem Resilience:....272
10.3.4 Climate Change as a "Threat Multiplier":....272
10.4 Environmental Risk Pathways Affecting Health....273
10.4.1 Disease Burden: Endemic and Emerging Zoonoses....273
10.4.2 Environmental Pollution....274
10.4.3 Economic Burden....274
10.4.4 Antimicrobial Resistance (AMR):....274
10.4.5 Urban Vulnerability and Habitat Change....275
10.5 Multisectoral Divisions Supporting the One Health Framework....275
10.6 Regulatory Role in Risk Reduction....278
10.6.1 Strategic Policy and Legal Frameworks for One Health: Needs Assessment and Prioritisation....278
10.6.2 Punjab's Current Regulatory Landscape: Challenges and the Need for Integration....279
10.6.3 EPA Punjab as a regulatory bridge....281
10.7 Punjab's One Health Governance Infrastructure....281
10.7.1 One Health Hub:....282
10.7.2 IHR Coordination....282
10.7.3 District-Level Implementation:....282
10.7.4 Legal Framework....282
10.7.5 Punjab Food Authority (PFA):....282
10.7.6 Smog Prevention....282

DRAFT SOE 2025

10.7.7 National Alignment 282
10.8 Current Progress and Technical Strengths (2025 Lens) 283
10.8.1 Digital Surveillance 283
10.8.2 Integrated Data Flow and Response System 283
10.8.3 Laboratory Networks 283
10.8.4 Pandemic Fund Grant: 283
10.8.5 Immunization: 284
10.9 Ongoing Challenges and Risk Trends 284
10.9.1 Antimicrobial Resistance (AMR): 284
10.9.2 Workforce Disparities: 284
10.9.3 Financing: 284
10.9.4 Infection Prevention and Control (IPC): 284
10.9.5 Rising Vector-Borne Threats: 284
10.10 Strengthening One Health Frameworks in Punjab 285
10.10.1 Align with National and Global Health Security Frameworks 286
10.10.2 Establish Strong Governance and Coordination 286
10.10.3 Develop Policy and Legal Frameworks 286
10.10.4 Strengthen Integrated Surveillance and Workforce Capacity 286
10.10.5 Focus on Prevention and Community Engagement 286
10.10.6 Monitor Progress with Measurable Indicators 286
10.11 Conclusion 287
Chapter No. 11: Bird Strike Risk Reduction 289
11.1 Introduction 289
11.2 Enforcement by EPA Punjab 290
11.3 Enforcement Data (2025) 291
11.4 Conclusion 293
Chapter No. 12: Stubble Burning and Smog Mitigation 294
12.1 Overview 294
12.2 Environmental Impacts of Stubble Burning 295
12.2.1 Farmer Awareness and Capacity Building Campaigns 296
12.3 Preventive Instruments 301

DRAFT SOE 2025

12.3.1 Distribution of Super Seeders and Rice Straw Shredders 301
12.3.2 Impact of Preventive Measures 303
12.4 Need for Strategic Surveillance 305
12.5 EPA's Monitoring Framework 305
12.5.1 Surveillance Squad Deployment 306
12.5.2 Remote Sensing and Technology Integration 307
12.5.3 Public Reporting Mechanisms 308
12.5.4 Quick Response Centres (QRCs) 310
12.5.5 Incident Reporting and Response Mechanism 311
12.5.6 Green Punjab App and Digital Monitoring Platform 311
12.6 Inter-departmental Coordination & Enforcement 312
12.6.1 Collaboration with Agriculture Department 312
12.6.2 District and Tehsil-Level Coordination Mechanisms 312
12.6.3 Police Department Coordination 313
12.6.4 Centralised Coordination through Smog War Room 313
12.7 Environmental Outcomes 313
12.7.1 Reduction in Fire Anomalies 314
12.7.2 Emergency Response Performance 314
12.7.3 Air Quality Improvements 315
12.7.4 Soil Health and Agricultural Benefits 316
12.7.5 Behavioural Change and Long-term Sustainability 316
12.8 Way Forward 317
Part III Digital Transformation & Coordinated Environmental Governance 318
Chapter No. 13: Digital Environmental Governance 319
13.1 Introduction 319
13.2 EPA Punjab's Digital Transformation Framework 319
13.3. Digital Monitoring System and Dashboards 320
13.3.1. AI-Driven Smart Monitoring 322
13.3.2. Environmental Approval Management System (EAMS) 323
13.3.3. Unique Identification System and E-Mapping of Industries 326
13.3.4. EPA Punjab Industrial Directory 328
13.3.5. Certified Private Laboratory Digital Portal 330

DRAFT SOE 2025

13.3.6. Air Quality Monitoring System 334
13.4 Digital Transformation of Field Operations 342
13.4.1 Revamping of the Eco Watch Application 342
13.4.2 Plastic Confiscation Verification System 344
13.4.3 Revamping of the 1373 Helpline 346
13.4.4 Revamping of the Green Punjab Application 347
13.5 Digital Institutional Reforms 349
13.5.1 Human Resource Management Information System (HRMIS) 350
13.5.2 Electronic Filing and Office Automation System (e-FOAS) 351
13.5.3 Digital Compliance Verification System 352
13.5.4 Online Adjudication Hub 354
13.5.5 Internal Accountability Dashboard 355
13.5.6 Establishment of the IT Support Unit 357
13.6 Conclusion 358
Chapter No. 14: Inter-departmental & International Coordination 359
14.1. Introduction 359
14.2. International Engagements by EPA Punjab 360
14.2.1 World Economic Forum 2025 361
14.2.2. Second High-Level World Health Organization (WHO) Conference 362
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) 363
14.2.4. Regional Training Workshop on Air Quality Data Analysis, 30 June-04 July 2025, Kathmandu, Nepal. 363
14.2.5. Regional Representation of EPA Punjab AT SACEP–AIT Programme (Bangkok, September 2025) 363
14.2.6. Transformative Action to End Open Burning of Waste in South Asia 366
14.2.7. Conference Of Parties (COP-30) under UNFCCC 366
14.2.8. Strengthening Regional Capacity for Wastewater and Environmental Surveillance (WES) in Public Health Systems of IsDB Member Countries 371
14.2.9. Clean Air Week 2025 372
14.2.10. International Technical Partnerships and Bilateral Cooperation Initiatives (In Pipeline) 373
14.3. Local Partnership & Coordination Mechanism 374

DRAFT SOE 2025

14.3.1. Memorandums of Understanding with Local Authorities 375
14.3.2. Youth Engagement and Academic Partnerships for Environmental Action: 378
14.4 Conclusion: From Engagement to Endurance 381
Part IV Integrated Sustainability, Public Engagement & Future Outlook 383
Chapter No. 15: Whole of Government Approach for Greener Punjab 384
15.1 Introduction 384
15.2 Sectoral Integration of Environmental Governance in Development Projects 384
15.3 Green Public Investment Framework 385
15.4 EP&CCD Development interventions under ADP 386
15.5 Institutional Environmental Governance Reforms 390
15.6 Sectoral Environmental Investment Analysis 391
15.7 Urban Development Sector 393
15.8 Agriculture Sector 394
15.9 Waste Management Sector (Suthra Punjab Program) 395
15.10 Disaster Management Sector 395
15.11 Environmental Co-benefits of ADP Investments 397
15.12 Governance Performance & Monitoring 398
15.13 Challenges & Implementation Constraints 398
15.14 Conclusion 399
Chapter No. 16: Behavioural Change through Community Engagement 400
16.1 Introduction 400
16.2 Understanding Behavioural Patterns in Environmental Governance 401
16.2.1 Positive Behavioural Patterns 401
16.2.2 Negative Behavioural Patterns 401
16.3 EPA Punjab's Integrated Behavioural Transformation Model 402
16.3.1 The Green Behaviour Transformation Model 402
16.4 Building Environmental Behaviour from Childhood 403
16.4.1 Mera Pouda Mera Class fellow 404
16.4.2 Green School Certification Program 405
16.4.3 Environmental Council 406
16.4.4 Im4Climate Campaign 407

DRAFT SOE 2025

16.4.5 Docudrama 408
16.4.6 Public Awareness Play “Dharti Maa” at Alhamra Art Council 410
16.5 Digital Media Engagement 412
16.5.1 Social Media Platforms & Digital Outreach 412
16.5.2 AI-enabled Citizen Engagement 416
16.6 Technology-Driven Environmental Communication & Enforcement Visibility 417
16.6.1 Environmental Protection Force & Enforcement Visibility 417
16.6.2 Drone Surveillance & Smart Environmental Monitoring 417
16.6.3 Liquid Tree & Innovative Environmental Communication 418
16.6.4 AQI Forecasting & Public Environmental Advisory System 419
16.7 Electronic Media Engagement 420
16.7.1 Strategic Media Communication & Leadership Outreach 420
16.7.2 Public Awareness Campaigns & Environmental Narrative Building 421
16.7.3 Media Visibility of Environmental Enforcement & Field Operations 421
16.7.4 Technology-Driven Environmental Monitoring & Smart Enforcement 421
16.7.5 Sectoral Environmental Compliance & Regulatory Reporting 422
16.8 National & International Print Media Coverage 426
16.8.1 EPA Post-Smog Appraisal & Institutional Learning 426
16.9 Outcomes and Societal Impact of Media & Community Engagement 427
16.9.1 Environment as Mainstream Public Discourse 428
16.9.2 Transformation of Environmental Governance into Publicly Visible Governance 428
16.9.3 Strengthening Public Trust, Responsiveness & Environmental Awareness 428
16.9.4 Emergence of Participatory Environmental Culture 428
16.9.5 Enhancing Institutional Credibility & Global Visibility 429
16.10 Centre for Knowledge Exchange and Policy Dialogue (CKE&PD) 429
16.11 Conclusion 430
Chapter 17 Future Direction 431
17.1 Environmental Governance Maturity 431
17.1.1 Progress Achieved in 2025 431
17.1.2 Focus Areas for 2026 432
17.2 Strategic Outlook for 2026 433
17.2.1 Key Strategic Priorities for 2026 434

DRAFT SOE 2025

17.3 Conclusion 438
Acknowledgements 439
EPA Punjab's Success Stories 446
Achievements 450
Annexures 454
References: 483

DRAFT SOE 2025

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

DRAFT SOE 2025

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

DRAFT SOE 2025

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 / Polyethylene Terephthalate
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 Licence Management Information System
PM	Particulate Matter
PM2.5	Particulate Matter (≤2.5 µm)
PM10	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 Centres
QRU	Quick Response Unit
RNA	Rapid Needs Assessment
RVM	Reverse Vending Machine
RWH	Rain Water Harvesting

DRAFT SOE 2025

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 to 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

DRAFT SOE 2025

Executive Summary

The year 2025 marked a defining period for environmental governance in Punjab, reflecting a visible shift in the scale, speed, and maturity of response by the Environment Protection & Climate Change Department and EPA Punjab. Despite the province's vast demographic, industrial, agricultural, and urban pressures, EPA Punjab demonstrated strong institutional performance through expanded enforcement, digital transformation, real-time monitoring, improved service delivery, and coordinated field operations. The Department moved beyond routine regulatory functions and positioned environmental protection as a data-driven, technology-enabled, and whole-of-government agenda. This year, Punjab not only strengthened its traditional regulatory role but also introduced new systems, new sectors of intervention, and new mechanisms of accountability, making 2025 a year of measurable progress, institutional innovation, and forward-looking environmental reform.

Punjab entered in 2025 with an already complex environmental profile shaped by population growth, transport expansion, industrial activity, agricultural intensity and rising consumption. These pressures were further intensified by extreme climatic episodes like pre-monsoon drought (record heat reaching 49.5°C in southern districts), abnormal monsoon rainfall and severe floods across 23 districts. Punjab being the most populous province Pakistan and a major economic hub, its environmental burden remained closely linked with air quality, water resources, ecosystems, public health, and urban infrastructure. Despite these conditions, EP&CCD and EPA Punjab demonstrated strong institutional performance by moving beyond routine inspections and reactive enforcement towards a more coordinated, technology-enabled, and evidence-based model of environmental governance.

The Environment Protection & Climate Change Department responded by shifting the operating model of environmental governance from manual to digital, from reactive to proactive, and from isolated enforcement to informed decision-making. The institutional focus moved beyond conventional regulatory control towards real-time monitoring, data integration, digital approvals, AI-assisted surveillance, public dashboards, and targeted field interventions. This transformation became the central feature of environmental governance in 2025.

Air pollution remained the most critical environmental and public health challenge. Vehicular emissions, industrial smoke, brick kilns, stubble burning, dust and winter temperature inversions continued to worsen air quality, especially in Lahore and other urban-industrial districts. Punjab has 22.2 million vehicles, more than 9,000 brick kilns, thousands of industrial units, and major agricultural burning zones. However, 2025 also showed measurable improvement. Average PM2.5 levels across the province declined from 118 $\mu g/m^3$ in 2024 to 78 $\mu g/m^3$ in 2025, reflecting a reduction of nearly 33%. In Lahore, the October–December average AQI improved by 18–19%, while the number of severe hazardous days dropped significantly.

DRAFT SOE 2025

These improvements were supported through large-scale enforcement, expanded monitoring, and coordinated field action. EPA Punjab carried out more than 81,000 brick kiln inspections, sealed non-compliant units, tested vehicle emissions, deployed fog cannons for localised particulate reduction, and planted more than 448,000 trees in brick kiln belts, industrial areas, and public spaces. A satellite and ground-based surveillance mechanism was used to monitor stubble burning, supported by 67 Quick Response Centres along motorway corridors. As a result, fire anomalies declined by 65% compared with 2024. The Air Quality Monitoring System was expanded to 41 stations across 18 districts, providing live public air quality data through the government's own monitoring network.

Water stress and wastewater pollution remained another major challenge. Punjab's groundwater extraction far exceeds recharge, while urban centres such as Lahore and Faisalabad continue to witness rapid groundwater decline. In southern Punjab, salinity has affected large groundwater areas. Untreated municipal and industrial wastewater continues to contaminate drains and rivers, particularly the Ravi River and Hudiara Drain. In response, EPA Punjab strengthened wastewater regulation through the establishment of a Specialised Wastewater Unit, issuance of hearing notices and Environmental Protection Orders, monitoring of major drains, and assessment of highly polluted industrial clusters such as the Kasur tannery area. Water recycling was promoted through the installation of 2,242 recycling plants at commercial car wash stations, while rainwater harvesting was made mandatory for new constructions.

Waste management, plastic pollution, healthcare waste, and hazardous waste also received focused attention in 2025. Punjab generates approximately 57,000 tonnes of municipal solid waste daily, requiring stronger regulation and institutional coordination. EPA Punjab conducted more than 113,000 inspections related to plastic pollution, seized 419 tonnes of banned plastic, and certified major public and commercial locations as plastic-free. The Plastic Management Information System was introduced to register producers, collectors, and recyclers. In healthcare waste management, a certified firm system was developed and treatment facilities were upgraded, resulting in improved handling of high-risk hospital waste.

A major achievement of 2025 was the introduction of new sectors and the strengthening of existing regulatory functions. Environmental approvals, air quality monitoring, wastewater regulation, plastic control, healthcare waste management, climate finance, digital enforcement, citizen services, and international climate engagement were all expanded. Existing functions such as EIA/IEE processing, inspections, complaints, adjudication, and compliance monitoring were digitised and scaled. At the same time, new tools such as AI-powered CCTV monitoring, geo-tagged industrial databases, QR-code verification systems, and online adjudication platforms were introduced to make governance more transparent, traceable, and efficient.

The Environmental Assessment Management System transformed the approval process by enabling proponents from all 41 districts to submit applications digitally without traveling to

DRAFT SOE 2025

Lahore. EPA Punjab processed a record 2,317 environmental applications and issued 2,013 approvals in 2025. The Eco Watch Application digitised enforcement activity across seven modules and recorded more than 150,000 field actions. More than 14,000 industries were assigned Unique IDs and geo-located for systematic monitoring. AI-powered CCTV cameras installed on industrial stacks allowed live monitoring from EPA headquarters, reducing dependence on physical inspections alone. The Online Adjudication Hub resolved more than 1,000 compliance cases, many within a week. The 1373 Helpline was upgraded, while internal complaint dashboards were linked with PMDU, improving public accountability.

The whole-of-government approach was another defining feature of 2025. Environmental improvement was no longer treated as the responsibility of one department alone. Air pollution, stubble burning, wastewater, plastic control, public health, urban development, agriculture, transport, industry and disaster response required coordinated action across departments and agencies. EP&CCD worked with district administrations, transport authorities, agriculture departments, industries, local governments, health institutions, development agencies and international partners. This collaborative approach helped align enforcement, monitoring, public awareness, investment, and emergency response under a shared environmental agenda.

Punjab also strengthened its position in climate finance and global environmental engagement. The EP&CCD development budget increased from PKR 5 billion in 2023–24 to PKR 15 billion in 2025–26, representing a 200% increase. Punjab's climate-tagged budget reached approximately PKR 795 billion, covering mitigation, adaptation, and supporting sectors. Major initiatives such as the CM Saaf Pani Programme, Punjab Clean Air Program, renewable energy expansion, Green Credit Program, and multilateral partnerships reflected a shift from small-scale interventions to larger, system-level investments. Punjab also increased its international presence through participation in COP-30, UNFCCC observer engagements, World Economic Forum events, WHO platforms, ICIMOD workshops, and regional forums.

Overall, the State of Environment Report 2025 presents a province under significant environmental pressure but also one that has begun to respond with seriousness, scale, and institutional innovation. The year demonstrated that Punjab's environmental challenges are complex and interconnected, but they can be addressed through data-driven governance, digital systems, strict enforcement, inter-departmental coordination, public participation, and sustained investment.

The way forward for 2026 must build on these gains. Priority areas include focused enforcement in pollution hotspot districts, province-wide expansion of air quality monitoring, predictive governance through AI and IoT-based sensing, stronger wastewater regulation, climate-resilient water management, introduction of a provincial emissions trading system, expansion of digital environmental services, and development of a centralised Environmental Data Exchange Platform. The core challenge now is to sustain the improvements achieved in 2025, scale them across all districts, and institutionalize environmental governance as a shared responsibility of government,

DRAFT SOE 2025

industry, communities, and citizens. The progress made in 2025 should not remain an exceptional response to an extraordinary year; it must become the new normal for a cleaner, healthier, and more climate-resilient Punjab.

DRAFT SOE 2025

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*)

DRAFT SOE 2025

Part I: Environmental Governance Framework & Provincial Context

DRAFT SOE 2025

Chapter No. 1: Introduction

1.1 Background

The State of Environment Report is prepared by the Environmental Protection Agency, Punjab, as part of its continuing public mandate to document, interpret and communicate the environmental condition of the province in a systematic and publicly accessible manner. This mandate emanates from the statutory functions assigned to the Agency under clause (d), sub-section (1) of section (6) of the Punjab Environmental Protection Act 1997, "**The Provincial Agency Shall – prepare and publish an annual Punjab Environmental Report on the state of the Environment"** whereby the Agency is required, inter alia, to collect, compile and disseminate environmental information, to monitor environmental quality and to prepare reports for the purposes of 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 the province is informed by credible and organised evidence. It therefore 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 laid by the State of Environment Report 2024. That earlier report established an important basis for provincial environmental reporting by consolidating major environmental themes, institutional developments and regulatory concerns within a single public document. The current report continues that exercise with greater policy maturity and sharper 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 and interrelated pressures. Urban expansion, industrial growth, agricultural intensity, ecological stress, resource depletion and climatic variability increasingly interact in ways that cannot be understood in isolation. In such circumstances, a comprehensive environmental report becomes indispensable. It provides a coherent basis for understanding how environmental change is unfolding across the province and how public institutions are responding to that change.

1.2 Purpose

The State of Environment Report 2025 has been prepared to provide a consolidated account of the environmental status of Punjab and the activities undertaken by the Environment Protection and Climate Change Department (EP&CCD) during the reporting year. The report serves as the Department's official annual progress, bringing together environmental information, monitoring results, regulatory interventions and institutional developments in a single reference document.

DRAFT SOE 2025

The purpose of the report is to document and communicate the condition of the province's environment and the Department's response to key environmental challenges. By compiling information from various sectors and programmes, the report provides a structured record of environmental trends, management actions and developments that occurred during the year. It also contributes to institutional knowledge and serves as a reference for government agencies, researchers, development partners and other stakeholders interested in Punjab's environmental landscape.

1.3 Objective

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

The report further aims to document the 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 environmental management efforts and the issues addressed by the quarter concerned

Another 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 resource for future environmental planning, policy formulation and management interventions by highlighting key trends, knowledge gaps and areas where further action may be required.

DRAFT SOE 2025

1.4 Structure

The State of Environment Report 2025 is structured around four integrated thematic parts that collectively present the institutional, environmental, technological and strategic dimensions of environmental governance in Punjab.

i. **Part I:** Environmental Governance Framework & Provincial Context outlines the regulatory and institutional foundation. It provides the governance structure under PEPA 1997, the evolving role of EPA Punjab, the shift towards preventive and evidence-based governance, judicial oversight along with Punjab's environmental profile covering population growth, urbanisation, industrial expansion, climate stress and ecological pressures.

ii. **Part II:** Environmental Quality Assessment & Pollution Management provides a comprehensive assessment of environmental conditions across 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 also evaluates pollution sources, ecological hotspots, monitoring systems, enforcement measures, remediation efforts and environmental outcomes across the province.

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

iv. **Part IV:** Institutional Performance, Public Outreach and Strategic Outlook focuses on environmental mainstreaming across Development Schemes, Public Engagement, Behavioural Pattern, Media Engagements & Future Outlook, acknowledgements, Success

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Stories and Achievements for advancing governance maturity and institutional preparedness in Punjab.

The State of Environment Report 2025 is structured into four parts covering environmental governance and provincial context, environmental quality and pollution management, digital transformation and international linkages, and institutional performance, public engagement and future priorities for environmental management in Punjab.

1.5 Scope

The State of Environment Report 2025 provides a comprehensive assessment of Punjab's environmental conditions, governance systems, pollution trends and regulatory responses across key sectors. The report encompasses 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 frameworks, policy interventions and programmatic initiatives undertaken by EP&CCD Punjab and its functional arm EPA Punjab throughout the year. By synthesizing field data, monitoring outcomes and governance indicators, the report serves as both a performance accountability document and a strategic reference for evidence-based environmental policymaking in Punjab.

1.5.1 Significance for Environmental Governance

The significance of this report lies in its contribution to a more transparent, evidence-based and accountable model of environmental governance. In a province as large and complex as Punjab, environmental protection cannot rely on isolated interventions alone. It requires continuity in observation, seriousness in analysis and clarity in public communication. This report contributes to all three.

By systematically presenting environmental information, the report strengthens transparency and improves confidence in the seriousness of institutional processes. By documenting environmental conditions alongside official actions, it reinforces accountability and creates a basis for reflection on both progress and continuing gaps. By assembling environmental themes within a common framework, it supports policy coherence and enables institutions to engage with environmental issues in a more integrated manner.

The report therefore occupies an important place within provincial environmental governance. It is not simply a publication; it is part of the governance process itself.

1.5.2 Public Value and Policy Relevance

The value of the report extends beyond the institutional requirement of documentation. It carries wider public and policy significance by creating a common evidentiary basis for environmental understanding. It helps policymakers, researchers, academic institutions, development partners, industry and citizens engage with environmental questions through a credible public reference point.

DRAFT SOE 2025

For policymakers, the report provides a structured basis for understanding provincial environmental priorities and identifying areas requiring stronger coordination, sharper regulatory attention or improved institutional response. For researchers and academic institutions, it offers an organised entry point into environmental inquiry. For the public, it affirms that environmental information is a matter of legitimate public concern and public right.

In this way, the report contributes not only to governance, but also to civic awareness. It helps establish the environment as a shared public issue, closely connected with health, livelihoods, quality of life and the long-term sustainability of development.

1.5.3 Instrument of Transparency and Accountability

One of the most important functions of the State of Environment Report is to strengthen transparency in environmental governance. Environmental regulation gains legitimacy when it is accompanied by open communication, structured evidence and visible institutional reasoning. By bringing environmental information into the public domain, the report advances that objective.

At the same time, the report serves as an instrument of accountability. It records environmental conditions, institutional concerns and public sector responses in a manner that can be examined and understood. This form of documentation is itself a public responsibility. It ensures that environmental governance is not exercised in opacity, but within a framework of disclosure and explanation.

The report therefore helps build institutional credibility. It reflects the understanding that environmental governance must not only act, but also communicate the basis of its action with clarity and responsibility.

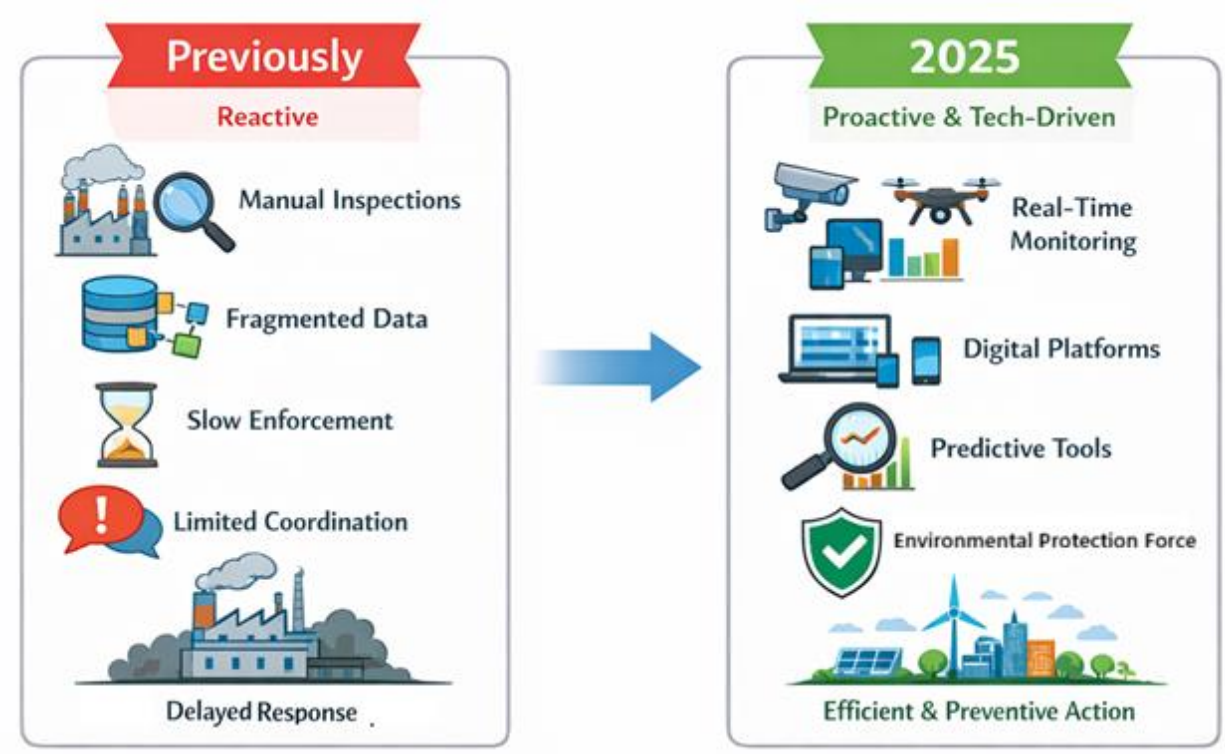
1.6 Practical Applications of the Report

This report serves as a practical governance tool that goes beyond documenting environmental conditions. It consolidates environmental data, monitoring outcomes and institutional actions into a coherent policy-relevant framework that directly supports decision-making at multiple levels. It enables institutional prioritisation by identifying sectors where environmental pressures demand sustained regulatory attention. It strengthens policy formulation by presenting environmental trends and governance concerns together, allowing for integrated and evidence-based responses. It grounds public discourse in verified data, fostering informed community engagement and environmental accountability. It also promotes preventive governance by making environmental deterioration visible at early stages, enabling timely intervention before challenges escalate. Most importantly, this report shifts environmental governance from reactive and fragmented responses towards proactive, coordinated and informed stewardship of Punjab's natural resources and ecological systems.

DRAFT SOE 2025

1.7 2025 at a Glance

The environmental governance landscape witnessed a clear shift from 2024 to 2025, moving beyond conventional, reactive enforcement towards a structured, technology-driven and proactive regulatory framework. In 2024, environmental management largely relied on manual inspections, fragmented data systems, limited monitoring infrastructure and delayed enforcement mechanisms, which constrained timely decision-making and reduced overall effectiveness. Coordination among departments was comparatively weak, compliance verification processes were slower and public engagement mechanisms were less integrated, resulting in gaps in transparency and accountability.



In contrast, 2025 marked a transformative phase characterized 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 replaced manual workflows, significantly improving efficiency, traceability and responsiveness. Monitoring evolved from periodic inspections to continuous surveillance through AI-enabled CCTV systems, drone-based inspections and real-time emissions tracking. The introduction of predictive tools, such as advanced AQI forecasting models, shifted the focus from reactive responses to pre-emptive action, enabling authorities to anticipate and mitigate environmental risks in advance.

Institutionally, 2025 demonstrated stronger governance through structured accountability mechanisms, performance-based evaluations and ISO-certified quality systems and enhanced inter-departmental coordination. Enforcement capacity was significantly strengthened with the

operationalization of a dedicated Environmental Protection Force and the adoption of zero-tolerance compliance policies. Additionally, industrial regulation, waste management and resource conservation initiatives became more standardised, technology-backed and enforceable.

The findings presented in this report indicate that 2025 marked a significant transition towards a mature, integrated and data-driven environmental governance model emphasizing prevention, transparency and sustainability. The evidence supporting this assessment is presented throughout the subsequent chapters through environmental data, regulatory outcomes, institutional performance and documented achievements.

1.8 Limitations and Implementation Challenges

This report reflects the most credible and complete environmental picture of Punjab that current systems can offer. It has been prepared with care, rigor and a genuine commitment to accuracy. However, intellectual honesty requires that its boundaries be clearly stated. Environmental monitoring networks are not yet uniform across all districts of the province. Data collection in certain areas remains irregular or incomplete. Some critical environmental indicators particularly those relating to groundwater quality, soil health and biodiversity lack the consistent baselines needed to support reliable trend analysis. Where such gaps exist, this report acknowledges them openly rather than substituting data with assumption or estimation.

The challenges do not end with data. Translating sound environmental policy into consistent field-level outcomes remains a complex undertaking. Inter-departmental coordination, while improving, is not yet seamless across all relevant institutions. District-level technical and human capacity continues to develop but has not yet reached the depth required for fully integrated environmental management. Compliance verification in remote or rapidly industrialising areas remains difficult. The pace of urbanisation and industrial expansion in certain parts of Punjab continues to place pressure on regulatory systems that are still scaling up to meet demand. These are not simple administrative shortcomings. They are structural challenges shaped by decades of under-investment, rapid demographic change and the inherent complexity of governing a province as large and diverse as Punjab.

It is equally important to recognise that progress has been made. The institutional landscape of 2025 is meaningfully stronger than that of previous years. Digital monitoring systems, real-time data platforms and strengthened enforcement mechanisms have brought greater transparency and responsiveness to environmental governance. Yet progress in some areas does not erase continuing gaps in others. EPA Punjab acknowledges both with equal candor. Honest recognition of limitations is not a weakness it is a precondition for improvement. This report is offered in that spirit. Future editions will work systematically to narrow these gaps, strengthen the evidence base and build a progressively more complete and reliable account of Punjab's environmental condition.

DRAFT SOE 2025

Chapter No. 2: Regulatory Framework & Governance Paradigm

2.1 Statutory Mandate & Core Functional Framework

The Punjab Environmental Protection Act, 1997 provides the legal foundation for environmental governance in the province, establishing the institutional authority, regulatory mechanisms and enforcement powers necessary to protect, conserve and improve the environment. The Act seeks to prevent and control pollution, regulate the use of hazardous substances and ensure sustainable development by integrating environmental considerations into planning and decision making. It lays down a comprehensive framework that combines policy oversight, regulatory authority, project-level environmental assessment, monitoring and enforcement, enabling the provincial government to address environmental challenges systematically. By defining the roles 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 implementable. Over time, the Act has facilitated the development of an institutional environmental governance framework in Punjab that integrates environmental protection with economic and social development objectives, thereby constituting a key component 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 clearly defining institutional roles, powers and accountability. These provisions enhance the Punjab Environmental Protection Agency's implementation capacity by granting statutory authority for regulation, enforcement, monitoring and interdepartmental coordination. By embedding compliance and enforcement mechanisms in law, the Act enables the EPA to carry out effective, on-ground environmental management, ensuring a structured and legally enforceable environmental governance regime to control pollution and promote 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. It 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 PEPA, 1997 deals with the establishment of the Provincial Environmental Protection Agency as the principal executive authority responsible for administering and implementing the Act, the rules and regulations made thereunder. Read with Sections 6 and 7, the Act empowers the Provincial Agency to enforce environmental laws, monitor environmental quality and compliance with Punjab Environmental Quality Standards (PEQS), regulate activities having actual or

DRAFT SOE 2025

potential environmental impacts, coordinate with Government Agencies and initiate enforcement proceedings in cases of non-compliance. Together, these sections establish the policy-making and regulatory framework essential for effective environmental governance in Punjab.

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

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

Section 6 of PEPA, 1997 defines the functions of the Provincial Agency and authorises EPA Punjab to administer and implement the provisions of the Act, the rules and regulations made thereunder. The Section empowers the Provincial Agency to establish and enforce Punjab Environmental Quality Standards (PEQS), undertake environmental monitoring, inspections, investigations and research, coordinate with Government Agencies and local authorities, and promote measures for pollution control, environmental protection and sustainable development. It further authorises the Agency 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 for effective implementation of the Act. The Section empowers EPA Punjab to conduct inquiries and investigations, obtain information and documents, enter and inspect premises in accordance with law, collect and analyse samples, and initiate enforcement proceedings in cases of environmental violations. It further authorises the Provincial Agency to exercise regulatory oversight and undertake enforcement measures necessary for ensuring compliance with Punjab Environmental Quality Standards (PEQS), environmental laws, rules and regulations made under PEPA, 1997.

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

Sections 12, 14, 15 and 16 of PEPA, 1997 form the operational backbone of EPA Punjab. Section 12 mandates that projects likely to cause adverse environmental effect undergo an Initial Environmental Examination or Environmental Impact Assessment and obtain prior approval, ensuring preventive environmental regulation. Section 14 regulates hazardous substances, requiring approval for handling, storage, transportation and disposal to safeguard human health and the environment. Section 15 of the Punjab Environmental Protection Act, 1997 deals with the regulation of motor vehicles, prohibiting the operation of vehicles that emit air pollutants or noise above the permissible Environmental Quality Standards. It empowers the Provincial Agency to take measures such as requiring pollution control devices, maintenance or emission testing measures to ensure compliance and to prevent vehicles that exceed limits from being operated. Section 16 allows the Agency to issue Environmental Protection Orders to enforce corrective measures, suspend operations, or mandate restoration, providing a flexible administrative

DRAFT SOE 2025

enforcement mechanism. Collectively, these sections integrate assessment, regulation, risk management and enforcement.

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

Sections 31 to 33 of PEPA, 1997 empower the provincial government and the Agency to make rules, regulations and delegations for effective implementation. Section 31 empowers the Government to make rules for carrying out the purposes of the Act. Section 32 authorises amendment of the Schedule to the Act, while Section 33 empowers the Provincial Agency to make regulations consistent with the Act and rules. These provisions ensure flexibility, technical capacity and coordinated governance across 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

DRAFT SOE 2025

			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

DRAFT SOE 2025

			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 notified various rules and regulations to ensure environmental protection, pollution control and sustainable development within the province. These instruments provide the legal framework for regulating industrial activities, managing waste, controlling air, water and noise pollution and ensuring compliance with environmental quality standards in Punjab. They guide EPA Punjab in inspections, monitoring, enforcement and data collection, enabling consistent and effective implementation and enforcement of the Act and rules made thereunder across the province. The major rules and regulations notified under this legislative framework, which form the operational backbone of environmental governance in Punjab, are discussed 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, made under Section 31 of the ibid Act, 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 prohibit open burning of waste, stubble and other pollutants and impose administrative penalties for non-compliance, for prevention and control of air pollution and protection of public health.

Regulatory Significance: The Punjab Environmental Protection (Smog Prevention and Control) Rules 2023 improve air quality by reducing emissions from industries, vehicles and brick kilns while restricting the open burning of crop residues, waste and other pollutants. These rules protect public health in general and encourage cleaner industrial and transport practices and ensure accountability through administrative penalties for non-compliance, supporting a healthier and

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more sustainable environment. Current year reports indicate a general improvement in air quality across Lahore and other parts of Punjab, reflecting the positive impact of these measures.

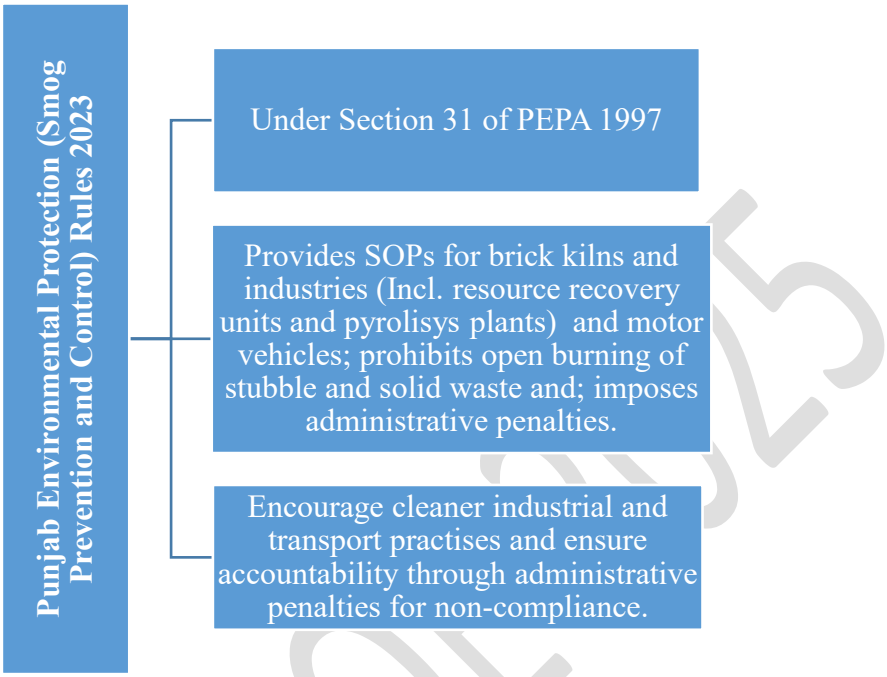

Figure 2.1: Overview of the Punjab Environmental Protection (Smog Prevention and Control) Rules 2023

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 require every healthcare facility to prepare and implement a Hospital Waste Management Plan, constitute dedicated waste management teams and ensure the proper segregation, collection, storage, transportation, treatment and disposal of hospital waste in accordance with prescribed procedures. The Rules establish a regulatory framework for the environmentally sound management of infectious and hazardous healthcare waste in order to minimise environmental contamination, safeguard public health and ensure safe handling of hazardous healthcare materials.

Regulatory Significance: The Punjab Hospital Waste Management Rules, 2014 provide a comprehensive legal and operational framework for the safe management of hospital waste across healthcare facilities in the province. The Rules help protect healthcare workers, patients and the general public from exposure to infectious and hazardous waste, reduce contamination of soil, air and water resources and strengthen environmental and public health safeguards through mandatory waste segregation, treatment and disposal mechanisms. By prescribing institutional responsibilities and compliance requirements, the Rules also enhance regulatory oversight and promote environmentally responsible healthcare waste management practices.

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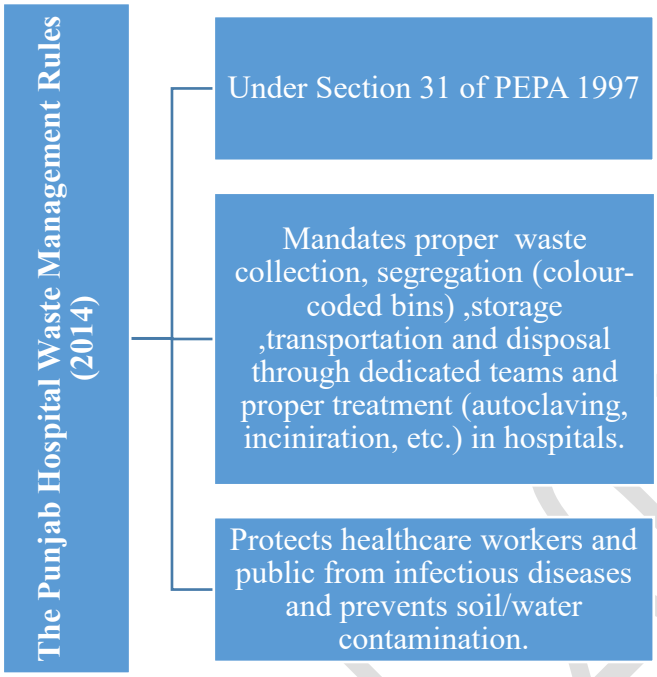

Figure 2.2: Overview of the Punjab Hospital Waste Management Rules (2014)

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 emitting air pollutants or noise in excess of the prescribed Punjab Environmental Quality Standards (PEQS). The Rules authorise officers of the Punjab Environmental Protection Agency and other notified authorities to inspect motor vehicles, conduct emission and noise testing and initiate enforcement proceedings against non-compliant vehicles in accordance with the prescribed legal procedure. The Rules further provide a regulatory framework for monitoring vehicular emissions and ensuring compliance with environmental standards aimed at the prevention and control of 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 regulatory oversight of motor vehicles, the Rules contribute to the protection of ambient air quality, public health and the environment. The Rules also promote compliance with environmental standards through periodic inspection and emission testing mechanisms, thereby supporting environmentally responsible transport practices and strengthening the enforcement mandate of the Punjab Environmental Protection Agency under the Act and the rules made thereunder.

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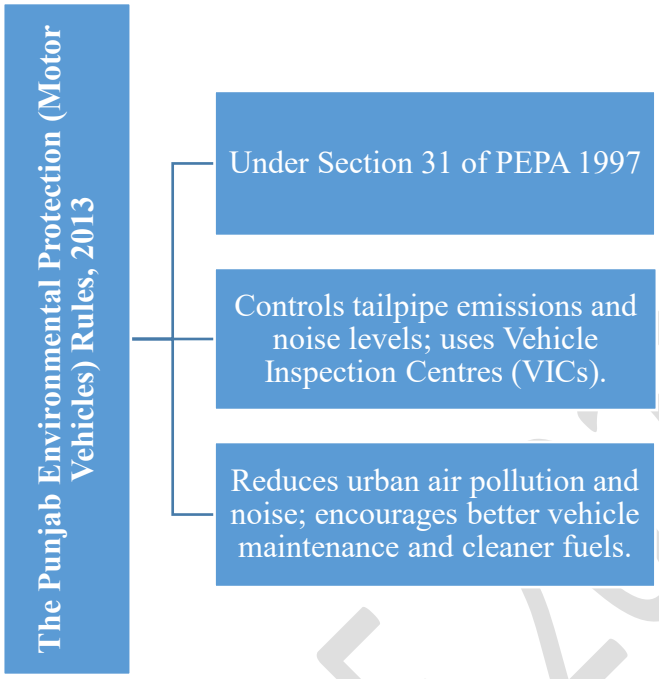

Figure 2.3: Overview of the Punjab Environmental Protection (Motor Vehicles) Rules, 2013

2.3.4 The Punjab Bio-Safety Rules, 2014

Formulated under Section 31 of 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 for evaluation and management of potential biosafety risks associated with research, handling, commercial application and industrial use of such organisms and materials. The Rules further aim to ensure biosafety compliance, protection of human health and the environment and adherence to prescribed regulatory standards.

Regulatory Significance: The Punjab Bio Safety Rules, 2014 establish a regulatory framework for the handling, use, transport, storage and management of genetically modified organisms (GMOs) and hazardous biological materials. The Rules aim to protect human health and the environment by regulating potential biosafety risks arising from the misuse, accidental release or unauthorised handling of such materials. They prescribe risk assessment, containment and laboratory safety measures for research, industrial and commercial applications, while establishing biosafety committees and institutional oversight mechanisms for monitoring and regulatory compliance. The Rules further facilitate responsible scientific research and technological development within prescribed biosafety and environmental safeguards.

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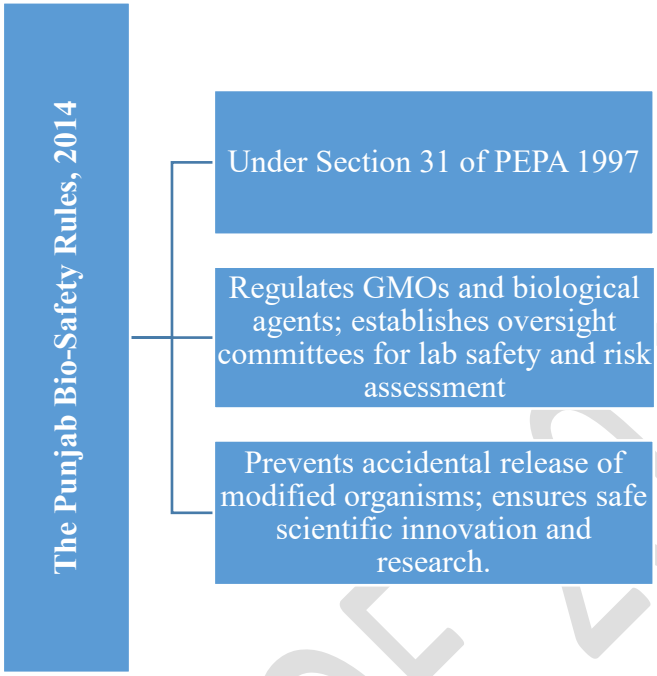

Figure 2.4: Overview of the Punjab Bio-Safety Rules, 2014

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 provide a regulatory framework for controlling the production, sale, distribution and use of specified single-use plastic products within the Province. The Regulations prohibit the manufacture, import, sale, supply and commercial use of notified single-use plastic products, including cotton bud sticks, balloon sticks, disposable cutlery and other specified plastic items. The Regulations further require the online registration of producers, importers, brand owners, distributors, collectors, recyclers and bulk consumers and provide for the establishment of District Plastic Management Committees to facilitate coordination, monitoring and implementation at the district level.

Regulatory significance: The Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Products) Regulations, 2023 establish a statutory mechanism for reducing plastic pollution and promoting environmentally sound waste management practices across the Province. By restricting the production and consumption of notified single-use plastic products, the Regulations aim to minimise the accumulation of non-biodegradable waste in urban areas, water bodies and agricultural lands, thereby protecting the environment and public health. The Regulations also promote the collection, segregation, recycling and environmentally responsible management of plastic waste through registration, monitoring and compliance obligations imposed

DRAFT SEP 2025

upon relevant stakeholders. Furthermore, the regulatory framework encourages the adoption of sustainable and environmentally friendly alternatives to single-use plastics and strengthens institutional enforcement through inspection, monitoring and regulatory action in accordance with the Act and the regulations made thereunder. Collectively, these measures support sustainable environmental governance and contribute towards the reduction of plastic-related environmental degradation within the Province.

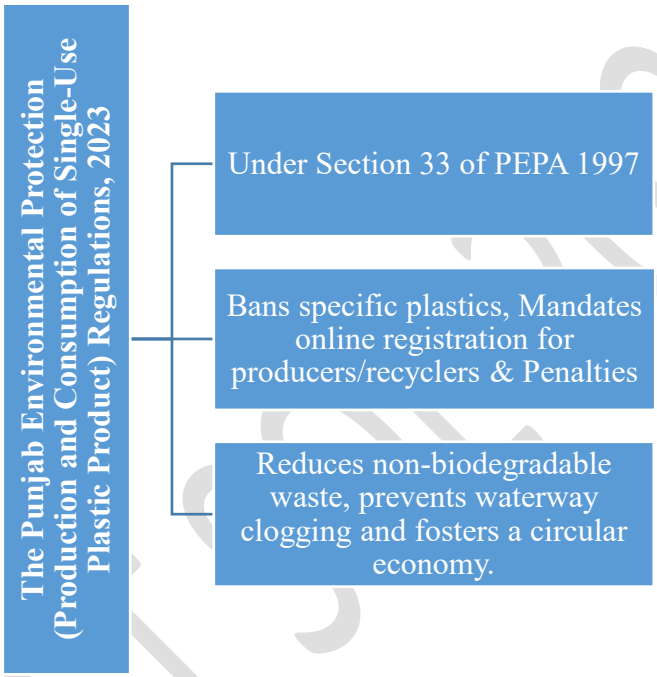

Figure 2.5: Overview of the Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Product) Regulations, 2023

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 to make regulations, consistent with the Act and the rules made thereunder, for carrying out the purposes of the Act.

The Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2022 establish the procedural and regulatory framework for the review and approval of Initial Environmental Examinations (IEEs) and Environmental Impact Assessments (EIAs) in respect of scheduled development projects. The Regulations require proponents of projects falling within the prescribed categories to submit an IEE or EIA, as the case may be, prior to commencement of construction or operation and before obtaining relevant approvals where applicable. The Regulations prescribe procedures relating to

submission, scrutiny, public participation, review timelines, grant or refusal of approval and compliance with environmental management and mitigation measures. The regulatory framework is intended to ensure that potential adverse environmental effects of proposed projects are identified, assessed and appropriately mitigated in accordance with the requirements of the Act and the regulations made thereunder.

Regulatory Significance: The Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2022 provide a legally structured environmental assessment mechanism for infrastructure, industrial and other development projects within the Province. Through the mandatory review of IEEs and EIAs, the Regulations enable the Punjab Environmental Protection Agency to assess potential environmental impacts at the planning stage and ensure incorporation of appropriate mitigation and environmental management measures prior to project implementation. The Regulations further strengthen environmental decision-making through prescribed procedures for technical review, public participation and post-approval compliance, thereby promoting sustainable development and protection of the environment in accordance with the objectives of the Act.

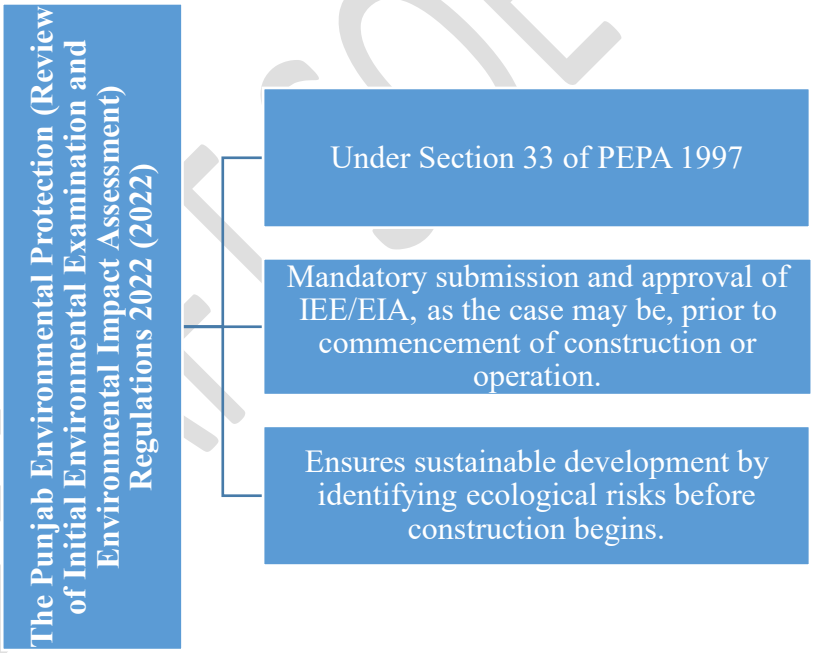

Figure 2.6: Overview of the Punjab Environmental Protection (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations 2022 (2022)

2.3.7. Punjab Environmental Quality Standards: Legislative Overview

The Punjab Environmental Quality Standards (PEQS) are the environmental quality standards notified under the Punjab Environmental Protection Act, 1997 (PEPA). Under Sections 6(1) (e), 6(1) (f) and 6(1) (g) of PEPA, 1997, the Punjab Environmental Protection Agency is empowered

to prepare, establish and enforce the Punjab Environmental Quality Standards for the discharge or emission of effluents, wastes, air pollutants and noise, as well as standards for the quality of ambient air, water and land, subject to approval of the Punjab Environmental Protection Council where required under the Act. The PEQS prescribe the environmental standards and permissible limits applicable for the prevention and control of pollution within the Province.

So far, seven Punjab Environmental Quality Standards (PEQS) relating to different environmental media, emissions and regulated activities have been notified under the Punjab Environmental Protection Act, 1997, 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,**	12th of August, 2016	Standards Governing treatment and disposal, by incineration, autoclaving, microwaving and deep burial.

DRAFT SOE 2025

	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

The EPA Punjab ensures compliance by inspecting, monitoring and taking enforcement actions under its legal powers. It can also impose administrative penalties, as outlined in the Punjab Environmental Protection (Administrative Penalty) Rules 2013. For judicial matters, the Punjab Environmental Tribunal handles environmental offenses and appeals, creating a complete system that combines executive enforcement with judicial oversight to uphold PEQS across the province.

2.4 Environmental Adjudication and Tribunal Framework in Punjab

2.4.1 Punjab Environmental Tribunal

The Punjab Environment Tribunal is a specialised judicial body established under Section 20 of PEPA 1997, which, after devolving to the province through the 18th Constitutional Amendment, was adapted for Punjab via the Punjab Environmental Protection (Amendment) Act 2012. The Government is empowered to establish as many Tribunals as necessary by Gazette notification, defining territorial limits or class of cases for each, with its procedure governed by the Punjab Environmental Tribunal Rules, 2012. The Environmental Tribunal consists of a Chairperson and two Members, including one Member possessing technical or scientific expertise. The presence of the Chairperson and at least one Member constitutes the quorum for proceedings of the Tribunal. Decisions of the Tribunal are made by majority opinion.

2.4.2 Functions of the Punjab Environmental Tribunal

The PET exercises exclusive jurisdiction over all matters under PEPA, with its proceedings carrying the full weight of judicial proceedings under the Pakistan Penal Code and the Code of Criminal Procedure, making it legally equivalent to a court of law. Complaints may be brought before it by the Punjab EPA, other authorities, or aggrieved persons for violations such as unlawful discharge of effluents, excess emissions, mishandling of hazardous substances and non-compliance with IEE/EIA approvals, while it also holds the power to impose compensatory costs of up to Rs. 100,000 against false or vexatious complainants. Beyond adjudication, the PET serves a broader enforcement role by directing government departments to ensure IEE and EIA compliance and functions as the judicial arm of Punjab's environmental governance structure alongside the Punjab Environmental Protection Council (Apex policy-making body) and the Punjab EPA (Regulatory body), collectively forming a system of checks and balances for environmental management across the province.

DRAFT SOE 2025

2.4.3 Progress of PET throughout the Year 2025

The Punjab Environmental Tribunal maintained an active judicial calendar throughout the year 2025, handling two primary categories of cases: Departmental Complaints and Environmental Appeals. The following is a general overview of the Tribunal's performance based on the official statement covering the period from 01.01.2025 to 31.12.2025.

i. Departmental Complaints

Punjab Environmental Protection Agency actively files and pursues departmental complaints before the Punjab Environmental Tribunal to ensure compliance with environmental regulations. These complaints mainly address violations of mandatory IEE/EIA requirements and highlight the Agency's proactive enforcement role.

A pendency of 49 cases at the start of the year (01.01.2025). During the year, 288 new complaints were instituted, bringing the total to 337. Out of these complaints 327 were disposed of, leaving a balance of only 10 cases as of 31.12.2025. A fine of Rs. 14,585,000 was imposed across 299 cases for violation of Section 12 of PEPA 1997, reflecting active enforcement of environmental standards related to IEE/EIA compliance. Out of the remaining 28 cases, 05 cases resulted in acquittal, 04 cases were dismissed, 11 cases were disposed of through other final orders, 02 cases stood abated, and 02 cases were consigned to record. In addition, 04 cases were kept pending through sine die adjournment.

ii. Environmental Appeals

Under the provisions of the Punjab Environmental Protection Act 1997, aggrieved proponents and public file appeals before the Punjab Environmental Tribunal against enforcement actions taken by the Punjab Environmental Protection Agency. These appeals typically challenge penalties, Environmental Protection Orders (EPOs) and actions taken under the Smog Rules, reflecting the exercise of legal rights and ensuring transparency and accountability in environmental regulation.

The year began with 236 pending appeals. During the year, 624 new appeals were instituted, making the total 860. Out of these, 747 were disposed of, leaving a balance of 113 appeals pending at year-end. Notably, out of the disposed appeals, 609 were appeals filed under Smog Rules 2023 and 46 were appeals against EPO violations of different provisions of PEPA 1997, indicating that smog-related enforcement was a dominant area of activity during this period.

Overall, the data reflects that the Punjab Environmental Tribunal remained highly active throughout 2025, disposing of the vast majority of its caseload in both categories, with fines imposed under departmental complaints demonstrating meaningful financial accountability for environmental violations.

2.5 Specialised Units

In recognition of the increasingly complex and technically demanding nature of environmental enforcement, EPA Punjab has established a set of specialised units that extend the Agency's

DRAFT SOE 2025

operational capacity well beyond traditional regulatory functions. These units bring together expertise in strategic analysis, information technology and aerial surveillance forming an integrated, multi-dimensional enforcement and intelligence architecture. Together, they equip EPA Punjab with the tools, data and situational awareness necessary to confront environmental violations with precision, speed and strategic foresight.

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

The Strategic and Analysis Wing serves as the analytical engine of EPA Punjab's operational framework. Operating at the intersection of data, strategy and enforcement, SAW equips leadership with the strategic insight necessary to move beyond reactive responses towards a more anticipatory, evidence-driven model of environmental governance one capable of addressing Punjab's increasingly complex pollution challenges with institutional precision.

i. Performance Evaluation and Data Analysis

SAW's foundational mandate is the regular collection and analysis of environmental data received from all fragments of EPA Punjab, like field offices, EPA Labs across Punjab, different sections of EPA working in EPA Headquarters (HQs) and comparative analysis with international studies. SAW also collects data from many other sources, like field inspections, reports on industrial compliance, air quality sensors and even satellite images. Using this data, it creates clear, easy-to-understand insights that help EPA to make informed decisions. These analysis enable EPA Punjab to identify pollution hotspots with spatial precision, track enforcement trends over time, generate comprehensive situational assessments and forecast emerging environmental risks before they escalate into crises.

Among SAW's most significant achievements in 2025 was the preparation and presentation of a comprehensive data-driven report that provided scientific evidence strong enough to justify the replacement of the Site Inspection Report (SIR) with a more robust and analytically grounded monitoring mechanism, marking a decisive shift towards evidence-based environmental enforcement. Building on this, SAW developed and operationalized an interactive dashboard that was formally recognised as the Internal Accountability Dashboard (IAD), demonstrating institutional transparency and data governance maturity within EPA Punjab. Furthermore, SAW established a landmark inter-organisational paradigm by collaborating with the Punjab Safe Cities Authority (PSCA), which for the first time dedicated a desk to environmental monitoring in coordination with EPA Punjab, a milestone that reflects the expanding institutional footprint of SAW beyond EPA's internal operations and into broader provincial governance structures.

ii. Execution of New Initiatives and Operational Horizons

SAW leads the conceptualization and execution of landmark programmes that push EPA Punjab into new operational frontiers. The AQI Forecasting System stands as one of SAW's most significant contributions delivering real-time and predictive air quality monitoring in Lahore and equipping both policymakers and the general public with timely to support informed decision-

DRAFT SOE 2025

making. The Emission Testing System (ETS) enhances EPA Punjab's ability to accurately measure and regulate vehicle emissions. By using scientific methods and reliable equipment, it ensures that vehicles meet environmental standards, helping reduce air pollution and hold owners accountable for compliance. Anti-Smog Guns Operations coordinate enforcement in Lahore during periods when air pollution is expected to rise sharply. These operations involve monitoring pollution sources, ensuring compliance with environmental regulations and taking timely action to protect public health, especially for vulnerable groups like children, the elderly and people with respiratory conditions. While Anti-Stubble Burning Operations take action on the ground to reduce crop residue burning in agricultural areas. Each initiative reflecting SAW's commitment to designing responses that are strategic, scalable and grounded in environmental evidence. (Sand trolley squads)

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

2.5.2.2. IT Support Unit

The IT Support Unit serves as the digital backbone of Environmental Protection Agency, Punjab, driving the agency's mission through technology across three key areas: Internal Efficiency, Regulatory Oversight and Citizen Empowerment. By integrating modern digital tools into every aspect of its operations, EPA Punjab ensures that environmental governance is not only effective but also transparent and accessible to all.

i. Internal Efficiency

On the internal side, the IT Support Unit manages a range of tools designed to streamline administrative and operational functions across the agency. The Internal Accountability Dashboard (IAD) maintains transparency and accountability across all departments, while E-Pay Integration simplifies the imposition and collection of environmental fines through a secure digital payment system. The E-Biz System supports core business processes and an Inventory Dashboard enables effective tracking of assets and resources. Together, these tools significantly reduce paperwork, improve inter-departmental coordination and allow EPA Punjab's staff to dedicate their efforts towards the agency's primary mandate of protecting the environment.

ii. Regulatory Oversight

For regulatory oversight, the IT Support Unit supports a robust set of monitoring and enforcement systems that strengthen EPA Punjab's capacity to regulate industries and track environmental conditions across the province. UID & E-Mapping enables comprehensive industrial baselining by digitally identifying and mapping industries operating across Punjab, providing regulators with an accurate and up-to-date picture of the industrial landscape. The Private Lab Portal facilitates the verification of environmental testing data submitted by accredited laboratories, ensuring the integrity of compliance reporting. The Air Quality Monitoring System (AQMS) continuously

DRAFT SOE 2025

tracks ambient air quality across key locations in Punjab through its dedicated public platform at (aqi.punjab.gov.pk), making real-time environmental data available to both regulators and the public. AQI Hourly Forecasting further enhances decision-making by providing predictive air quality updates, enabling timely regulatory responses. Eco Watch supports and coordinates field operations, allowing ground teams to document and report environmental violations efficiently. Collectively, these systems extend EPA Punjab's regulatory reach well beyond traditional inspection methods, enabling faster, data-driven and more effective enforcement.

Additionally, a dedicated Live Plastic Confiscation Tracking System provides real-time visibility into plastic seizure operations conducted across the province, enabling supervisory oversight, operational transparency and data-driven enforcement coordination in Punjab's ongoing crackdown on illegal plastic use. Collectively, these systems extend EPA Punjab's regulatory reach well beyond traditional inspection methods, enabling faster, data-driven and more effective enforcement.

iii. Citizen Empowerment

Recognizing that environmental protection is a shared responsibility, the IT Support Unit has developed several accessible platforms to engage citizens and build public trust in EPA Punjab's operations. The Plastic QR system enables the public traceability of plastic waste, promoting accountability across the plastic supply chain. The 1373 Helpline provides citizens with a direct and convenient channel to report environmental concerns and receive timely feedback from the agency. The E-Library offers the public and relevant stakeholders easy access to environmental laws, guidelines, research and educational resources, fostering greater environmental awareness. The Confirmation of Compliance tool allows regulated entities to verify and demonstrate their compliance status transparently. The Eco Chatbot provides instant, round-the-clock assistance and guidance to citizens navigating EPA Punjab's digital services, ensuring that help is always within reach.

Together, these systems reflect EPA Punjab's commitment to becoming a truly digitally empowered institution one that is capable of efficient internal management, real-time environmental monitoring, proactive enforcement and meaningful, ongoing engagement with the people of Punjab.

2.5.2.3. Drone Surveillance Unit

The Drone Surveillance Unit is among the most transformative innovations within EPA Punjab's enforcement architecture, deploying thermal drones to detect, document and deter environmental violations particularly in remote or expansive areas where ground-based inspection is logistically constrained.

EPA Punjab operates the DJI Mavic 3T, a professional-grade thermal drones combining a wide-angle 4/3 CMOS visual camera with a high-sensitivity infrared thermal sensor for simultaneous optical and thermal imaging. With a 45-minute flight time, 15 km transmission range and wind

DRAFT SOE 2025

resistance up to 12 m/s, it is purpose-built for sustained field reconnaissance. Its thermal analysis capability is particularly effective in detecting heat-emitting industrial violations, illegal burn sites and effluent discharge anomalies invisible to conventional cameras.

These assets are deployed over industrial zones, brick kiln clusters, waste dumping sites, agricultural burn areas and riverbanks capturing real-time visual and thermal data across large geographic areas with a level of detail previously unattainable. The unit's aerial presence also serves a strong deterrence function, discouraging non-compliance without a proportional increase in field staff deployment. Additionally, drones surveys of flood-affected areas and industrial accident sites provide rapid situational data supporting both immediate response and longer-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 represents a fixed, continuous and wide-area environmental monitoring capability. Unlike drone deployments that are mission-specific and time-bound, Hawk Eye operates as a persistent surveillance network, providing uninterrupted visual monitoring of high-risk environmental zones including industrial clusters, brick kiln belts and major waste disposal sites. The system enables EPA Punjab to remotely observe, record and flag environmental violations in real time, significantly reducing dependence on physical field presence while maintaining round-the-clock oversight. By feeding live footage and alerts directly into EPA Punjab's centralised monitoring framework, Hawk Eye strengthens the continuity of environmental surveillance and ensures that enforcement responses are triggered by verified, real-time evidence rather than periodic inspections alone. Together, the Drone Surveillance Unit and Hawk Eye Surveillance System represent EPA Punjab's commitment to building a technologically advanced, data-driven enforcement that is increasingly shaping the broader governance transformation observed across the Agency by 2025.

2.6 Governance Shift Observed by 2025

EPA Punjab shows a clear and visible shift in how it approaches environmental regulation in 2025. This change is not abrupt, but gradual shaped by evolving environmental challenges, increasing public awareness, judicial scrutiny and the growing expectation that environmental protection must be integrated into development rather than treated as an afterthought. The Agency's governance approach has matured in line with broader trends in institutional reform and sustainable development, with a noticeable move away from ad-hoc responses towards more structured, anticipatory regulation.

i. **From Reactive to Preventive Governance:** EPA Punjab has moved away from crisis-driven responses towards structured, advance planning. An AQI Forecasting Calendar now predicts periods of poor air quality well in advance, enabling strategic deployment of enforcement resources and timely public advisories. Pre-smog season scans of major districts identify high-risk

DRAFT SOE 2025

industrial zones, brick kiln clusters and stubble-burning areas before the season begins. Smart monitoring systems, including real-time sensors and predictive modelling, enable continuous emission tracking, while an inspector-less inspection mechanism at the Smog Control Room ensures round-the-clock industrial chimney surveillance. Digital dashboards further ensure accountability and data-driven decision-making throughout the enforcement cycle.

ii. **From Manual to Digital Administration:** EPA Punjab has transitioned from paper-based, in-person regulatory processes to a fully digital workflow through the Environmental Assessment Management System (EAMS) and e-FOAS. Project proponents now submit IEEs, EIAs and compliance documents online, while permits, compliance certificates and protection orders are digitally issued and tracked in real time, significantly improving efficiency, transparency and regulatory control across the province.

iii. **From Siloed to Coordinated Governance:** EPA Punjab has broken away from institutional isolation by actively collaborating with provincial planning departments, local governments, health and industry departments, the Agriculture Department, PDMA Punjab, Traffic Police, the Transport Department and the Punjab Safe Cities Authority. This interdepartmental coordination aligns environmental regulation with public health priorities, sustainable development goals and real-time urban surveillance, enabling a more holistic and effective regulatory response.

iv. **Transitioning to Evidence-Based Environmental Stewardship:** EPA Punjab has progressively replaced complaint-driven, manual enforcement with a model guided by scientific data, aerial surveillance, satellite imagery, digital inspection tools and centralised data capture systems. This evidence-based approach enables the Agency to anticipate environmental risks, identify pollution trends, prioritise high-risk activities and ensure that 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 basis for regulation, enforcement and sustainable development, supported by key provisions on environmental standards, impact assessments, hazardous substances and compliance mechanisms, alongside targeted rules on plastics, smog control, biosafety, hospital waste and vehicle emissions that ensure practical implementation through monitoring and enforcement; over time, this system has evolved from a reactive and siloed approach to a preventive, digital, coordinated and evidence based model, driven by tools such as EAMS, e-FOAS, smart monitoring and interdepartmental collaboration, thereby enhancing transparency, efficiency and accountability while enabling proactive risk management and better alignment of environmental protection with public health and sustainable development priorities.

DRAFT SOE 2025

Chapter No. 3: Judicial Interventions 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.), decided/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 the year 2018. Over the years, these proceedings have developed into one of the most consequential and wide-ranging judicial interventions in environmental governance in the history of Punjab. The Honourable Court, through the Judicial Water and Environmental Commission constituted in these proceedings, has continuously monitored environmental compliance, issued directions to departments, overseen enforcement of environmental laws and supported the Environmental Protection Agency (EPA), Punjab and the Environment Protection & Climate Change Department (EP&CCD) in controlling smog, air pollution, industrial emissions, vehicular pollution, water conservation, waste management, urban greening and protection of natural resources.

The present chapter is a sector-wise account of judicial interventions and the directions issued by the Honourable Court from the inception of the petition through the year 2025. The orders reproduced and summarized herein are taken directly from the proceedings and reflect the breadth and depth of the Court's engagement with environmental issues confronting Punjab and specifically the city of Lahore.

3.1 Judicial Water and Environmental Commission

The Honourable Court constituted the Judicial Water and Environmental Commission in these proceedings on 31.10.2019. The Commission was tasked with monitoring environmental compliance, conducting inspections, coordinating with departments and placing reports before the Court. The Members of the Commission have, over the years, filed detailed reports covering smog control, industrial emissions, vehicular pollution, groundwater depletion, tree plantation, waste management, traffic congestion, urban planning, brick kiln conversion, water recycling and environmental compliance of development projects.

The Honourable Court has repeatedly appreciated the efforts of the Members of the Commission and directed all departments and authorities to extend full cooperation to the Commission for the implementation of environmental measures. The Commission has met on a regular basis, held

DRAFT SOE 2025

meetings with relevant government departments and functioned as the primary instrument through which the Court has supervised implementation of its directions.

In the order dated 03.05.2024, the Court clarified that all actions taken by the Judicial Water and Environmental Commission are being done on the directions of this Court where proceedings are held on every Friday and under the constitutional jurisdiction of this Court. The Court further directed that the Environmental Tribunal should stay its hands as the matter relates to a larger issue of public interest being overseen by this Court through the Commission set up under the orders passed by this Court in its constitutional jurisdiction.

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 order dated 14.02.2025, the Court directed that the names of the Members of the Commission be forwarded by the Awards Recommending Committee for conferment of a suitable civil award for the most meritorious and distinguishable services rendered by these Members. Vide letter dated 06.03.2025, the names of the Members of the Commission were recommended for civil awards and that letter was sent to the Secretary (I&C), Government of Punjab.

3.2 Smog Control and Anti-Smog Measures

The Honourable Court played a central role in shaping Punjab's anti-smog governance framework through a series of directions aimed at institutional coordination, emergency response, public health protection and emission control. The Court emphasised that smog should not be treated as a routine environmental issue but as a public health and environmental emergency requiring coordinated action across multiple departments. Through continuous judicial oversight, directions were issued regarding crisis management mechanisms, closure of educational institutions during severe smog episodes, regulation of commercial activities, industrial emission controls and enforcement of environmental compliance measures.

The Court further stressed the importance of inter-departmental coordination, real-time monitoring, public safety and strict implementation of mitigation measures during smog season. Various institutions including PDMA, Environment Protection Department, district administration, law enforcement agencies, industries and business sectors were directed to undertake immediate and long-term interventions to reduce pollution levels and manage smog related emergencies effectively.

3.2.1 Declaration of Smog as Calamity and Crisis Management

In the order dated 07.10.2022, the Court directed the establishment of a Crisis Room in the Environment Department, headed by the Secretary Environment, for continuous monitoring and coordination of anti-smog measures. The Court further directed that smog and climate emergency be specifically addressed in the context of Lahore.

DRAFT SOE 2025

One of the significant directions was issued on 27.12.2022, wherein the Court, while taking note of the report regarding PTZ cameras, directed that the Members of the Commission shall coordinate with the Safe City Authority to ascertain whether the already installed PTZ cameras across Lahore could be effectively utilized and oriented towards areas reported to be contributing to air pollution. The Court also directed the appearance of the Director General, PDMA on the next date of hearing.

In the same order dated 27.12.2022, the Court observed that since smog had been declared a calamity, it would be appropriate for the Provincial Disaster Management Authority (PDMA) to assume the lead role in coordinating the overall response for controlling smog.

Note: *The declaration of smog as a calamity was not made by the Court but had already been notified by the Provincial Government of Punjab under Section 3 of the Punjab National Calamities (Prevention and Relief) Act, 1958 vide Relief Commissioner's Order No. Smog-2020/10/Coord-I dated 14.10.2020. The Court's directions were issued in light of this pre-existing executive declaration to operationalize 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 recognised the severe public health impacts of smog particularly on children and vulnerable populations. In this regard, directions were issued to regulate educational activities during periods of severe air pollution in order to minimise public exposure and reduce mobility.

Court Order dated 17.11.2023

It is therefore directed that any such notification to be issued either by the Secretary, Primary and Secondary Healthcare Department, Government of Punjab or by the office of the Deputy Commissioner, Lahore shall be issued in consultation with the Members of the Commission. Further, it is directed that the notification shall mention at least closure of public schools, colleges and universities and all educational institutions for each Saturday till end of January, 2024. Also the Government shall take measures for declaring two days in the week as work from home in the private sector in the Province of Punjab.

3.2.3 Closure of Markets, Restaurants, Hotels and Commercial Activities

The Court also issued directions regarding regulation of commercial and business activities during smog season in order to control unnecessary emissions and reduce urban congestion during high pollution periods. Enforcement agencies and district administration were directed to ensure strict implementation of the prescribed operational restrictions.

Court Order dated 24.11.2023

On the request of learned Members of the Commission, a direction is to CCPO to implement order of this Court regarding closure of markets and hotels at the time which has been settled by this Court. The order shall also be conveyed to the Secretary to the Chief Minister for passing on

DRAFT SOE 2025

necessary instructions to CCPO in this regard which will go a long way in the control of smog as restrictions should not be confined to Friday and Saturday of the week but must be observed across the board on all the days of the week as directed by this Court already.

3.2.4 Installation of Catalytic Converters and Emission Control Devices

The Honourable Court emphasised 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 directions highlighted the responsibility of industrial and trade bodies to ensure compliance among their members.

Court Order dated 26.04.2024

A direction is issued with regard to the installation of effluent treatment plant, emission control devices and catalytic converters on generators by industries throughout Punjab. In this regard, directions shall be conveyed to the Chambers of Commerce and industries across Punjab for seeking compliance of their Members to these directions. These Chambers shall inform the Members of the Commission regarding steps taken for compliance of these directions within four weeks from the order of this Court.

Court Order dated 20.06.2025

Report has been filed by the learned Members of the Commission. It refers to a letter written to various trade organisations regarding installation of catalytic converters on generators. Learned Members are required to follow up on this letter and apprise this Court on the next date of hearing. Similarly, letters have been written to the cooperative societies for installation of recharge wells.

3.2.5 Working Hours for Markets and Business

The Court also directed regulatory authorities to continue monitoring commercial activities and ensure implementation of operational regulations designed to minimise congestion, emissions and environmental violations in major business areas.

Court Order dated 07.06.2024

The Court directed that LDA and other Departments shall continue to monitor the activities being carried out in Tollington Market to ensure that these are being done according to the regulations which have been formulated for the purpose.

3.2.6 EPA Appreciation and Support during Smog Season 2025

During the Smog Season 2025, the Punjab Environmental Protection Agency (EPA) remained at the forefront of implementation, coordination and enforcement of anti-smog measures across the province. The efforts of EPA Punjab were widely acknowledged at different administrative and operational levels due to continuous field monitoring, emergency response coordination, scientific surveillance and strict enforcement actions against environmental violations. Special monitoring squads, emission testing operations, industrial inspections and real-time air quality monitoring

DRAFT SOE 2025

mechanisms were actively deployed to support the provincial anti-smog strategy. EPA Punjab also worked in close coordination with district administration, law enforcement agencies, PDMA and other departments to ensure timely implementation of directions issued for public health protection and pollution control during severe smog episodes.

3.3 Control of Environmental Stressors

Since the initiation of the smog proceedings, the Honourable Lahore High Court has continuously monitored major environmental stressors contributing to deteriorating air, water and ecological conditions across Punjab. Through a series of detailed judicial directions issued over multiple years, the Court has gradually developed a broad environmental governance framework covering industrial emissions, brick kilns, stubble burning, vehicular pollution, groundwater depletion, waste management, plantation, environmentally sustainable infrastructure and protection of agricultural land. These directions not only strengthened enforcement responsibilities of the concerned departments but also introduced long term structural reforms aimed at environmental sustainability, institutional coordination and public compliance

3.3.1 EPA Operations against Industrial Units

Industrial emissions and non-compliance with environmental standards remained one of the central concerns repeatedly addressed by the Court throughout the proceedings. The Honourable Court consistently directed the Punjab EPA to strengthen enforcement actions against polluting industrial units across Punjab through inspections, sealing operations, installation of pollution control technologies and strict regulatory oversight. Particular emphasis was placed on accountability of officers responsible for enforcement failures and on ensuring installation of dry scrubbers, effluent treatment plants and other pollution mitigation systems within industrial facilities before allowing continued operations.

The Court issued directions from the earliest dates of the proceedings for EPA Punjab to enforce environmental standards against industrial units throughout Punjab. These directions covered sealing of non-compliant units, action against officers who failed in enforcement, installation of dry scrubbers, effluent treatment plants and 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 in respect of several units.

Court Order dated 11.11.2022

DRAFT SOE 2025

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 on old Bull Trench technology has been a persistent concern of the Court since the very beginning of these proceedings. The Court has monitored conversion of brick kilns to Zig Zag technology across Punjab through numerous orders over the years.

Court Order dated 31.01.2020

It is imperative therefore that the brick kilns be converted to the latest technology and for which a timeline has been provided depending upon the various regions which have been divided into zones. The brick kilns which fall within the red zones have been directed to shift to zigzag technology and to take stern action by the Government officials within whose jurisdiction the violation takes place. The officials concerned especially the Deputy Commissioners shall render full assistance in this regard

3.3.3 Stubble Burning — Enforcement and Imposition of Fines

The issue of crop residue burning was repeatedly highlighted by the Court as a major seasonal contributor to smog formation in Punjab. The Court directed strict administrative coordination among the Environment Protection Department, district administrations and other provincial departments to prevent stubble burning during peak smog months. The directions focused on preventive enforcement, issuance of district level circulars, awareness measures and regulatory action against violations to reduce agricultural emissions during the winter season.

Court Orders dated 05.08.2020, 22.10.2020,03.12.2020,

The Court directed issuance of a Circular to all the Deputy Commissioners of the Districts in Punjab regarding stubble burning. The Environment Protection Department was directed to ensure that the stubble burning activities are not carried out during the period starting early October and the implementation of the measures to forestall such acts by the farmers will be made in coordination with the other departments of the Govt. of the Punjab.

DRAFT SOE 2025

3.3.4 Vehicular Emissions and Transport Sector Reforms

Vehicular emissions were consistently recognised by the Court as one of the most significant anthropogenic contributors to urban air pollution and smog in Punjab. In response, the Court issued multiple directions aimed at strengthening transport sector regulation through stricter vehicle inspections, impounding of smoke emitting vehicles, implementation of electronic enforcement mechanisms, induction of eco-friendly transport systems and inter-agency coordination for roadside emissions monitoring. These measures collectively reflected the Court's emphasis on transitioning towards cleaner and more environmentally responsible transportation systems across Punjab

3.3.4.1 Impounding of Smoke Emitting Vehicles

Court Order dated 05.10.2023

It is reiterated as a clear direction that if any vehicle is found to be emitting hazardous smoke beyond the prescribed limits, it will be impounded and it is not sufficient that these vehicles be challaned or imposed fines. The vehicles will only be let off once they comply with the standards for plying on roads.

3.3.4.2 E-Challan on Vehicular Smoke Emission

Directions were issued for EPA & CTO & PSCA regarding Enhancement of Fine regarding Non-use of Helmets and E-Challan on Vehicular Smoke Emission. EPA & CTP & PSCA were directed in respect of Fine Imposed On Smoke Emitting Vehicles from as early as 2020. Similarly, EPA & CTO & VICS were directed in respect of Control On Vehicular Emission, Vehicular Inspection And Certificate System For Punjab.

3.3.4.3 Eco-Friendly Buses and Transport Policy

Court Order dated 15.11.2024

The Learned Advocate General Punjab has apprised that administrative approval has been given for induction of eco-friendly buses in Lahore. The relevant documents in this regard have been placed on the record and the budgetary allocation has also been made which is duly reflected in the budgetary documents of the Finance Department for the financial year 2024-25. This is indeed a commendable step and will contribute to lessen the environmental pollution and consequently the smog.

3.3.4.4 Motorway Police Coordination with EPA for Vehicle Inspection

Court Order dated 16.05.2025

The report on behalf of EPA has also been filed which refers to a meeting with Director General, EPA and representative of motorway police to constitute a team to take action against smog emitting vehicles and deploy monitoring teams on toll plazas. It is directed that the motorway police shall coordinate with EPA in this regard to provide suitable places to deploy monitoring

DRAFT SOE 2025

teams at all entry and exit points at the toll plazas. This direction shall be conveyed by the learned D.A.G to the Inspector General Motorway Police. The checking of polluting vehicles shall begin with the heavy transport vehicles only.

The instruments acquired by EPA should be stationed at entry and exit points of motorways to check violations of standards by vehicles of different categories.

3.3.5 Water Conservation and Groundwater Protection

The depletion of groundwater reserves and unsustainable water consumption emerged as another major environmental concern repeatedly addressed during the proceedings. Recognizing the growing stress on groundwater aquifers in Lahore and across Punjab, the Honourable Court issued several directions relating to groundwater recharge, water conservation, installation of treatment systems and regulation of wasteful domestic water practices. The Court emphasised both long term sustainability measures and strict enforcement actions to discourage excessive water usage and to promote environmentally responsible urban development practices.

3.3.5.1 Installation of Recharge Wells

The Court, from the early days of the proceedings, has been deeply concerned about the depletion of groundwater in Lahore and across Punjab. Directions were issued for installation of recharge wells in parks, housing societies and public places for replenishment of groundwater.

Court Order dated 20.06.2025

Letters have been written to the cooperative societies for installation of recharge wells. Learned Members of the Commission have referred to reports regarding work on yellow line running along canal road. It is apprehended that a large number of trees will be cut down for the purpose. Learned A.A.G is directed to seek instructions from the relevant Department in this regard and to file a report.

Court Order dated 31.01.2025

The report also refers to the list of recharge wells which have been installed and a further 10 recharge wells are under the process of being installed. Such measures will be highlighted during the meeting under the Chief Secretary, Punjab.

3.3.5.2 Prohibition on Use of Water Pipes for Car Washing

The Court remained consistently concerned regarding declining groundwater levels and directed various departments and housing societies to undertake groundwater replenishment measures through installation of recharge wells. These directions reflected the Court's broader emphasis on sustainable urban water management and protection of natural hydrological systems in Punjab.

Court Order dated 20.10.2023

DRAFT SOE 2025

The Members of the Commission shall require the Deputy Commissioner office to issue a circular to all cooperative housing societies with regard to the orders of this Court placing a prohibition on use of water pipes for washing of cars and irrigating gardens at the residences within the jurisdiction of those societies. A similar notice shall also be sent by the Registrar cooperative housing societies as also the D.G LDA shall ensure that this is also informed to the residents of the societies of LDA. The notice must inform the management of societies that in case of failure to control this practise the management will be personally responsible in this regard.

Court Order dated 04.12.2024

With regard to water conservation it is directed that upon first violation of use of water pipes for washing of commercial and residential areas, fine of Rs.10,000/- shall be imposed on residential premises and it shall be Rs.20,000/- as regards the commercial premises. In case of a second violation, the water connection to these premises shall be disconnected and this order shall be conveyed by WASA to all its officers.

3.3.5.3 Water Conservation — Ban on Hose Pipes

In order to discourage unnecessary wastage of potable water, the Court issued strict directions restricting the use of water pipes for washing cars and irrigating residential lawns. The Court further emphasised administrative enforcement through housing societies, district administrations and WASA authorities while also introducing financial penalties and disconnection measures for repeated violations.

Court Order (2025)

Simultaneously, wide campaign shall be initiated and this shall be directed to be undertaken by the Chief Secretary, Punjab informing general public regarding water conservation as also that the Government had taken a decision imposing of complete ban on the use of water for washing of cars and use of hose pipes in the houses. Anyone found in violation of these directions will be imposed a fine of Rs.10,000/-. Similarly the Local Governments as also the Development Authorities across Punjab shall be required to incorporate the rules for treatment plants to be installed in future construction of houses and commercial buildings.

3.3.5.4 Grey Water Treatment Plants in Residential Houses

The Court also encouraged incorporation of environmentally sustainable infrastructure within residential developments by directing installation of grey water treatment systems in larger residential houses. These directions reflected the Court's focus on wastewater reuse, reduction of freshwater dependency and promotion of environmentally compliant construction standards within urban housing sectors.

Court Order dated 23.02.2024

Installation of grey water treatment plant in residential houses of 01-kanal and above. It is directed that the regulations be approved expeditiously by the Authority. In addition, rules and concessions

DRAFT SOE 2025

relating to buildings which are constructed according to the environmental standards will be placed before the next date of hearing.

3.4 Tree Plantation, Miyawaki Forests and Protection of Green Areas

Protection and expansion of urban green cover remained an important area of concern throughout the proceedings. The Court repeatedly emphasised plantation drives, preservation of public green spaces and introduction of Miyawaki forests as part of urban ecological restoration efforts. Through these directions, the Court promoted institutional responsibility among public authorities, educational institutions and private sector entities for increasing urban plantation and protecting environmentally sensitive green areas from encroachment or conversion

3.4.1 Miyawaki Forests

Court Order dated 05.10.2023

Learned counsel for LDA shall explore in combination with PHA regarding Miyawaki Forests to be set up at different places within Lahore. In this regard learned counsel for restaurants has also undertaken that one such Miyawaki Forest will be sponsored and initiated by the Association of Restaurants in Lahore.

3.4.2 Tree Plantation in Public Schools and Colleges

Court Order dated 05.10.2023

Learned Member of the Commission, in charge of trees and parks across Lahore has also filed a report which refers to substantial steps regarding tree plantation. It has been stated in that report that the public colleges have taken steps for Committees to be set up for each college which would be titled Botany Association of the College and the terms of reference be also mentioned in the notification issued by the public colleges. It is expected that the associations so set up will take immediate measures for the implementation of TOR of the Association. Similar instruction shall be issued to all public and private schools across Lahore and similar notifications shall be issued by these schools. The order of this Court shall be circulated throughout these schools.

It is also directed that henceforth open spaces/playgrounds under the supervision of public colleges and schools will not be converted to any other use. In case such an action is required to be taken, a proper application shall be filed to this Court for seeking permission.

3.5 Agriculture Sector — Super Seeders and Mechanised Farming

The agriculture sector remained an important focus of the Court particularly in relation to controlling stubble burning and reducing seasonal smoke emissions contributing towards smog formation. Recognizing that enforcement alone would not be sufficient without providing practical alternatives to farmers, the Court consistently emphasised mechanised agricultural solutions including procurement and distribution of super seeders. Through continuous monitoring of

DRAFT SOE 2025

summaries, financial approvals and departmental coordination, the Court ensured progress towards introducing sustainable crop residue management practices across Punjab.

The Court played a key role in ensuring procurement and distribution of super seeders by the Agriculture Department to control stubble burning by providing farmers an alternative mechanism for clearing fields. Over multiple dates, the Court monitored the summary for purchase of super seeders, its forwarding to the Finance Department, and allocation of funds.

3.6 Environmental Compliance of Development Projects

3.6.1 No Conversion of Agricultural Land

The Court expressed serious concern regarding rapid urban expansion and conversion of fertile agricultural land into commercial and housing developments across Punjab. In order to protect agricultural resources and prevent environmentally unsustainable land use changes, strict directions were issued to district administrations and relevant authorities prohibiting conversion of agricultural land for commercial purposes and housing schemes.

Court Order dated 16.08.2024

It is once again directed and which direction shall be conveyed to all the relevant officers of the Districts that no conversion of agricultural land shall take place across Punjab and the use of said land for commercial purposes and for setting up of housing schemes is prohibited.

3.6.2 Green Standards in Building Regulations

The Court also emphasised the need to integrate environmental sustainability within future urban construction and building regulations. Directions were issued for formulation of environmentally compliant building standards including incorporation of treatment plants and environmentally sustainable construction incentives in future residential and commercial developments across Punjab

Court Order dated 27.06.2025

Learned counsel for LDA has informed that the rules and concessions relating to buildings which are constructed according to the environmental standards will be placed before the next date of hearing. It is directed that Local Governments as also the Development Authorities across Punjab shall be required to incorporate the rules for treatment plants to be installed in future construction of houses and commercial buildings.

3.7 Waste Management and Plastic Pollution

Waste management and plastic pollution emerged as important environmental concerns repeatedly addressed during the proceedings. The Court issued multiple directions relating to garbage disposal, recycling mechanisms, plastic waste management, landfill gas collection and sanitation practices in urban areas. Through these directions, the Court sought to strengthen institutional responsibility, improve public cleanliness, reduce environmentally harmful waste disposal

DRAFT SOE 2025

practices and promote environmentally sustainable waste management systems throughout Punjab.

3.7.1 LWMC — Prohibition on Garbage Burning

Improper disposal and burning of municipal waste was identified as a significant contributor to urban pollution and environmental degradation. The Court directed LWMC and concerned authorities to strengthen public awareness and ensure proper waste disposal practices in order to maintain cleanliness and prevent environmentally harmful garbage burning activities.

Court Order dated 25.11.2022

An order has also been issued directing the employees to counsel the owners of the houses and shops etc. for proper disposal of garbage waste in order to ensure cleanliness of roads and green belts.

3.7.2 Recycling of Solid Waste and Reuse of Plastic

The Court also encouraged environmentally sustainable waste management practices through promotion of recycling and reuse of plastic materials. The directions reflected the broader objective of reducing environmental pollution caused by unmanaged solid waste and encouraging circular waste management approaches within Punjab.

Court Order dated 07.07.2022

"It is also informed that Members of the Commission are in negotiation with certain multinational companies regarding recycling of solid waste and reuse of plastic. Further report shall be submitted on the next date of 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, remained one of the recurring environmental issues highlighted throughout the judicial proceedings. The Court consistently directed strict enforcement of the ban on polythene bags, imposition of penalties, and development of district-level waste collection and disposal mechanisms to mitigate plastic pollution and improve environmental conditions across Punjab.

These directions were issued through multiple orders, including those dated 07.02.2020, 24.09.2020, 22.10.2020, 11.12.2020, 14.04.2022, and 26.04.2024, wherein the Punjab Environmental Protection Agency (EPA) was specifically directed to enforce the ban on polythene bags and ensure imposition of fines on violations. In addition, vide order dated 26.04.2024, the Court directed formulation of a comprehensive policy at the district level for collection and disposal of polythene bags.

DRAFT SOE 2025

In terms of the applicable regulatory framework, enforcement of restrictions on single-use plastics is now governed under the **Punjab Environmental Protection (Single-Use Plastic) Regulations, 2023**, which constitute the current statutory instrument for regulating manufacture, sale, distribution, and use of polythene and other single-use plastic items. Accordingly, all enforcement actions are required to be read in conjunction with the said Regulations, which operationalize the policy intent reflected in the Court's directions.

3.7.4 Land Fill Gas Collection — Environmental Concern

The Court also addressed environmental risks associated with landfill gas emissions and their contribution towards air pollution. Concern was expressed regarding the environmental impacts of unmanaged landfill gases and directions were issued for EPA and LWMC to jointly examine the issue and submit detailed reports regarding mitigation measures and environmental safeguards.

Court Order dated 21.02.2025

Another issue of significance is the measures being taken by LWMC for the land fill gas collection. This is a major cause of environmental concerns relating to air pollution and it is directed that EPA shall look into the matter and file a report in conjunction with the Members of the Commission on the next date of hearing.

3.8 Public Awareness, Technology-Based Monitoring and PEMRA

The Court repeatedly emphasised that environmental protection and smog control could not be achieved through enforcement measures alone and required strong public awareness, citizen participation and technology driven monitoring systems. Through various directions issued during the proceedings, the Court encouraged the use of digital applications, surveillance technologies, media campaigns and inter-agency coordination mechanisms to strengthen environmental governance and public engagement. These measures reflected the Court's broader approach towards integrating technology, public outreach and institutional coordination within environmental management and compliance monitoring frameworks across Punjab.

3.8.1 PITB Application

The Court recognised the importance of citizen engagement and technology enabled complaint management systems for improving environmental governance and enforcement. In this regard, directions were issued regarding the development and promotion of a digital complaint registration application developed by PITB to facilitate public reporting of environmental and water related violations across Punjab

Court Order dated 11.08.2022

The report has been filed by the Judicial Water and Environmental Commission. It refers to the application for smartphones that has been developed by the Punjab Information Technology Board (PITB). By the development of Punjab Performance Management Framework where complaints

DRAFT SOE 2025

can be registered by the general public regarding violations of the orders of this Court in respect of various water and environmental issues on which directions have already been issued. This Application can be downloaded by the users on their smartphones and the complaints can be got registered with the Commission which can then take actions in respect of those complaints and direct the departments to initiate proceedings on those complaints. The Director General Public Relations Punjab is directed to advertise by all means available in the print and electronic media the fact regarding the setting up of the application so that the general public may know about the existence of this application and thereby create awareness regarding the issues of water conservations and environment.

3.8.2 PEMRA — Smog Awareness Campaign

Court Order dated 26.05.2023

The Members have informed that billboards have been erected while advertising the necessary information regarding smog. PEMRA has also been informed regarding the need to issue directions to all media outlets for advertisement of smog awareness to be telecast without fail. Learned D.A.G shall coordinate with PEMRA in this regard.

3.9 Inter-Departmental Coordination

A distinctive feature of these proceedings has been the Court's consistent emphasis on coordination among multiple departments and agencies. The departments that have been regularly called upon to appear, file reports and comply with directions include: EPA Punjab, EP&CCD, District Administration, CCPO, Traffic Police, CTO, LDA, WASA, PHA, LWMC, PDMA, Agriculture Department, School Education Department, Higher Education Department, Transport Department, Regional Transport Authority, PEMRA, PITB, Pakistan Railways, MCL, Pakistan Food Authority, Irrigation Department, Forest Department, and the Ministry of Climate Change and Environmental Coordination.

The Court has also directed that meetings be held between relevant departments to resolve specific issues. The Commission has convened meetings with the Secretary Transport, Secretary Environment, Secretary Agriculture, Agriculture Minister, Chief Secretary Punjab and other senior officials. The Court has directed that the Commission be given full access to all relevant departments and that departments extend full cooperation to the Commission.

3.10 Institutional Strengthening and Enforcement Support to EPA

The proceedings have provided critical institutional support to EPA Punjab in carrying out enforcement operations. The Court has consistently backed EPA's enforcement actions and directed police and civil administration to provide assistance during environmental inspections.

Court Order dated 12.07.2024

DRAFT SOF 2025

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 has been taken on the part of the CCPO and the S.P Operations in raiding Warehouses at different places in Lahore which resulted in seizure of a large quantity of old tyres which were being used for producing fuel to be used in industries in and around Lahore. It is directed that these Godowns will not be desealed until directed by this Court.

3.11 Conclusion

The proceedings in Writ Petition No. 227807/2018 titled Haroon Farooq Vs. Government of Punjab etc. have, over the years since 2018 through 2025, constituted the most sustained and comprehensive judicial engagement with environmental governance ever witnessed in Punjab. The Honourable Lahore High Court, through continuous monitoring and directions issued from time to time, has strengthened implementation of environmental laws and provided critical and sustained support to EPA Punjab and EP&CCD in controlling smog, reducing air pollution, promoting water conservation, ensuring environmental compliance, encouraging adoption of cleaner technologies and protecting the natural resources of Lahore and Punjab.

The judicial interventions have facilitated coordinated action among departments, strengthened environmental enforcement mechanisms, and ensured accountability in matters relating to environmental protection. In particular, the support extended by the Honourable Court during the smog seasons of 2022, 2023, 2024 and 2025 enabled EPA Punjab to take decisive enforcement action that contributed to significant improvement in air quality during the smog season. The directions of the Court in relation to 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 directly translated into enforcement actions by EPA Punjab.

The Court has also appreciated the measures taken by EPA Punjab and acknowledged the commendable work of the Judicial Water and Environmental Commission whose Members have rendered most meritorious and distinguishable services. The recommendation for conferment of civil awards upon the Members of the Commission is a recognition of the pivotal role they have played in environmental governance in Punjab.

The proceedings have demonstrated that sustained judicial oversight, working in partnership with a proactive and committed regulatory agency like EPA Punjab, can produce tangible and measurable results in environmental protection. The continued engagement of the Honourable Court in the years ahead will remain an important pillar of environmental governance in Punjab.

DRAFT SOE 2025

Chapter No. 4: 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 experiences significant pressure on its natural systems arising from rapid urbanisation, industrial concentration and intensive agricultural practices. These dynamics have placed increasing strain on air, water, land and ecological resources.

Understanding Punjab's environmental profile is essential for contextualizing the nature and scale of environmental stress in the region. By examining demographic trends, climate stressors and key environmental pressure points, provides us a foundational overview of the factors shaping environmental change in Punjab, setting the context for deeper analysis in subsequent sections.

4.2 Population, Urbanisation and Industrial Density

Population growth, accelerating urbanisation and increasing industrial density are closely interconnected forces shaping Punjab's environmental profile. High population density intensifies demand for land, water, energy and infrastructure, while rapid urban expansion often outpacing planning and service provision has transformed land use patterns and strained environmental resources. At the same time, the concentration of industrial activities in urban and peri urban areas has increased pressure on air, water and land systems, particularly where industrial zones overlap with residential and agricultural spaces. Together, these dynamics create compounded environmental stress, forming a critical backdrop for understanding environmental challenges in Punjab.

4.2.1 Population & Demographic Overview

Punjab is one of the most populous regions, with a large and steadily growing population that has significant implications for environmental sustainability. Population growth trends reflect both natural increase and migration patterns, contributing to rising pressure on land, water and public services. The sheer size of the population intensifies demand for food production, housing and energy, thereby amplifying environmental stress across the province.

As per the Pakistan Population and Housing Census 2023, Punjab remained the most populous province of Pakistan, with a total population of 127.68 million. Based on the prevailing annual growth rate of approximately 2.53 percent, the population of Punjab is projected to reach approximately 134.3 million by 2025, placing significant pressure on environmental resources, infrastructure and public services. Lahore continues to be the most populous city of the province, with an estimated population of around 15.23 million, followed by Faisalabad with approximately

DRAFT SOE 2025

3.98 million inhabitants, making them major urban centres with heightened environmental and sustainability challenges.[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 vary considerably across the province due to geographic, economic and infrastructural factors. The province as a whole is densely populated relative to many other parts of Pakistan, with the highest concentrations of people in and around major cities like Lahore, Faisalabad, Rawalpindi and Gujranwala. These urban corridors attract internal migration for employment, education and services. In contrast, districts in the south like Rajanpur and Layyah are less densely populated due to more arid conditions and agricultural constraints. Many central and northern districts sit along fertile river plains, sustaining larger rural populations and moderate densities.

4.2.2. Urbanisation

The urbanisation trajectory of Punjab, marks a profound demographic and spatial shift that has fundamentally altered the province's landscape. Historically, Punjab's urban transition began from a modest base; in 1951, a mere 17.4% of the population resided in urban centres. Fast forward to the 7th Population and Housing Census 2023 and that figure has surged to 40.71%. Approximately, 51.97 million people are now classified as urban dwellers.[3]

This demographic surge is mirrored by an aggressive physical expansion of built up environments. Spatial analysis provided by The Urban Unit's Punjab Cities Growth Atlas reveals that the contiguous urban extent of the province's 50 large cities nearly tripled between 1995 and 2015. The built-up area escalated from approximately 891 sq km to 2,589 sq km during this 20-year period, representing a massive land conversion of 1,698 sq km. This outward "sprawl" indicates that the urban footprint is expanding much faster than the population itself, consuming roughly

[1] National-Census-Report-2023.pdf
[2] Pakistan Cities by Population 2026
[3] pbs.gov.pk/wp-content/uploads/2020/07/Provincial-Census-Report-2023-Punjab.pdf

DRAFT SOE 2025

1.26% of the province's total land area as of 2015. This growth is heavily concentrated, with primary hubs like Lahore contributing a disproportionately large share of this spatial footprint.[4]

With an average annual urban growth rate of approximately 3.67%, the province is rapidly approaching a tipping point. Projections from the Punjab Economic Research Institute (PERI) and the Asian Development Bank (ADB) suggest that if current trends continue, the number of urban residents in Punjab could surpass rural dwellers by the early 2030s. Mega cities like Lahore and Faisalabad are the primary anchors of this growth, though secondary cities like Rawalpindi, Gujranwala and Sahiwal are also expanding at an accelerated pace.[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: it is demographic, with millions moving into the urban fold and spatial, with cities physically encroaching upon the rural hinterland. This unplanned expansion creates a cycle of increased resource demand and environmental stress. If left unmanaged, the continued conversion of fertile land and the rising cost of providing infrastructure to sprawling settlements will pose significant risks to the province's long term economic and environmental sustainability.

4.2.3 Industrial Density

The industrial architecture of Pakistan was fundamentally anchored by the province of Punjab. This dominance was driven by a high density of industrial clusters strategically positioned around major urban centres. The Gujranwala, Gujrat and Sialkot alongside Faisalabad created a continuous belt of manufacturing activity. This density was further bolstered by massive infrastructure projects, such as the Allama Iqbal Industrial City in Faisalabad, which served as a primary Special Economic Zone (SEZ) under the CPEC framework. These clusters were

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

DRAFT SOE 2025

interconnected by a sophisticated network of motorways (M-2, M-3 and M-4), which facilitated the rapid movement of raw materials and finished goods, effectively turning these transit routes into vibrant industrial corridors.

i. Textile and Apparel Industries

Faisalabad remained the undisputed "Manchester of Pakistan," representing the highest density of textile manufacturing in the country. According to the Pakistan Economic Survey 2024-25, the textile group maintained the largest weight in the Large-Scale Manufacturing (LSM) index, with garment exports showing a year on year growth of 7.14%. Beyond Faisalabad, significant clusters existed in Lahore and Sheikhupura as shown in fig. 4.1. These areas faced the highest water resource pressure, with textile dyeing and processing units being primary consumers of groundwater.

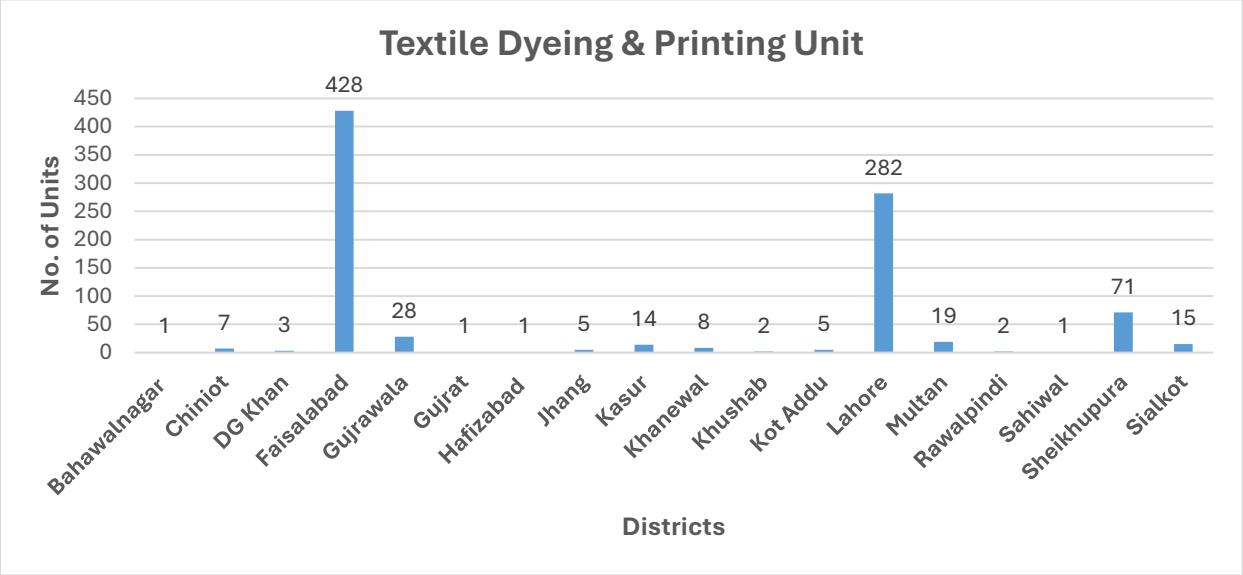

Figure 4.1: Textile Industry Network across the Punjab (Data source: EPA Punjab)

ii. Rice Mills and Agro Processing

Concentrated primarily in the Basmati Belt (Gujranwala, Sialkot, Sheikhupura and Hafizabad), rice milling was a cornerstone of Punjab's export economy. In 2025, these districts saw a surge in high tech milling units to meet international sanitary standards. This sector reflected Punjab's agricultural strength, but the seasonal nature of processing often led to localised waste management challenges, specifically regarding rice husk disposal. Along these cities the rice mills are located almost in all districts of Punjab, a sum of 1399 rice mill are running in Punjab, district-wise details are shown in the fig. 4.2.

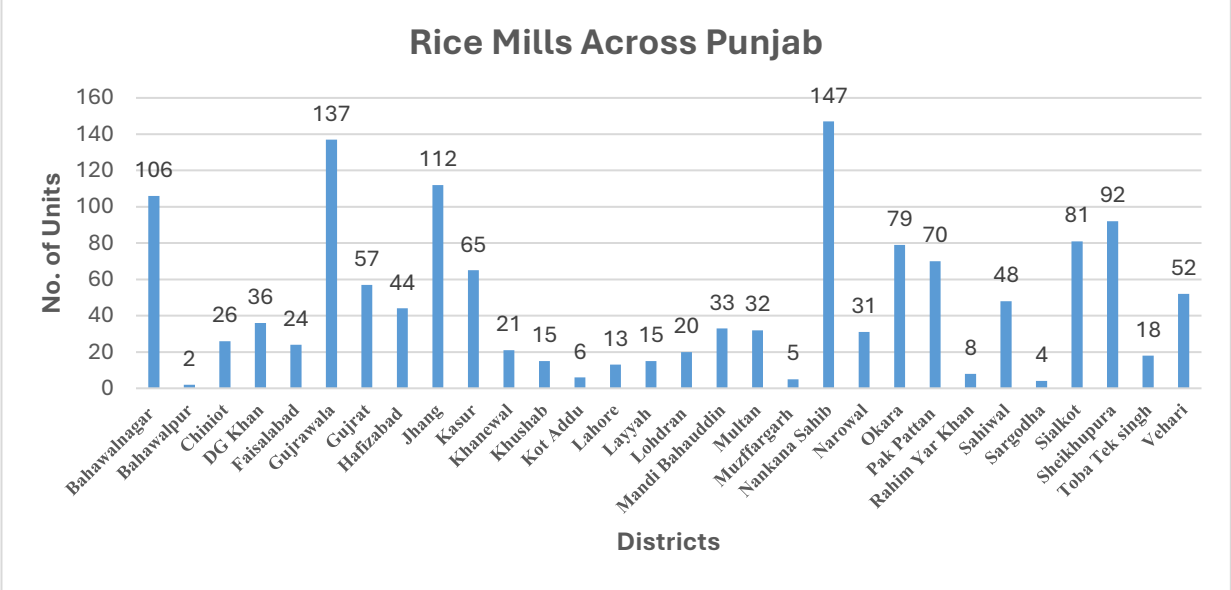

Figure 4.2: District-wise data of Rice Mills in Punjab (Data source: EPA Punjab)

iii. Cement and Construction Industries

The density of cement manufacturing was highest in the Salt Range clusters, specifically in the Chakwal and Khushab districts. Punjab hosted several of Pakistan's largest cement plants due to the proximity of limestone and gypsum deposits. In Punjab, currently 16 Cement Manufacturing plants are present and Mianwali is on the top with 5 cement plants followed by Chakwal and DG Khan with 4 and 2 plants respectively, as shown in fig. 4.3. As of 2025, this sector faced increased scrutiny under the Punjab Green Development Program (PGDP) due to its heavy carbon footprint and its impact on local air quality and water tables in the Potohar plateau.

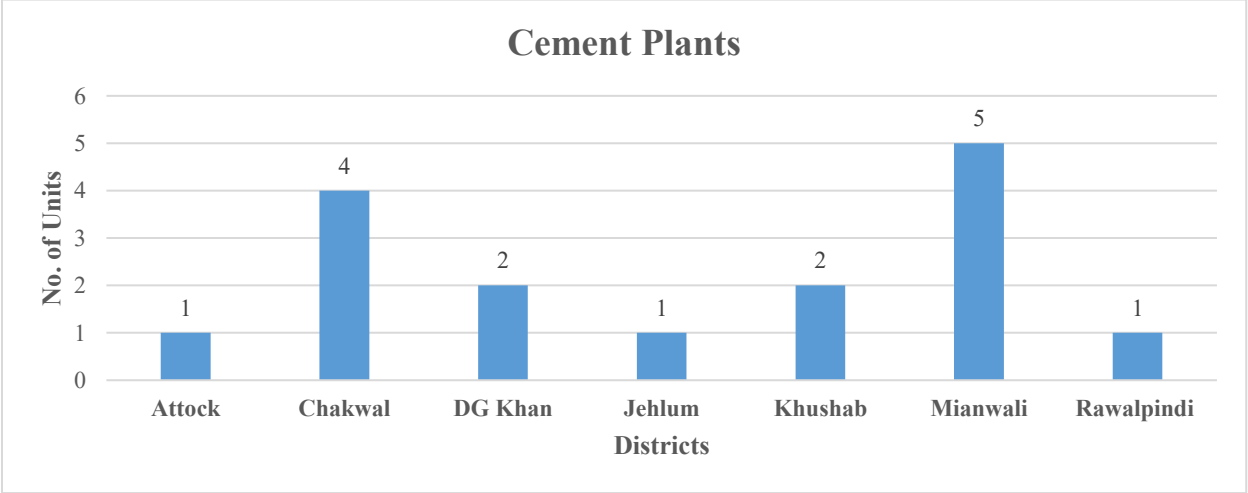

Figure 4.3: Cement Plants across Punjab (Data source: EPA Punjab)

Additionally, the Cement Blocks manufacturing is being done in different districts of Punjab, Lahore is on the top of the list with 28 units, followed by Kasur and Sheikhupura with 17 and 12 units respectively. These units also required water in excessive amount, form cause dust and particulate matter in surroundings, solid waste generation and noise pollution. The district-wise profile of Cement Plants and Cement Blocks Manufacturing units are shown in fig. 4.4.

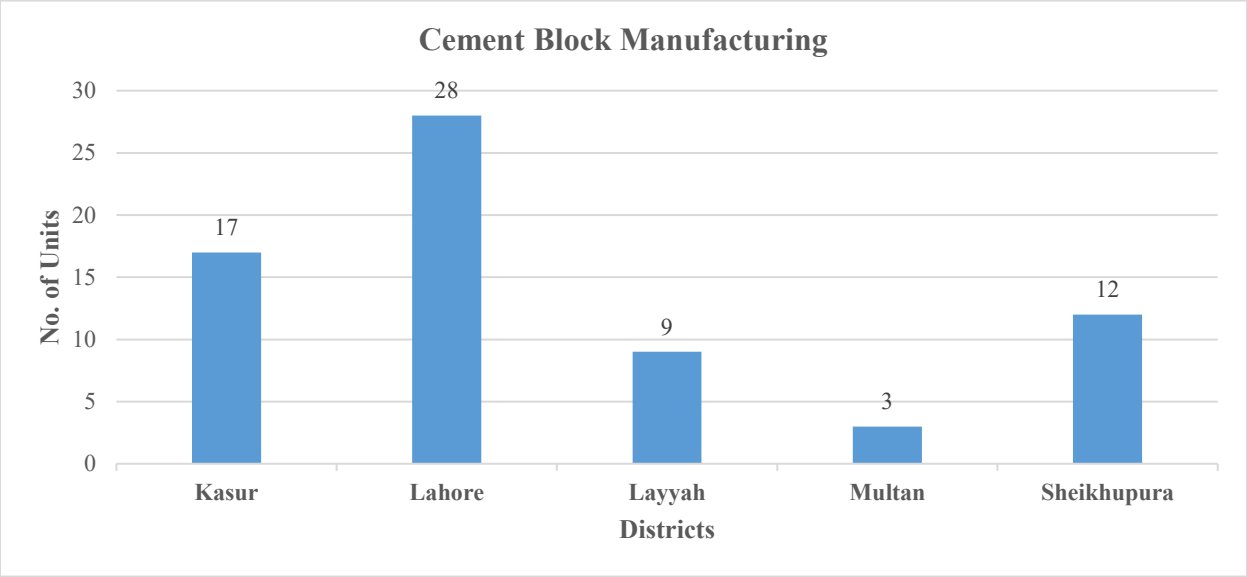

Figure 4.4: Cement Block Manufacturing Units across Punjab (Data source: EPA Punjab)

iv. Leather Tanneries

In Punjab's industrial landscape, the tanning sector is a major environmental concern due to its significant pollution load from untreated effluents and hazardous waste. Major industrial hubs include Kasur is top of the list with 292 units specializing in heavy leather followed by Sialkot with 233 tanneries focused on export quality sports goods and apparel leather. Smaller but significant clusters are also located in Lahore, Gujranwala and Multan as shown in fig. 4.5. Industrial clusters in Kasur and Sialkot frequently exceed National Environmental Quality Standards (NEQS), particularly for hexavalent chromium, which has caused extensive groundwater contamination and soil degradation. These pollutants often enter the food chain when chromium laden solid waste is repurposed for poultry feed, posing serious public health risks. To address these issues, the Government of Punjab is mandating the relocation of tanneries to organised zones like the Sialkot Tannery Zone (STAGL) and utilising the Green Punjab framework to enforce stricter monitoring and wastewater treatment compliance.

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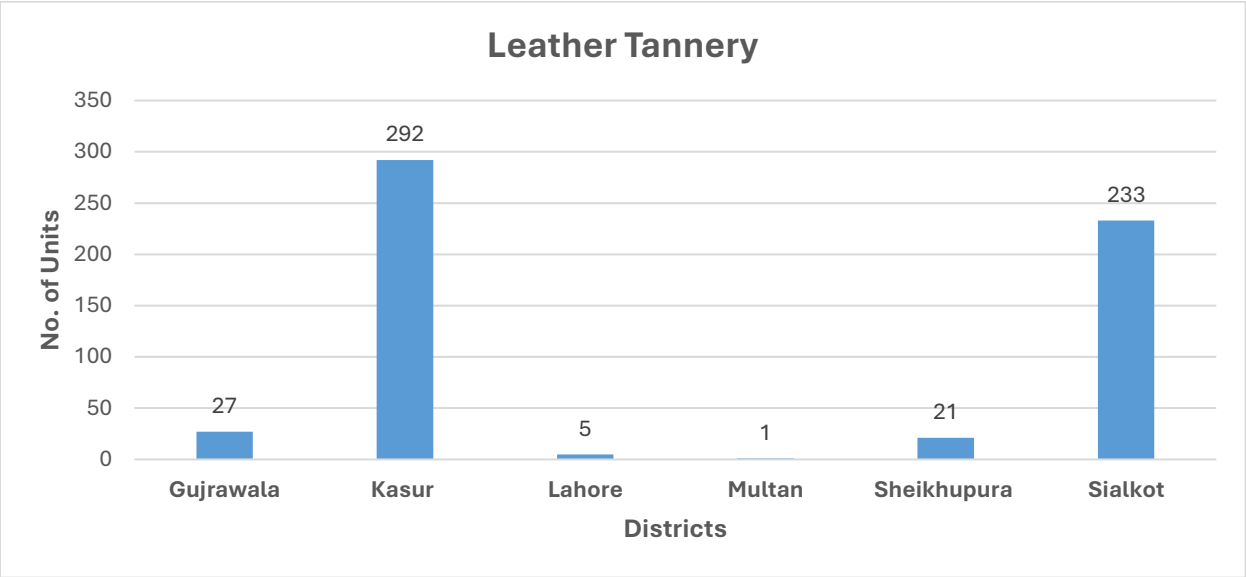

Figure 4.5: Leather Tanneries Profile in Punjab (Data source: EPA Punjab)

4.3. Climate Stressors

Climate stressors are environmental or climatic factors that affect ecosystems, agriculture, water resources and human livelihoods. In Punjab, they are a combination of natural stressors (temperature extremes, rainfall variability, natural floods) and anthropogenic stressors (deforestation, urbanisation, water overuse) that interact to intensify impacts.

4.3.1 Natural Stressors

Natural climate stressors are environmental conditions or events that affect ecosystems, human health and livelihoods, often without direct human causation, although human activity can amplify their intensity. In Punjab, these stressors primarily include temperature extremes, precipitation variability 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, where a steady increase in average temperatures has fundamentally altered 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, characterized 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 have had a cascading effect on the agricultural sector; the 2025 wheat harvest saw a yield reduction of approximately 12% in heat stressed zones, as the crop's grain filling stage was truncated by the sudden onset of high temperatures in early March.[7] In addition to thermal stress, 2025 was defined by erratic and violent precipitation patterns. Data from the Provincial Disaster Management Authority (PDMA) Punjab highlights a dramatic shift towards seasonal rains. These 2025 extremes illustrate a new climate normal for Punjab, where the predictability of seasons has been replaced by rapid successions of drought and deluge.

ii. Precipitation Variability

Punjab underwent a transformative and destructive monsoon season that solidified the new climate normal for the province. The year 2025 was characterized by a rapid transition from extreme moisture deficits in the early months to a state of atmospheric saturation. According to the National Disaster Management Authority (NDMA), the province recorded a 57% positive rainfall anomaly during the July to September, ranking it as the 8th wettest monsoon in Punjab's history. This intensified rainfall, driven by a neutral El Niño Southern Oscillation (ENSO) phase and a northward shift of the monsoon axis, most notably in Sheikhupura, which witnessed a record breaking 216.8 mm of rain in a single day on July 16, 2025.[8]

The human and economic toll of the 2025 floods in Punjab was profound, with the Provincial Disaster Management Authority (PDMA) reporting impact across all 23 districts. The catastrophic flooding, fueled by both torrential rains and overflows from the Chenab, Ravi and Sutlej rivers, affected approximately 4.2 to 5.1 million people.[9] In Southern Punjab, districts like Muzaffargarh and Rajanpur faced the most severe inundation, as broken embankments and upstream water releases swallowed entire villages. The disaster forced the evacuation of over 2.8 million individuals, many of whom sought refuge in relief camps as more than 213,000 houses were damaged or completely destroyed.[10]

Agriculture, the backbone of Punjab's economy, suffered a crippling blow. Initial assessments from the UNOCHA and PDMA indicate that over 1.3 million acres of standing crops primarily rice, cotton and sugarcane were submerged. The flooding hit at a critical growth stage for the Kharif crops, leading to an estimated 15–20% drop in agricultural output. This destruction has created a ripple effect on food security, with wheat flour prices spiking by 25% in early September and

[7] Impact of Climate Change on Pakistan's Food Security | The Agricultural Economist
[8] PostMoonsoonReport-2025.pdf
[9] Floods affect 4.2m people in Punjab - Newspaper - DAWN.COM
[10] Rapid Needs Assessment Report: Floods in Punjab (23 September 2025) - Pakistan | ReliefWeb

DRAFT SOF 2025

concerns mounting over the ability of farmers to secure seeds for the upcoming Rabi (wheat) planting season due to 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
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

The Punjab province underwent a period of acute climatic volatility between September 2024 and May 2025, transitioning from a severe winter precipitation deficit to a record-breaking spring heatwave. Data consolidated by the Pakistan Meteorological Department (PMD) and the National Drought Monitoring Centre (NDMC) confirms that, during these months rainfall across the province was approximately 38% below the long-term average, with some districts recording deficits as high as 42%. This prolonged dry spell, which spanned over 200 days in several southern districts, led to a rapid depletion of soil moisture and critical water shortages in the Indus Basin irrigation system. By January 2025, the National Disaster Management Authority (NDMA) categorised the situation in the Potohar region and South Punjab as a "Mild to Moderate Meteorological Drought," significantly increasing the irrigation demand for the Rabi crop cycle.[11]

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

DRAFT SOE 2025

As the province moved into the second quarter of 2025, the lack of atmospheric moisture catalyzed an early onset heatwave emergency. According to PDMA Punjab, April 2025 was characterized by a high pressure "heat dome" that trapped thermal energy over the plains, pushing daytime temperatures 4°C to 7°C above the seasonal average. During this period, major urban and agricultural hubs including Multan, Bahawalpur and Rahim Yar Khan recorded consistent daytime highs between 44°C and 46°C. PDMA assessment noted that the thermal intensity was compounded by the absence of pre-monsoon showers, leading to a Flash Drought scenario that threatened the terminal growth of the wheat crop and caused significant heat stress for livestock in the Cholistan region.[12]

The scale of this extreme weather event is reflected in the frequency of high intensity days documented by provincial authorities. PDMA Punjab reported approximately 20 to 22 days of Severe Heatwave conditions in April alone, where temperatures remained significantly higher than the historical threshold[13]. The NDMA's Summer Hazards Contingency Plan 2025 highlighted that this was the most persistent spring heat stress recorded in the region in recent years. These conditions forced the activation of emergency protocols, including over 1,500 heatstroke centres and adjusted school timings. This sequence of events serves as a stark indicator of Punjab's heightened vulnerability to compounding extremes, where a dry winter directly amplifies the severity of a subsequent heatwave.[14]

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
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

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

DRAFT SOE 2025

These prolonged high temperatures create multiple stress pathways:

- **Agricultural and Water Resource Stress**

The agricultural heartland of Punjab faced severe Terminal Heat Stress during the 2024–2025 season. As temperatures spiked to 45°C in late April, crops such as wheat experienced accelerated evapotranspiration, which shortened the grain filling period and led to shriveled seeds. For moisture intensive crops like rice and cotton, the 38% rainfall deficit necessitated an immediate reliance on groundwater. However, the National Disaster Management Authority (NDMA) noted that the lack of winter recharge caused water tables to drop in districts like Multan and Khanewal. This forced farmers to increase tube well operations, significantly raising the cost of production while surface water availability in the canal commands remained 15% to 20% below the required discharge for early Kharif.[14]

- **Human Health and Livelihood Stress**

The human cost of the 20–22 days of extreme heat in April was felt most acutely by the province's informal labor force. PDMA Punjab documented a surge in heat related emergencies among outdoor laborers and the elderly, as the Feels Like index (heat index) frequently crossed 50°C in the southern belt. Beyond the direct health risks of dehydration and heatstroke, the heatwave triggered an "Economic Stress" loop; rural households faced a double blow of reduced agricultural yields and increased expenditures for cooling and emergency livestock fodder. The NDMA Summer Hazards Contingency Plan 2025 highlighted that livestock in the Cholistan and Thal deserts suffered from reduced milk productivity and increased mortality rates due to the drying of traditional "Tobas" (water ponds), further straining the livelihoods of pastoralist.[14]

4.3.2. Anthropogenic Climate Stressor

Punjab province faced a critical escalation of anthropogenic climate stressors in 2025. Human activities ranging from the conversion of ancient forests into fuel to the uncontrolled sprawl of concrete cities fundamentally continue to reshape the regional climate. In 2025, these pressures were no longer seen as distant threats but as the primary drivers behind the record-breaking heatwaves and devastating pluvial floods that defined the year. In Punjab, these stressors significantly affect 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 major climate stressors with profound environmental, economic and social consequences. Large-scale clearing of forests for agriculture, urban expansion and timber has drastically reduced tree cover, disrupting ecosystems and

DRAFT SSE 2025

weakening natural climate regulation. Trees, which play a key role in cooling the environment and maintaining rainfall patterns, have been lost at a scale that has contributed to rising temperatures, more frequent heatwaves and increasingly erratic rainfall, heightening drought risk. Reports from 2024–2025 indicate that the water table in central Punjab is dropping by nearly 1 metre annually, forcing a reliance on expensive mechanisation like the Super Seeder to maintain crop yields.[15] The degradation of forests and rangelands has also released significant amounts of stored carbon dioxide, further contributing to global warming and placing additional pressure on water resources, agriculture and human health, while communities dependent on forest resources face economic challenges.

Despite the provincial government's ambitious afforestation initiative to plant 51 million saplings in the 2025–2026 cycle, net forest loss has remained high due to ongoing illegal logging and land clearing for housing. The consequences of vegetation loss were tragically underscored in 2025 when deforestation was identified as a primary driver of catastrophic floods: the lack of root systems in upper Punjab failed to hold soil, leading to massive siltation in rivers, widespread landslides and extensive crop and orchard losses more than 1.5 million acres of farmland, including an estimated 25–30% of mango orchards in South Punjab were destroyed.[16] The removal of trees has also intensified the Urban Heat Island effect, with cities such as Lahore and Gujranwala recording surface temperatures 5–7°C higher than surrounding rural areas and has crippled the hydrological cycle of the Indus Basin, contributing to a reported drop in water tables by nearly one metre annually in central Punjab, increasing reliance on mechanised irrigation.[17]

DRAFT SOE 2025

[15] Super Seeder: A Viable Option for Resource Conservation and Productivity Enhancement of Wheat Crop in Punjab, Pakistan | Pakistan Research Journal of Social Sciences
[16] Flood 2025 and Loss of Mango Orchards in Punjab, Pakistan - TheWaterChannel
[17] Planning for Sustainable Green Urbanism: An Empirical Bottom-Up (Community-Led) Perspective on Green Infrastructure (GI) Indicators in Khyber Pakhtunkhwa (KP), Pakistan - PMC

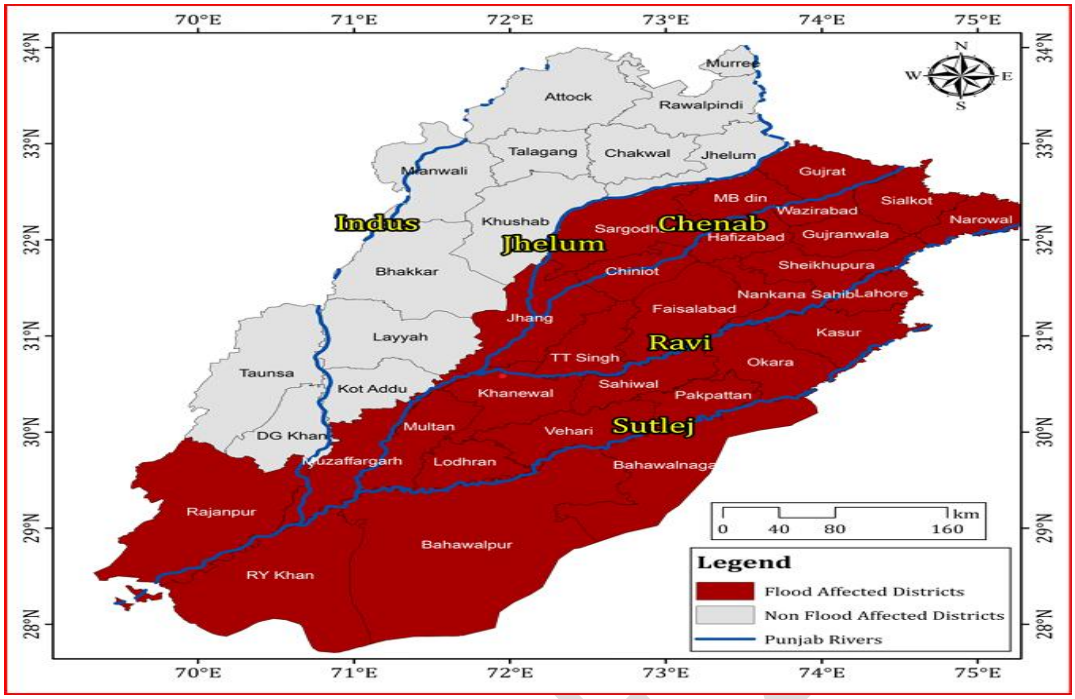

Figure 4. 1: Flood Hit Districts of Punjab in 2025[8]

Deforestation in Punjab acts as a double-edged sword for air quality. Trees are vital carbon sinks and their removal releases stored CO_2 while removing the natural filtration system.[18] This loss is a primary driver of the Smog Emergency; the highest polluted areas in Lahore consistently correspond to those with the lowest vegetation level. Residents of Lahore now lose an average of 5.3 years of life due to air pollution, an issue exacerbated by the lack of green buffers to trap industrial and vehicular emissions.[19]

In Punjab, deforestation acts as a multidimensional climate stressor, interacting with heatwaves, erratic rainfall and flooding to threaten livelihoods, agriculture and water security. Efforts such as the Billion Tree Tsunami programme in Pakistan are aimed at mitigating these risks, but enforcement and local participation remain critical for success.

ii. Urban Sprawl and Infrastructure Expansion

Urban sprawl in Punjab acts as a climate stressor by replacing carbon sequestering farmland with heat absorbent concrete. This horizontal expansion creates Urban Heat Islands, where dark surfaces trap solar radiation, spiking local temperatures and forcing a higher demand for energy intensive cooling. The paving over of the Indus Basin also disrupts the water cycle. Impervious surfaces prevent rainwater from recharging underground aquifers, leading to simultaneous groundwater depletion and intensified urban flash flooding during the monsoon.

[18] Decoding carbon sequestration: The impact of agriculture, conservation policies, climate and land use
[19] Current landscape and future directions of policies addressing air quality improvement in Pakistan: a scoping review - PMC

DRAFT SOE

Furthermore, sprawl increases food miles and vehicular emissions as residential areas drift further from city centres. Without green buffers, these sprawling zones trap pollutants, contributing significantly to the region's recurring smog crises and overall greenhouse gas footprint.

iii. Agricultural Expansion and Irrigation Practises

Punjab is heavily dependent on agriculture, which covers over 80% of rural livelihoods. However, intensive agricultural expansion and unsustainable irrigation practices have become a major climate related problem in the province. Farmers often rely on multiple cropping cycles and high yield varieties, which dramatically increase water demand. To meet this demand, groundwater extraction has risen sharply, particularly in districts such as Faisalabad, Multan, Bahawalpur and Sargodha. Over time, this has led to a falling water table, reducing the province's resilience to dry spells and droughts, which are becoming more frequent due to climate variability.

Unsustainable irrigation practices, such as flood irrigation without proper drainage, exacerbate the problem. Large areas of cultivated land suffer from waterlogging and salinization, which degrade soil fertility and reduce crop yields. These issues are particularly severe in southern Punjab, where the arid climate limits natural recharge of groundwater. During periods of low rainfall, such as the dry spell from September 2024 to March 2025, farmers face critical water shortages, threatening food security and income.

Moreover, the problem is compounded when heavy monsoon rains occur. Saturated and degraded soils cannot absorb water efficiently, increasing flood risks and crop losses. In Punjab, this combination of over extraction, poor irrigation management and climatic variability has made agricultural water management a pressing environmental and socio-economic problem.

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

DRAFT SOE 2025

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, yet its role as the nation's breadbasket is increasingly threatened by severe ecological decay. The province faces a critical tipping point where intensive farming driven by stubble burning and groundwater depletion converges with rapid, unplanned urbanisation and toxic industrial emissions. These local stressors are further intensified by climate change, manifesting in lethal heatwaves and erratic monsoons that threaten both public health and crop yields. To secure Punjab's future, it is now a matter of survival to transition towards sustainable resource management and climate resilient policies.

4.4.1 Air Quality Pressure

The air quality crisis in Punjab, matured into a critical environmental pressure point, shifting from a seasonal nuisance to a year-round structural threat to the province's ecological and economic viability. This pressure is driven by a convergence of stagnant meteorological conditions specifically temperature inversions and high intensity anthropogenic emissions that trap a toxic cocktail of PM2.5 and nitrogen oxides near the ground. While the government reported a 56% reduction in peak pollution intensity in November 2025 compared to 2024,[20] the systemic pressure remained high, with more than 20 million people affected by smog related respiratory and

[20] SMOG Mitigation | Environment Protection Department

DRAFT SOE 2025

cardiovascular emergencies throughout the year.[21] This environmental decay is not merely a health crisis but an economic tax, as the World Bank estimates that air pollution costs Pakistan roughly 6.5% of its annual GDP.

The cumulative effect has reached a tipping point where the environment can no longer self-regulate. In 2025, air quality monitoring became more transparent with the installation of 30 new regulatory grade stations, revealing that AQI levels in cities like Dera Ghazi Khan and Kasur occasionally spiked to 500, surpassing even Lahore's traditionally high levels.[22] Experts note that breathing the air in Punjab during 2025 was equivalent to smoking nearly a pack of cigarettes a day for vulnerable populations in the most affected districts.[23]

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
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. Water Resources Pressure

Punjab's water crisis is a systemic collapse driven by a massive deficit between extraction and 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 natural replenishment is only 3-5 MAF. This has led to a water table decline of 2.5 to 3 feet per year in major hubs like Lahore and Faisalabad. In Southern Punjab districts such as Bahawalpur and Rahim Yar Khan, the depletion of fresh aquifers has caused up coning, where deeper saline

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

DRAFT SOE 2025

water rises, rendering nearly 60% of the groundwater unfit for crops and leading to a 28% drop in wheat yields in affected hotspots.[24]

The quality of surface and groundwater is equally dire due to industrial and agricultural negligence. The World Wildlife Fund (WWF-Pakistan) frequently categorizes the Ravi River as a biological sewer, as its dry season flow consists almost entirely of untreated municipal and industrial waste. Heavy metals like Chromium and Lead from tanneries in Sialkot and Kasur, combined with high nitrate levels from agricultural runoff, have contaminated the food chain. Consequently, over 80% of water samples in urban centres like Multan and Lahore fail safety standards, forcing residents into water poverty and increasing the prevalence of waterborne diseases and arsenic poisoning.[25]

These combined pressures result in water scarcity, contamination of drinking water and economic losses for farmers, particularly in southern Punjab districts such as Bahawalpur and Rahim Yar Khan. Urban areas like Lahore and Multan are also affected, with residents frequently relying on bottled or filtered water due to contamination risks.

4.4.3. Soil and Land Pressure

Farmers often cultivate wheat, rice and sugarcane year after year, depleting essential nutrients and organic matter from the soil. Burning crop residues destroys beneficial soil microbes, reduces moisture retention and releases carbon back into the atmosphere, contributing to climate change. Intensive use of synthetic fertilisers and pesticides further degrades soil structure, reducing its fertility and increasing vulnerability to erosion and desertification, especially in southern districts like Bahawalpur, Rahim Yar Khan and southern Multan. Central Punjab, including Faisalabad and Sargodha, experiences compaction and loss of arable land due to over irrigation and mechanised farming. Land degradation reduces agricultural productivity, forcing farmers to invest more in chemical inputs, creating a vicious cycle of environmental and economic stress.

4.4.4. Biodiversity Pressure

Punjab's landscapes, from the salt crusted ranges to the Indus plains, are at a critical ecological tipping point. In cities like Lahore, the canopy has shrunk by over 70%, fragmenting natural corridors and leaving endemic species like the Punjab Urial increasingly isolated. This deforestation is exacerbated by a spike in wildfires, with over 1,000 alerts in recent years scorching thousands of acres of remaining forest land.

The Punjab's wetlands, which act as blue lungs, are also failing. With 60% of Pakistan's inland wetlands already degraded, sites like Chashma Lake and the Pakpattan marshes are succumbing to industrial runoff and water diversion. The ecological impact is stark: migratory bird populations at Uchalli Lake have plummeted by 99%. This collapse of aquatic and avian life disrupts the

[24] Water Quality Reports
[25] Freshwater | WWF

DRAFT SOE 2025

broader food web, as the loss of natural predators and pollinators begins to undermine the agricultural productivity that forms Punjab's economic backbone.[26]

In a proactive response, 2025 saw the launch of the Green Punjab Mission, an ambitious attempt to restore balance by planting 51 million trees by 2026.[27] This effort is supported by the July 2025 IUCN led biodiversity survey, the first structured attempt to create a scientific baseline for the province's flora and fauna.[28] While these policy shifts offer a glimmer of hope, the current forest cover of just 3.1% against an international recommendation of 25% underscores the urgent need for sustained, data driven conservation to prevent total ecosystem collapse.[29]

4.4.5. Climate and Atmospheric Pressure

The climate of Punjab is profoundly shaped by its geography a vast, low lying fertile plain that experiences some of the most dramatic seasonal shifts in atmospheric pressure in the world. This dynamic is primarily driven by the thermal contrast between the landmass and the surrounding oceans. During the peak summer months (April to June), intense solar radiation causes the air over the Punjab plains to heat rapidly and expand, resulting in a persistent thermal low-pressure system. Temperatures in this period have reached near record highs, with April 2025 being the second warmest in 65 years, reaching a mean maximum of 38.87°C.[30] This low pressure acts as a vacuum, eventually drawing in the high pressure, moisture laden winds from the Arabian Sea and the Bay of Bengal, triggering the South Asian Monsoon. In June 2025 alone, this pressure gradient resulted in rainfall totals of 42.50 mm, which is 44% above the historical normal for that month.[31]

Conversely, during the winter (December to February), the air cools and becomes denser, creating a stable high-pressure system. This heavy, stagnant air frequently leads to temperature inversions, where pollutants and moisture are trapped near the ground, causing the severe smog crises.[32] These shifts are becoming more erratic due to climate change; for instance, blocking highs in May 2025 led to prolonged heatwaves where night temperatures in D.G. Khan did not drop below 33.5°C, illustrating how pressure anomalies are now dictating both the agricultural productivity and public health of the province.[33]

Punjab is highly vulnerable to the impacts of climate change, which intensify existing environmental pressures. Greenhouse gas emissions from stubble burning, industrial activity and transportation contribute to global warming. The province has experienced rising average temperatures, erratic rainfall patterns and prolonged heatwaves, particularly in southern districts

[26] https://researcherslinks.com/current-issues/Field-Validation-of-Avian-Diversity-at-Uchalli-Wetland/20/1/6830/html
[27] 51m trees: Largest forest to be grown under Green Punjab Mission
[28] Punjab's flood-affected ecosystems under spotlight in ambitious biodiversity survey
[29] Punjab surpasses 2025 monsoon plantation target despite record flooding
[30] Pakistan_Monthly_Climate_Summary_Apr_2025.pdf
[31] Pakistan_Monthly_Climate_Summary_Jun_2025.pdf
[32] SOE
[33] Pakistan Monthly Climate Summary May 2025 | PDF | Natural Hazards | Oceanography

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like Bahawalpur and Multan. Flooding during monsoons in central Punjab is becoming increasingly common, damaging crops, homes and infrastructure. These climatic changes threaten agricultural productivity, food security and livelihoods, especially for small farmers who lack resources to adapt. The combination of local emissions and global climate impacts creates a feedback loop, where environmental degradation accelerates climate risks and vice versa.

4.4.6. Waste and Resource Pressure

Waste and Resource Pressure in Punjab, reached a critical tipping point, as the province's population of approximately 134.3 million generated an unprecedented 57,000 tonnes of municipal solid waste daily. This surge transformed waste management from a municipal utility into a primary environmental threat. According to the Spectreco Waste to Value 2025 Report, this volume resulted from rapid urban expansion across 36 districts, creating an estimated $860 million annual financing shortfall required to manage the ecological fallout of uncollected refuse.[34]

i. Systematic Waste Pressure and Legacy Backlogs

The environmental crisis in 2025 was defined by a legacy of neglect. While the provincial government's Suthra Punjab initiative scaled up to collect approximately 50,000 tonnes per day, a significant portion of this volume consisted of legacy waste years of accumulated trash from streets and vacant plots that was moved into formal systems for the first time.[35] Despite these interventions, the provincial government confirmed that by late 2025, over 8.15 million tonnes of waste had been disposed of, yet the lack of sufficient engineered landfills meant that much of the daily output continued to exert extreme pressure on the province's soil and air quality.[36]

ii. Resource Inefficiency and the Circular Economy Gap

The pressure on resources throughout 2025 was increasingly viewed through the lens of lost economic and environmental value. Punjab generated millions of tonnes of plastic waste, yet the recycling rate remained stagnant at roughly 4-9%, representing a massive leakage of resources from the economy.[37] The open burning of this plastic and municipal waste as a critical driver of PM 2.5 levels. To mitigate this, 2025 saw the launch of a $528 million (PKR 150 billion) public investment plan designed to foster local manufacturing of waste to energy technology and recycling infrastructure.[38]

iii. Legislative Shifts and 2025 Targets

[34] Spectreco Launches Waste to Value 2025 Report
[35] Suthra_Punjab_Handbook_1ca7000839.pdf
[36] 8.15m tonnes waste disposed of under Suthra Punjab Program
[37] Pakistan generates 3.9m tonnes of plastic waste annually: report
[38] SOE

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To address these pressures, the provincial government implemented a data driven governance model. By the end of 2025, over 30,000 vehicles and 150,000 workers were tracked via GPS and digital platforms to ensure collection targets were achieved.[39] Furthermore, the 2025-26 Provincial Budget allocated Rs. 14.4 billion specifically for the Lahore Waste Management Company (LWMC) to pioneer low cost treatment and waste to energy pilot projects. These measures marked the beginning of a transition from a sweep and dump culture to a circular model that aimed to reduce methane emissions by 75% at landfill.[35]

Simultaneously, resource pressure is most acutely felt in the depletion of the Indus Basin aquifer, which remains the second most over stressed groundwater reserve globally. In Punjab, agriculture consumes over 90% of available groundwater via approximately 1.5 million tube wells, leading to a water table drop of 4 to 5 feet annually in southern districts like Dera Ghazi Khan and Rajanpur. This over extraction is coupled with deteriorating quality, indicates that salinity and industrial runoff have compromised nearly 70% of groundwater in certain regions.[40]

4.4.7. Human Health Pressure

Environmental degradation in Punjab has direct and severe impacts on human health and livelihoods. During the 2025 flood events, the province suffered a loss of human lives and an estimated financial loss of PKR 326.777 million, underscoring the devastating consequences of climate induced disasters.[41] Such extreme events not only cause immediate fatalities and economic damage but also aggravate existing environmental and public health vulnerabilities. Poor air quality from stubble burning, industrial emissions and vehicular pollution causes respiratory and cardiovascular illnesses, especially in vulnerable populations such as children, the elderly and those with pre-existing conditions. Contaminated water and flood affected sanitation systems increase the risk of gastrointestinal diseases, skin infections and other waterborne illnesses. Rural communities relying on canals or shallow wells become particularly exposed after floods, while urban populations in Lahore, Faisalabad and Multan face compounded risks from damaged infrastructure and pollution. The intersection of climate disasters and ongoing air, water and soil pollution make human health a critical environmental pressure point in 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,	Lahore, Faisalabad, Multan, Gujranwala, Bahawalpur	EPA, NDMA

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

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		hazardous AQI peaks		
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 highlights that Punjab is undergoing an intense and interconnected environmental transition driven by rapid population growth, expanding urban landscapes, concentrated industrial activity and increasing climate variability. These factors are no longer acting in isolation but are collectively amplifying pressure on air quality, water resources, land productivity and ecological systems, pushing the province towards a critical threshold. The evidence reflects a shift from manageable environmental challenges to a systemic, multi-dimensional crisis where rising temperatures, erratic rainfall, floods, heat waves, groundwater depletion, pollution and biodiversity loss are reinforcing one another. At the same time, the growing impact on human health, agriculture and economic stability underscores that environmental degradation is directly linked with development outcomes. This evolving situation

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clearly signals that traditional approaches are no longer sufficient and there is an urgent need for integrated, data driven and climate resilient strategies that align urban planning, industrial regulation and natural resource management. Ultimately, the current trajectory presents both a warning and an opportunity highlighting the necessity for immediate, coordinated action to ensure long term environmental sustainability, economic resilience and improved quality of life across the province.

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Part II Environmental Quality Assessment & Pollution Management

[42]Chapter No. 5 Air Quality of Punjab

Part 1

5.1 Situational Analysis of Air Quality:

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

Air pollution and climate change share common drivers, particularly fossil fuel combustion, which simultaneously releases greenhouse gases and degrades air quality. Among the major pollutants, PM2.5 and PM10 are considered particularly harmful because of their ability to penetrate deep into the respiratory system and bloodstream, causing severe health complications. Emissions stem from traffic, industry and agriculture, with secondary particulates formed from precursors such as VOCs, SO_2, NO_x and NH_3, adding complexity to air quality management[2].Globally, trends in air pollution vary significantly across regions. While North America and Europe have witnessed reductions in fine particulate matter (PM2.5), exposure levels in Central and South Asia have continued to rise [3].

Evidence from South Asian cities demonstrates the seriousness of the issue. Studies monitoring PM10, NO_x, SO_2 and CO concentrations over several years revealed that PM10, CO and NO_x levels frequently exceeded National Environmental Quality Standards (NEQS), while Air Quality Index

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[42] World Health Organization (WHO). (2021). WHO Global Air Quality Guidelines: Particulate matter, ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide

[2]Afifa., Kashaf Arshad, Nazim Hussain, Muhammad Hamza Ashraf, & Muhammad Zafar Saleem. (2024). *Air pollution and climate change as grand challenges to sustainability*. *Science of The Total Environment, 928*, 172370. https://doi.org/10.1016/j.scitotenv.2024.172370
Air pollution and climate change as grand challenges to sustainability - ScienceDirect

[3]Wenhua Yu, Tingting Ye, Zhuying Chen, Rongbin Xu, Jiangning Song, Shanshan Li, & Yuming Guo. (2024). *Global analysis reveals region-specific air pollution exposure inequalities*. *One Earth, 7*(11), 2063–2071. https://doi.org/10.1016/j.oneear.2024.09.017

[4] Nawaz, Rab & Ashraf, A. & Nasim, & Irshad, Muhammad & Zaman, Qamar & Latif, Maria. (2023). Assessing the Status of Air Pollution in the selected Cities of Pakistan. Pollution. 9. 381-391. 10.22059/POLL.2022.347922.1604.
Assessing the Status of Air Pollution in the selected Cities of Pakistan | Request PDF

[5]Robert Cichowicz, & Anna Dominika Bochenek. (2024). *Assessing the effects of urban heat islands and air pollution on human quality of life*. *Anthropocene, 46*, 100433. https://doi.org/10.1016/j.ancene.2024.100433

[6] Pakistan's Smog Crisis: Punjab Air Quality Emergency and… | The Grand Review

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(AQI) values consistently ranged between unhealthy and severe categories [3]. Research has also shown that climatic variables such as temperature fluctuations, fog and dust storms, together with pollutants like NO_2, significantly influence the incidence of acute respiratory illnesses. Geographically Weighted Regression (GWR) analyses confirmed that these impacts vary spatially, emphasizing the importance of location-specific interventions. Similarly, assessments using AQI and the Multi Pollutant Index (MPI) identified Lahore and Karachi among the most polluted urban centers in Pakistan, particularly in areas characterized by dense industrial activity and heavy traffic congestion [4].

The severity of urban air pollution is intensified by climatic and meteorological conditions. Phenomena such as the urban heat island effect, atmospheric stagnation, low wind speeds and temperature inversions often trap pollutants close to the ground, resulting in localized pollution hotspots. Climate change is expected to further influence atmospheric chemistry and weather patterns, thereby altering pollutant dispersion and complicating air quality management efforts. In response to these growing concerns, the WHO has developed Air Quality Guidelines (AQGs) prescribing permissible concentration limits for major pollutants to safeguard 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 health emergency. As the monsoon season ends and temperatures drop, the atmosphere stabilizes with low wind speeds and frequent temperature inversions, trapping pollutants close to the ground. This meteorological setup coincides with peak emissions from human activity. The most significant contributor is crop residue burning, particularly rice straw after the Kharif harvest in October and November, which releases dense smoke laden with particulate matter that spreads across cities like Lahore, Faisalabad and Multan. Alongside this, industrial emissions from factories and brick kilns, combined with vehicular pollution from outdated vehicles and poor fuel standards, further degrade air quality [6].

5.2 Pollution Index of Punjab

The Punjab Air Quality Index (AQI) Report for 2025 by EPA Punjab reveals a pronounced seasonal trend in pollution levels across the province. For the calendar year 2025, The year began with high pollution in January (276) and February (approx. 240), followed by a gradual improvement during the spring and monsoon months, where AQI values reached their lowest in July (77) and August (87) due to increased precipitation and atmospheric dispersion. However, the onset of the smog season in October (155) led to a sharp deterioration, with November and December recording unhealthy averages of 212 and 226, respectively. It is critical to note that for many 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 due to the delayed installation of Air Quality Monitoring Systems y (AQMS), with many stations becoming fully operational only in late 2025.

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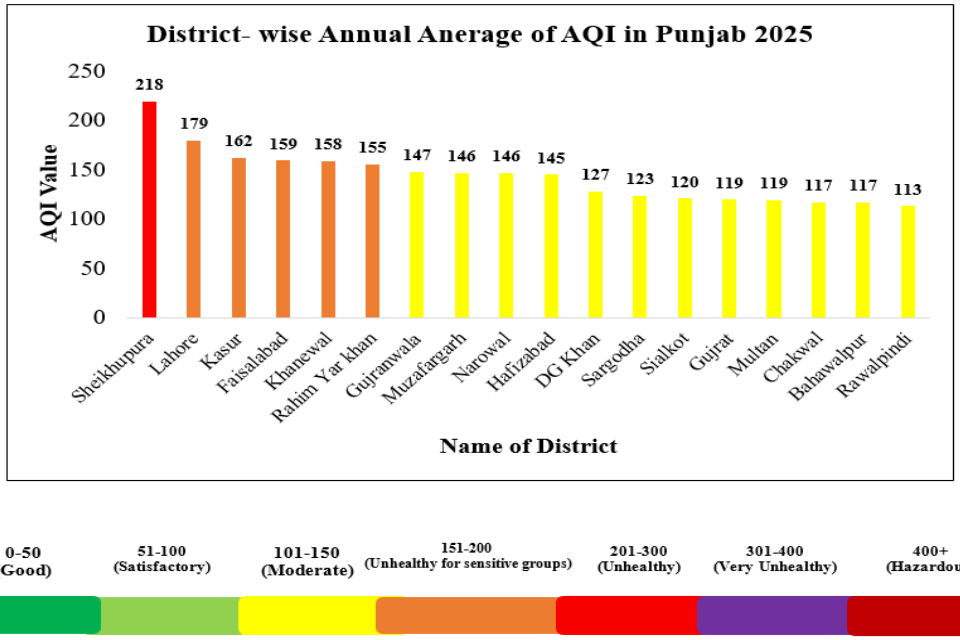

Graph 5.1 District wise Annual average value of AQI in Punjab, 2025

5.2.1 Pollution Index of hotspot districts:

The annual average Air Quality Index (AQI) values for the selected hot spot districts indicate notable variation in air quality conditions, with values ranging from **113 to 218**. Overall, the data show that most districts fall within the **"Moderate" to "Unhealthy for Sensitive Groups"** categories, while one district i.e. Sheikhupura reaches the **"Unhealthy"** level, reflecting a significant and widespread air pollution concern.

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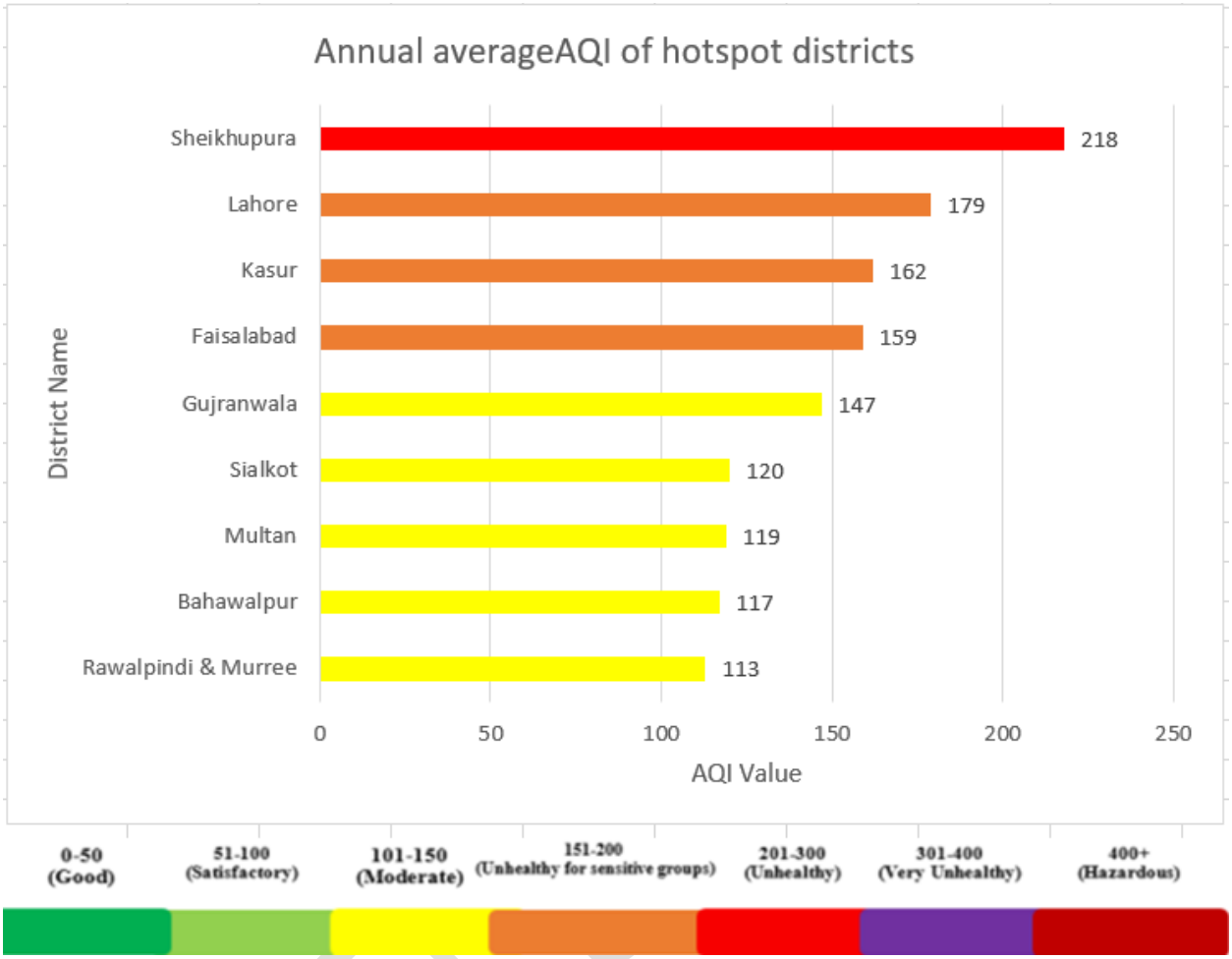

Graph 5.2 Annual average AQI level of hotspot districts in Punjab in 2025

The pollution index is influenced primarily by the type, number and emission potential of industries, along with other anthropogenic sources such as vehicular traffic, agricultural burning and energy generation. For instance, districts like Lahore, Sheikhupura, Faisalabad and Gujranwala consistently show higher AQI levels because they have a dense concentration of high-emission industries such as steel re-rolling mills, textile processing units, chemical manufacturing and thermal power plants. These sectors release large quantities of particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide (SO_2), nitrogen oxides (NO_x) and volatile organic compounds (VOCs), significantly increasing the pollution load.

In contrast, districts such as Bahawalpur and Rawalpindi exhibit relatively lower AQI levels due to their limited industrial base and lower emission intensity. Their pollution sources are fewer and less diverse, resulting in a lower cumulative pollution index. Similarly, Sialkot and Multan fall in a moderate category where industrial activity exists but is either less intensive or more dispersed, leading to comparatively moderate AQI values.

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Another critical factor explaining AQI variation is meteorological conditions. During winter months, temperature inversion low wind speeds and reduced atmospheric mixing height prevent the dispersion of pollutants, causing their accumulation near the ground. Districts located in central Punjab, especially around Lahore, are more prone to these conditions, which is why they experience severe smog episodes and higher AQI levels. Additionally, proximity to agricultural areas leads to increased exposure to stubble burning emissions, further elevating AQI in districts like Sheikhupura, Kasur and Faisalabad.

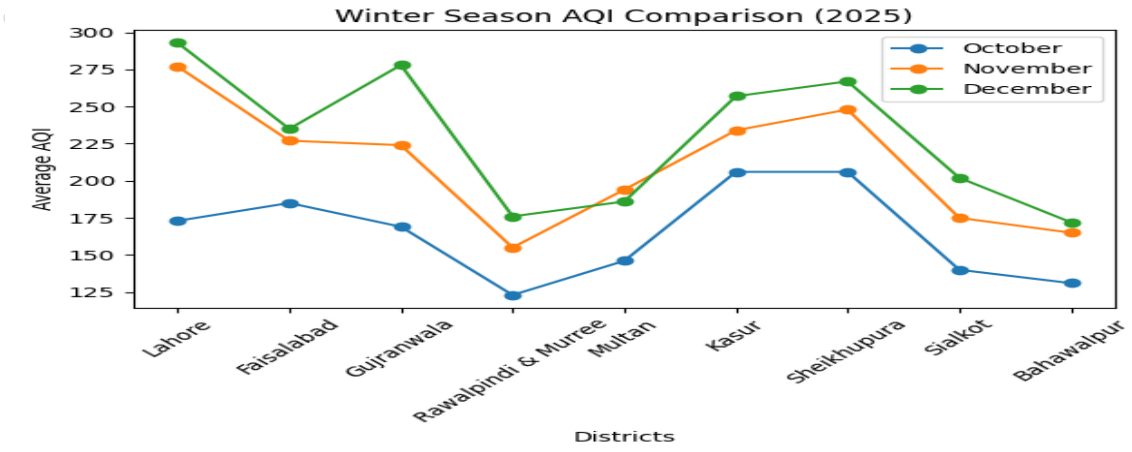
On the other hand, districts in southern Punjab, such as Bahawalpur and Multan, often experience better dispersion conditions due to relatively higher wind speeds and open landscapes, which help dilute pollutants and result in lower AQI levels despite the presence of emission sources.

Urbanization and traffic density also play a significant role. Highly urbanized districts like Lahore have intense vehicular emissions and construction activities, which further increase their pollution index. In contrast, less urbanized districts with lower traffic volumes naturally maintain better air quality.

In summary, high AQI levels are observed in districts with a high pollution index, driven by dense industrial activity, heavy traffic, energy generation and unfavorable meteorological conditions. Conversely**,** lower AQI levels are found in districts with fewer emission sources, lower industrial density and better atmospheric dispersion conditions. This variation highlights the need for district-specific air quality management strategies, focusing on controlling 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 the 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 progresses. The graphical trend indicates that AQI values increase steadily from October to December in almost all districts, reflecting the intensification of



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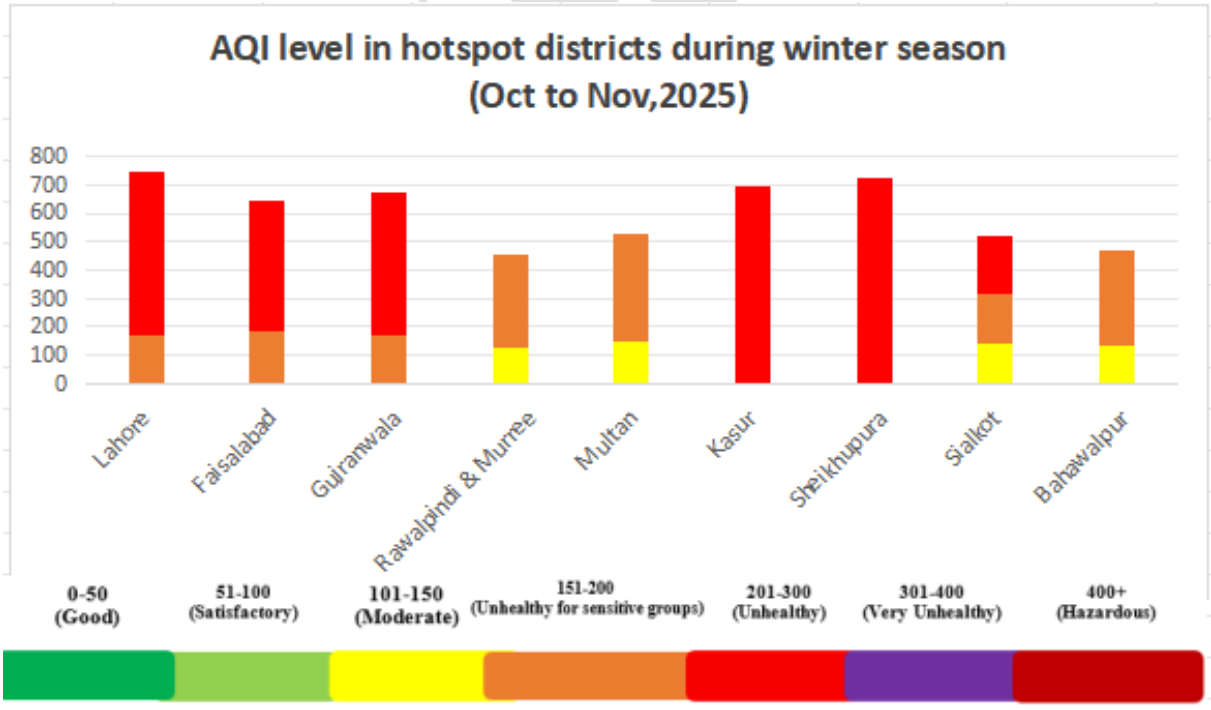
smog conditions due to unfavorable meteorological factors such as temperature inversion, low wind speeds and reduced atmospheric mixing height.

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

The most severe pollution levels are concentrated in the central Punjab industrial belt, particularly in Lahore, Gujranwala, Faisalabad, Sheikhupura and Kasur. Among these, Lahore records the highest AQI values, rising sharply from 173 in October to 293 in December, reflecting extreme pollution stress. A major contributing factor to the elevated AQI in Kasur and Sheikhupura is the widespread practice of crop residue (stubble) burning during the winter months, which significantly intensifies air pollution in these districts.

The steep upward trends in these districts highlight the combined impact of dense industrial activity, vehicular emissions and poor atmospheric dispersion capacity, making them the core smog hotspots of the province.

Moderate but consistently high AQI levels are observed in Faisalabad, Multan and Sialkot. Faisalabad shows a steady increase from 185 in October to 235 in December, largely due to emissions from the textile sector and associated industries. Multan presents a slightly different pattern, with AQI increasing from 146 in October to 194 in November, followed by a minor decrease to 186 in December, suggesting some localized meteorological influence or improved dispersion conditions. Sialkot demonstrates a gradual rise in AQI, indicating moderate industrial emissions but comparatively better air circulation than central districts.



Graph 5.4 Range of AQI levels during winter season

In contrast, relatively lower AQI levels are recorded in Rawalpindi, Murree and Bahawalpur. Rawalpindi and Murree show the lowest AQI values among the hotspot districts, increasing from 123 in October to 176 in December, while Bahawalpur follows a similar but slightly higher trend. These districts benefit from favorable geographical and meteorological conditions, such as higher wind speeds, better ventilation and lower industrial density, which contribute to improved air quality and reduced pollution accumulation.

Overall, the winter AQI trend clearly demonstrates that air pollution in Punjab's hotspot districts is both seasonally driven and spatially concentrated. The progressive increase in AQI values underscores the dominant role of meteorological conditions in exacerbating pollution levels during winter, while the significantly higher values in central Punjab highlight the impact of concentrated emission sources. This pattern emphasizes the need for targeted mitigation strategies focused on high-risk districts, particularly within the central industrial corridor, along with the integration of meteorological forecasting into air quality management frameworks

5.3 Major Sources of Air Pollution in Punjab:

Air pollution in Punjab is driven by a complex mix of anthropogenic and natural sources. Rapid industrialization, urban expansion and reliance on vehicles have intensified emissions of fine particulates, toxic gases and black carbon. Seasonal agricultural practices and domestic fuel use further compound the problem, while natural factors such as dust storms and pollen contribute additional loads. Together, these sources create persistent smog episodes, degraded air quality and significant public health risks across the province.

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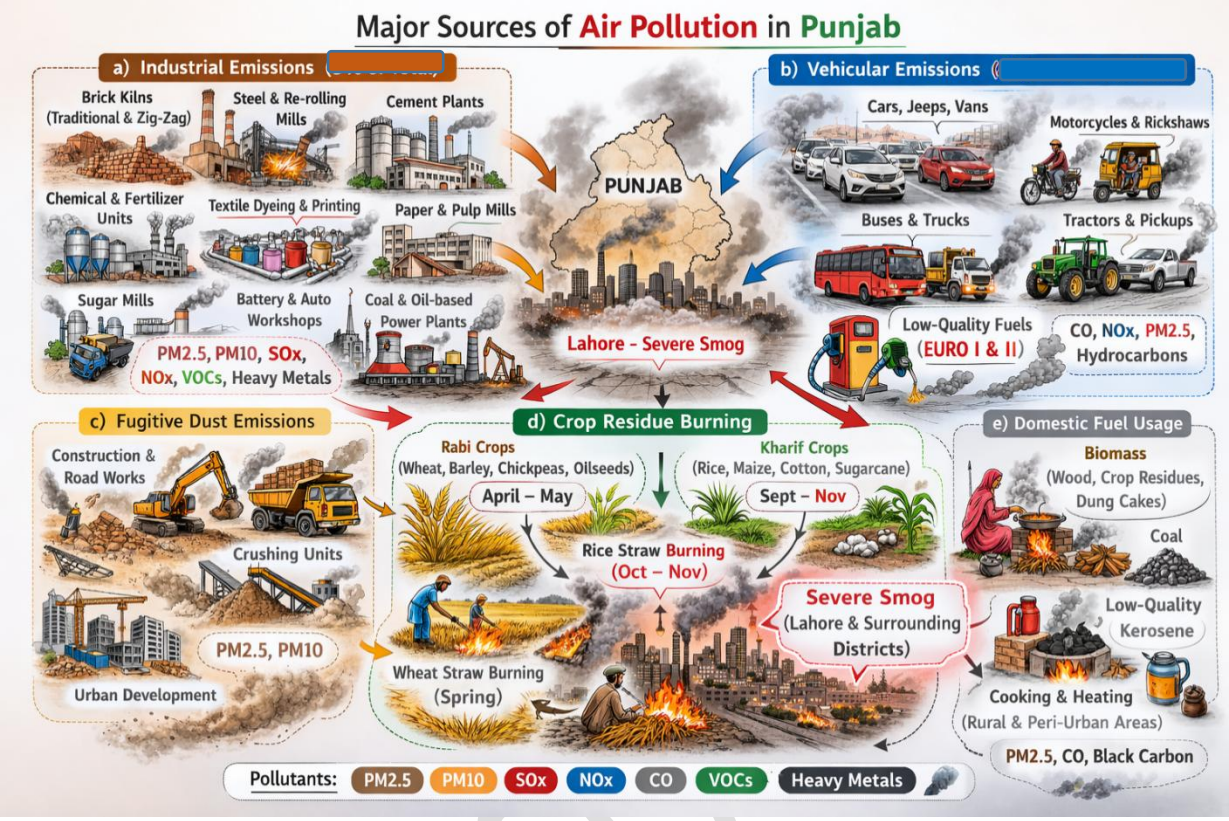

Figure 5. 1: Anthropogenic Sources of Air Pollution in Punjab

5.3.1 Anthropogenic Sources of air pollution in Punjab:

5.3.1.1 Industrial Emissions Punjab hosts a large number of air-polluting industries that release fine particulates ($PM_{2.5}$, PM_{10}), black carbon, sulfur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOCs), acid fumes and heavy metals. Major contributors include brick kilns (both traditional and zig-zag), steel furnaces and re-rolling mills, cement plants, chemical and fertilizer units, textile dyeing and printing facilities, paper and pulp mills, sugar mills, battery manufacturing and recycling units, food processing industries (ghee, edible oils, bakeries), coal- and oil-based power plants and auto-part workshops. Many of these rely on low-grade fuels such as coal, furnace oil and biomass, releasing high levels of SO_2, CO and fine particulates. Industrial emissions(Non Combustion Industrial Process) account for roughly 9% and Industries contribute 24% of Punjab's total air pollution load, ranking second after transport sources[10].

5.3.1.2 Vehicular Emissions According to the Punjab Bureau of Statistics (2024)[9], the province has 22.2 million registered vehicles, including cars, jeeps, motorcycles, rickshaws, buses, tractors, vans and pickups. Of these, 7 million are concentrated in Lahore division, the highest in Punjab. Many vehicles use low-quality fuels and lack emission control technologies. Diesel-powered vehicles are particularly problematic, emitting large amounts of NOx and particulate matter. According to CM Punjab Roadmap for smog mitigation report 2024 found that transport sector emissions contribute over 39% of Punjab's total air pollution, making transport the single largest

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source of smog and degraded air quality. Low-Quality Fuel Usage (EURO I & II) Pakistan's transport sector largely operates on outdated EURO I and EURO II emission standards, which permit far higher pollutant levels compared to modern EURO IV–VI standards. The use of low-quality fuels and lack of catalytic converters result in inefficient combustion and high emissions of CO, NOx, hydrocarbons and particulate matter. This outdated fuel regime significantly worsens urban air quality.

5.3.1.3 Fugitive Dust Emissions: Construction activities, road works, dredging and crushing units generate fugitive dust and other miscellaneous sources which is a major source of $PM_{2.5}$ and PM_{10} contributes 1% of total emission in Punjab[10]. With rapid urbanization and ongoing development projects across Punjab, dust emissions remain a widespread problem, especially in expanding metropolitan areas such as Lahore, Faisalabad, Multan, Rawalpindi and Gujranwala.

5.3.1.4 Crop Residue Burning: Punjab, has two main cropping cycles: Rabi (winter) and Kharif (summer). Wheat, barley, chickpeas and oilseeds are harvested in April–May, while rice, maize, cotton and sugarcane are harvested between September and November. Farmers often burn crop residues to clear fields quickly. Wheat straw burning occurs in spring, but the most severe period is October to November, when rice straw burning coincides with stable atmospheric conditions, trapping pollutants and intensifying smog episodes in Lahore and surrounding districts. Historical estimates suggest Punjab contributed the majority of Pakistan's biomass burning emissions, with wheat straw and bagasse together accounting for nearly 11% of total emissions in Punjab[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 contributes to localized pollution. Biomass (wood, crop residues, dung cakes), coal and low-quality kerosene are commonly used in rural and peri-urban households for cooking and heating. These fuels release particulate matter, carbon monoxide and black carbon, adding to the overall pollution burden. energy consumption for domestic as well as commercial purpose contributes 16% of total air emissions[10].

5.3.2 Natural Sources of air pollution in Punjab:

5.3.2.1 Dust Storms and Windblown Soil Southern Punjab, particularly Bahawalpur, Rahim Yar Khan, Multan and Dera Ghazi Khan, experiences frequent dust storms due to its proximity to the Cholistan Desert and semi-arid landscapes. Strong pre-monsoon winds lift large amounts of coarse particulates (PM10), which can travel long distances and degrade air quality in urban centers. Western Punjab, near the Suleiman Range, also contributes localized dust emissions from dry soils and sparse vegetation[11]

5.3.2.2 Desert Dust Transport The Cholistan Desert is a major source of fine and coarse dust, especially during the summer months when winds are strong. This dust is often transported across districts, affecting cities such as Multan and even reaching Lahore. The phenomenon intensifies during dry spells, when vegetation cover is minimal and soil erosion is high.[12]

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5.3.2.3 Pollen and Biological Particulates In northern Punjab, particularly Rawalpindi and Murree, forested areas contribute spores and biological particulates, which are more pronounced during humid conditions. This seasonal emission aggravates respiratory issues and adds organic particulates to the air[13].

5.3.2.4 Forest and Grassland Fires Occasional wildfires in the Potohar Plateau and Murree Hills during dry summer months release smoke and fine particulates. Similarly, riverine forests along the Indus and Ravi belts may experience grassland fires during drought periods, adding localized emissions. While less frequent than crop residue burning, these fires still contribute to episodic air quality deterioration[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 atmospheric chemistry[43] and air quality.

5.4 Pollution Hotspot Assessment through E-Maps

Pollutant-based hotspots assessment of selected hotspot districts was carried out using industrial emission inventory data integrated with GIS-based spatial visualization. The analysis focused on nine major air pollution hotspot districts of Punjab, including Lahore, Faisalabad, Gujranwala, Rawalpindi, Multan, Kasur, Sheikhupura, Sialkot, Bahawalpur and Murree.

The primary dataset comprised sector-wise industrial distribution, including total number of industries and those identified as air pollution-causing units. This information was used as a proxy indicator to assess spatial pollution hotspot within each district.

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[43] [9n]Publications and Reports | Bureau of Statistics, Punjab

[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

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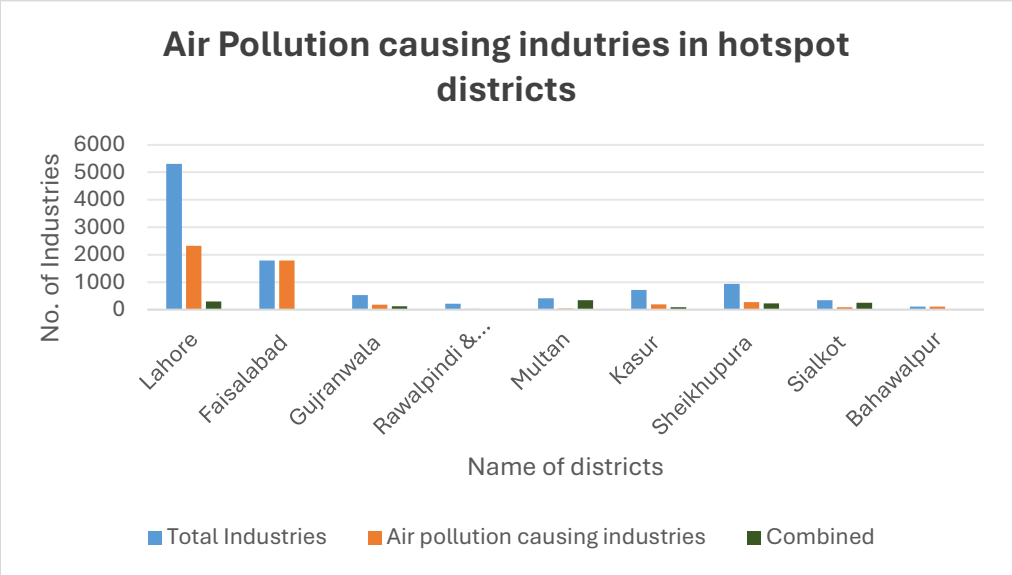
[14] Nafees, M., Rashid, W., Sultan, H., Khan, N. H., Khurshid, M., Ali, W., & Bohnett, E. (2024). Occurrence, probable causes and management of forest wildfires in the Northern Highlands of Pakistan. *Environmental Challenges, 15*, 100930. https://doi.org/10.1016/j.envc.2024.100930

[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

5.4.1 Industrial Contribution to Pollution

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



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 most industrialized region. Here, air-polluting industries are either highly clustered in major industrial estates and urban corridors (e.g., Lahore, Faisalabad, Sheikhupura, Kasur) or more dispersed within mixed land-use areas (e.g., Sialkot). This region shows the highest pollution intensity, with multiple hotspots formed by textile, leather, chemical and manufacturing industries, along with extensive brick kiln belts in peri-urban zones.

Lahore represents the most intense and highly clustered industrial hub, with dense concentrations along the Kot Lakhpat, Quaid-e-Azam Industrial Estate corridor and Raiwind Road. Additional clusters along major transport routes and scattered inner-city units create a complex pattern of high pollution intensity, especially in southern and south-western zones.

In Faisalabad, industries are also strongly clustered, primarily dominated by textile, dyeing and manufacturing units concentrated in urban industrial zones, with peripheral brick kilns forming secondary pollution belts. The pattern is reinforced by linear development along roads and dispersion toward downwind areas.

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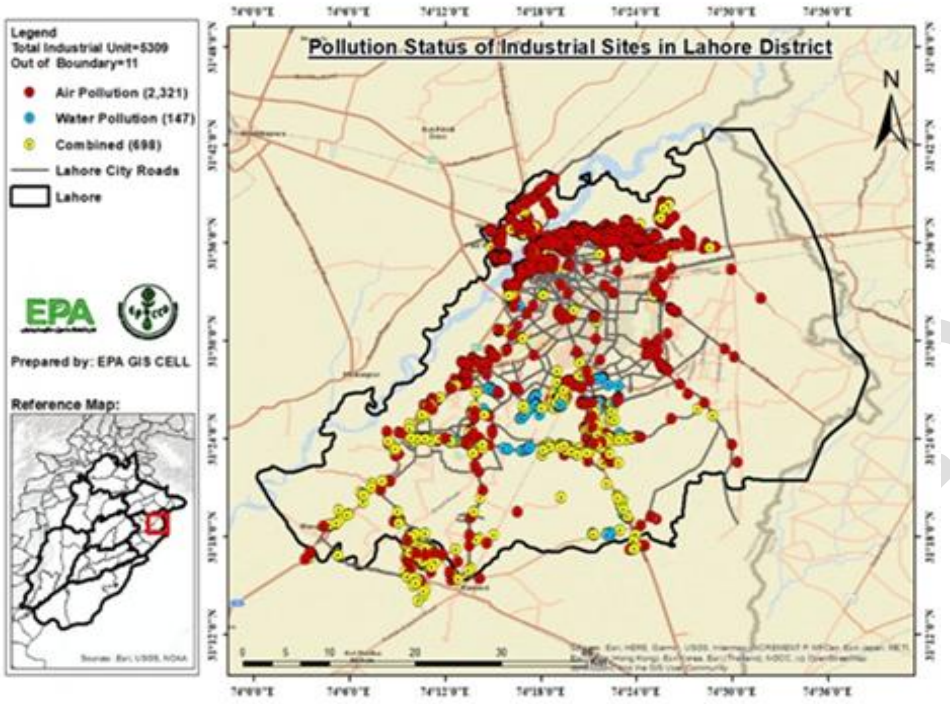
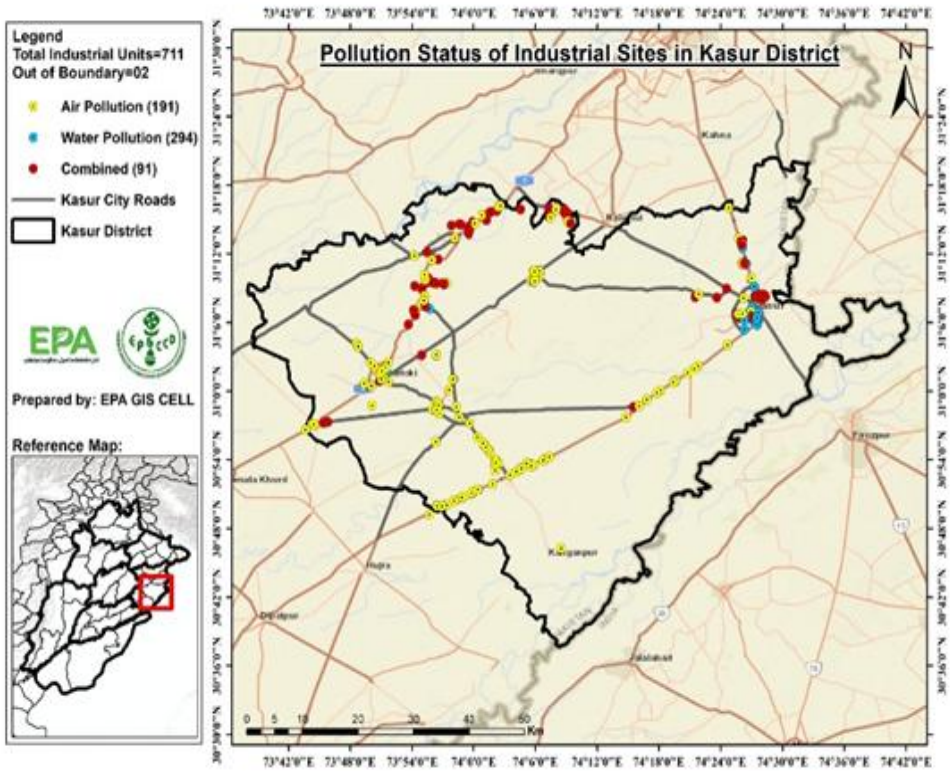
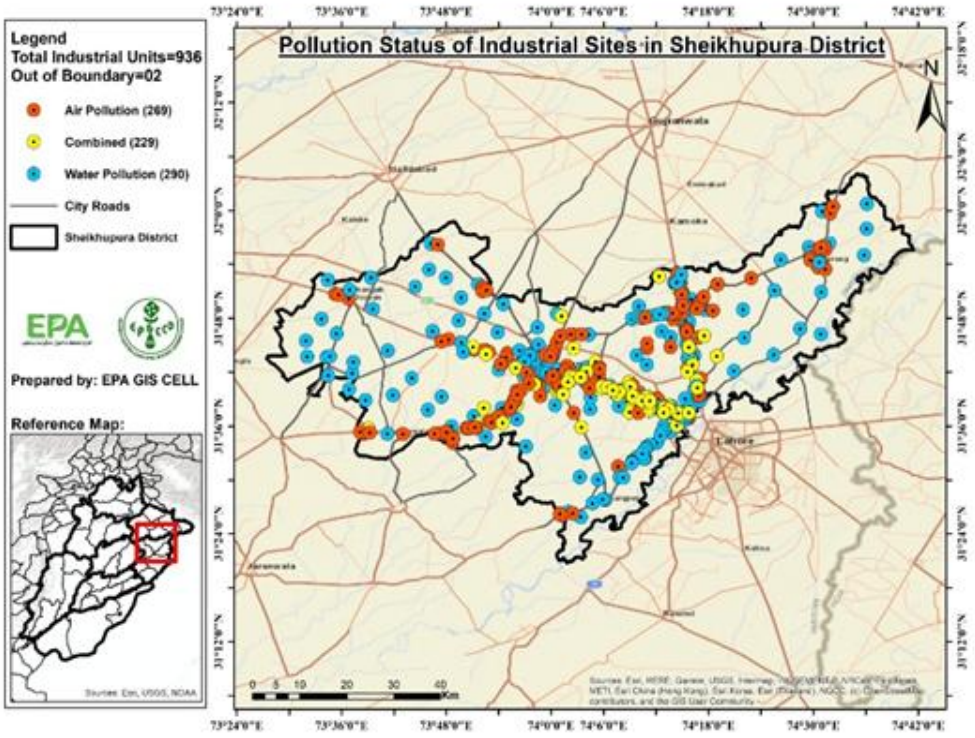

Legend
Total Industrial Unit=5309
Out of Boundary=11
Air Pollution (2,321)
Water Pollution (147)
Combined (698)
Lahore City Roads
Lahore
EPA
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Lahore District
N


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:
Pollution Status of Industrial Sites in Kasur District
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

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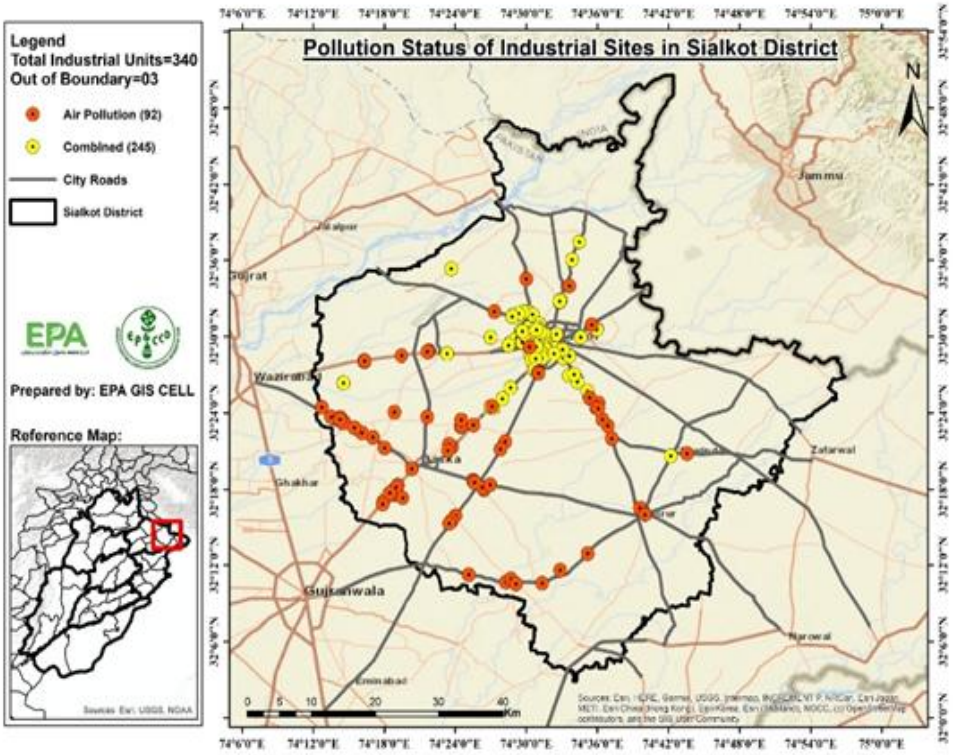
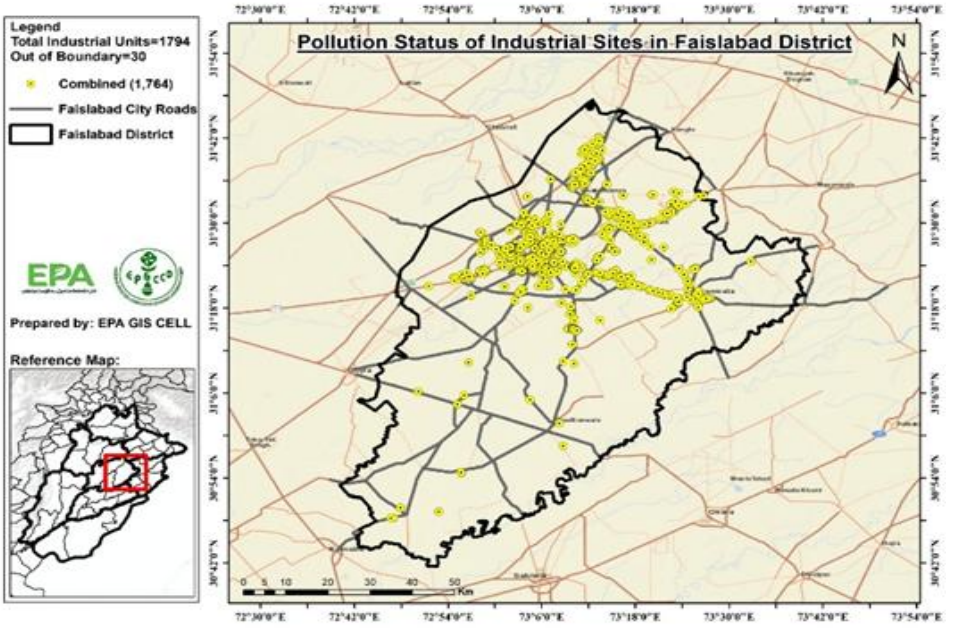

Legend
Total Industrial Units=340
Out of Boundary=03
Air Pollution (92)
Combined (245)
City Roads
Sialkot District
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Sialkot District
N
Jammu
Wazirabad
Gujranwala
Zafarwal
Narowal
Ghakhar
Emmabad
0 5 10 20 30 40 Km


Legend
Total Industrial Units=1794
Out of Boundary=30
Combined (1,764)
Faislabad City Roads
Faislabad District
Prepared by: EPA GIS CELL
Reference Map:
Pollution Status of Industrial Sites in Faislabad District
N
0 5 10 20 30 40 50 Km

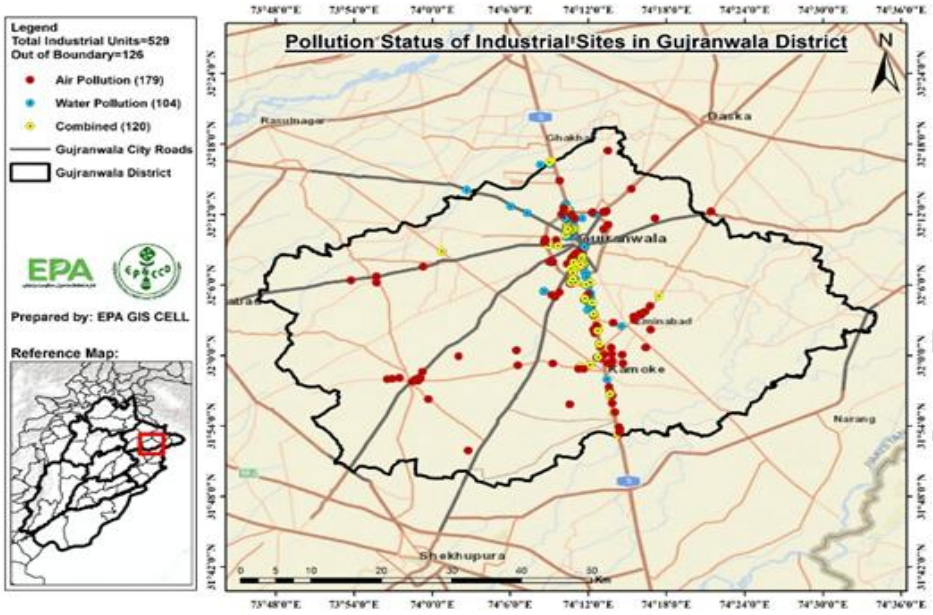


Figure 5.2: Pollution hotspot mapping of central Punjab districts

Sheikhupura exhibits a corridor-based and clustered industrial structure along the Lahore–Skp axis, with major industrial estates forming hotspots and additional pollution contributed by brick kilns in peri urban fringes.

In contrast, Kasur is dominated by a single major industrial cluster of tanneries and leather processing units, forming a concentrated hotspot, complemented by peripheral brick kilns and scattered small industries.

Sialkot shows a more dispersed and mixed land-use pattern, where small and medium-scale export-oriented industries are embedded within residential areas, resulting in diffuse pollution rather than dominant clusters.

5.4.3 Air Pollution Assessment in Southern Punjab Districts:

Southern Punjab (including Multan and Bahawalpur) is characterized by a mixed and relatively low to moderate industrial density. Multan shows moderate clustering along highways and industrial estates, while Bahawalpur exhibits a highly dispersed pattern dominated by small-scale industries and brick kilns. In both districts, peripheral kiln belts and scattered agro-based industries are the primary pollution sources, resulting in diffuse but widespread air pollution rather than concentrated hotspots.

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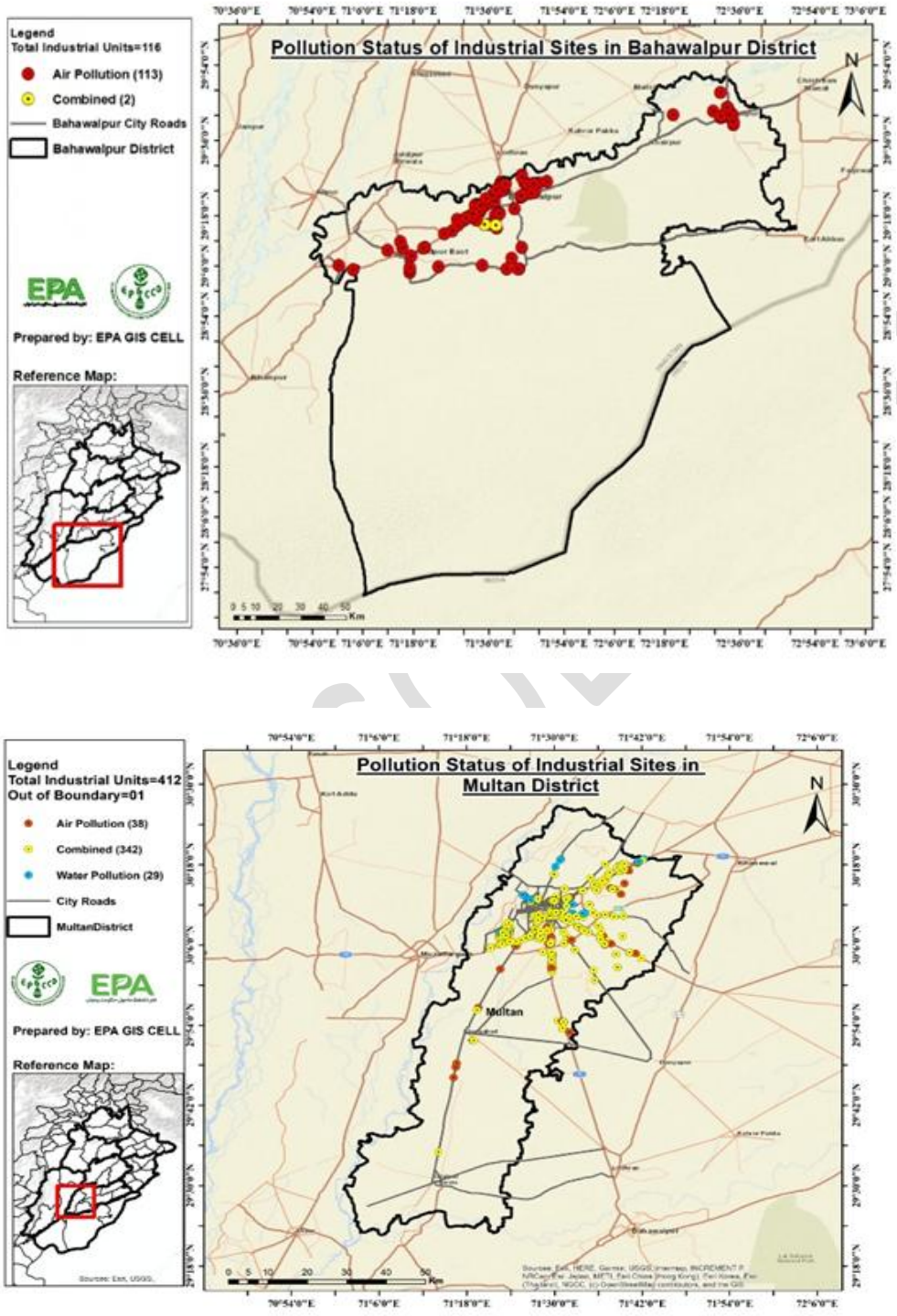

Figure 5.3: Pollution hotspot mapping of Southern Punjab districts

Similarly, Multan presents moderate clustering, with industries located mainly along highways and on urban outskirts, while brick kilns and agro-based activities create a widespread peripheral pollution belt.

Bahawalpur exhibits the most scattered and low-density industrial distribution, dominated by small-scale industries and brick kilns spread across urban and rural areas, leading to diffuse pollution sources rather than concentrated hotspots

5.4.4 Air Pollution Assessment in Northern Punjab Districts:

Northern Punjab (represented here by Rawalpindi) has a comparatively moderate and limited industrial base. Industries are scattered rather than clustered, with a few significant point sources such as cement and thermal power plants contributing disproportionately to emissions. Overall, pollution is more localized and less spatially dense compared to Central Punjab.

The city's industrial base mainly includes pharmaceutical units, flour mills, a thermal power plant and a cement plant, which are not heavily clustered but are instead distributed across specific industrial and peri-urban locations. Among these, the cement plant and thermal power facility represent the most significant contributors to air pollution due to their higher emissions of particulate matter and gaseous pollutants.

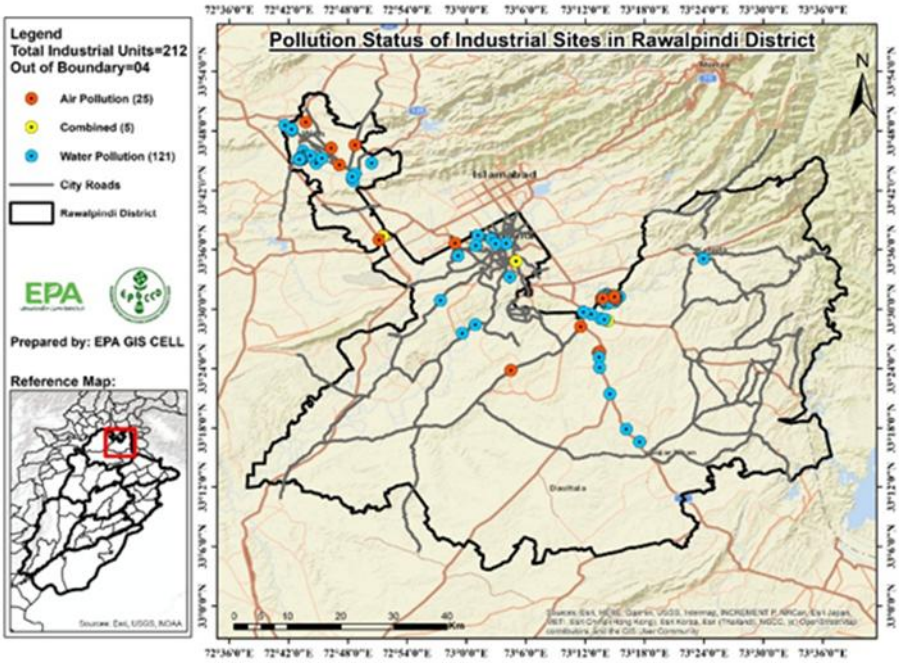

Figure 5.4: Pollution hotspot mapping of Northern Punjab districts

Unlike highly industrialized cities, Rawalpindi does not exhibit dense industrial clustering. Instead, it shows a scattered distribution of small to medium-scale industries, often located along major transport routes and near the city's outskirts to reduce congestion within the urban core.

In addition, limited brick kiln activity in surrounding peri-urban areas contributes to a peripheral belt of pollution, while wind patterns and proximity to Islamabad further influence pollutant dispersion across the region.

5.5 Assimilation Capacity of Punjab's Industrial Districts

Assimilation capacity refers to the natural environment's ability to absorb, disperse and neutralize pollutants without exceeding prescribed air quality standards. It represents the maximum pollutant load that an area can sustain without causing long-term environmental degradation. This concept is widely used to assess the pollution load-carrying capacity of a region under varying atmospheric and industrial conditions[14]. The assimilative capacity of the atmosphere is primarily governed by meteorological parameters, including wind speed, mixing height, atmospheric stability and temperature inversions. Among these, the mixing height plays a critical role in determining the vertical extent to which pollutants can disperse. Lower mixing heights, especially during winter, restrict vertical dispersion and lead to pollutant accumulation near the ground, while higher mixing heights enhance dilution and dispersion.[15]

In the literature, assimilative capacity is often evaluated using proxy indicators such as the ventilation coefficient, which is the product of wind speed and mixing height. Higher ventilation coefficients indicate stronger dispersion potential and improved air quality conditions, whereas lower values signify stagnant atmospheric conditions and increased pollution concentrations[16].Urban environments present a highly complex scenario for assessing assimilative capacity due to the presence of multiple emission sources, including point sources (industries), line sources (vehicular emissions) and area sources (domestic and commercial activities). These sources emit a wide range of pollutants in different forms and quantities, at varying heights and time intervals. Additionally, meteorological variability further influences pollutant behavior through processes such as transport, dispersion, chemical transformation, deposition and absorption, making urban air quality dynamics highly complex[17].

Assimilation capacity also exhibits significant spatial and temporal variability. It is generally higher during daytime and in seasons characterized by strong winds and thermal mixing, while it decreases during stable atmospheric conditions, particularly in winter when temperature inversions are common. Regions with flat or basin-like topography tend to have lower dispersion potential, leading to frequent smog events, whereas hilly or elevated terrains facilitate better air circulation and pollutant dilution[18, 19] 44

DRAFT SEP 2025

14Goyal, S. K., & Rao, C. V. C. (2007). Assessment of atmospheric assimilation potential for industrial development in an urban environment: Kochi (India). Science of the Total Environment, 376(1–3), 27–39. https://doi.org/10.1016/j.scitotenv.2007.01.067

15 Yang, S.-S., & Pan, C.-J. (2025). Climatology of the Atmospheric Boundary Layer Height Using ERA5: Spatio-Temporal Variations and Controlling Factors. *Atmosphere*, *16*(5), 573. https://doi.org/10.3390/atmos16050573

16 Govande, A., Attada, R., Shukla, K. K., Muralidharan, S., Kunchala, R. K., Chilukoti, N., & Kaushik, G. (2024). *Analyzing and predicting ventilation coefficient over India using long-term reanalysis datasets and hybrid machine learning approach*. https://doi.org/10.21203/rs.3.rs-4551619/v1

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 dramatic variation in assimilation capacity across Punjab is primarily a result of the "Bowl Effect" seen in the central regions. During the winter months (October–February), districts like Lahore and Gujranwala experience a meteorological phenomenon where a layer of warm air settles above a layer of cool, stagnant air near the ground. This acts as a "lid," preventing industrial

17 Wagner, P., & Schäfer, K. (2017). Influence of mixing layer height on air pollutant concentrations in an urban street canyon. Urban Climate, 22, 64–79.

18 23 Kumar, A., & Goyal, P. (2011). Assessment of ventilation coefficient and its relation with air pollution dispersion. Atmospheric Environment, 45(30), 5401–5407.

19 Shahid, M., & Sabir, S. (2024). Investigation of causes and effects of winter smog in Lahore, Pakistan. *International Journal of Agriculture and Sustainable Development*, *6*(1), 1-15. journals.uol.edu.pk.

22 Ali, G., Gohar, A., Bao, Y., Ullah, W., Ullah, S., Guan, Q., Liu, X., Li, L., Lei, Y., Li, G., & Ma, J. (2020). Spatiotemporal trends of aerosols over urban regions in Pakistan and their possible links to meteorological parameters. *Atmosphere, 11*(3), 306. https://doi.org/10.3390/atmos11030306

23 Aized, T., Rehman, S. S., Farhan, M., Kazim, A. H., & Rehman, S. U. U. (2019). Design and analysis of wind pump for wind conditions in Pakistan. *Advances in Mechanical Engineering, 11*, 168781401988040. https://doi.org/10.1177/1687814019880405

24 Abedrabboh, O., Alfarra, M. R., Al-Ansari, T., & Fountoukis, C. (2025). Enhancing human thermal comfort in hot arid cities: A systematic review of urban heat island observations and mitigation strategies. Building and Environment, 283, 113398. https://doi.org/10.1016/j.buildenv.2025.113398

25 Pakistan Meteorological Department. (2024). *State of Pakistan Climate in 2024*. Government of Pakistan.

26 Bilal, M., Hassan, M., Tahir, D., Iqbal, M., & Shahid, I. (2022). Understanding the role of atmospheric circulations and dispersion of air pollution associated with extreme smog events over South Asian megacity. Environmental Monitoring and Assessment, 19227 Wagner, P., & Schäfer, K. (2017). Influence of mixing layer height on air pollutant concentrations in an urban street canyon. Urban Climate, 22, 64–79.

27 Slater, J., Espita-Casanova, D., Bathan, G., Ecal, D., Aftab, L., Jamshaid, H., Shafique, S., Amjad, M, Malley, C.S., Integrated Assessment of Air Pollution and Climate Change Mitigation in Pakistan. Climate and Clean Air Coalition Supporting National Action & Planning Initiative Project Report.

DRAFT SOE 2025

emissions from rising and dispersing. Because these districts are topographically flat and far from the sea, there are no strong coastal breezes or mountain-induced winds to "wash" the air. Consequently, even a small amount of industrial smoke stays trapped at breathing level for days[26]

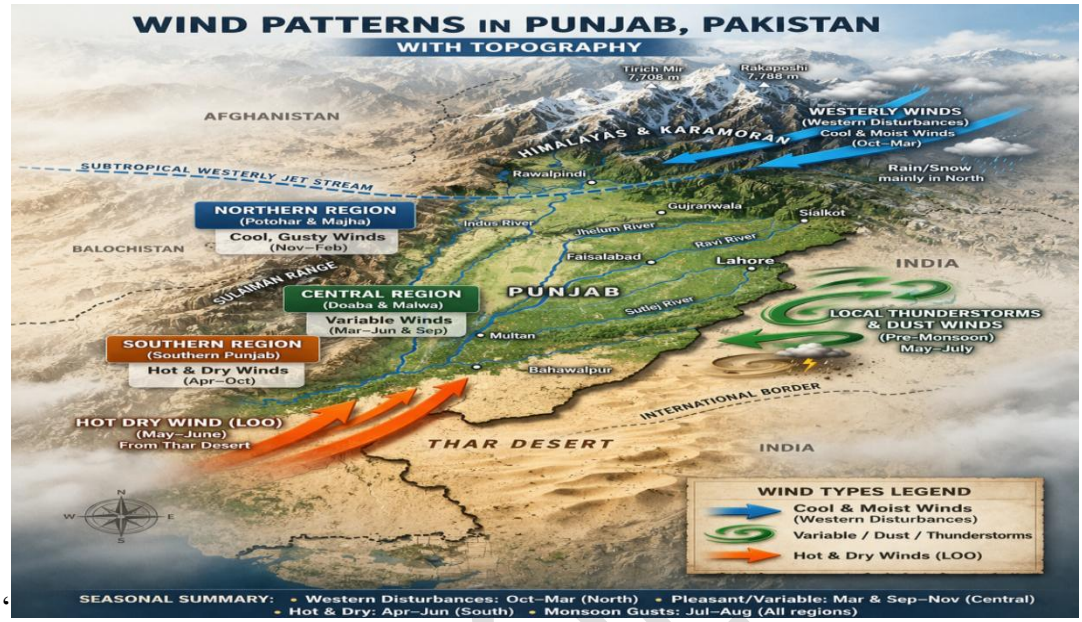

Figure 5.5: Wind Patterns in Punjab, Pakistan

In contrast, the Northern Uplands (Rawalpindi and Murree) benefit from a more rugged landscape. The varying elevations create natural turbulence in the air, which breaks up concentrated plumes of smoke from large sources like cement plants. Similarly, the Southern Districts benefit from higher thermal energy; as the ground heats up more intensely than in the north, it creates upward "thermals" that lift pollutants higher into the atmosphere, where stronger upper-level winds can carry them away from population centers[27].

Ultimately, while the Central Districts have the most advanced industrial technology, they have the least natural defense against pollution. This means that a factory in Lahore must have significantly stricter emission controls than the same factory in Mianwali, simply because the air in Lahore has almost zero capacity to clean itself.

5.6 EPA Punjab's Air Quality Management Regime

The **Environmental Protection Agency (EPA) Punjab** played a crucial role in ensuring compliance with these reforms. Enforcement measures included sealing non-compliant factories and brick kilns, imposing fines on smoke-emitting vehicles and penalizing farmers for stubble burning. EPA also expanded its network of real-time air quality monitoring stations, making pollution data publicly accessible. These actions not only curbed emissions but also enhanced transparency and accountability, ensuring that reforms translated into tangible improvements in air quality. During critical smog events, Section 6(1)(t) of the Punjab Environmental Protection

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Act, 1997, was invoked to restrict outdoor activities and mandate early closure of markets in Lahore, Faisalabad, Gujranwala and Multan.

As a result of these combined reforms and enforcement measures, Punjab has seen a decline in the intensity of smog episodes compared to 2021–22, when Lahore often ranked among the world's most polluted cities. Real-time monitoring stations now provide transparent AQI data and public health advisories help minimize exposure risks. While challenges such as seasonal crop burning and rapid urbanization remain, the synergy between policy frameworks and EPA enforcement has set Punjab on a path toward cleaner air and healthier living conditions, marking a significant step forward in environmental governance.

5.6.1 Air Quality Management Cycle

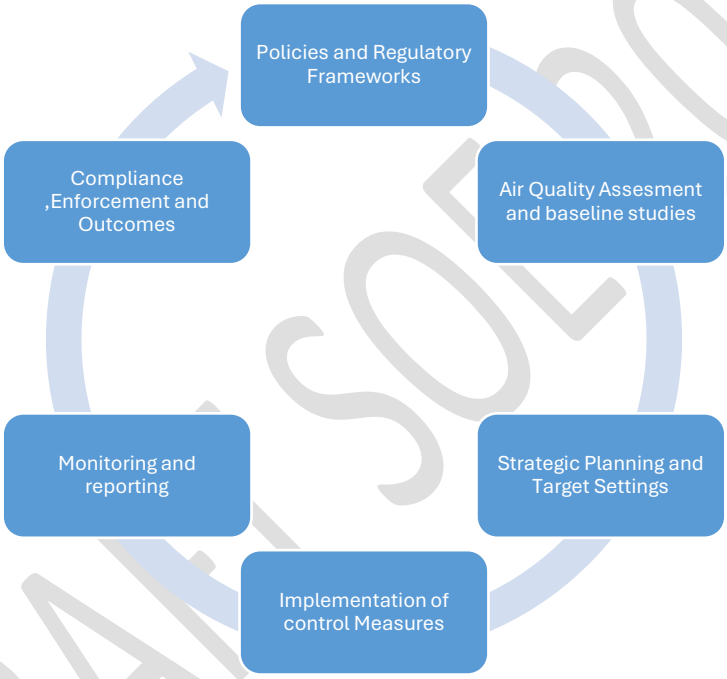

Figure 5. 6: Air Quality Management Cycle

The EPA Punjab's air quality improvement strategy focuses on reducing emissions across transport, industry, agriculture, domestic fuel use and fugitive dust sources while protecting public health from hazardous pollutants. Central to this approach is the expansion of continuous monitoring stations, emission inventories and smog forecasting systems to provide real-time data and early warnings. Sector-specific emission reduction plans, industrial compliance measures, vehicular emission control program and interventions against reduction of PM concentrations and other primary pollutants. These efforts are reinforced by regulatory instruments such as ambient air quality standards, Environmental Quality Standards and economic tools including penalties and incentives to drive compliance.

DRAFT SOE 2025

Equally important is institutional coordination, with EPA Punjab working closely with departments of Transport, Industries, Agriculture, Punjab Safe City Authority, Punjab Highway patrol and Lahore Waste Management Company, alongside local governments and regional partners to address cross-border pollution. The strategy also emphasizes climate co-benefits by integrating air quality and greenhouse gas mitigation, while transparency and accountability are enhanced through citizen engagement and open data platforms. Collectively, these measures aim to deliver improved air quality, public health gains, strengthened institutions and greater public awareness, ensuring a resilient and sustainable environmental management system 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, to combat with its severe air pollution challenges, the EPA has established an air quality monitoring network.

In year 2025 the air quality monitoring network in Punjab, experienced significant expansion and enhancement. EPA Punjab has successfully installed additional AQMS in other major cities and industrial zones across the province, contributing to a more comprehensive understanding of regional air quality trends. This extensive monitoring infrastructure allows the EPA to track seasonal variations, identify major sources of pollution (such as industrial emissions, vehicular exhaust and transboundary smog) and evaluate the effectiveness of implemented environmental regulations and initiatives, such as the "Clean Punjab" program or actions against industrial violators. The continuous collection of this data is vital for public health advisories, environmental impact assessments and guiding efforts towards achieving cleaner and healthier air for all citizens of Punjab.

A network of air quality monitoring stations provides continuous data on key pollutants, including particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide, nitrogen dioxide, carbon monoxide and ozone. In year 2025 EPA Punjab has expanded the network of AQMS across Punjab by adding This initiative builds upon the network of 41 Air Quality Monitoring Stations (AQMSs) established in 18 districts as illustrated in Fig 5.5. Which provide continuous data on ambient air quality. The Environmental Protection Agency (EPA), Punjab, has established a formal mechanism for the calculation and dissemination of the Air Quality Index (AQI) across the province. This initiative is part of the agency's broader mandate to protect and improve environmental quality, prevent pollution and promote sustainable development.

Figure 5. 7: Air Quality Monitoring Station

Figure 5. 8: Inside view of AQMS

The AQI is calculated using hourly average concentrations of key criteria pollutants, including PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO and O_3 in line with the Punjab Clean Air Policy (2023). The data collected from this networks instrumental in assessing the Air Quality Index (AQI), identifying pollution hot spots and informing policy decisions aimed at mitigating air pollution. This extensive monitoring infrastructure allows the EPA to track seasonal variations, identify major sources of pollution (such as industrial emissions, vehicular exhaust and transboundary smog) and evaluate the effectiveness of implemented environmental regulations and initiatives.

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

5.6.3 AQMS in Lahore:

Lahore has faced severe smog since five years, particularly during the winter months. To address this critical issue, the Environmental Protection Agency Punjab has strategically increased the number of Air Quality Monitoring Stations (AQMS) in the city. Currently, 13 local AQMS are operational at key locations across Lahore, providing continuous data on ambient air quality, enabling real-time monitoring of pollutants and supporting timely public health advisories. In addition, three trans-boundary AQMS have been installed around Lahore to monitor air pollution originating from neighboring regions or cross-border sources. These stations help distinguish between local emissions and externally transported pollutants, allowing for more accurate assessment and targeted mitigation strategies. The locations of all AQMS are illustrated in the figures below, highlighting the integrated approach to air quality management in Lahore.

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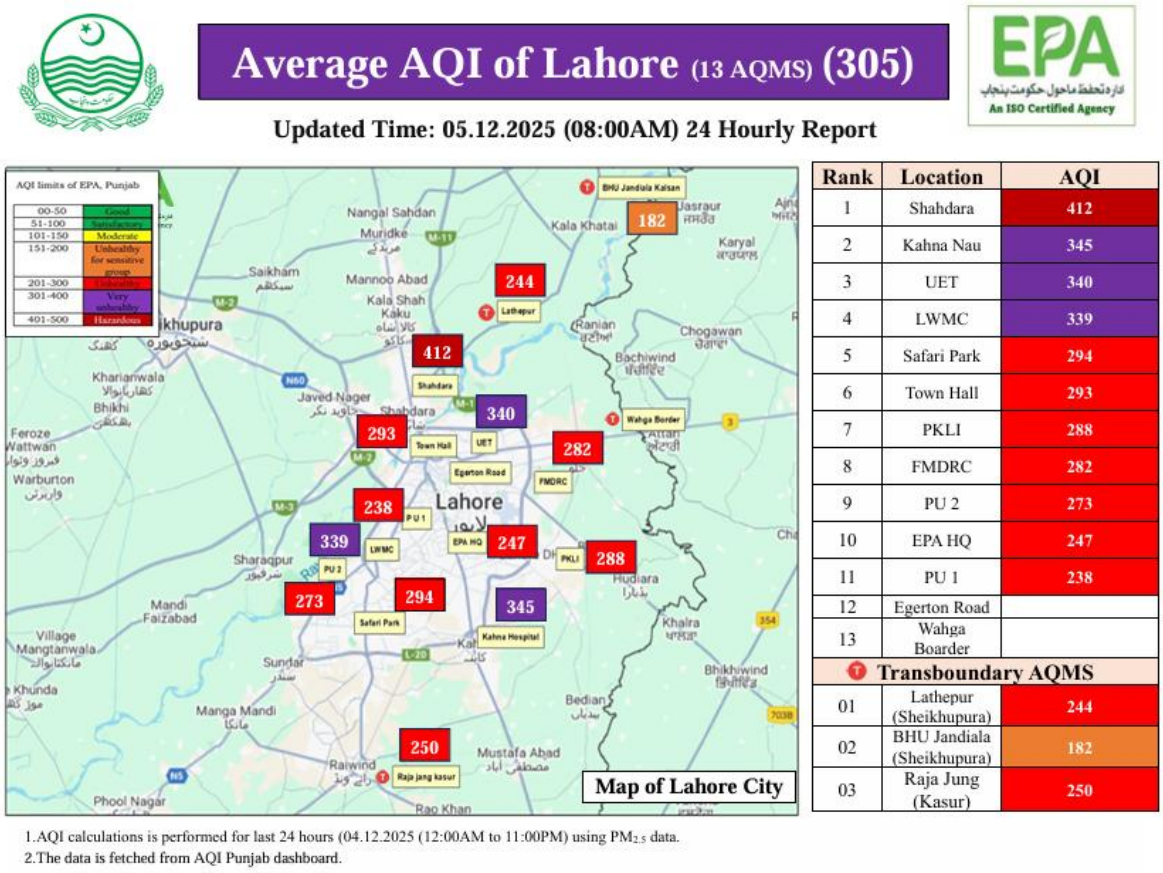

Rank	Location	AQI
1	Shahdara	412
2	Kahna Nau	345
3	UET	340
4	LWMC	339
5	Safari Park	294
6	Town Hall	293
7	PKLI	288
8	FMDRC	282
9	PU 2	273
10	EPA HQ	247
11	PU 1	238
12	Egerton Road	
13	Wahga Boarder	
Transboundary AQMS		
01	Lathepur (Sheikhupura)	244
02	BHU Jandiala (Sheikhupura)	182
03	Raja Jung (Kasur)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

Figure 5.10: AQMS Station in Lahore

To ensure consistency and transparency, AQI values are calculated on the basis of average concentrations of these pollutants and disseminated at regular intervals throughout the day. This structured reporting system enables timely communication of air quality conditions to government departments, stakeholders and the public. By institutionalizing AQI reporting, EPA Punjab has strengthened its capacity to provide evidence-based advisories, enhance public awareness and support policy-level interventions for air quality management.

5.6.4 AQI Dissemination Dashboard

The Environmental Protection Agency Punjab has operationalized AQI Punjab Dashboard as a comprehensive real time air quality dissemination platform for public awareness, environmental monitoring and evidence-based decision making. The dashboard is powered by a network of regulatory grade ambient air quality monitoring stations integrated with meteorological and weather observation systems across Punjab. The platform provides hourly updated Air Quality Index (AQI) values along with pollutant specific concentrations including $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO and O_3. In addition to real time monitoring, the dashboard also presents city wise trends, historical comparisons, monthly pollutant patterns, station specific analysis and area wise AQI

categorization to enable better understanding of pollution dynamics. The system serves as a centralized public information platform through which citizens, researchers and policymakers can access transparent and reliable air quality data along with health advisories and environmental alerts.

5.6.5 AQI Forecasting and Early Warning System

In order to strengthen proactive environmental governance and public awareness, EPA Punjab has also developed Pakistan's first localized AQI forecasting and early warning system integrated with the AQI Punjab platform. The forecasting framework utilizes machine learning techniques, meteorological observations, satellite based atmospheric datasets and historical pollutant trends to predict upcoming air quality conditions with enhanced spatial and temporal accuracy. The system combines real time emissions data, weather variables, wind patterns, humidity, temperature inversions and regional atmospheric movements to generate forecast based AQI outlooks and pollution advisories. These predictive capabilities support timely decision making, early dissemination of smog alerts and public health precautions, particularly during high pollution episodes and seasonal smog events in Punjab.

5.7 Environmental Monitoring and Scientific Surveillance

Following the establishment of real time AQI monitoring and forecasting systems, EPA Punjab immediately strengthened its environmental monitoring framework to ensure effective ground level implementation and regulatory oversight. The Agency adopted a two-dimensional monitoring approach consisting of field monitoring and scientific monitoring mechanisms. Field monitoring focuses on physical inspections, compliance verification, emission source identification and enforcement activities carried out by field formations across Punjab. Simultaneously, scientific monitoring is being undertaken through regulatory grade air quality monitoring stations, meteorological observations, digital mapping systems, satellite datasets and data driven analytical tools. The integration of both operational and scientific monitoring frameworks has enabled EPA Punjab to improve environmental surveillance, identify pollution hotspots more effectively and undertake evidence-based interventions for air quality management across the province.

5.7.1 Industrial monitoring through Unique ID Allotment:

As part of strengthening its monitoring framework, the Environmental Protection Agency Punjab has conducted comprehensive inventories of industrial units and brick kilns across the province. To ensure data integrity and support effective monitoring and enforcement, inspectors are required to record both the Unique Identification Number (UID) and the corresponding name of each industry or brick kiln during inspections. A total of 14,000 industrial units have been assigned UIDs during year 2025 through a structured and transparent process, as outlined below.

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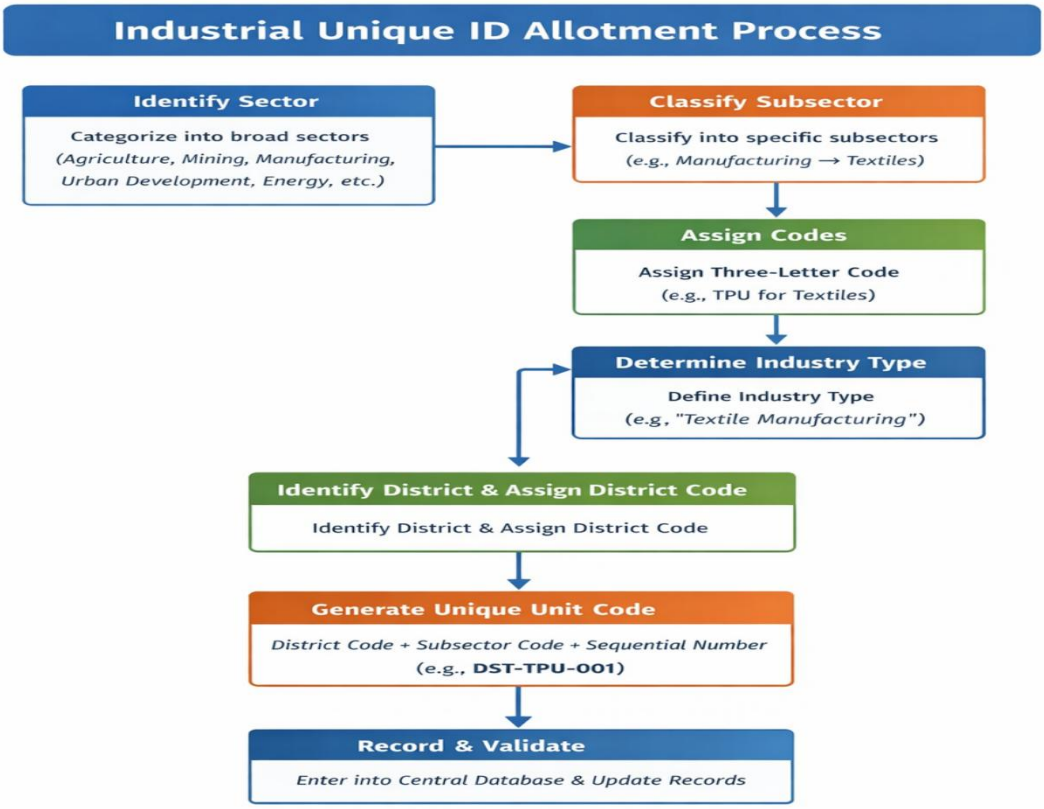

Figure 5. 11: Industrial Unique ID Allotment Process

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

Punjab has successfully completed the e-mapping of industrial units across the province, enabling spatial monitoring, pollution profiling and improved planning of inspection activities. District wise industrial cluster maps have been developed to identify pollution hotspots, assess sectoral concentration and prioritize targeted environmental interventions. In addition, updated digital industrial directories are being maintained to monitor field inspections, track compliance status and support evidence based regulatory decision making. The integration of spatial mapping with centralized environmental databases has significantly enhanced transparency, monitoring efficiency and enforcement coordination, thereby strengthening the overall framework of environmental governance in Punjab. E-Maps of selected districts are provided 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 specialized GIS wing, these drones are being deployed to monitor environmental violations in real time.

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

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.

Figure 5.12: Drones for Air Quality Monitoring

Figure 5.13: DSS Operations

5.7.3.2 Field Operation of DSS: The Drone Surveillance Squad (DSS) has monitored industries and under construction sites, also performed AQMS Drone surveillance and GIS mapping of

AQMS stations across Punjab. In eight districts. The DSS significantly enhanced monitoring of industrial compliance, construction activities and air quality management, strengthening environmental enforcement and surveillance capacity.

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 Punjab has established a dedicated Patrolling Squad to monitor air pollution hotspots and curb pollution sources. The squad conducts continuous surveillance across Lahore and undertakes special inspection visits throughout the province in accordance with a structured weekly monitoring plan. Its mandate is to identify pollution emitting sources and promptly report violations to higher authorities for necessary 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, strengthens enforcement efficiency and ensures timely intervention against non-compliant units. Monitored units are reported to the concerned district officers through the Inter-Accountability Dashboard, along with documented evidence of violations. Upon receiving the report, the concerned district office take action against complaint to resolve the issue. The

DRAFT SOE 2025

concerned officer is required to take appropriate action and ensure that the complaint is resolved and formally closed within 20 days.

Figure 5.14: HawkEye 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

DRAFT SOE 2025

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 makes it mandatory for all industrial units operating boilers, furnaces, or incinerators to install CCTV cameras with specified technical standards. These cameras must be positioned to capture the stack terminals where emissions are released and provide live online access to EPA Punjab for continuous monitoring. EPA officers observe the feeds as well as EPA Punjab has established an AI-integrated monitoring system that operates continuously to enforce emission control standards. The system is trained to detect violations such as denial of access to monitoring feeds, unclear chimney views, offline or interrupted feeds and the presence of black smoke. the unit is considered in violation. In such cases, officers lodge complaints through EPA helpline 1373, notifying the industry owner and relevant district officer. Repeated violations reported on Inter Accountability Dashboard and concerned district officer take action against violator as per law and in extreme cases. This system ensures accountability and strengthens EPA's ability to enforce emission control standards across Punjab.

Figure 5.15: CCTV Monitoring of industries

5.7.6 Scientific Surveillance

EPA Punjab has established a scientific surveillance framework based on real time environmental intelligence, regulatory grade monitoring infrastructure and data driven analytical systems. The mechanism utilizes ambient air quality monitoring stations, meteorological sensors, satellite observations, AQI forecasting models and digital mapping platforms to continuously assess environmental conditions across Punjab. Through pollutant specific analysis, trend evaluation and spatial monitoring, the system enables identification of pollution hotspots, seasonal variations and emerging environmental risks. Scientific surveillance not only strengthens evidence based policymaking and regulatory planning but also supports timely advisories, forecasting and targeted environmental interventions for effective air quality management.

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5.7.7 Stack Emission Monitoring:

The monitoring of industrial stack emissions is the backbone of environmental enforcement in Punjab. The Environmental Protection Agency (EPA) Punjab, through its laboratory, utilizes high-precision, regulatory-grade instruments to ensure that "Point Source" emissions comply with the Punjab Environmental Quality Standards (PEQS).

5.7.7.1 Stack Emission Monitoring Process:

Regulatory stack testing begins with Isokinetic Sampling, a technical necessity for measuring Particulate Matter (PM). Because particles have mass and momentum, the air must be pulled into the sampling probe at the exact same velocity as the gas moving up the stack; if the pull is too fast or too slow, the sample will not accurately represent the true concentration of dust. The EPA field teams use a probe inserted into a "Sampling Port" (a hole drilled at a specific height, usually 8 times the stack diameter above any bend) to extract these samples.

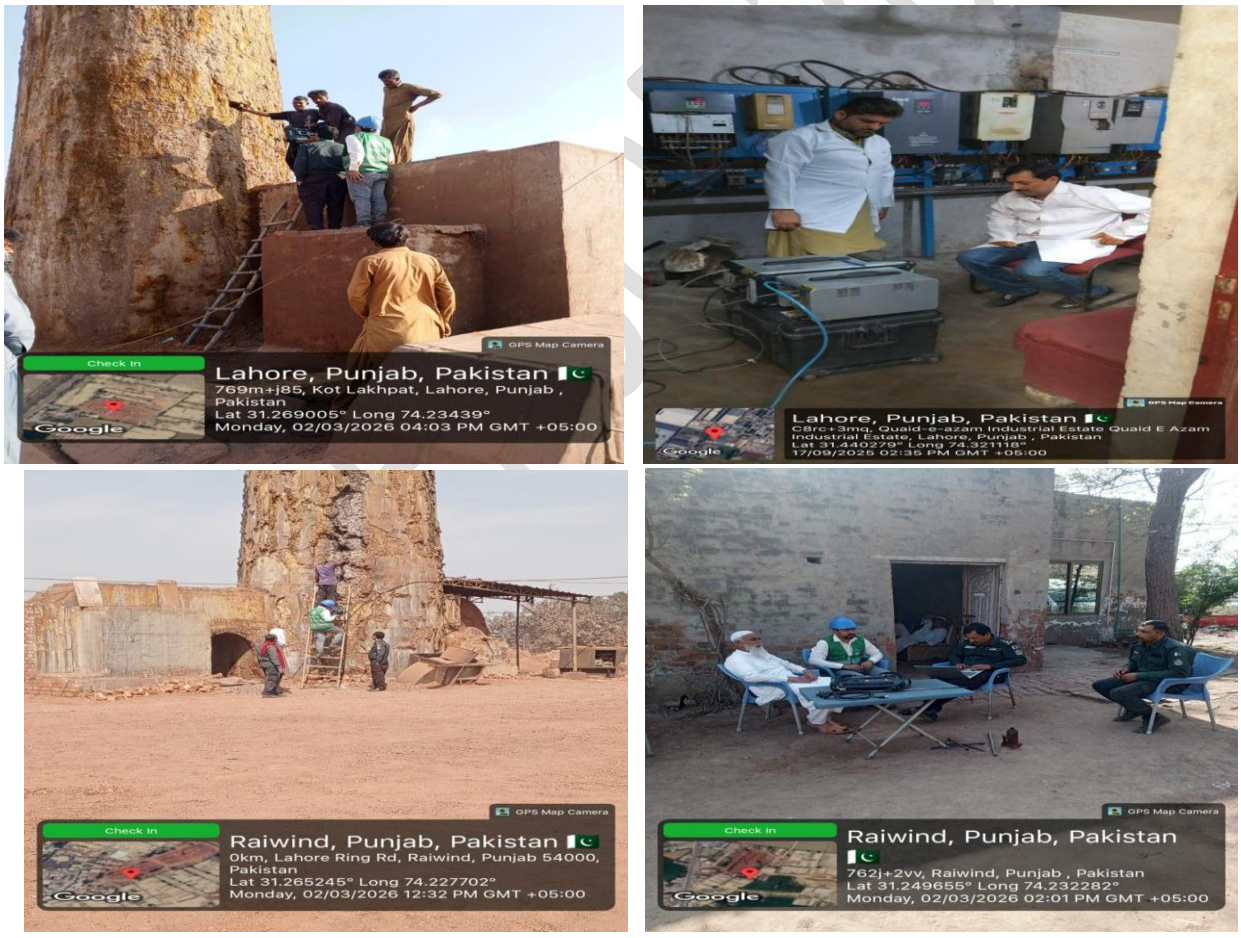


Figure 5.16: Stack Emission Monitoring of Industries in Punjab

For gaseous pollutants like Sulfur Dioxide (SO2), Nitrogen Oxides (NOx) and Carbon Monoxide (CO), the EPA employs portable but highly sophisticated Analyzers. These devices, such as the

LANCOM 4, provide a digital readout of the gas concentrations in real-time. A critical part of the paragraph-level methodology is Oxygen Correction. Since a factory could technically "dilute" its smoke by pumping in excess fresh air to lower the concentration, the EPA calculates the "Corrected Concentration" based on a standard oxygen percentage. This ensures that the reported values reflect the actual efficiency of the fuel combustion and the scrubbing system, regardless of how much air is being pushed through the stack.

5.8 Enforcement Actions:

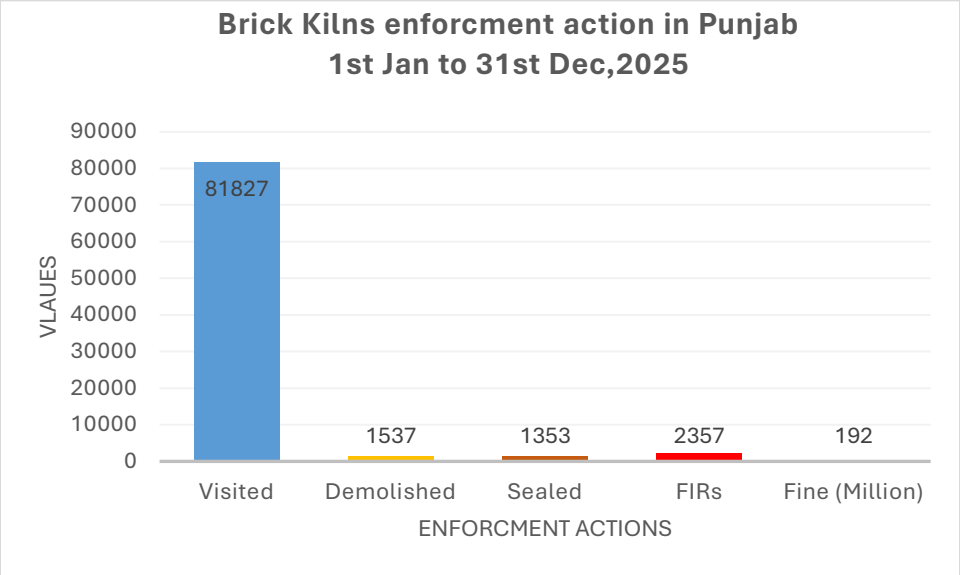
The Punjab Environmental Protection Agency has taken strict enforcement actions under the Punjab Environmental Protection Act (amended 2017) and the Punjab Smog Prevention and Control Rules, 2023 to control air pollution and smog. The agency conducts inspections, issues Environmental Protection Orders (EPOs), imposes fines, seals non-compliant industries and prosecutes violators. Under the Smog Rules 2023, special focus is given to construction dust, industrial emissions, brick kilns and vehicular pollution, especially during smog season. These actions aim to reduce particulate matter levels and protect public health across Punjab.

5.8.1 Brick Kiln Inspections:

EPA Punjab has zero tolerance for brick kilns which are operating on conventional technology or use substandard fuel such as hard coke, tyres, plastics, rubber, latex, lather, Rexene, pyro oil, tyre carbon, plastic waste lumps, hospital waste or any other fuel specify by agency. A total of 81,827 kilns were visited by enforcement teams, showing extensive inspection coverage across the province during 2025.

Figure 5.17: Enforcement actions at Brick Kilns in Punjab

As a result of non-compliance with environmental standards, 1,537 kilns were demolished and 1,353 were sealed, indicating strict punitive measures. Additionally, 2,357 FIRs (First Information Reports) were registered against violators, reflecting legal proceedings initiated under environmental laws. The authorities also imposed fines amounting to 192 million rupees reinforcing financial accountability.



Graph 5.6: Brick Kilns Enforcement Actions in Punjab

5.8.2 Industrial Inspections:

The Environmental Protection Agency (EPA) enforces industrial emission standards through inspections and air quality monitoring near industrial zones. When violations occur, it pursues legal action, including fines and facility closures. In addition to enforcement, the EPA promotes cleaner technologies by offering technical assistance and incentives for best practices. Industries such as steel mills and boiler operations are required to install and maintain emission control systems. These include baghouse filters to capture particulate matter, scrubbers to remove sulfur oxides and other gases, electrostatic precipitators to further reduce particulates and catalytic

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converters to lower nitrogen oxide (NOx) emissions. Through these measures, the EPA ensures compliance, reduces pollution and advances cleaner industrial processes.

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

Under smog rules 2023 the enforcement data for industrial units in Punjab reflects extensive regulatory action over the period 1st Jan 2025 to 31st Dec 2025. Inspection teams conducted 44684 visits during this period, demonstrating strong monitoring efforts. In terms of strict enforcement measures, 319 units were demolished and 1834 units were sealed due to non-compliance with environmental regulations. Additionally, 649 FIRs were registered against violators, indicating legal proceedings under environmental laws. Financial penalties were also imposed, with total fines amounting to 128 million rupees

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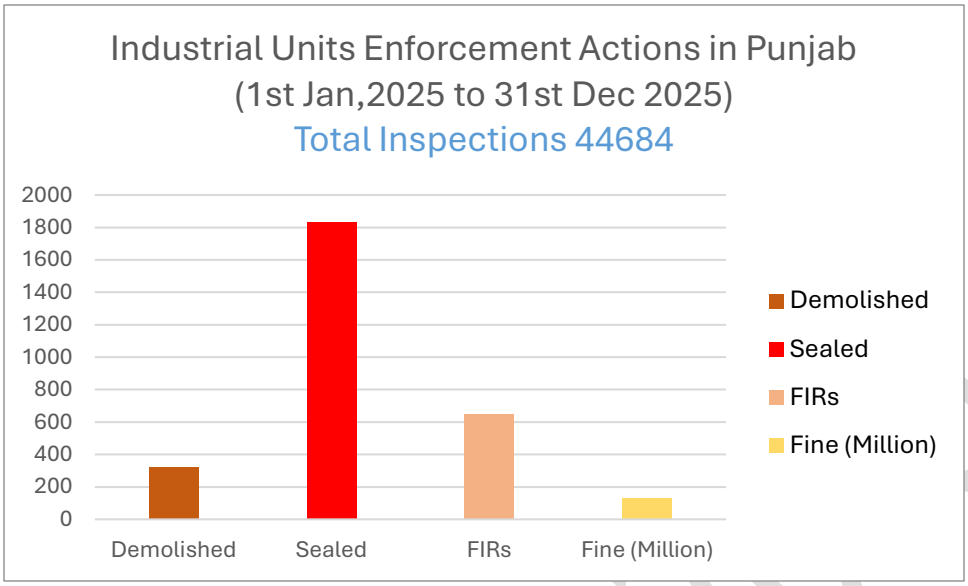

Graph 5. 7: Industrial Units Enforcement Actions in Punjab

5.8.3 Anti - Stubble Burning Enforcement:

The Environmental Protection Agency (EPA), Punjab, has successfully executed the Action Plan for Prevention and Control of Stubble Burning in hotspot areas along motorways and around Lahore. Ten surveillance beats were deployed with round-the-clock monitoring, while 67 Quick Response Centers (QRCs) were activated to ensure rapid firefighting capability across 538 villages covering 2.11 lakh acres of rice cultivation.

A robust Incident Reporting and Response Mechanism was operationalized, enabling immediate communication of stubble burning incidents through EPA Surveillance Squads, the EPD Helpline (1373), Robo Calls, District Administration and other credible sources. Verified reports were promptly transmitted to the nearest QRC, which mobilized water bowsers and firefighting staff to extinguish fires and prevent their spread. This coordinated system ensured timely detection, swift response and effective mitigation of stubble burning incidents.

The Agriculture Department facilitated water refilling arrangements and operational support, ensuring smooth functioning of QRCs. As a result, stubble burning was significantly curtailed, environmental degradation minimized and public health safeguarded. The successful implementation of this plan demonstrates proactive environmental management, inter-agency coordination and measurable progress toward sustainable agricultural practices.

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

5.8.4 Fugitive Dust Management:

Fugitive dust emissions are a major contributor to PM2.5 and PM10 pollution. To address this, EPA Punjab introduced strategic measures in 2025, including the mandatory requirement that all sand trolleys transporting construction material must be properly covered with tarpaulin sheets or similar durable coverings to prevent dust emissions on roads. During the smog season, no uncovered trolley was allowed to enter Lahore. Enforcement was strengthened where twelve squads were deployed in three shifts at six key excavation sites Manga Mandi, Kartar Band, Nonarian, Bahadru/Charmro, Saggian and Ganja Kalan to monitor compliance. These squads worked round the clock to inspect sand and clay loading trolleys, ensuring loads were properly covered and transported in line with environmental guidelines.

Sand trolley inspections were undertaken to ensure strict compliance with environmental guidelines and Standard Operating Procedures (SOPs) governing the transportation of construction materials. These inspections aimed to minimize dust emissions, enforce proper covering of loads and prevent violations that contribute to air pollution and public health risks.

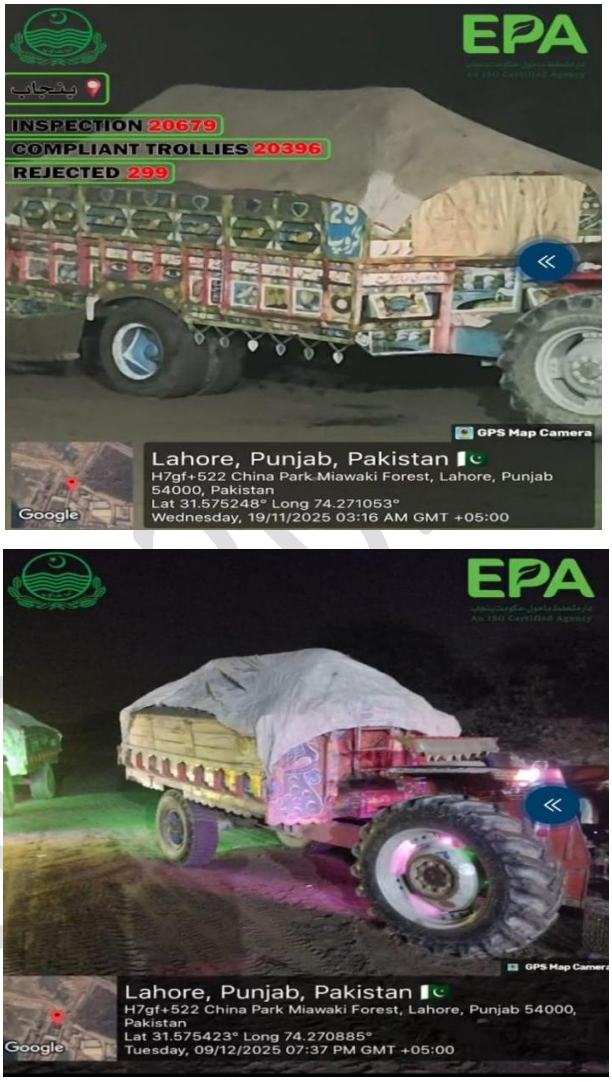

Figure 5.20: Covered Sand Trolleys in Punjab

A total of 20,679 inspections were carried out to monitor transportation activities. Out of these, 20,396 trolleys were found compliant with the required Standard Operating Procedures (SOPs), indicating a very high compliance rate. However, 299 trolleys were rejected or returned due to violations such as improper covering or failure to meet environmental guidelines.

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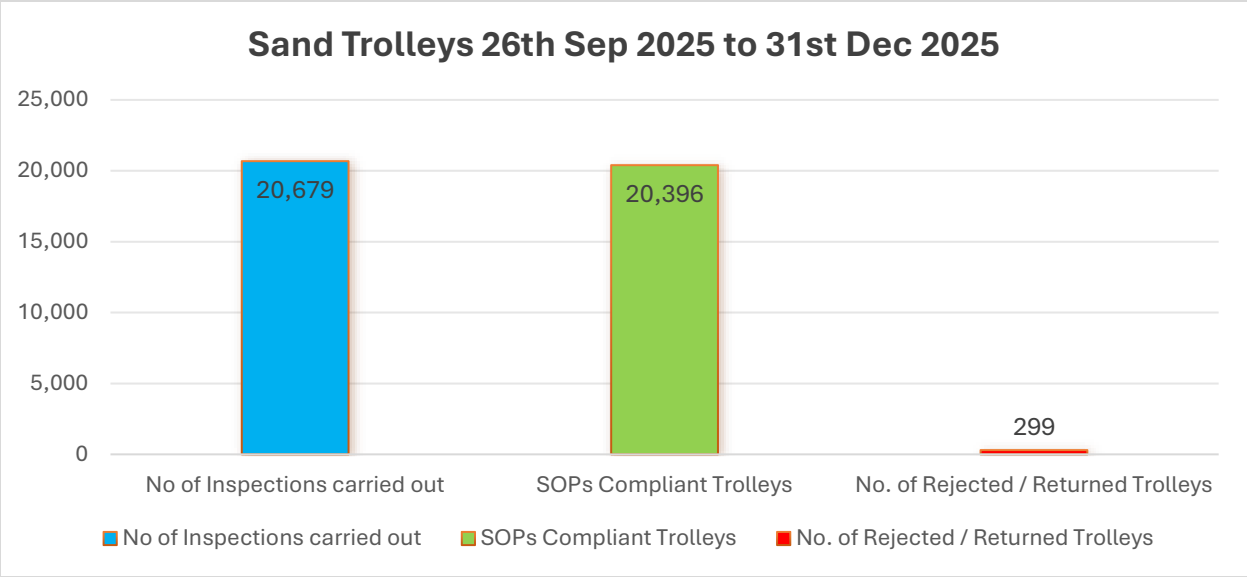

Graph 5.8: Sand Trolleys Enforcement Actions in Punjab

This high compliance rate demonstrates the effectiveness of regulatory oversight and the growing commitment of transporters to environmental safeguards. At the same time, the rejection of non-compliant trolleys highlights the need for continued vigilance and strict enforcement to deter violations.

5.8.5 Emission Testing of Vehicles:

According to study conducted by the Urban Unit, vehicular emissions were identified as one of the major anthropogenic sources contributing to urban air pollution and smog in Punjab. In response to these findings, the Honorable Chief Minister Punjab personally initiated and directed focused interventions to control vehicular emissions under the Clean Air Campaign 2025. As part of this initiative, EPA Punjab launched a emission testing system (ETS) targeting light transport vehicles (LTVs). The campaign utilizes KANE EGAS Emission Analyzers for monitoring carbon monoxide (CO) and other vehicular emission parameters to ensure compliance with Rule 3 of the Punjab Environmental Protection (Motor Vehicles) Rules, 2013, which prohibits the operation of motor vehicles emitting pollutants beyond the prescribed Environmental Quality Standards. The initiative reflects Punjab's commitment towards reducing transport related emissions, improving urban air quality and strengthening scientific environmental enforcement mechanisms across the

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province. applicable the standards established under clause (g) of subsection (1) of section 6 of the Act ibid. Authorized test centers have been established in across Lahore at different locations.

5.8.5.1 Formation of ETS Squads:

Figure 5.21: Emission Testing Squads (ETS) Monitoring

A total of 70 ETS squads were deployed across Lahore conduct on ground emission testing and compliance checks. In order to enhance operational effectiveness, special night shifts and weekend operations were also introduced to ensure continuous monitoring during peak traffic movement and commercial activity hours. Furthermore, an appointment-based emission testing system was implemented to facilitate citizens, reduce operational congestion and improve public accessibility to emission testing services.

5.8.5.2 Test Validation:

All Light Transport Vehicles (LTVs) and motor cars operating on the roads of Lahore are required to undergo the Emission Testing System (ETS) implemented by the Punjab Environmental Protection Agency (EPA). Only those vehicles that meet the prescribed Punjab Environmental Quality Standards (PEQS) for exhaust emissions and noise levels are permitted for road use. Vehicles that successfully pass the test are issued a green EPA' sticker as proof of conformity.

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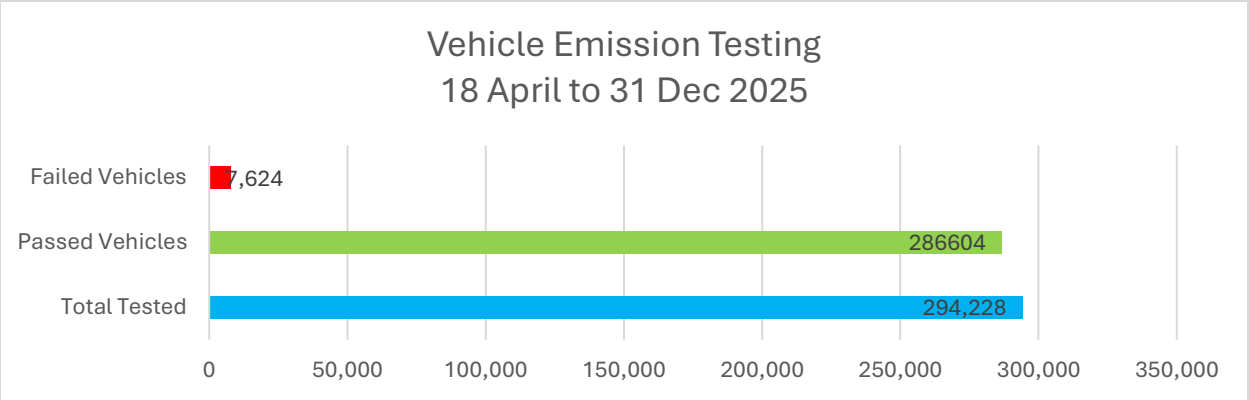


Graph 5.9: Vehicle Emission Testing Statistics in Lahore

Figure 5.22: Emission Testing and Green Sticker Affixation

The Punjab EPA conducted emission testing for 294,228 light transport vehicles (LTVs) across major districts. Of these, 7,624 vehicles failed to meet Punjab Environmental Quality Standards

(PEQS) and are subject to fines or possible impoundment, while compliant vehicles received the green EPA compliance sticker.

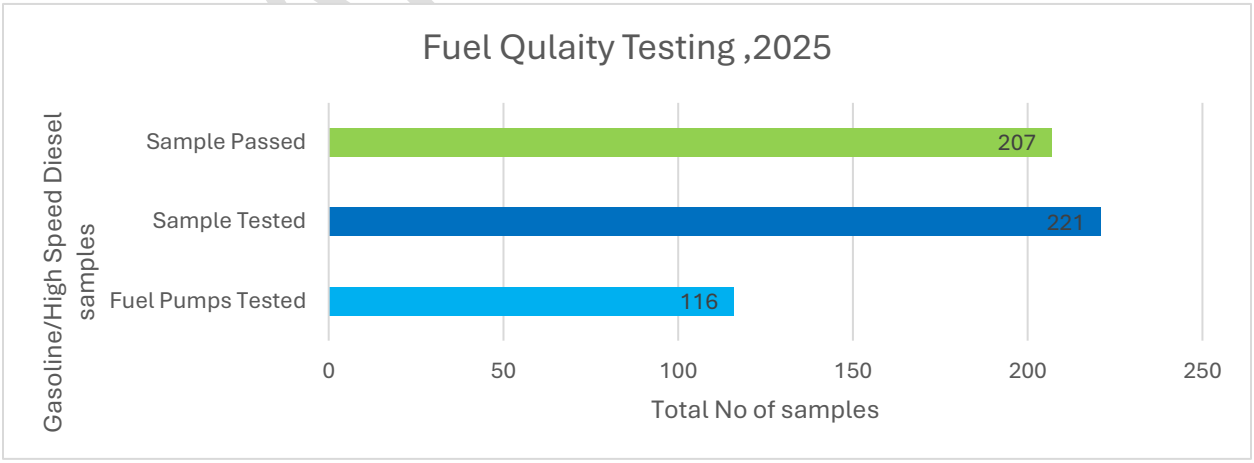
5.8.6 Fuel Quality Inspections:

In pursuance of Rule 2(n) of the Punjab Environmental Protection (Smog Prevention and Control) Rules, 2023 and orders issued under Section 6(1)(t) of the Punjab Environmental Protection Act, 1997, the Environmental Protection Agency (EPA) Punjab has initiated strict enforcement measures to ensure compliance with Oil and Gas Regulatory Authority (OGRA) fuel specifications. This action is aimed at curbing vehicular emissions, reducing smog and safeguarding public health.

Figure 5.23: Fuel Quality Testing Enforcement Actions in Punjab

To address fuel related pollution three mobile fuel testing laboratories are regularly inspecting fuel quality at sale points, helping prevent fuel adulteration that leads to high emissions. This results in cleaner-burning fuels, improved engine performance and ultimately healthier air for all citizens.

During the enforcement campaign, EPA Punjab inspected 116 fuel pumps across to verify compliance with OGRA approved specifications for gasoline and high-speed diesel.



Graph 5.10: Fuel Quality Testing Enforcement Actions in Punjab

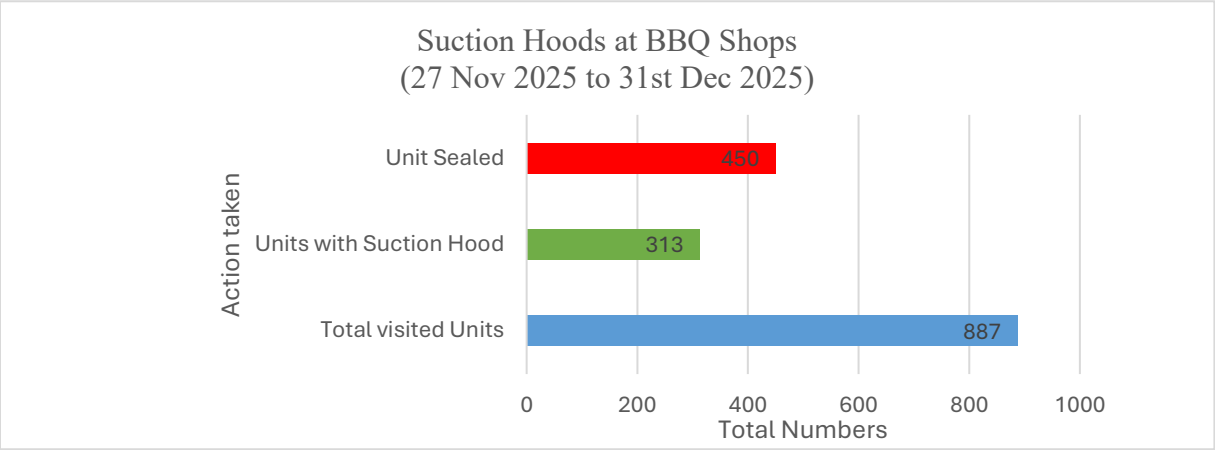
Results in graph shows that majority of retail outlets are supplying fuel of acceptable quality, but the detection of non-compliant samples underscores the need for continued monitoring and strict enforcement to ensure that only standard fuel is available in the market.

5.8.7 Installation of Suction Hood at commercial restaurants:

The Environmental Protection Agency (EPA) Punjab, under the Punjab Environmental Protection Act, 1997, has mandated the installation of Type-I suction hoods in commercial restaurants and outdoor cooking stations using coal, wood, or charcoal to control air pollution. These hoods capture smoke, grease vapors, particulate matter, volatile organic compounds (VOCs) and other pollutants generated during grilling, preventing their release into the atmosphere. Such emissions, including CO, CO_2, NOx, PM, PAHs and trace metals, contribute significantly to 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 significantly reduce harmful emissions and improve ambient air quality, protecting public health. EPA punjab has issued technical design and SOPs for suction hood installation which is given in Annexure 2 of this chapter.

Figure 5.24: Installation of Suction Hoods at Restaurant

Between 27 November and 31 December 2025, Punjab EPA inspected 887 commercial units; 313 units complied with the regulations, while 450 non-compliant units were sealed



Graph 5.11: Suction Hood Enforcement at BBQ Shops

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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 levels of airborne particulate matter. This intervention is designed as an immediate, localized air quality control measure, Fog cannons are mechanical dust suppression device; their intended purpose is to reduce local dust concentrations arising from:

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

The project aim was to enhance air quality and reduce environmental impact through deployment of 15 fog cannons in Lahore i.e. Vehicle fleet across designated operational areas by covering total distance of 47000 km EPA, Punjab anticipate significant improvements in service delivery and sustainability.

5.8.8.1 Environmental Impacts:

The fleet operations have significantly influenced the environment in various ways includes reduction in carbon emissions and improvement in air quality. When used correctly and selectively, they can temporarily lower ambient PM_{10} levels within a radius of 50–100 meters, particularly under calm or stagnant meteorological conditions. Peak deployment during severe smog episodes. Priority given to traffic corridors and hotspots.

Figure 5.25: Fog cannon operations and coverage

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

Fog cannon operations at multiple sites proved significant in reducing PM_{10}, the following charts show consistent decrease around 20% to 48% demonstrating their ability to suppress fine dust in localized, high-exposure areas such as unpaved roads and industrial zones. The fog cannon deployments presented in this study were conducted as operational field demonstrations intended to evaluate the localized dust-suppression potential of fog cannons under real-world conditions rather than as a controlled scientific experiment designed to establish statistically rigorous emission reduction factors.

For the Kahna and Thokar deployments, fog cannons were operated within an approximate 1 km radius of the fixed ambient air quality monitoring stations located at DHQ Hospital Kahna and the LWMC Office near Thokar, respectively. At Quaid-e-Azam Industrial Estate (QIE), a mobile monitoring unit was deployed in conjunction with the fog cannon operation to assess changes in particulate matter concentrations before and after deployment. The reported $PM_{2.5}$ and PM_{10} reductions were therefore derived from actual field measurements recorded immediately before and after fog cannon operation at the respective locations. However, meteorological factors were not involved in this study. However, the deployment methodology was designed in accordance with the intended operational use of fog cannons as localized dust-control devices. Prior to deployment, EPA field teams identified dust-prone locations based on elevated PM concentrations, visible dust generation, traffic intensity, construction activities, and industrial emissions. Fog cannons were then positioned to maximize coverage of the identified dust source areas while operating under suitable meteorological conditions, particularly periods of low-to-moderate wind speeds where droplet capture efficiency is expected to be highest. Monitoring data were recorded before deployment and after sustained operation to assess immediate localized impacts.

Though temporary, these reductions highlight fog cannons as effective rapid response tools for mitigating acute pollution episodes, complementing long-term emission control strategies and offering immediate public health benefits. Area wise fog cannon operation effectiveness studies are illustrated below:

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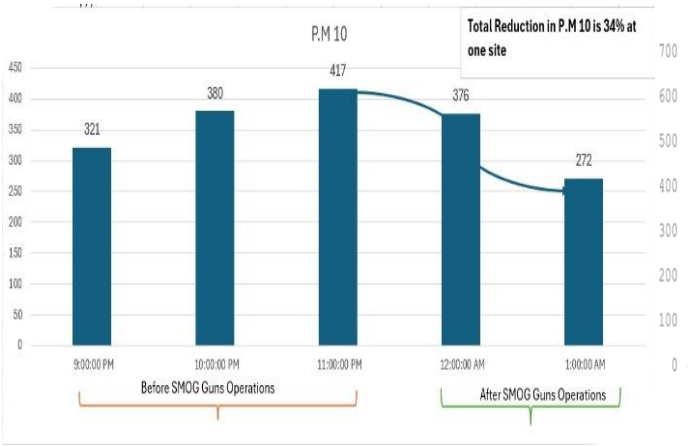
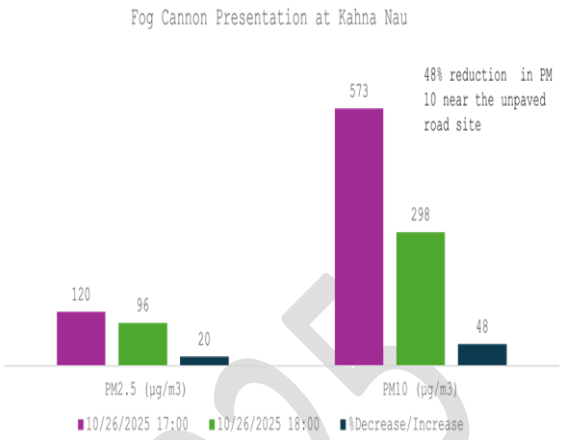
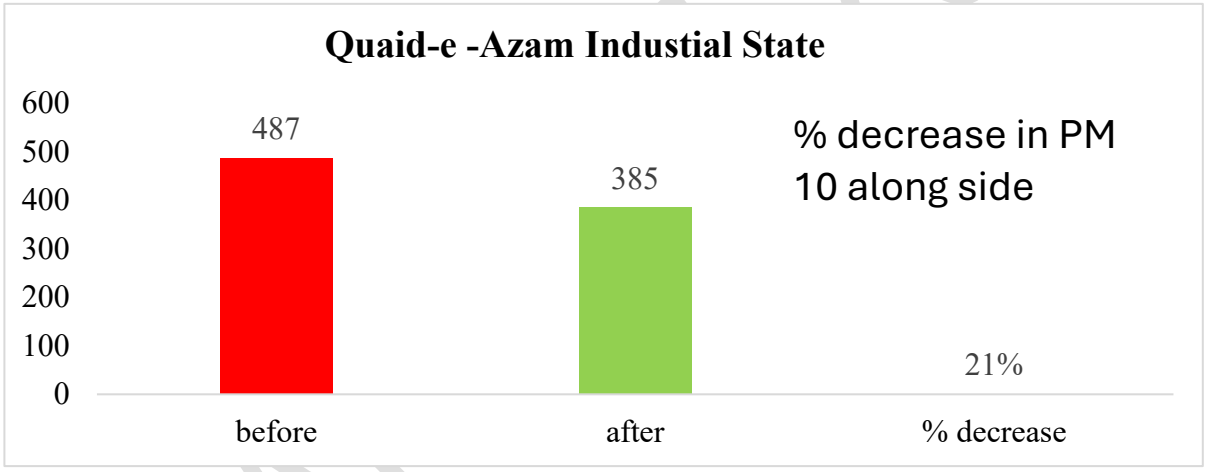


Fog cannon Deployment at Thokar



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 by the Central Pollution Control Board (CPCB) showed fog cannons reduced $PM_{2.5}$ by only 10–15% within 50–100 meters of the spray zone. No measurable impact was observed on overall city AQI. CPCB recommended using only near construction corridors, not for general smog control[28]. Fog cannons were deployed near coal yards and highways to suppress coarse dust (PM_{10}). They helped reduce visible dust but were ineffective against $PM_{2.5}$, the dominant pollutant in urban smog[29].In controlled industrial settings, fog cannons achieved up to 90% dust reduction, improving air quality for workers. However, these results do not apply to open urban environments with complex pollution sources[30].

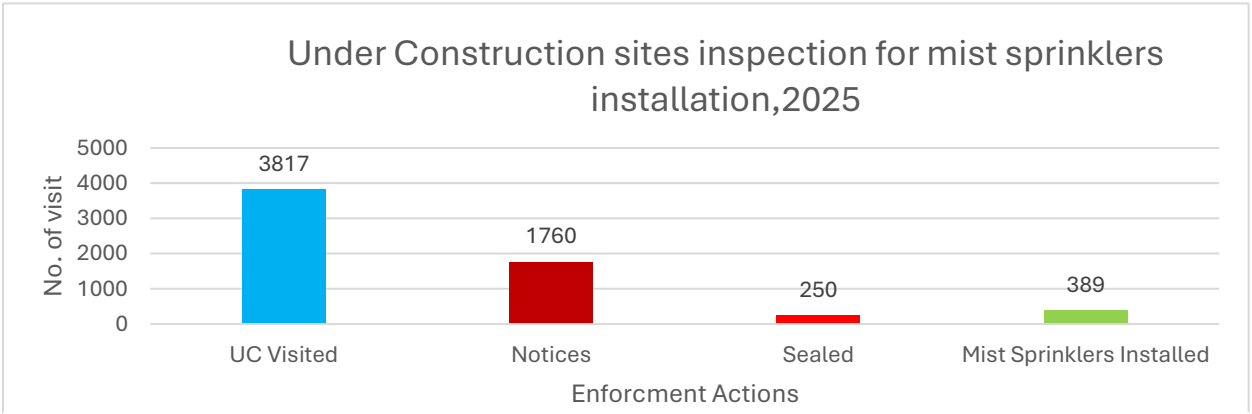
5.8.9 Mist Sprinkles Installation at Under Construction Sites:

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

Key measures include:

- **Installation of mist sprinkler systems** around construction sites before work begins, with nozzles properly spaced and system capacity adjusted to site conditions.
- **Operational controls** such as proper storage and covering of materials, controlled demolition and excavation, reduced vehicle speeds, regular site cleaning and water sprinkling during ground leveling.
- **Site safety** measures to prevent water accumulation and mosquito breeding.
- **Display of guidelines** on banners at construction sites

Figure 5.26: Mist Sprinklers installation at under construction sites



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 use natural processes and ecosystems to address environmental and social challenges. These solutions include practices such as wetland restoration, urban forests, green roofs, rain gardens and floodplain management, which help reduce the impacts of climate change, flooding, pollution and biodiversity loss. The Environmental Protection Agency (EPA) shifted toward Nature-Based Solutions because traditional "grey infrastructure," such as concrete drainage systems and treatment facilities, is often expensive and less adaptable to climate-related challenges. EPA recognized that NbS are more sustainable, cost-effective and resilient, while also improving water quality, enhancing biodiversity, reducing urban heat and supporting public health. As a result, the EPA has increasingly integrated green infrastructure and ecosystem-based approaches into its environmental policies and water management strategies.

5.9.1 Miyawaki Forest Initiative

The Miyawaki forest method is a nature-based solution that involves planting dense clusters of native trees and vegetation to create fast-growing, self-sustaining forests in urban and degraded areas. This approach helps improve air quality, increase biodiversity, reduce urban heat, absorb carbon dioxide and manage stormwater naturally. A Miyawaki forest was also established at Hiran Minar to promote ecological sustainability, biodiversity conservation and urban greening. Recognizing these environmental benefits, the Environmental Protection Agency (EPA) has supported similar urban forestry and green infrastructure initiatives as part of its broader commitment to climate resilience and sustainable urban development. Through grants, community partnerships and environmental restoration programs, the EPA encourages the development of compact urban forests and tree-planting projects that align with Nature-Based Solutions by restoring ecosystems and improving the quality of life in communities.

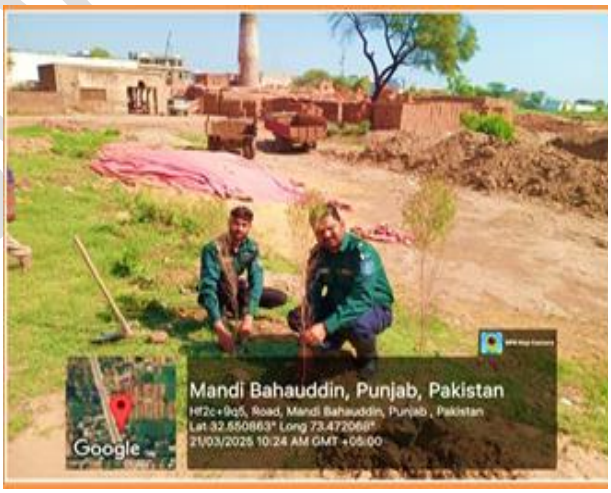
5.9.2 Tree Plantation

In Spring 2025, the Environmental Protection Agency (EPA), Punjab initiated a focused tree plantation campaign at brick kilns under the flagship "Plant for Pakistan" initiative part of the Chief Minister's broader vision to increase green cover and improve environmental quality across the province.

Trees act as natural sinks for air pollutants, playing a vital role in improving environmental quality. Through the process of 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 SO_2 and NO_x. This source sink relationship is essential for regulating atmospheric pollution levels. Recognizing brick kilns as major emission sources, the Environmental Protection Agency Punjab strategically targeted these sites under its plantation campaign to mitigate emissions and improve air quality. The initiative aims to plant 60 trees per kiln, with an overall target of 513,060 trees across key divisions of Punjab, including Lahore, Gujranwala, Multan, Faisalabad,

DRAFT SOE 2025

Bahawalpur, Sahiwal, Sargodha, Rawalpindi and Dera Ghazi Khan, where kiln clusters are densely located. Implemented in phases and supported by a monitoring mechanism to ensure tree survival and assess impact, the campaign has shown strong progress in its first phase by targeting 4,167 brick kilns and planting 270,679 trees, contributing significantly toward afforestation and pollution reduction objectives.



In addition to the targeted plantation around brick kilns, the Environmental Protection Agency Punjab expanded the initiative to industrial areas, public places and educational institutions, where a total of 177,735 trees were planted. This broader plantation effort contributes to the development of green belts that act as natural barriers, intercepting pollutants at the source and limiting their dispersion into nearby residential areas. Along roadsides, these trees function as effective sinks for vehicular emissions, while also reducing dust resuspension caused by traffic movement.

Tree plantation at industrial units

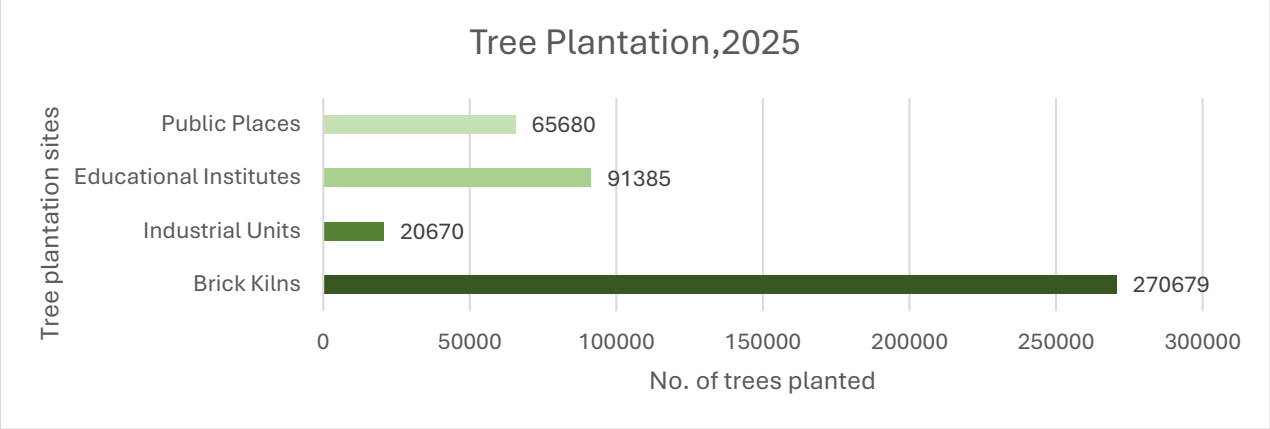
Tree plantation at educational institutes

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 addresses environmental degradation at its source but also aligns with national climate objectives of increasing forest cover, reducing carbon emissions and building climate resilience. By targeting high-emission industrial sectors, the EPA is setting a strong precedent for how industrial development and environmental stewardship can go hand in hand, creating healthier and more sustainable communities across Punjab.



Graph 5.14: Tree Plantation in Punjab

5.10 Policy Reforms:

5.10.1 Punjab Clean Air Program (P-CAP)

P-CAP is a World Bank–supported initiative designed to strengthen air quality management governance and reduce harmful $PM_{2.5}$ exposure in Lahore Division. Approved in March 2025 with a US$300 million IDA credit, the program runs until June 2030 and involves multiple Punjab government departments, including Environment Protection & Climate Change, Agriculture, Industries, Transport and Planning & Development. Its structure focuses on three main areas: improving governance and public awareness around air quality, reducing emissions from the transport sector through modernization and e-mobility and tackling agricultural pollution by promoting alternatives to crop residue burning. With a total financing package of US$510 million (including borrower contributions), the program emphasizes climate change mitigation, low-carbon urban development and citizen engagement. As of late 2025, implementation progress and monitoring were rated satisfactory, reflecting strong institutional commitment. Overall, P-CAP represents a comprehensive effort to address Lahore's severe smog challenge by combining 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 introduced the **Punjab Green Credit Program (PGCP)** as a flagship initiative to combat air pollution and improve environmental quality. This innovative, performance-based scheme directly rewards citizens for adopting sustainable practices such as installing solar appliances, using bicycles and electric vehicles, reporting polluting sources and implementing energy efficient measures.

By linking financial incentives to tangible green actions, PGCP not only reduces smog, greenhouse gas emissions and particulate pollution but also enhances public health through cleaner air and healthier living conditions. The program represents a transformative step in making environmental

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responsibility economically rewarding, fostering 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 proven to be a highly effective measure in reducing air pollution and greenhouse gas emissions. EPA Punjab has already taken a significant step by purchasing 250 electric bikes and 50 hybrid vehicles to strengthen field operations.

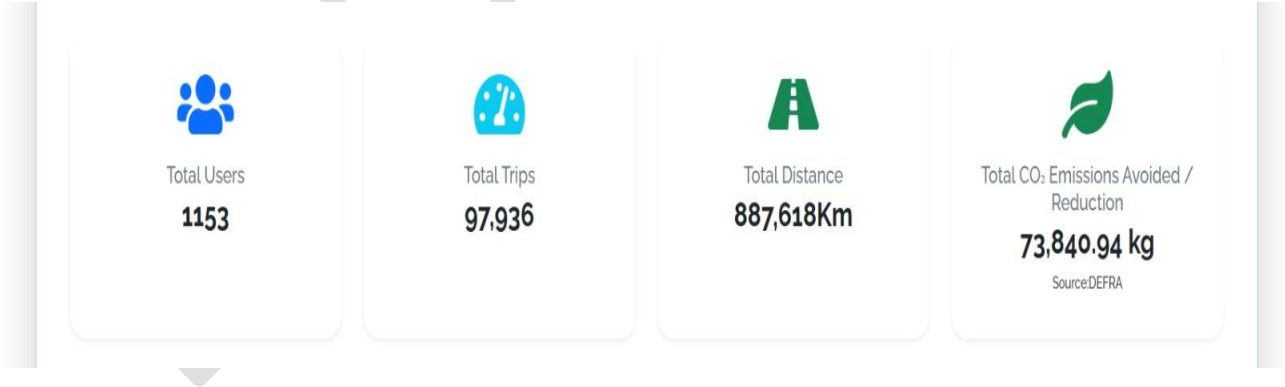
Figure 5. 28: Purchase of E-Vehicles for field operations by EPA Punjab

Evidence shows that a 1% increase in EV sales in a city can lower local CO_2 emissions by 0.096% and reduce emissions in nearby cities by 0.087%, demonstrating both direct and regional benefits[31]. Furthermore, EV adoption contributes to improved air quality, as each additional EV unit sold reduces PM2.5 concentrations by 1.75×10^{-5} µg/m³[32] Since PM2.5 is a major contributor to smog and respiratory illnesses, this reduction directly supports public health. Collectively, these findings confirm that EVs are beneficial not only for mitigating climate change but also for alleviating smog, enhancing 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 step toward sustainable mobility. Collectively, these beneficiaries have completed 97,936 trips and covered a distance of 887,618 kilometers. This transition to clean transport has yielded substantial environmental benefits, with an estimated reduction of 73840.94 kilograms of greenhouse gas emissions. The initiative demonstrates the program's effectiveness in promoting eco-friendly transportation solutions while contributing to climate resilience and improved air quality in the 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)

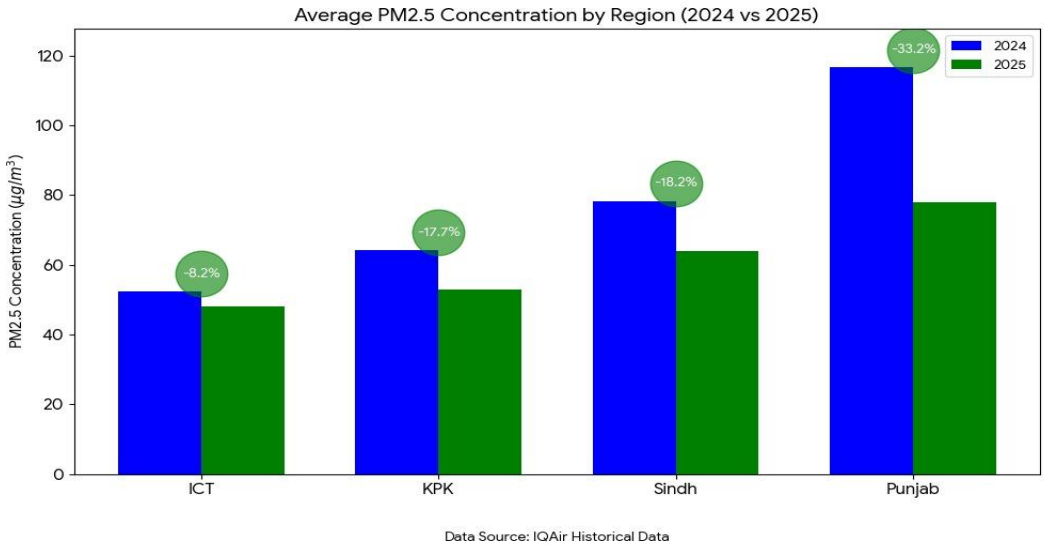
5.11.1 Net pollution shift in 2025

The expansion of the Air Quality Monitoring System (AQMS) across 18 districts of Punjab, operational since June 2025, represents a significant institutional advancement in strengthening air

quality management and surveillance. Although a comprehensive and validated assessment of pollution trends will be formally presented in the 2026 report by the Environmental Protection Agency (EPA) Punjab, preliminary insights can be derived from the IQAir Annual Report 2025. Lahore, being the most smog-affected region, has been a primary focus of air quality monitoring efforts. In this context, the Environmental Protection and Climate Change Department (EPCCD) has been operating AQMS installations in Lahore for the past years, generating indigenous, continuous data that provides valuable baseline insights into long-term air quality trends and highlights key pollution patterns in the region.[45]

5.11.2 Air Quality Improvement in Punjab:

In Punjab, a substantial reduction in $PM_{2.5}$ concentrations from 2024 to 2025 is observed, as reported in the IQAir Annual Report 2025. In 2024, Punjab recorded the highest $PM_{2.5}$ level (around 118 µg/m³) among all regions, which then dropped to approximately 78 µg/m³ in 2025, reflecting a significant decline of about 33%.



Graph 5.15 Substantial Reduction in PM 2.5 levels in Punjab

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

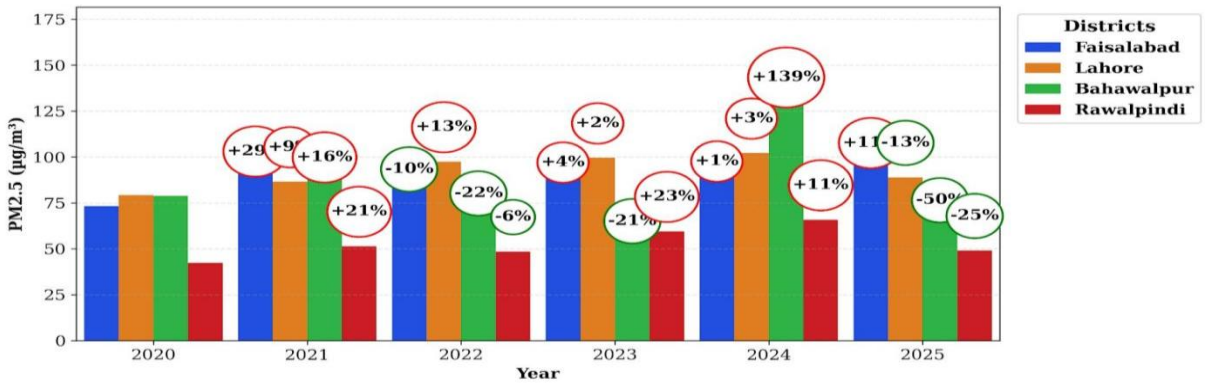
30 https://www.australianmining.com.au/news/dust-control-solutions-in-mining/

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

5.11.3 Particulate Matter reduction in Hot spot districts:

IQAir 2025 report reveals that $PM_{2.5}$ levels in major Pakistani cities Lahore, Bahawalpur, Rawalpindi and Faisalabad show strong fluctuations from 2020 to 2025.Air pollution increased significantly in 2021 across all cities. In 2022–2023, trends were mixed, with some cities improving while others continued to worsen. A major spike occurred in 2024, especially in Bahawalpur, indicating severe pollution episodes. By 2025, a general decline is evident in most cities, suggesting some improvement in air quality.



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

In summary, Pakistani cities exhibit strong inter-annual variability with recurring pollution spikes, especially in 2021 and 2024. While some improvements are visible by 2025, the overall trend highlights inconsistent control measures and the continued influence of industrial emissions, urbanization and seasonal smog conditions.

Furthermore, Graph 5.17 illustrated below clearly indicates a significant improvement 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%)

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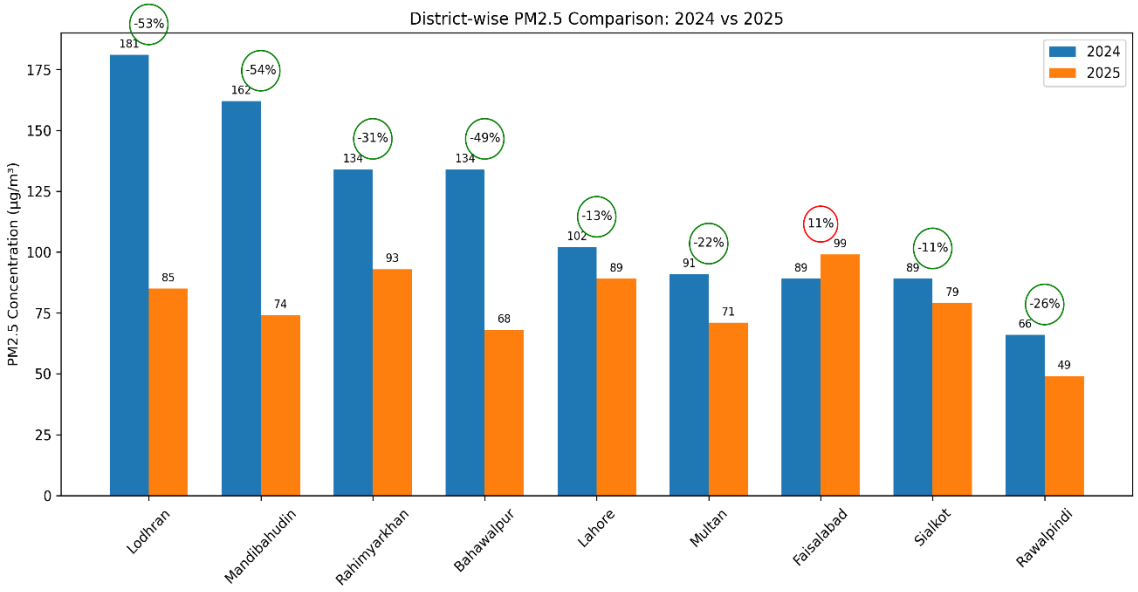

Graph 5.17 Trends in PM2.5 reductions in Punjab districts

experienced substantial reductions in $PM_{2.5}$ levels, reflecting a strong positive trend in air quality. Similarly, urban centers like Lahore (−13%), Faisalabad (+11%), Multan (−22%) and Rawalpindi (−26%) also showed notable improvements, although the reduction magnitude varies. Only Faisalabad shows a slight increase (+11%), indicating localized factors affecting air quality.

This overall improvement can be attributed to the enhanced regulatory and enforcement measures undertaken by Environmental Protection Agency Punjab, including stricter industrial emission controls, implementation of zig-zag technology in brick kilns, improved vehicular emission monitoring and coordinated smog mitigation actions during peak seasons. Additionally, favorable meteorological conditions in 2025 such as increased rainfall, better wind dispersion and reduced temperature inversion events played a crucial role in lowering pollutant concentrations. The combined effect of policy interventions and supportive weather conditions has contributed to a measurable improvement in air quality across Punjab in 2025.

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 critical component of EPA Punjab's strategy to mitigate these peaks has been the mandatory installation of Emission Control Systems (ECS) across the industrial landscape. Moving beyond mere monitoring, the EPA enforced the installation of wet scrubbers, baghouse filters and electrostatic precipitators in high-emission units such as steel re-rolling mills and food processing

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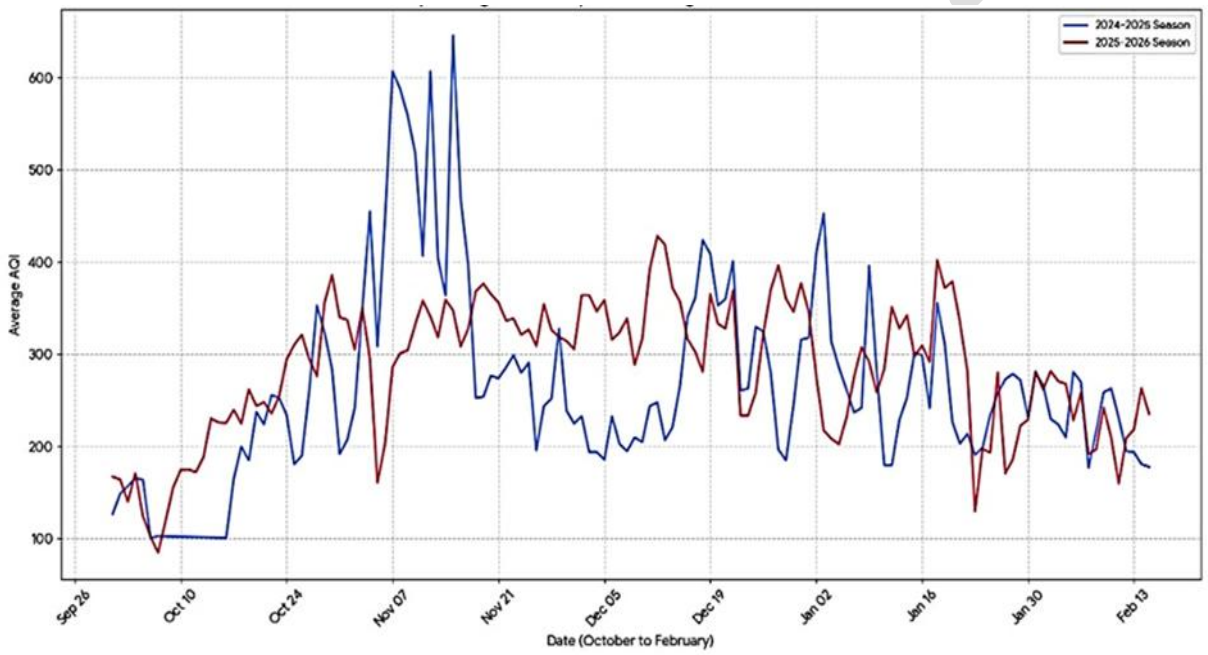
plants. Targeted control of dust emissions through installation of mist sprinklers at under construction sites, suction hood fixation at restaurants as well timely deployment of fog cannons at pollution hotspots. This was coupled with the successful conversion of brick kilns to Zig-Zag technology, which significantly reduces black carbon emissions. These technical interventions are designed to lower the "pollution load" at the source, ensuring that even when weather conditions are unfavorable, the total volume of particulates entering the atmosphere is reduced compared to the unregulated levels seen in early 2024.



Graph 5.18 Net Pollution shift in Lahore, 2025

The graph illustrates the AQI trends specifically for the Smog Season (October – December), comparing the high-intensity periods of both years to show how the concentration of pollutants responded to these industrial and regulatory curbs. Despite these industrial improvements, the report emphasizes that meteorological factors remain the ultimate arbiter of daily air quality.

5.11.5 Improvement in Air Quality and Reduction in Pollutants

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

Emissions from industrial boilers decreased by 25% due to the installation of emission control systems such as wet scrubbers. In the brick kiln sector, conversion of 4,073 units to Zigzag technology led to improved combustion efficiency, contributing to a 16.08% reduction in greenhouse gases and a 29.32% decline in particulate matter.

In the steel sector, significant emission reductions were driven by the widespread adoption of emission control systems and the near elimination of non-compliant units. As a result, particulate emissions dropped by 49.34% between 2021 and 2025.

Overall, these sectoral interventions, supported by regulatory enforcement and technological upgrades, have substantially improved air quality in Punjab.

5.12 Conclusion

Province-wide $PM_{2.5}$ levels declined compared to 2024, with notable reductions in several hotspot districts, reflecting the combined impact of regulatory measures, industrial emission controls and favorable meteorological conditions. Lahore, being the most smog affected city, recorded substantial annual improvement, particularly during the peak smog season (October–December). This progress is associated with interventions by the Environmental Protection Agency Punjab and the Environmental Protection and Climate Change Department Punjab, including stricter emission regulations, installation of industrial control technologies, adoption of zig-zag technology in brick kilns and enhanced dust mitigation efforts.

Regionally, Central Punjab remains the most industrially concentrated and pollution-intensive area, Northern Punjab exhibits moderate and scattered industrial activity, while Southern Punjab shows a more dispersed industrial pattern dominated by small-scale industries and brick kilns. Overall, 2025 reflects incremental but meaningful progress in air quality management across Punjab, while highlighting the continued need for sustained enforcement, technological upgrades and expanded monitoring to ensure long-term and stable improvements.

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Chapter 5

Part 2: Emission Inventory of Major Industrial Sectors of Punjab

5.13 Sector wise emission load of Punjab

A fundamental requirement for effective air quality management and emission control is the development of accurate emission inventories, which depend heavily on reliable emission factors. Traditionally, emission inventories in developing regions rely on default emission factors provided by international bodies such as the IPCC and USEPA. However, these default values are often derived under controlled conditions and may not accurately reflect local fuel characteristics, combustion technologies and operational practices. In Punjab, for example, the widespread adoption of zig-zag brick kilns, variability in coal quality and inconsistent combustion conditions can significantly influence emission profiles.

In this context, the present study aims to develop locally representative emission factors (Bottom-Up Approach) using field measurements and practical estimation techniques. Due to the limitations associated with direct measurement of flue gas flow—such as high cost, technical complexity and field constraints a CO_2-based flue gas volume estimation method has been adopted. This approach utilizes measured CO_2 concentration, known CO_2 generation from fuel combustion and stack temperature to estimate total exhaust gas volume, which is then used to calculate emission factors for key pollutants.

The study not only provides emission factors specific to local conditions but also contributes to improving the accuracy of emission inventories, supporting evidence-based policymaking and strengthening regulatory frameworks for air quality management in Punjab.

The comprehensive industrial emission inventory for Punjab's 10 divisions highlights a significant environmental challenge driven by a high-density industrial base. Across the province, the total industrial load contributes approximately **57.8 Million Tons (Mt) of CO_2** and a substantial gaseous pollutant load of **79.20 Kilotons (kt) of NO_x, 69.76 kt of CO and 30.66 kt of SO_2**. **Particulate Matter (PM**, the primary driver of the seasonal smog crisis, stands at **35.21 kt** annually. The data reveals that while industrial growth is distributed, the pollution "hotspots" are heavily concentrated in the Lahore, Gujranwala and Faisalabad divisions, which together account for nearly half of the province's total industrial units.

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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

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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

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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
	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

As long as the Major Industry is concerned, there are three "Critical Sectors" that contribute mainly to the air quality index (AQI) of the province:

- **Cement Plants:** This sector is the largest contributor to NO_x (60.64 kt) and PM (16.72 kt). The cement based CO_2 is around 33.96 Mt. While EPA Punjab's efforts have led to modernized Emission Control Systems (ECS) like electrostatic precipitators, the sheer scale of production makes them a top-tier regulatory priority.
- **Brick Kilns:** A dominant source of CO (29.16 kt) and SO_2 (20.84 kt). The transition to Zig-Zag technology has significantly reduced the black carbon intensity, but the high volume of sulfur-rich coal remains a challenge for regional haze.
- **Rice Mills & Textile Units:** The Rice Mills contribute significantly to localized PM (1.89 kt), CO (3.73 kt) and NO_x (0.60 kt), and Textile Units contribute CO (5.35 kt) and NO_x (3.47 kt),, due to the use of biomass and high-temperature boiler operations.

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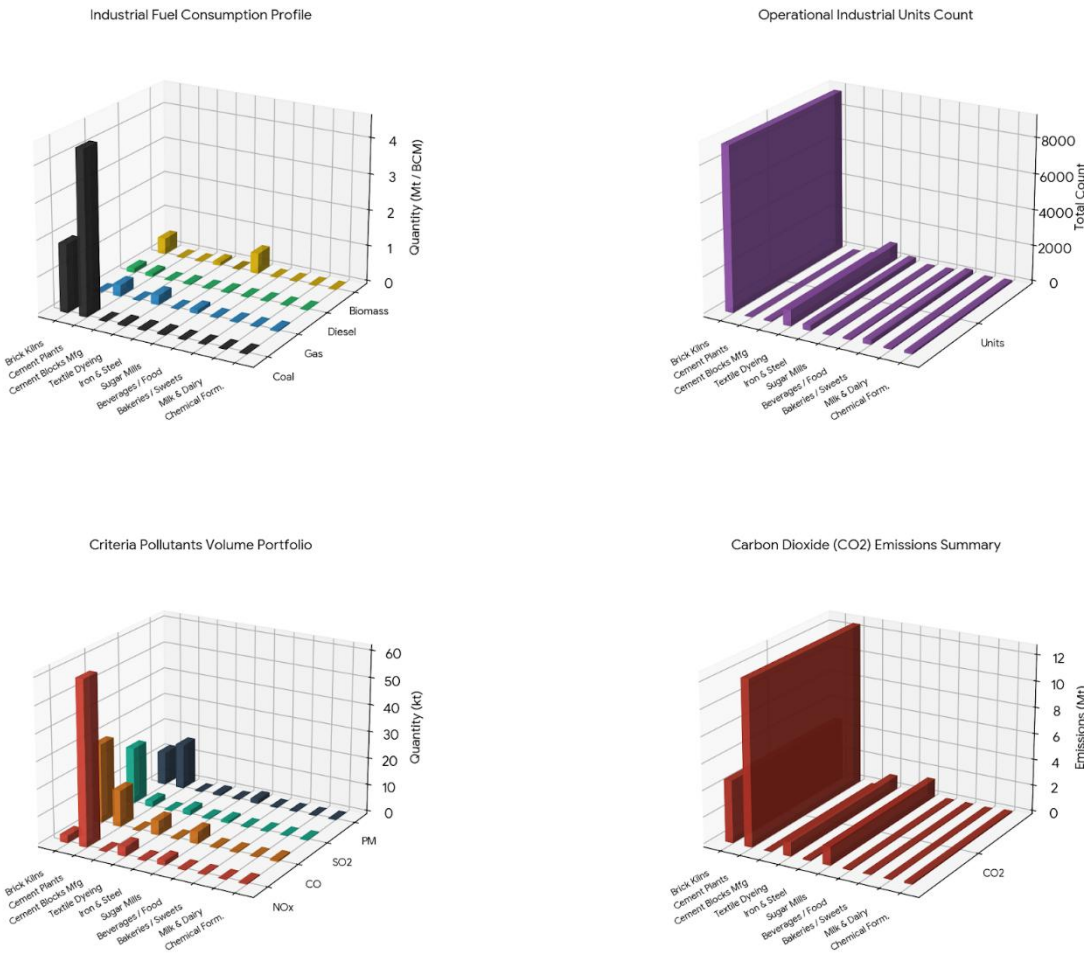

Graph 5.19 Industrial emission and resource consumption analysis

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

DRAFT SOE 2025

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

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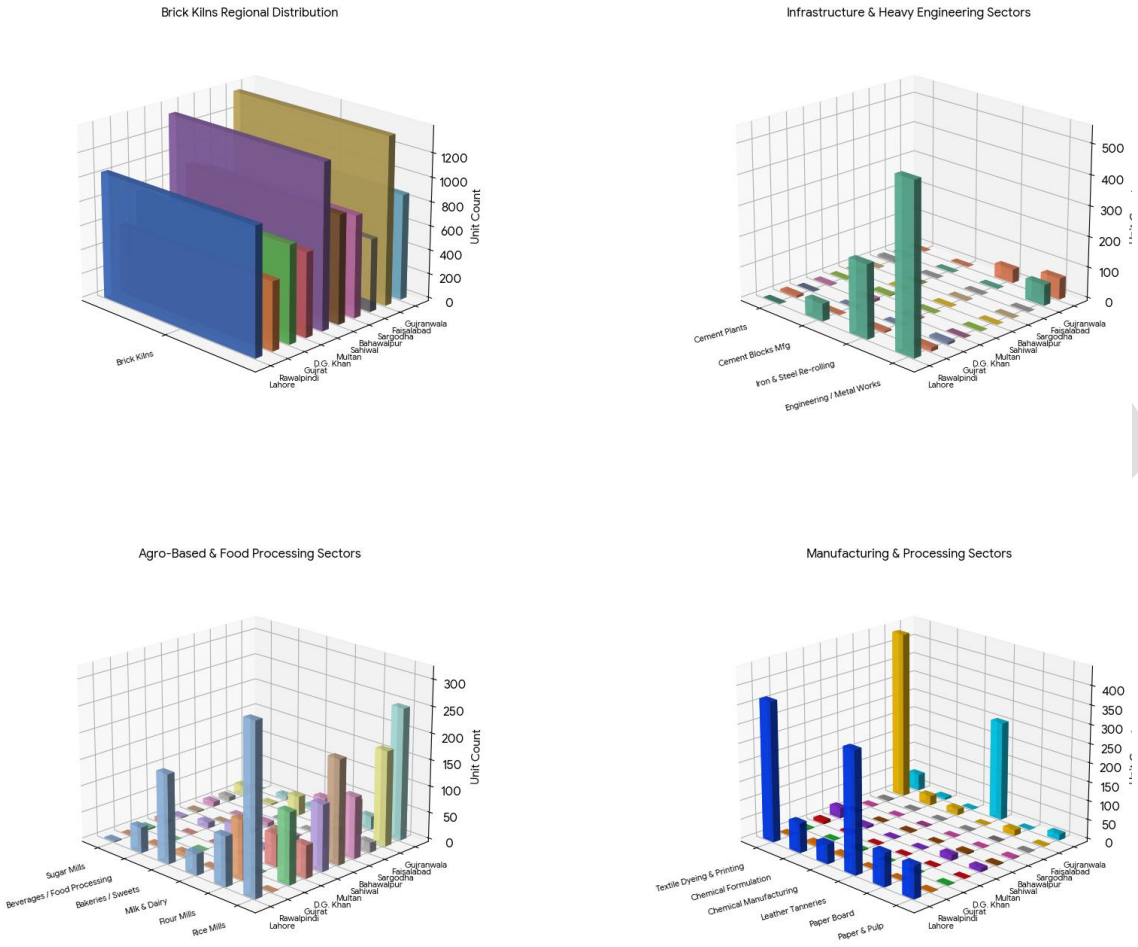

Graph 5.20 Punjab industrial inventory analysis (2025)

5.13.2 Dominant Sources of Industrial Air Pollution in Punjab

The study provides emission factors specific to local conditions (Bottom-up Approach). It also contributes to improving the accuracy of emission inventories, supporting evidence-based policymaking and strengthening regulatory frameworks for air quality management in Punjab

The compiled emission inventory for Punjab, covering around **14,649** industrial units **across 23 sectors**, provides a comprehensive assessment of fuel consumption and pollutant emissions. The analysis reveals that total annual fuel consumption amounts to **6.68 Mt of coal, 1.38 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 kt of CO, 79.20 kt of NO_x, 30.66 kt of SO_2 and 35.21 kt of 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 being only 16 units, emerge as the largest contributor to NO_x (60.65 kt) and a major source of particulate matter (16.66 kt). Additionally, process emissions contribute significantly, with cement-related CO_2 emissions alone reaching 33.96 Mt, highlighting 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 massive point-source emitters of Nitrogen Oxides (NOx) and Particulate Matter (PM). As the cement plants are mostly in hilly areas, PM is either dispersed or washed out due to meterological factors, not seriously contributing to local AQI.
- Unlike NOx or PM, which can be trapped or chemically neutralized using end-of-pipe technologies, CO_2 is an inherent byproduct of the chemistry of cement itself. Consequently, significant carbon reduction requires nascent and expensive Carbon Capture and Storage (CCS) infrastructure or the development of entirely new low-carbon binding materials, making it the most stubborn environmental challenge in the sector
- Brick kilns (9,041 units) represent the most widespread combustion source and are the largest contributors to CO (29.16 kt) and SO_2 (20.84 kt). Their reliance on coal, combined with relatively lower combustion efficiency, makes them a key driver of regional air quality degradation, particularly during winter smog episodes.
- Rice mills and biomass-based industries contribute significantly to PM emissions (1.89 kt) due to combustion of agricultural residues such as rice husk, leading to localized particulate pollution.
- Textile dyeing and printing units (893 units) are notable contributors to NO_x emissions (3.47 kt) due to extensive use of high-temperature gas-fired boilers.

The sectoral distribution clearly indicates that emissions are highly skewed, with a small number of sectors contributing disproportionately to total pollution loads. This highlights the importance of targeted regulatory interventions rather than uniform control strategies.

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

The inventory also reflects the impact of fuel type on emissions:

- Coal-based sectors (brick kilns, cement, steel) dominate CO, SO_2 and PM emissions
- Gas-based sectors contribute more to NO_x emissions
- Biomass combustion contributes significantly to PM emissions

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Overall, the results emphasize that while progress has been made in certain areas (e.g., adoption of zig-zag kilns and emission control systems in cement plants), the scale of industrial activity continues to exert substantial pressure on air quality.

5.14. Actions and Policy Reforms

5.14.1 Actions & Reforms by EPA Punjab (Already Implemented)

The report credits EPA Punjab with several regulatory and enforcement measures that contributed to the 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

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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 centralized 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	EPA Punjab / EPCCD	Real-time data collection for evidence-based decision-making.

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districts (operational since June 2025).		
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 Plant.	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

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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.

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5.15 Limitations of the Report

- Brick kiln coal consumption was not directly measured but was deduced from the Economic Survey of Pakistan using a default factor of 42 grams of coal per brick.
- Data of only operational units is calculated.
- The CO_2-based flue gas volume estimation method introduces compounding limitations.
- Small-scale, informal and unregistered industrial units are not included in the inventory. While the report covers 14,649 industrial units across 23 sectors.
- Fuel quality variability is not adequately reflected in the inventory. Coal, diesel and biomass quality varies significantly across suppliers and seasons, yet the inventory assumes average default values.
- Biomass fuel consumption was estimated indirectly based on production capacity rather than direct measurement. Actual biomass use varies with moisture content, seasonal availability and operator practices.
- Trans-boundary pollution from India is acknowledged but not quantified. The report notes that trans-boundary pollution, particularly during winter months, significantly affects AQI in central Punjab districts, but it does not provide any quantitative estimate of its contribution to each district's pollution load.

Assimilation capacity assessment was qualitative rather than quantitative. The report describes assimilation capacity using categories such as "Very Low," "Low," "Moderate," and "High" based on general meteorological patterns, but it does not provide quantitative ventilation coefficient modeling for each district.

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Chapter No. 6: Water Resources and Waste Water Management in Punjab

6.1 Introduction

Punjab historically known as the "Land of Five Rivers" possesses one of the world's largest and most extensive water management systems. The province depends upon an interconnected network of rivers, canals, barrages, reservoirs and groundwater aquifers that collectively sustain 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, support one of the largest irrigation systems in the world 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 industrialization the demand for clean and reliable freshwater resources has increased significantly making water security a critical environmental and economic priority for the province.

Alongside increasing water consumption wastewater generation has also expanded rapidly across Punjab. Wastewater generated from municipal settlements, industrial operations, commercial activities, hospitals and agricultural runoff has emerged as one of the major environmental challenges facing the province. Large volumes of untreated municipal sewage and industrial effluents are discharged into rivers, drains and canals while agricultural runoff containing fertilizers and pesticides further contributes to the degradation of water quality. Urban drains in several cities have increasingly transformed into carriers of untreated wastewater creating serious risks for aquatic ecosystems, groundwater quality and public health. Excessive groundwater extraction combined with contamination from pollutants has further intensified pressure on Punjab's freshwater resources and reduced the natural recovery capacity of underground aquifers.

Punjab's industrial sector remains one of the major contributors to wastewater pollution particularly in industrial clusters associated with textile processing, tanneries, chemicals, pharmaceuticals, food processing and other manufacturing activities. Industrial wastewater often contains hazardous pollutants, heavy metals and untreated chemical discharges which place considerable stress on aquatic environments and surrounding communities. Recognizing the environmental and public health implications of declining water quality and increasing wastewater generation the Government of Punjab has undertaken multiple regulatory, technological and enforcement based interventions aimed at strengthening water resource management and wastewater governance.

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6.2 Punjab's Water Resources Profile: Overview

Punjab's water system is sustained through a complex combination of surface water and groundwater resources that collectively support agriculture, industry, domestic consumption and urban development across the province. The province primarily depends upon the Chenab, Jhelum, Ravi and Sutlej rivers supported by an extensive canal network operating under the Indus Basin Irrigation System. In addition to surface water more than 1.3 million tube wells extract groundwater from alluvial aquifers to meet increasing agricultural and municipal demands. Despite possessing one of the most developed irrigation systems in the region Punjab faces growing challenges related to water quality, resource depletion and long term sustainability. Monitoring data from the Pakistan Council of Research in Water Resources (PCRWR) and WAPDA indicate that while upstream and western water sources generally remain comparatively cleaner significant deterioration is being observed in eastern rivers, urban water supplies and groundwater reserves due to untreated sewage, industrial discharges, agricultural runoff and naturally occurring contaminants such as arsenic. Increasing population pressure, rapid urbanization and rising water demand have further intensified stress on freshwater resources making water security and safe drinking water availability one of the most critical environmental challenges confronting Punjab today. As of 2024, 47% of Pakistan's population has access to safe drinking water up from 39% in 2022 (PCRWR, 2025) though still far from the SDG 6.1 universal access target. As the country's most populous province Punjab is at the heart of this challenge. A comprehensive water resources profile of Punjab is given in the 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 post1960 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

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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 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 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 under increasing environmental and hydrological stress due to rapid urbanization, population growth, industrial expansion and unsustainable groundwater extraction. The province primarily depends upon the Indus River System, comprising the Ravi, Chenab, Jhelum and Sutlej rivers, supported by one of the world's largest canal irrigation networks. Despite this extensive infrastructure, the overall freshwater balance of Punjab is becoming increasingly fragile as water demand continues to exceed sustainable recharge capacity.

Groundwater has now emerged as the dominant source of water supply for domestic, agricultural and industrial consumption, particularly in major urban and peri-urban areas. Over the past several decades, excessive dependence on tube wells and uncontrolled groundwater abstraction has resulted in continuous decline of aquifer levels across central and southern Punjab. PCRWR 2022 assessment indicate that groundwater levels in several districts are severely declining i.e. Bahawalpur 1.5–1.9 m/yr, Multan 1.0–1.2 m/yr, Rawalpindi 0.8–1.2 m/yr, Lahore 0.8–0.9 m/yr, Faisalabad 0.6–0.8 m/yr.

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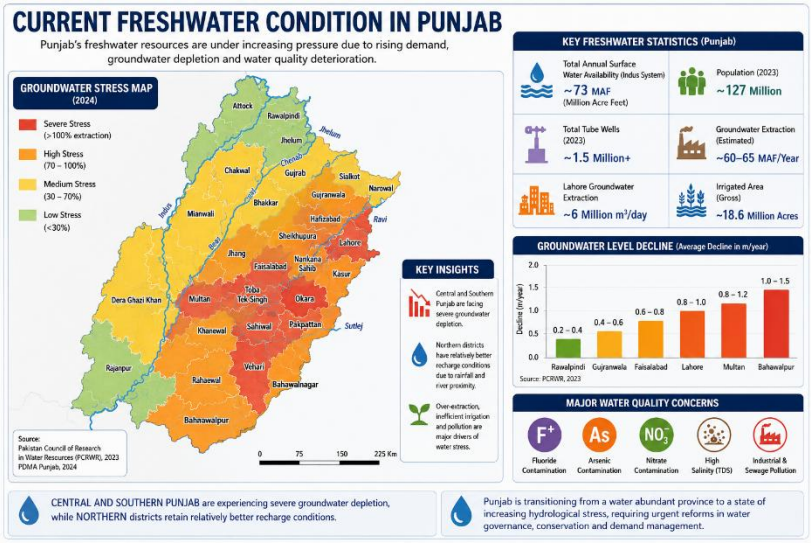
Punjab currently operates more than 1.5 million tube wells, compared to only a few thousand during the 1960s, demonstrating the province's increasing dependence on underground water reserves. In Lahore alone, groundwater extraction has reached critical levels, with the city reportedly extracting more than 6 million cubic meters of groundwater daily to fulfill municipal, industrial and commercial requirements.

The situation is further aggravated by declining groundwater recharge, inefficient irrigation practices, water intensive cropping patterns and contamination from untreated industrial effluents, municipal wastewater and agricultural runoff. Several regions of Punjab are now facing deterioration in groundwater quality, including rising salinity, fluoride, arsenic and nitrate contamination. Climate change induced variability in river flows, irregular monsoon patterns and increasing heat stress are also intensifying freshwater insecurity across the province.

Spatially, northern Punjab continues to retain relatively better groundwater recharge conditions due to rainfall and river proximity, whereas central and southern districts such as Lahore, Faisalabad, Multan, Pakpattan, Okara and Vehari are experiencing severe aquifer depletion trends. The current freshwater condition therefore reflects a transition from historically water abundant conditions toward a state of increasing hydrological stress, requiring 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 dependent upon groundwater abstraction to fulfill agricultural, domestic and industrial demand. The rapid increase in tube well installations over past decades has created unsustainable extraction pressure on underground aquifers. In several districts groundwater withdrawal has exceeded natural recharge rates resulting in continuous lowering of water tables. This decline is particularly severe in major urban and agricultural zones where freshwater demand remains consistently high throughout the year. Excessive abstraction not only reduces groundwater availability but also increases aquifer vulnerability to salinity intrusion and contaminant concentration.

Wastewater Intrusion into Freshwater Systems

Untreated municipal sewage and industrial wastewater have emerged as major stressors degrading freshwater quality across Punjab. In many urban areas drains carrying untreated effluents directly interact with irrigation channels and groundwater recharge zones. Continuous seepage from polluted drains introduces biological contaminants, heavy metals and toxic compounds into freshwater aquifers. Over time this interaction reduces the suitability of groundwater for drinking purposes and increases environmental stress on surrounding aquatic ecosystems.

Industrial Chemical Contamination

Industrial zones across Punjab generate wastewater containing chromium, lead, cadmium, sulfides, dyes, oils and other hazardous pollutants. Due to insufficient treatment infrastructure, significant portions of these pollutants enter freshwater systems through drains and seepage pathways. Persistent industrial contamination alters the chemical composition of surface and groundwater resources while increasing long-term ecological and public health risks. Industrial clusters located near rivers and irrigation networks create additional pressure on downstream freshwater quality.

Agricultural Intensification

Punjab's agricultural economy heavily depends upon intensive irrigation and chemical-based farming practices. Excessive application of fertilizers, pesticides and herbicides contributes to nutrient loading and chemical contamination of freshwater reserves. Irrigation return flows transport dissolved salts and agrochemicals into canals, ponds and underground aquifers gradually degrading freshwater quality. Continuous agricultural extraction also increases dependence on groundwater resources particularly during periods of canal water shortages.

Urbanization and Surface Sealing

Rapid urban development has significantly altered natural hydrological processes across major cities of Punjab. Expansion of roads, housing societies and commercial infrastructure has reduced permeable land surfaces limiting natural rainwater infiltration into underground aquifers. This

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reduction in groundwater recharge combined with increasing urban water demand has intensified freshwater stress particularly in densely populated urban centers.

Climate Variability and Hydrological Stress

Changing climatic conditions are increasingly affecting Punjab's freshwater sustainability. Irregular rainfall distribution, rising temperatures and prolonged dry periods reduce groundwater recharge potential while simultaneously increasing freshwater demand. Higher temperatures also increase evaporation losses from reservoirs, canals and agricultural lands reducing overall water availability within the freshwater system.

Inefficient Water Management Practices

Inefficient irrigation methods, aging municipal infrastructure and poor water distribution systems continue to contribute to large-scale freshwater losses across Punjab. Significant quantities of freshwater are lost through seepage, leakage, evaporation and unauthorized consumption before reaching end users. Limited adoption of water recycling, reuse technologies and conservation mechanisms 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 moving toward increasing freshwater stress due to continuous groundwater depletion, declining recharge capacity and deteriorating water quality. According to projections of the Pakistan Council of Research in Water Resources (PCRWR) Pakistan have crossed into water stress, Pakistan's per capita renewable freshwater availability is already estimated at approximately 860–900 m^3/capita/year below the internationally recognized water stress threshold of 1,000 m^3/capita/year (Falkenmark Index) and approaching the absolute scarcity threshold of 500 m^3/capita/year. Punjab being the country's largest agricultural and most densely populated province remains at the center of this emerging water crisis. Continuous over-abstraction of groundwater particularly in urban and agricultural regions is expected to further lower aquifer levels, increase pumping depths and reduce the long-term sustainability of freshwater reserves.

Climate change projections further indicate increasing hydrological uncertainty across the region. Rising temperatures, irregular monsoon patterns, prolonged dry periods and changing river flow regimes are expected to reduce natural groundwater recharge while simultaneously increasing freshwater demand for agriculture, domestic use and industrial activities. Urban expansion and concretization are also projected to reduce infiltration zones and natural recharge areas across major cities of Punjab. If untreated wastewater discharge, industrial contamination and inefficient water consumption patterns continue at the current scale, the province may face increasing risks related to freshwater scarcity, declining drinking water quality, agricultural stress and ecosystem degradation in coming decades.

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6.4. Conservation Approach by EPA Punjab

Recognizing the long-term implications of these emerging freshwater risks EPA Punjab has adopted a conservation-oriented regulatory approach aimed at reducing freshwater wastage and strengthening sustainable water management practices across the province. The conservation mandate focuses on promoting water reuse, improving groundwater recharge and integrating resource efficiency measures into commercial and urban development activities.

As part of this strategy EPA Punjab has made the installation of water recycling plants mandatory at service stations to reduce excessive freshwater consumption associated with vehicle washing activities and minimize wastewater discharge into drainage systems. In parallel rainwater harvesting systems have been incorporated into the environmental approval process for new development projects where required. These interventions collectively represent a strategic shift toward preventive and sustainability based freshwater governance aimed at reducing pressure on underground aquifers and improving long-term water security across Punjab.

6.4.1 Installation of Recycling Plants at Service Stations

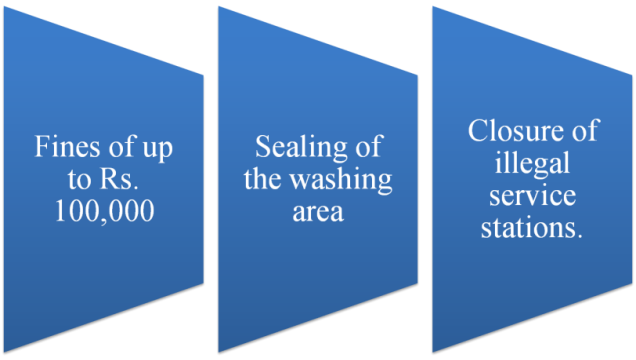
The EPA Punjab under powers granted by the Punjab Environmental Protection Act 1997 introduced strict regulations for water conservation and pollution control.

EPA Punjab directed all service stations in the province to install water recycling systems at their car wash facilities by a specific deadline. The goal was to minimize water wastage and prevent untreated wastewater from entering drainage systems.

Traditional car washing methods consume large quantities of water. According to Earth911 traditional car washes (without water conservation equipment) use between 15 and 85 gallons (roughly 57–322 liters) per vehicle.[46] To address this issue EPA Punjab made the installation of recycling plants mandatory for all service stations.

- Car wash stations were instructed to install recycling systems.
- Notices were issued.
- Many stations were sealed or fined for failing to comply.

Non-compliant service stations may face:



46 How new car wash technology saves water-Earth911

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These enforcement measures ensure that service stations follow environmentally responsible practices.

A recycling plant at a service station is essentially a **small wastewater treatment system** designed to clean and reuse water from vehicle washing. Through this system 70–90% of the water can be reused greatly reducing water consumption. The figure shows the overall working of a recycling plant.

A recycling plant typically comprises three main components that work in sequence to treat and reuse wastewater efficiently. 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 particles settle. Following this an underground grease trap is used to separate oil and grease from the water ensuring preliminary treatment. The second component is the prefabricated treatment plant which consists of 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 by eliminating bacteria; 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 removing odors, color 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. Together these components ensure a systematic and effective wastewater recycling process.

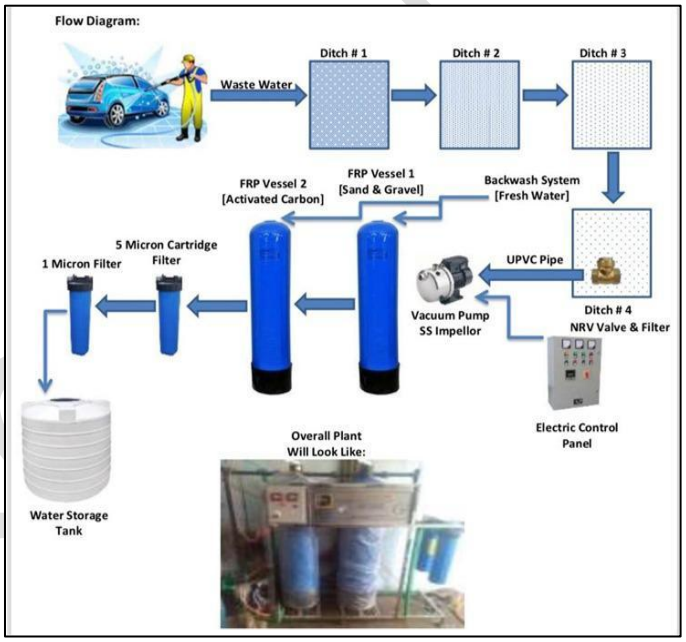
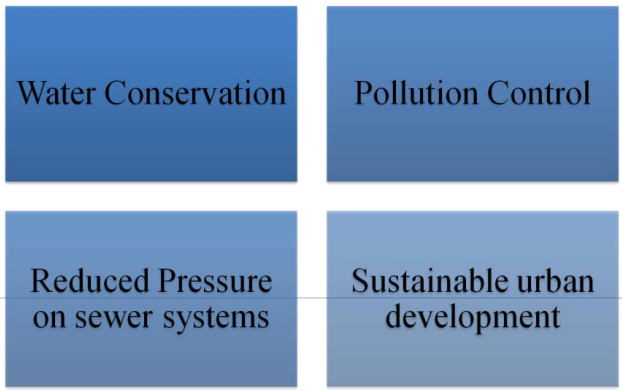


Figure 6.1: Working Mechanism of Recycling Plant

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



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EPA Punjab conducts regular inspections of service stations to ensure compliance. In some cities inspections have resulted in closure of stations that failed to install recycling plants demonstrating strict enforcement of environmental regulations. Overall enforcement statistics for the year 2025 is given in the table below.

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

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

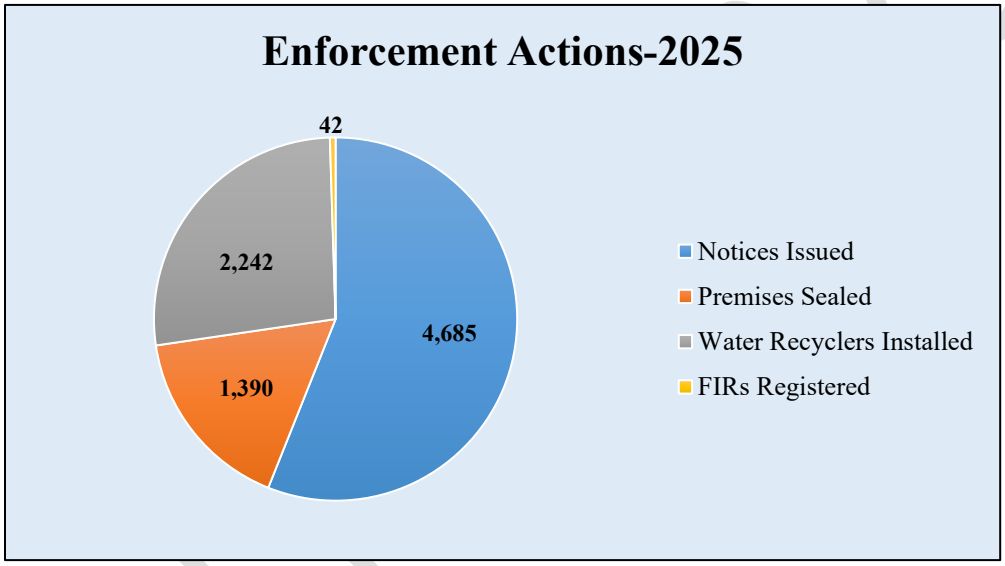


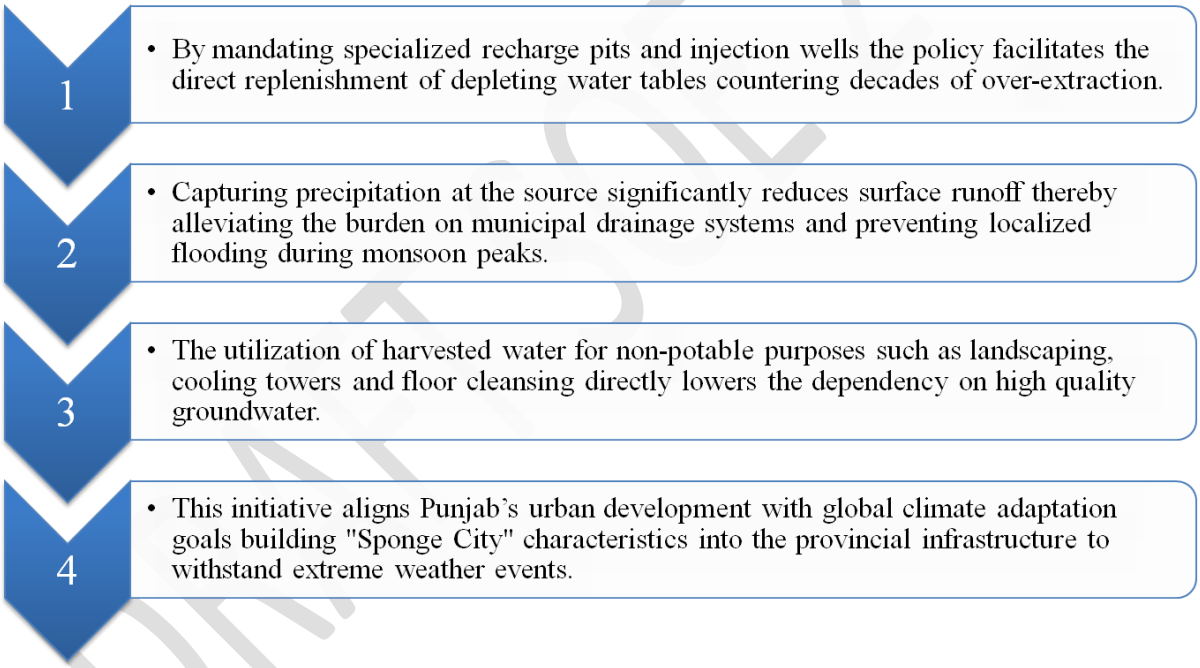
Figure 6.2: Breakdown of enforcement actions for water recyclers at service stations in 2025

6.4.2 Mandating Rainwater Harvesting in Urban Development (2025)

In a landmark move toward sustainable water governance the Environmental Protection Agency Punjab institutionalized rainwater harvesting (RWH) as a mandatory requirement for environmental clearance in 2025 (where needed). This initiative was operational through the stringent application of Section 12 of the Punjab Environmental Protection Act (PEPA) 1997 which governs the issuance of Environmental Approvals.

By integrating RWH mandates into the Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) processes the Agency has ensured that water conservation is no longer an optional feature but a fundamental prerequisite for new construction across the residential, commercial and institutional sectors.

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



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

- Project proponents are now required to submit detailed hydrologic designs and site-specific RWH plans as part of their Environmental Management Plans (EMPs).
- Compliance is verified through a dual stage process involving rigorous desk audits of project blueprints followed by on-site technical inspections during the construction and operational phases.

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- The Agency has collaborated with technical experts to provide developers with standardized guidelines for recharge mechanisms ensuring that RWH systems are geologically appropriate and maintain water quality.

The transition from reactive water management to a preventive regulatory framework marks a paradigm shift in the province's environmental stewardship. Beyond the technical benefits of slowing groundwater depletion the policy has catalyzed a cultural shift within the real estate and construction industries. Developers are increasingly recognizing "Water-Neutral" development as a hallmark of modern responsible project management.

As these systems become ubiquitous across the provincial landscape EPA Punjab anticipates a measurable enhancement in water security, a reduced urban environmental footprint and a more robust defense against the hydrological uncertainties posed by climate change.

6.5. Freshwater Contamination and Wastewater Challenges

Despite the implementation of multiple freshwater conservation measures by EPA Punjab including mandatory installation of water recycling plants at service stations and incorporation of rainwater harvesting systems in development projects freshwater contamination continues to remain a major environmental challenge across the province. Rapid urbanization, industrial expansion and increasing population growth have significantly increased the volume of municipal sewage and industrial wastewater generation beyond the existing treatment and management capacity. As a result large quantities of untreated wastewater are still being discharged into rivers, canals, drains and open land causing continuous deterioration of surface water and groundwater quality.

Punjab's water crisis is no longer defined solely by declining freshwater availability; it is increasingly shaped by the transformation of natural water bodies into wastewater carrying systems. Rivers, urban drains and canals that once served as freshwater resources are now under continuous pressure from municipal sewage, industrial discharges and mixed urban runoff. This shift has significantly reduced the environmental carrying capacity of freshwater systems and increased dependence on already stressed groundwater reserves. As wastewater volumes continue to rise across urban and industrial centers, the challenge for Punjab is no longer only conserving freshwater but also preventing existing water resources from progressively turning unusable due to contamination and unmanaged wastewater flows.

6.5.1. Wastewater Profile of Punjab

Wastewater generally refers to water that has been used in domestic, municipal, commercial, agricultural or industrial activities and has become unsuitable for direct reuse or discharge without treatment. In the regulatory context of Punjab, wastewater is assessed through the Punjab Environmental Quality Standards (PEQS) for Municipal and Liquid Industrial Effluents which provide permissible discharge limits for treated effluent before it is released into inland waters, sewage treatment systems or land. These standards evaluate wastewater on the basis of key

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parameters such as pH, temperature, BOD, COD, TSS, TDS, oil and grease, sulphides, chlorides, sulphates, heavy metals and other pollutants. Therefore, wastewater management in Punjab is not limited to the presence of water discharge alone; it is determined by whether the discharged effluent meets the prescribed environmental quality limits under PEQS.

Punjab's wastewater profile is shaped by its large population, expanding urban settlements, intensive agriculture and concentrated industrial activity. The province generates wastewater from major cities, industrial estates, housing societies, commercial areas, hospitals, service stations, livestock activities and agricultural fields. Urban centers such as Lahore, Faisalabad, Multan, Gujranwala and Rawalpindi generate large volumes of municipal sewage, while industrial districts such as Lahore, Faisalabad, Kasur, Sialkot, Sheikhupura, Gujranwala and Multan contribute significant industrial effluent loads. In many areas, drainage channels originally meant for stormwater have gradually become permanent carriers of mixed wastewater, receiving sewage, industrial discharge and runoff before ultimately affecting rivers, canals, soil and groundwater systems.

The main sources of wastewater in Punjab may therefore be categorized into municipal wastewater, industrial wastewater, agricultural runoff and commercial wastewater. Municipal wastewater contributes the largest volume because it is generated daily from households, markets, offices and urban settlements. Industrial wastewater, although comparatively more localized, presents the highest environmental risk because it may contain heavy metals, chromium, dyes, chemicals, oils, acids, alkalis and high organic load. Agricultural runoff adds fertilizers, pesticides, salts and irrigation return flows into the water environment, while service stations, hospitals, laboratories, workshops and housing societies create additional localized wastewater streams. This mixed wastewater burden makes Punjab's challenge both quantitative and qualitative: the province must manage the rising volume of wastewater while also controlling the toxic and persistent pollutants that threaten freshwater resources and public health.

This profile establishes the basis for examining Punjab's industrial wastewater situation in detail particularly the sources, contaminant characteristics, affected districts and regulatory interventions required to control wastewater pollution across the province.

6.5.2. Punjab's Industrial Waste Water: Overview

Punjab Pakistan's most populous and industrially active province faces a severe industrial wastewater crisis driven by decades of unplanned growth and weak environmental enforcement. Industries such as textiles, tanneries, steel, chemicals and pharmaceuticals discharge enormous volumes of effluent much of it untreated into open drains that feed directly into major rivers including the Ravi and Chenab.[47] Lahore alone generates an estimated 1,350 million litres of

47 MDPI Water (2018) — Water quality modeling, Ravi River, Punjab.

DRAFT SOE 2025

wastewater per day from its approximately 1,120 unplanned industrial units which flows largely untreated into the Ravi River.[48] Faisalabad the province's industrial heartland, channels effluent through the Madhuana and Paharang drains into the same river system with the average volume of wastewater disposed reaching 630 MLD including surrounding towns.[49] Kasur's tanneries have contaminated local groundwater with chromium levels exceeding the WHO safe limit of 0.05 mg/L leaving residents exposed to cancer, kidney failure and skin disease for generations.[50]

The contaminant profile of Punjab's industrial wastewater is dominated by heavy metals i.e. chromium, lead, cadmium, arsenic, nickel, zinc and copper alongside high concentrations of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS) and suspended solids (SS) all routinely exceeding Punjab Environmental Quality Standards (PEQS).[51] Textile effluents from Faisalabad and Lahore are particularly loaded with dyes, sulfates and metals.[52] 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 exceed the critical drinking water limit of 0.01 mg/L.[53] Studies show that 80% of cities in Pakistan use untreated industrial and municipal discharge for irrigation introducing heavy metals directly into the food chain through crops and vegetables.[54] A comprehensive Industrial wastewater profile of major cities in Punjab is given in the 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 [55] PMC 2017 [56] 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

48 ScienceDirect (2019) — Heavy metals in vegetables, Lahore wastewater irrigation

49 ResearchGate (2023) — Wastewater treatment in Pakistan: issues, challenges and solutions

50 Minute Mirror (2026) — From tanneries to toxins: a sustainability dilemma in Pakistan

51 ScienceDirect (2024) — Wastewater pollution & treatment efficiency, Faisalabad.

52 MDPI Processes (2022) — Heavy metals in industrial wastewater, Faisalabad.

53 PMC (2014) — Pollution status of Pakistan: heavy metal contamination of water, soil, vegetables.

54 NCBI/PMC (2023) — Heavy metals in soils & vegetables, Dera Ghazi Khan, Punjab.

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

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

DRAFT SOE 2025

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 [57] 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 [58] 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

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

Punjab continues to face mounting environmental challenges driven by rapid industrialization. Among the most pressing concerns is the management of industrial wastewater and combined pollution loads. These are the issues that demand systematic profiling, spatial mapping and data driven regulatory responses.

The **Pollution Status Mapping System** developed by the EPA GIS Cell provides exactly this kind of comprehensive assessment. This data driven approach enables regulators to identify pollution hotspots and prioritize targeted interventions. By integrating industrial inventory data with spatial pollution mapping policymakers are better equipped to design informed regulatory frameworks. Taken together, this data-driven framework equips environmental regulators to **prioritize targeted inspections**, design informed regulatory frameworks and allocate resources where the pollution burden is greatest rather than spreading enforcement capacity uniformly across all industrial sites. As Punjab scales this approach across all districts this Mapping System becomes an essential tool for evidence based environmental governance.

57 Lok Sujag — Kasur tanneries waste management & KTWMA.

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

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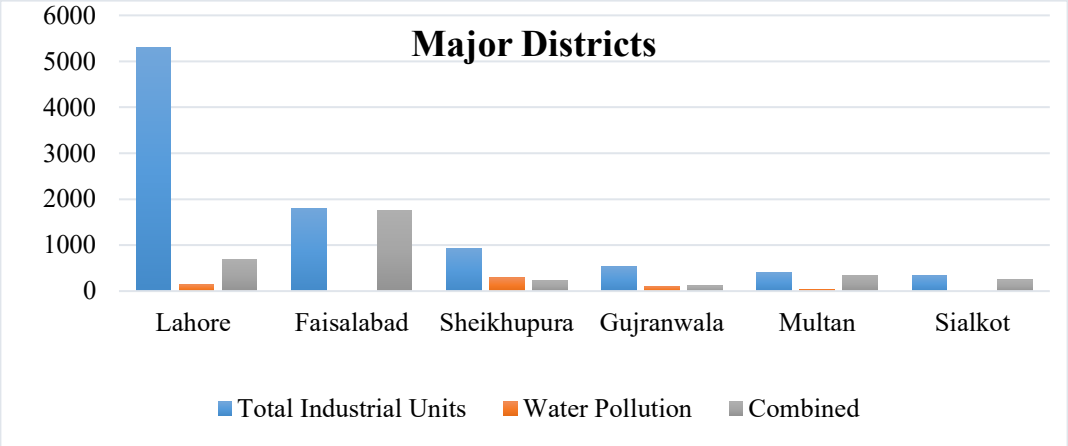
The following graphs illustrate the district wise distribution of industrial waste water hotspots across Punjab. The bar chart compares different districts based on Total industrial units present



there and those having water pollution and combined pollution impact. There's a general trend where districts with more industrial units tend to have higher water pollution though the intensity varies across regions. The overall pollution status maps are provided in **Annex-I** for reference

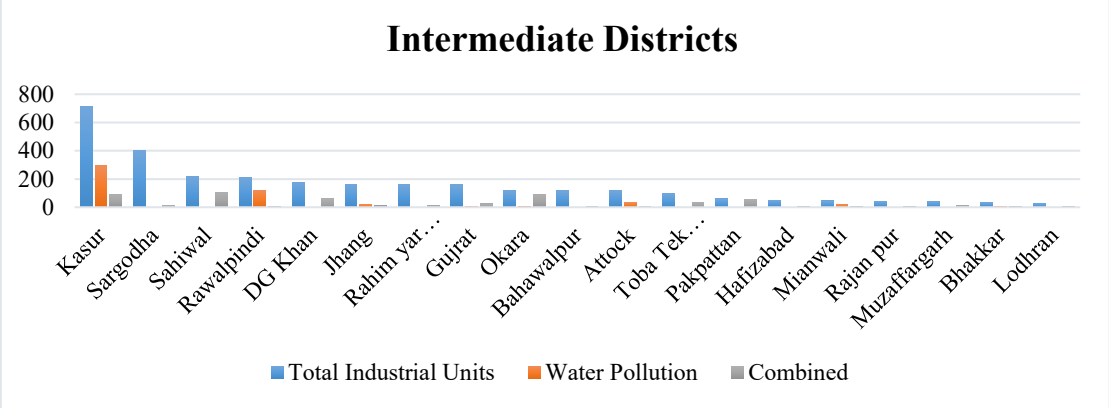


Figure 6.4: Water Pollution Status of industries in Intermediate Districts

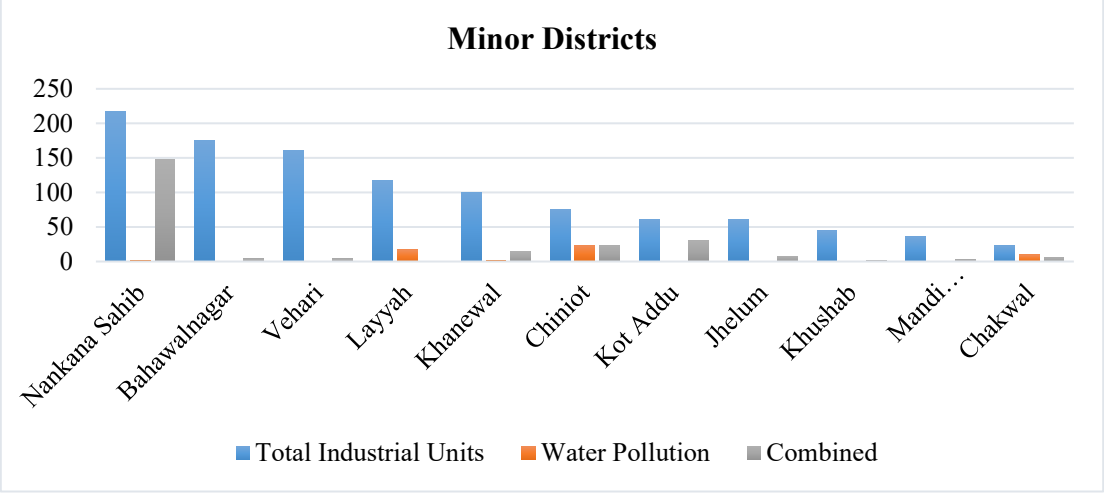


Figure 6.5: Water Pollution Status of industries in Minor Districts

6.7. Stressors Associated with Wastewater Pollution

Wastewater pollution in Punjab is not only a drainage or treatment issue; it creates multiple environmental stressors that affect soil quality, groundwater safety, agricultural productivity, ecosystem stability and public health. Untreated municipal sewage, industrial effluents and agricultural runoff introduce organic load, toxic chemicals, pathogens, heavy metals and salts into the environment. These pollutants gradually move through drains, rivers, agricultural fields and underground aquifers, creating long-term risks for environmental sustainability and human well-being.

6.7.1 Degradation of Freshwater Quality

Untreated wastewater directly affects rivers, canals, drains and groundwater reserves by increasing organic pollution, chemical contamination, suspended solids and toxic load. Once freshwater sources receive continuous wastewater discharge, their natural self-cleaning capacity is reduced. This lowers the availability of safe water for drinking, irrigation, livestock and domestic use.

6.7.2 Soil Fertility and Land Degradation

Wastewater used for irrigation or discharged onto open land can alter soil chemistry over time. High TDS, salts, heavy metals, oils, chemicals and untreated organic matter reduce soil fertility and affect soil structure. Continuous exposure may make agricultural land less productive, increase salinity and damage the natural nutrient balance of soil.

6.7.3 Food Security Risks

When contaminated wastewater enters agricultural fields, pollutants may accumulate in crops,

Figure 6.5: Water Pollution Status of industries in Minor Districts

vegetables and fodder. This creates risks for crop quality, livestock health and food safety. In the long term, reduced soil fertility, polluted irrigation water and heavy metal accumulation can affect agricultural productivity and create food security concerns for Punjab, which is Pakistan's major agricultural province.

6.7.4 Groundwater Contamination

Punjab's heavy dependence on groundwater makes wastewater seepage a major environmental risk. Polluted drains, lagoons, open wastewater ponds and unlined disposal channels can contaminate aquifers through seepage. Once groundwater is contaminated with pathogens, nitrates, heavy metals or industrial chemicals, restoration becomes extremely difficult and costly.

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6.7.5 Public Health Burden

Wastewater pollution increases exposure to waterborne and chemical-related diseases. Contaminated water can cause diarrhea, gastroenteritis, skin infections, hepatitis, typhoid and other health problems. In industrial areas, long-term exposure to heavy metals and toxic chemicals may increase risks of chronic illnesses, particularly among communities living near polluted drains and industrial clusters.

6.7.6 Aquatic Ecosystem Degradation

High BOD, COD, toxic chemicals and suspended pollutants reduce dissolved oxygen levels in water bodies and disturb aquatic life. Fish mortality, foul smell, black water, loss of biodiversity and degradation of riverine habitats are common outcomes of untreated wastewater discharge. This weakens the ecological balance of rivers, drains and wetlands.

6.7.8 Livestock and Rural Livelihood Impacts

In rural and peri-urban areas, contaminated water used by livestock can affect animal health and productivity. Polluted irrigation water and degraded soil also reduce crop yields, which directly affects farmer income and rural livelihoods. Therefore, wastewater pollution becomes both an environmental and socio-economic stressor.

6.7.9 Urban Environmental Stress

In cities, open drains carrying untreated wastewater create foul smell, mosquito breeding, localized flooding, poor sanitation and visual pollution. These conditions reduce urban environmental quality and increase the disease burden in densely populated settlements.

6.7.10 Industrial and Regulatory Pressure

Wastewater pollution also creates pressure on regulatory institutions because untreated discharge requires continuous monitoring, sampling, enforcement, prosecution and compliance verification. Where treatment infrastructure is weak or industries are scattered, environmental governance becomes more difficult and costly.

6.7.11 Climate and Resilience Concerns

Climate variability can worsen wastewater-related stress. During dry periods, reduced river flows lower dilution capacity, making pollution more concentrated. During heavy rainfall, overflowing drains spread contaminated wastewater into streets, fields and low-lying settlements. This increases both environmental and disaster-related vulnerability

6.8. Priority Sector Intervention by EPA Punjab

Tannery Wastewater Management

The tannery sector in Kasur is a vital pillar of Punjab's leather industry and export economy yet it has historically been a major source of industrial wastewater pollution due to the discharge of

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untreated or partially treated effluents containing hazardous chemicals such as chromium, sulfides and organic waste. In response to increasing regulatory pressure, evolving environmental standards and heightened awareness of public health risks the sector is undergoing a critical transition toward sustainability. This transformation emphasizes improved wastewater management, adoption of cleaner production techniques and the installation and effective operation of Wastewater Treatment Plants (WWTPs) alongside the relocation and consolidation of tanneries into specialized industrial zones particularly in Sialkot. Key milestones in this transition include the restructuring of tannery clusters in Sialkot and operational enhancements in the Common Effluent Treatment Plant (CETP) in Kasur reflecting Punjab's evolving regulatory and technological approach to reducing untreated discharge, strengthening effluent treatment capacity and ensuring the long-term environmental sustainability and global competitiveness of its leather industry.

6.8.1 Transforming the Kasur Tannery Cluster toward Environmental Sustainability

The Kasur tannery cluster is a vital industrial hub in Punjab yet it has long been characterized by severe environmental degradation primarily due to the discharge of hazardous wastewater containing high levels of chromium and other toxic chemicals. In response to this crisis, the Environmental Protection Agency (EPA) Punjab commissioned a specialized unit to conduct a comprehensive situational and technical analysis. The objective was to identify the root causes of pollution and develop an actionable roadmap for regulatory compliance.

To ensure a comprehensive understanding of the situation the specialized 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.
- Samples were collected from critical points such as individual tannery clusters, main drains, supply channels and treatment plant inlets/outlets. These were tested by both a private laboratory (M/S Pak Green Enviro-Engineering) and the EPA Lab in Lahore to assess pollutant levels against Punjab Environmental Quality Standards (PEQS).
- The team analyzed official disease reports from the District Headquarters (DHQ) Hospital Kasur and conducted community surveys to gauge the perceived environmental and health impacts on residents.
- The committee conducted physical inspections of treatment facilities, tannery zones and open wastewater ponds/lagoons to document on-ground conditions.

The assessment identified a total of 306 tanneries in Kasur with a significant majority (202 units) engaged in "wet blue" processing which involves chrome tanning. Approximately 60% of these tanneries are small to medium-sized (less than 60 Marla) and 70% operate using five or fewer tanning drums. Following Pie graph represents the unit connected to CETP and those disconnected

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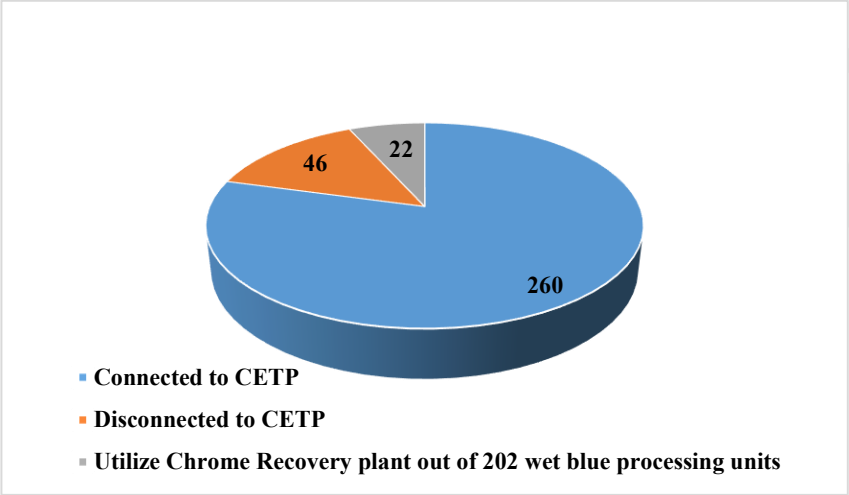
to CETP. There are 22 units out of 202 wet blue processing units that utilize chrome recovery plants.



The study highlights a systemic failure in pollution management specifically regarding chromium waste and regulatory compliance. Following observation has also been reported in study:

- Approximately 89% of wet blue tanneries (180 units) discharge their wastewater without any form of chromium recovery.
- The existing CRP has a capacity of 20,000 liters per day but is currently operating at only 1,500 liters per day covering less than 1% of the 180,000 liters of chromium laden water generated daily.
- The CRP's effectiveness is crippled by chemical shortages, transport payment delays, a lack of second shift staffing and the illegal sale of wastewater.

The following tables summarize the technical results and health findings from the specialized unit's report on the Kasur tannery cluster. These results highlight the discrepancy between current pollutant levels and the Punjab Environmental Quality Standards (PEQS).

This table outlines the levels of major pollutants recorded at critical sampling points compared to the legal limits established by PEQS.

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

Parameter	PEQS Limit	KTWMA Inlet Channel	KTWMA Outlet	Inlet Red	Main Drain Mixed	CRP Inlet	CRP Outlet (Post-Treatment)

		supply (Untreated)	(Post-Treatment)	Chan nel	(Treated and Red Channel)		
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 of the health data analysis from January to June 2025 provided conclusive evidence of the human cost of 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

DRAFT SOE 2025

Open Ponds in Tannery Zone

Aeration Pond

Tannery Water Inlet

Initial Manual Screening

Chrome Recovery Plant

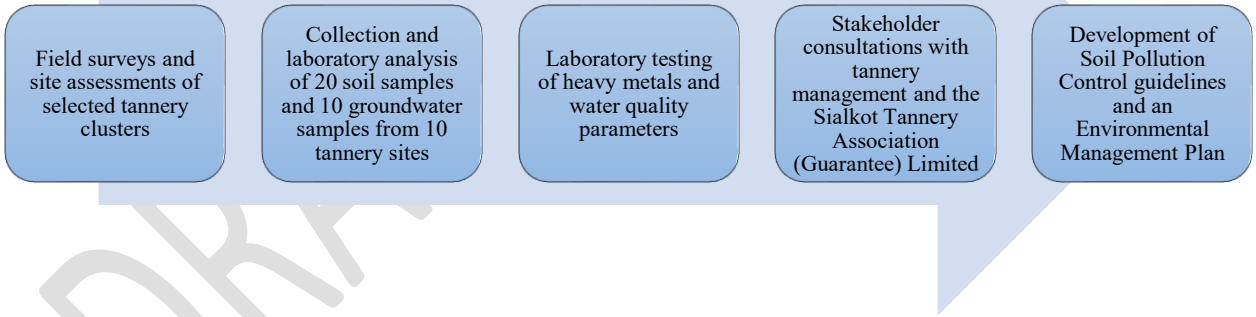
6.8.2 Environmental Management Plan for Decontamination of Tannery Sites in Sialkot

Sialkot hosts approximately 260 active tanneries across 10 clusters, employing around 6,500–7,000 workers. These tanneries are dispersed across urban and peri-urban areas posing environmental compliance challenges for international market requirements. Accordingly, an analytical study was undertaken in response to the government's concerns regarding the potential for water pollution arising from tannery operations.

An Environmental Management Plan (EMP) was developed to address 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 aimed to support the relocation of scattered tanneries to the newly planned Sialkot Tannery Zone and ensure environmentally responsible site management.

The primary objective of the assignment was to assess soil and groundwater contamination risks at existing tannery sites and develop an Environmental Management Plan to guide safe site management during and after the relocation of tanneries to Sialkot Tannery Zone.

The study included the following key activities:



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

- Heavy metal concentrations were found within internationally acceptable limits. Chromium levels ranged between 9–49 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. No significant heavy metal contamination was detected.

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- Some groundwater samples showed the presence of pathogens (E. coli and coliform bacteria) and slightly elevated fluoride levels indicating the need for treatment before drinking.

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 focus of the EMP shifted toward preventive environmental management during tannery relocation. The plan recommends the following measures:

- Proper drainage and disposal of process water and chemicals before dismantling equipment
- Safe storage and transportation of chemical containers and machinery
- Collection and proper disposal of solid waste and sludge
- Removal of stagnant wastewater and hazardous materials from sites
- Placement of safety signage at potential risk areas
- Ensuring no machinery, chemicals or waste remain on site after relocation

The Sialkot Tannery Association (Guarantee) Limited will:

- Issue Soil Pollution Control guidelines to all relocating tanneries
- Conduct on-site monitoring during relocation
- Verify proper site cleanup after relocation
- Ensure environmentally compliant operations at the new Sialkot Tannery Zone

This initiative supports:

- Environmentally responsible industrial relocation
- Improved compliance with international environmental standards
- Sustainable leather sector development in Sialkot
- Reduced environmental risks to soil, groundwater and public health

The Environmental Management Plan provides a practical framework for preventing environmental contamination during the transition of tanneries to the Sialkot Tannery Zone. By implementing preventive guidelines and monitoring mechanisms the project contributes to strengthening environmental compliance and promoting sustainable industrial practices in Pakistan's leather sector. The overall progress of tannery relocation is presented 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

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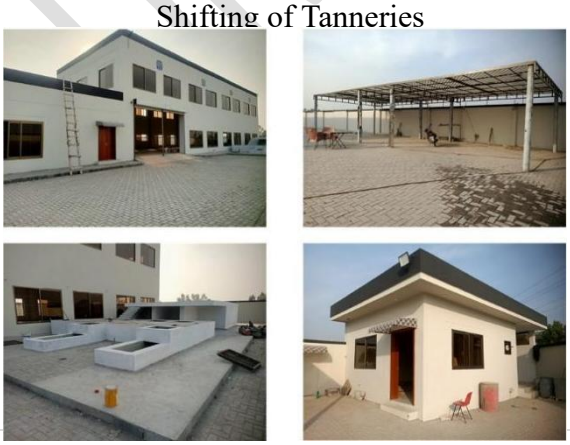
255 • No. of plots which are at construction of boundary wall stage

15 • No. of plots which are at earth filling stage

32 • No. of tanneries which are shifted with machinery equipment and have with

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 highlights how a specific industrial activity can generate concentrated wastewater pollution requiring targeted regulatory attention. However, wastewater pollution in Punjab is not limited to individual sectors alone. In many areas, untreated municipal sewage, industrial effluents and urban runoff from different sources ultimately converge into major drains and water channels, creating cumulative pollution loads that affect rivers, groundwater and surrounding communities. Therefore, alongside sector-specific interventions such as tannery wastewater management, EPA Punjab also adopted site-specific assessment of polluted drains to examine how mixed wastewater flows behave after entering the wider drainage network. This approach enables identification of pollution hotspots, major discharge points, affected industrial clusters and compliance status against Punjab Environmental Quality Standards. Within this framework, Hudiara Drain was selected as a critical case for detailed water quality assessment due to its transboundary nature, 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 turned perennial wastewater conduit. It holds significant environmental and geopolitical relevance as a trans-boundary water pollution channel between India and Pakistan. [59] Originally designed to carry excess rainwater and prevent

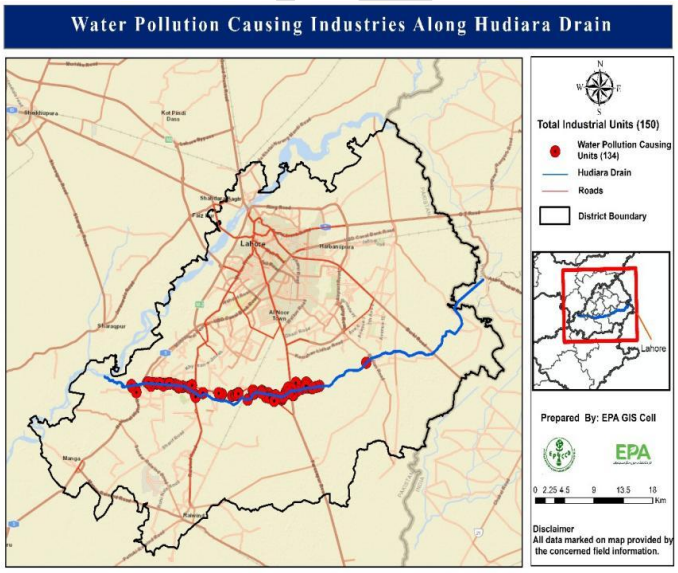
[59] Hudiara Drain - A Case of Trans-boundary Water Pollution Between India and Pakistan

DRAFT SOE 2025

seasonal flooding it has evolved into a major environmental hazard due to the heavy discharge of untreated municipal sewage and industrial effluents along its route.[60]

It originates near Batala City in the Gurdaspur District of Punjab, India. The total length of the drain is approximately 98.6 km. It flows for roughly 44.2 km within Indian Territory before crossing the international border into Pakistan at Laloo village. [61]It flows for another 54.4 km through the periphery of Lahore, Pakistan before discharging directly into the River Ravi. The drain has an annual average discharge of approximately 178 to 180 cusecs into the River Ravi making it one of the largest single sources of contamination for the river.[62]

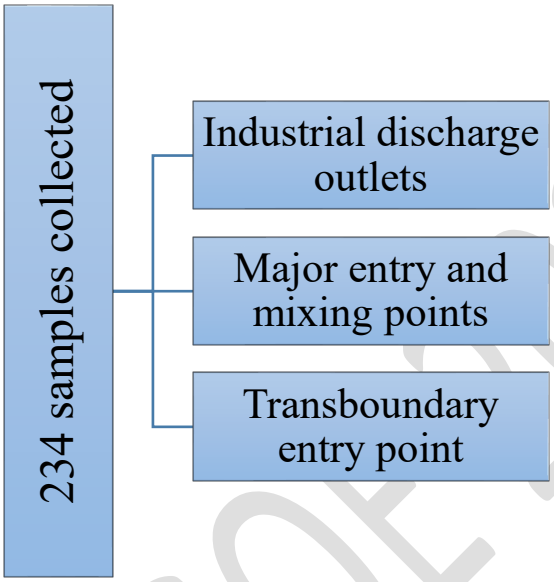
The Environmental Protection Agency Punjab initiated a comprehensive water quality monitoring program of the Hudiara Drain in response to growing concerns over industrial effluent discharge and its transboundary environmental implications. The drain which carries wastewater across the border into Punjab has long been subjected to pollution from industrial, municipal and agricultural sources posing risks to aquatic ecosystems, irrigation quality and public health.



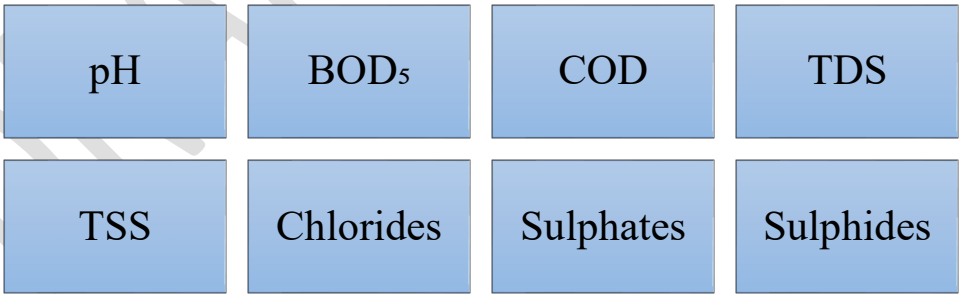
This GIS map prepared by the Environmental Protection Agency Punjab illustrates the severe industrial footprint along the Hudiara Drain within the Lahore District. It highlights a critical environmental concern: out of 150 total industrial units identified along the channel 134 are classified as "Water Pollution Causing Units." These polluting facilities represented by a dense string of red dots are heavily clustered along the southwestern stretch of the drain. The map serves as a stark visual record of the primary sources of toxic discharge that have transformed this former stormwater channel into a major perennial source of pollution for the River Ravi.

[60] Pollutant Analysis of Hudiara Drain, Lahore-Scribd
[61] Effect of Hudiara Drain on the Quality of Groundwater in The Housing Schemes of Lahore
[62] Hudiara Drain - A Case of Trans-boundary Water Pollution Between India and Pakistan

To systematically assess the extent and sources of contamination an extensive monitoring exercise was carried out from March to August 2025 focusing on key industrial discharge points as well as strategically selected locations along the 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 analysis of:



All results were evaluated against Punjab Environmental Quality Standards (PEQS). The data confirm that the Hudiara Drain is under severe environmental stress primarily due to excessive organic loading and untreated industrial effluent discharge. The findings reveal widespread and persistent non-compliance with Punjab Environmental Quality Standards (PEQS). The analytical results of samples are given in the table below.

Table 6.5. Sample Analysis vs PEQS (Technical Results)

DRAFT SOE 2025

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 PEQS across most industrial discharge points
- A significant pre-existing pollutant load at the transboundary entry point
- Compounding pollution effects from local industrial effluents
- Persistent exceedance of organic load and suspended solids standards.

DRAFT SOE 2025

GPS Map Camera
Lahore, Punjab, Pakistan
174 Lane 2, Wapda Town Block H 3 Wapda Town Phase 1
Lahore, Pakistan, Lahore, Punjab , Pakistan
Lat 31.428397° Long 74.259867°
23/06/2025 02:26 PM GMT +05:00
Google

GPS Map Camera
Lahore, Punjab, Pakistan
C6qr+c6j, Ali Pur Rd, Punjab University Employees
Housing Scheme Phase-ii, Lahore, Punjab , Pakistan
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GPS Map Camera
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54600, Pakistan, Lahore, Punjab 54600, Pakistan
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6.10. Institutional Response: Dedicated Wastewater Governance Framework

Keeping in view the increasing environmental stress caused by untreated wastewater, EPA Punjab adopted a focused and structured strategy for the water sector. For the first time, a dedicated institutional mechanism was developed to deal specifically with wastewater pollution, instead of treating it as a routine inspection matter. Under this approach, specialized wastewater units were constituted to identify, monitor and regulate major wastewater-generating sources across Punjab, particularly in industrial hotspots. These units were assigned the responsibility to conduct field inspections, collect effluent samples, prepare Site Monitoring Reports, initiate enforcement proceedings, verify compliance and ensure installation or improvement of wastewater treatment systems. This dedicated framework reflects EPA Punjab's shift from general enforcement toward sector-specific environmental governance, where wastewater pollution is addressed through profiling, surveillance, laboratory analysis, legal action and continuous compliance monitoring.

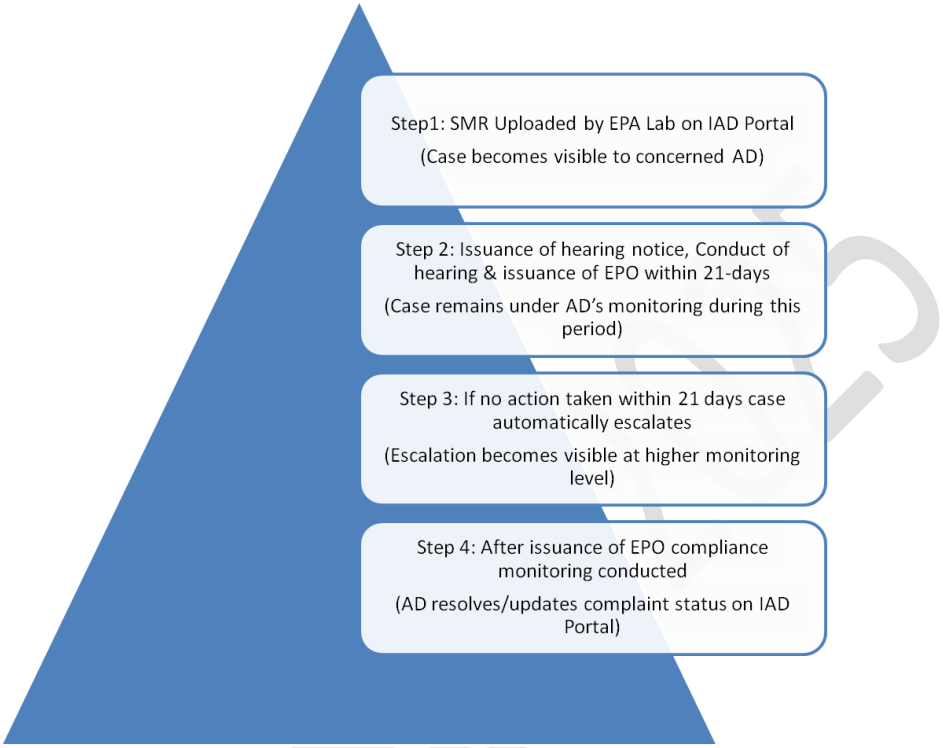
6.10.1. District-Level Enforcement: Specialized Water Unit & Surveillance Network

Rapid industrialization across Punjab has significantly contributed to economic growth but it has also intensified environmental challenges particularly the discharge of untreated industrial effluents into water bodies and drainage systems. The absence or ineffective operation of wastewater treatment infrastructure in many industrial units has led to the degradation of surface water quality and contamination of groundwater posing serious risks to ecosystems and public health. In response to these growing concerns and in line with its regulatory mandate EPA Punjab has strengthened its institutional framework to ensure systematic monitoring, enforcement and compliance in the management of industrial wastewater under Punjab Environment Protection Act 1997.

The EPA Punjab has constituted a Specialized Unit for Wastewater. The unit is tasked with creating a detailed profile of industrial wastewater across Punjab specifically targeting ten high priority "hotspot" districts. This process begins with field inspections and sample collection which are analyzed by the EPA Laboratory to produce Site Monitoring Reports (SMRs). If these reports reveal non-compliance the unit initiates formal enforcement under Section 16 of the Punjab Environmental Protection Act 1997. This includes holding legal hearings and issuing Environmental Protection Orders (EPOs) that mandate specific corrective actions. To ensure the pollution is actually addressed the unit verifies improvements through Compliance Status Reports (CSRs); any facility that remains in violation is then prosecuted before the Punjab Environmental Tribunal.

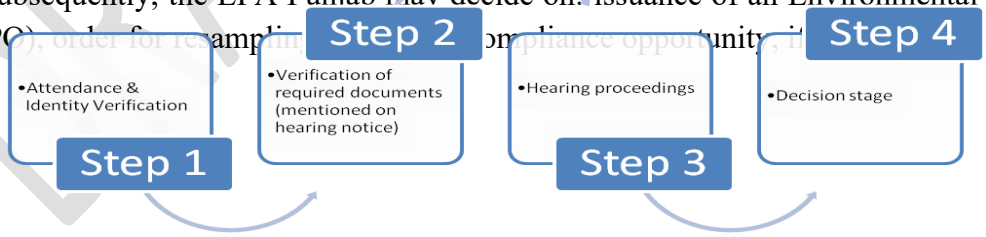
DRAFT SOE 2025

A core objective of the Unit is to ensure installation and effective operation of Wastewater Treatment Plants (WWTPs) in all significant effluent-generating entities. Below is the step by step illustration of working of Specialized unit for wastewater:



Hearing proceedings are conducted by following steps:

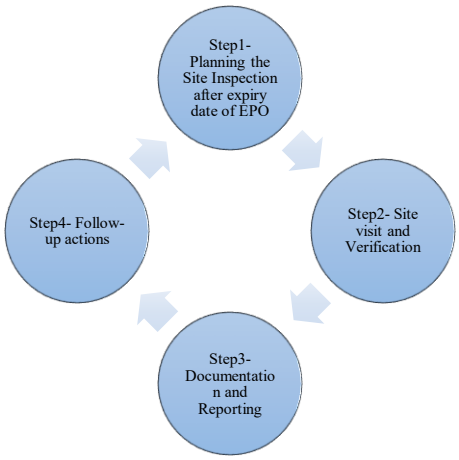
The official attendance record of the owner/authorized representative is maintained, followed by verification of required documents. A brief presentation of Sampling and Monitoring Report (SMR) findings is then conducted. The industry owner is given the opportunity to present their defense, supported by relevant documents. Clarification questions are addressed by the EPA Punjab. Subsequently, the EPA Punjab may decide on: issuance of an Environmental Protection Order (EPO), order for re-sampling, compliance opportunity, i



The Specialized Unit for Wastewater works under relevant Directorate EPA HQ with two Deputy Directors having field units. Each field unit consists of one Assistant Director (Unit Head), one Inspector and one Field Assistant. Given the higher concentration of effluent generating industries Faisalabad (Textile) and Kasur (Tanneries) have two units while the remaining eight hotspot districts have one unit each bringing the total initial deployment to twelve units. Given the interconnected nature of industrial wastewater drains and associated groundwater contamination

risks the Unit's operational jurisdiction is not confined to the ten designated hotspots; field teams may be deployed to any district of Punjab where effluent discharge poses a significant environmental or public health threat. The table below describes the designation and reporting hierarchy of specialized unit for wastewater:

Designation	Reporting Officer	Countersigning Officer
Assistant Director (Specialized Unit for Wastewater)	Deputy Director (R&I) or Deputy Director (RC) or as assigned by relevant Directorate of EPA	Relevant Directorate of EPA
Inspector (Specialized Unit for Wastewater)	Assistant Director concerned	Deputy Director concerned
Field Assistant (Specialized Unit for Wastewater)	Inspector concerned	Assistant Director concerned



The process of EPO compliance monitoring and field verification begins after the expiry date 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 comprehensive verification of environmental compliance. This includes assessing the installation and operational status of the Wastewater Treatment Plant (WWTP), evaluating any improvements made to the existing system, identifying effluent discharge points and ensuring adherence to prescribed environmental standards. The team also examines any potential bypass arrangements or risks of non-compliance. Following the inspection, the Inspector/FA prepares a Compliance Status Report (CSR) clearly categorizing the findings as full compliance, partial compliance or non-compliance and submits the report to the Assistant Director (AD) for review. If full compliance is confirmed supported by mandatory laboratory verification the case is formally closed. However, in instances of partial or non-compliance appropriate follow-up actions are initiated which may include re-inspection, re-sampling or the commencement of legal proceedings.

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The unit shall also take action against other sources of wastewater generation like housing societies, under the instruction of the authority. The core objective of the unit is to compile the profile of the wastewater generating industry and to take action against non-compliant units with the focus on wastewater treatment

Figure 6.6: Waste Water Treatment Plant

Following table illustrates the overall performance summary of the unit for the year 2025 from the date of its establishment onward. Overall, the data suggests a strong enforcement drive coupled with gradual improvements in wastewater management though some resistance to compliance remains.

Table 6.6. 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 shift moving away from fragmented reactive responses toward integrated, data driven and enforcement oriented governance. The initiatives documented in this chapter collectively reflect this transformation. Industrial wastewater profiling has replaced guesswork with evidence. GIS-based pollution mapping has turned scattered field observations into a strategic tool for targeting the most harmful sources first. Specialized enforcement units have brought focused regulatory attention to high priority industrial hotspots. Targeted interventions in the tannery sector from the Kasur CETP upgrades to the Sialkot relocation framework demonstrate that even deeply entrenched pollution problems can be systematically addressed. Monitoring of critical water bodies such as the Hudiara Drain has extended environmental oversight to transboundary pollution while mandatory water recycling at service stations and rainwater harvesting requirements in new developments signal a broader cultural shift toward conservation at source.

Together these initiatives establish a comprehensive regulatory framework that addresses both the causes and consequences of water pollution across Punjab. However, the scale of the challenge demands sustained commitment. Moving forward the Government of Punjab will continue to strengthen regulatory frameworks, close enforcement gaps and invest in advanced treatment technologies appropriate to the scale and diversity of the province's wastewater burden. Equally important is meaningful engagement with industry, local communities and institutional partners because lasting improvement in water quality and public health cannot be achieved through regulation alone. Punjab's water future depends on governance that is not only tougher but smarter, better resourced and built for the long term.

Looking ahead, Punjab faces an escalating set of water security challenges that extend beyond pollution control and demand equal 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 caused water tables to fall at alarming rates across large parts of the province with some areas now drawing from aquifers that replenish far more slowly than they are consumed. Climate change compounds this vulnerability by altering the timing, intensity and geographic distribution of monsoon rainfall, increasing the risk of both prolonged dry spells and destructive flood events that overwhelm drainage infrastructure and contaminate water sources simultaneously. In this context, treated wastewater reuse emerges not merely as an environmental objective but as a strategic water security imperative. Municipal and industrial effluent once adequately treated represents a reliable climate-independent source of water that can substitute for freshwater in agricultural irrigation, industrial cooling, groundwater recharge and urban landscaping. The Government of Punjab will therefore begin integrating wastewater reuse targets into its broader water resource planning, develop the legal and technical standards necessary to govern safe reuse and incentivize investment in tertiary treatment infrastructure at scale. Addressing these interconnected pressures, groundwater governance, climate adaptation and

DRAFT SOE 2025

circular water use will determine whether Punjab can secure safe and sufficient water not just for the present generation but for the decades ahead.

DRAFT SOE 2025

Chapter No. 7: Environmental Approvals and Development Oversight

7.1 Introduction

Environmental Approvals and Development Oversight is an essential component 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 he has filed with the [Provincial Agency] an initial environmental examination or, where the project is likely to cause an adverse environmental effect, an environmental impact assessment and has obtained from the [Provincial Agency] approval 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 provides detailed procedures for assessing the potential environmental impacts of proposed developments.

Development Oversight through the Environmental Approval (EA) regime has significantly influenced the development structure of Punjab by ensuring that projects are planned and executed in accordance with environmental sustainability principles rather than 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 the commencement of 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 are increasingly incorporating pollution control technologies, green belts, wastewater treatment arrangements and mitigation measures at the design stage itself. In this way, the Environmental Approval framework acts 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 processing of EAs in the year 2025 and issued 2013 EAs surpassing all previous year on tracker.

7.2 Environmental Approvals Matrix

Environmental Approvals Matrix of the EPA Punjab ensures environmental compliance through a comprehensive regulatory framework under the IEE/EIA Regulations, which have been carefully and technically crafted while taking into account the nature of the project, estimated cost, environmental impact, operational risks, future projections and sustainability considerations. Under these regulations, projects of relatively smaller scale are required to obtain Initial Environmental Examination (IEE) approval, whereas large-scale and environmentally sensitive

DRAFT SOE 2025

projects are obligated to secure Environmental Impact Assessment (EIA) approval prior to the commencement of any construction activity.

The purpose of this mechanism is to evaluate and mitigate potential environmental impacts at the planning stage so that adverse effects on public health, natural resources and surrounding communities may be avoided. Furthermore, after completion of construction and before initiation of operations, the project proponent is required to obtain confirmation of compliance from EPA Punjab to ensure that all environmental safeguards, conditions and mitigation measures approved in the IEE/EIA have been duly implemented. The Environmental Approvals issued by Environmental Protection Agency Punjab carry a validity period of three years from the date of issuance. In order to continue the project operations beyond the expiry period, the project proponent is required to obtain renewal of the Environmental Approval from EPA Punjab, subject to verification of continued compliance with environmental standards, approved conditions and applicable regulatory requirements.

The Environmental Approvals Matrix provides a consolidated, tiered account of all EA 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 and 2,013 Environmental Approvals were issued during the year. The matrix is organised around three administrative levels: the HQ tier under the Director General EPA Punjab, the district tier under the District Environmental Approval Committees (DEACs) headed by the Deputy Commissioners in 38 districts and the divisional tier under the Divisional Environmental Approval Committees (Div. EACs) headed by the Commissioners across 10 divisions of Punjab.

The environmental legal framework not only provides a strong mechanism for the issuance of Environmental Approvals (EAs), but also deals firmly with projects operating without it. Such violations are addressed through a proper legal and regulatory mechanism under the law. Under Section 12 of Punjab Environmental Protection Act 1997, commencement of a project without obtaining an Environmental Approval (EA), or failure to extend its validity before expiry, constitutes a constitutes an offence under Section 16 of PEPA 1997 (Penalties), triable by the Punjab Environmental Tribunal constituted under Section 17 of the Act. Furthermore, the power to review EAs has been delegated to District Environmental Approval Committees (DEACs) and Divisional Environmental Approval Committees (Div. EACs) for categories of projects specified in the Power Delegation Notification, thereby establishing the three-tier EA system operative in Punjab.

7.3 ISO-9000 Certification in Environmental Approval Regime

In 2025, EPA Punjab achieved a landmark institutional milestone with the ISO 9001:2015 certification for its licensing regime (Environmental Approvals). The certificate was issued by ISOQAR (accredited by UKAS & PNAC), following a third-party conformity assessment audit against the ISO 9001:2015 standard, and a rigorous evaluation of EPA Punjab’s operational systems, regulatory frameworks and service delivery mechanisms.

DRAFT SOE 2025

The Quality Policy, formally issued on 5 February 2025, commits the EIA Wing to strictly comply with all applicable environmental laws and regulations, thorough comprehensive technical review of EIA and IEE submissions, continual improvement of the Quality Management System, capacity building of the staff, and meaningful stakeholder engagement. By institutionalizing standardized review procedures, risk-based decision-making, quality assurance mechanisms, and performance monitoring, the ISO 9001:2015 framework strengthens the consistency, transparency, and effectiveness of environmental assessments and regulatory oversight. Therefore, the certification not only validates the procedural integrity of EPA Punjab's approval and compliance verification processes but also enhances the credibility of environmental decision-making, supporting improved environmental protection outcomes while maintaining internationally recognized standards of quality, accountability, and public service efficiency.

7.4 Provincial Level Environmental Approval Matrix

The concentration of HQ-level applications in a handful of districts reflects the geographic distribution of large-scale industrial activity across Punjab. Lahore, as the provincial capital and primary 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. These six districts together accounted for 60.6% of all HQ-level filings, confirming that Punjab's large-scale industrial activity remains geographically concentrated along the Central Punjab industrial axis.

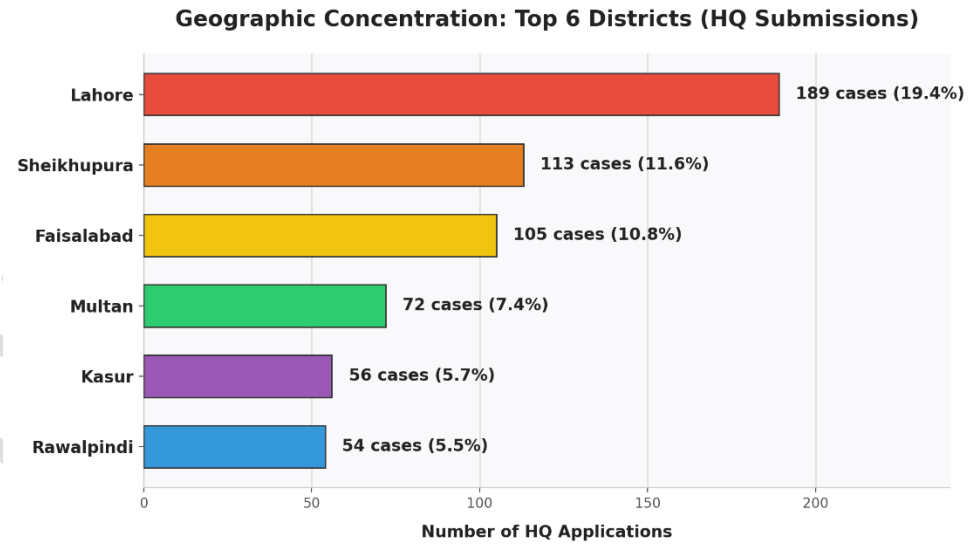

Figure 7.1: Geographic concentration of top 6 districts

The district-wise application data, read alongside individual project records, reveals distinct sectoral profiles for key districts receiving HQ-level Environmental Approvals in 2025. These profiles reflect the industrial character of each district and provide a granular picture of where specific types of development are seeking environmental clearance. Lahore received the highest

volume of HQ applications (189 cases: 85 EIA and 104 IEE). Of the EIAs, 25 EAs were issued covering a diverse range of sectors: oil, gas and LPG storage facilities (7 EAs), pharmaceuticals (3 EAs), chemicals and paints (2 NOCs) and an assortment of industrial units including automobile assembly, waste incineration and synthetic textiles. The IEE NOCs issued for Lahore (40) were similarly diverse, urban development (6 EAs), plastic manufacturing (4 EAs), apparel and stitching units (3 EAs), energy projects including biomass boilers and solar installations (3 EAs) and dyeing and textile units (3 EAs). Lahore's sectoral diversity at HQ level reflects its character as a mixed industrial and commercial metropolis, where no single sector dominates, a pattern consistent with its description as a mixed industrial cluster accommodating pharmaceutical, chemicals, textiles and light manufacturing simultaneously.

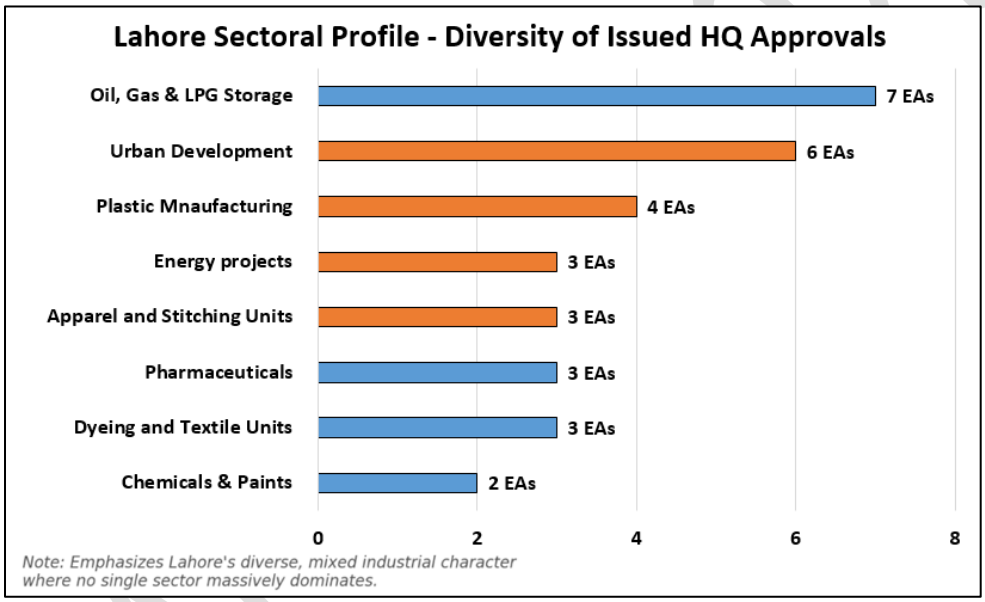

Figure 7.2: Lahore Sectoral Profile

Faisalabad, with 105 HQ applications (52 EIA and 53 IEE), is Punjab's most sector-concentrated industrial district at HQ level. Among the 22 EIA EAs issued, textile dyeing and printing were the leading sectors with 4 EAs, Pharmaceutical units received 3 EAs, Food and beverage processing received 2 EAs. The IEE NOC profile (29 cases) was dominated by textile spinning and weaving units, which received 9 NOCs, the highest single district-category figure in the IEE dataset, confirming Faisalabad as Punjab's primary textile spinning centre. Feed mills received 6 EAs, plastics and synthetic units 3 EAs and packaging material manufacturers received 3 EAs.

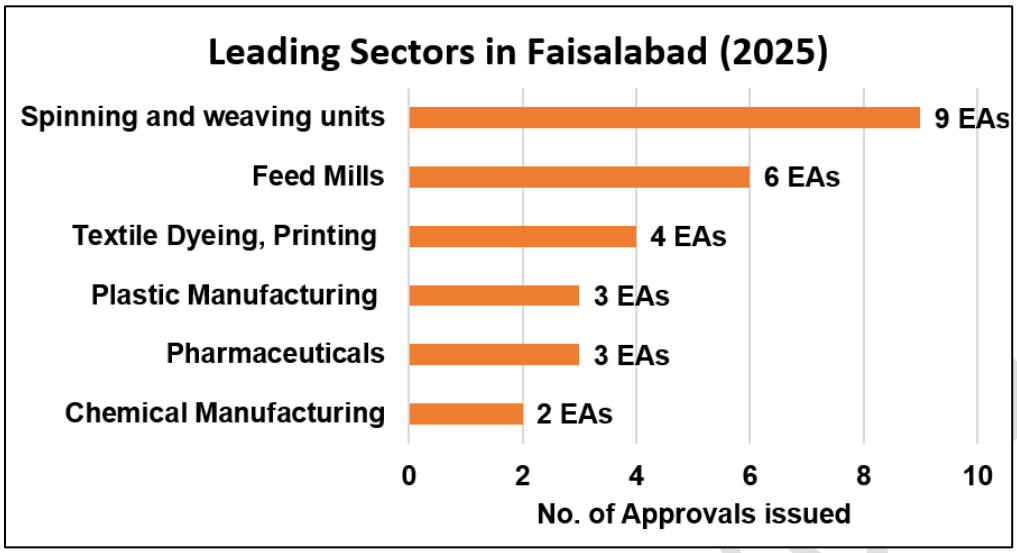

Figure 7.3: EA profile for Faisalabad

Sheikhupura, with 113 HQ applications (69 EIA and 44 IEE), reflects its character as a major manufacturing satellite of Punjab. Among EAs issued to the projects requiring EIA, textile manufacturing (dyeing) units, synthetic resins and allied mills, were the leading category with 5 EAs. Paper, board and packaging manufacturers and oil and gas storage facilities received 3 EAs each. The EAs issued to the projects requiring IEE (29) were led by plastics and synthetic product manufacturers (5) and textile spinning and weaving units (5), confirming Sheikhupura as a major hub for both polymer-based and fibre-based manufacturing.

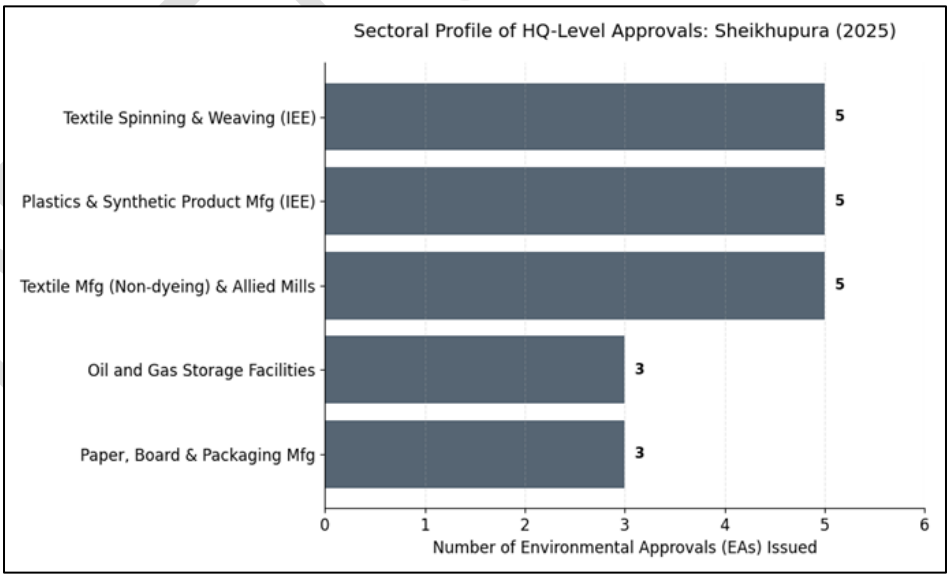

Figure 7.4: EA profile of Sheikhupura

Multan, with 72 HQ applications (20 EIA and 52 IEE), presents a distinctly different sectoral profile in the IEE categories. Food and beverage processing units dominated the IEE category with 7 EAs issued, the highest single food-sector figure among all districts. 3 EAs were granted to Plastics and synthetic manufacturers and packaging material producers each. Feed mills and poultry-related units received 3 EAs. Multan's dominance in food processing IEEs is consistent with its role as the commercial and agro-industrial capital of southern Punjab.

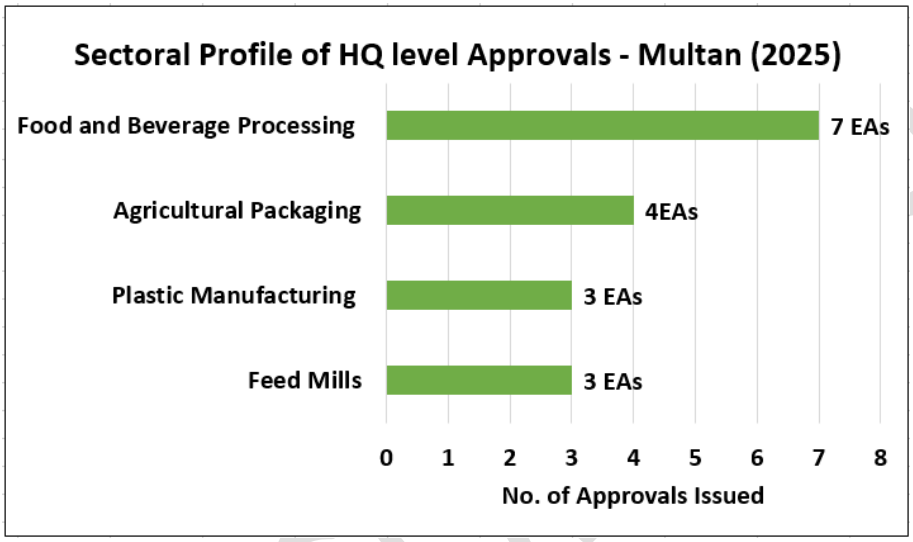

Figure 7.5: EA profile of Multan

Rawalpindi, with 54 HQ applications (34 EIA and 20 IEE), was dominated at EIA level by oil, gas and LPG storage facilities, which received 15 EAs issued. The remaining EIA NOCs covered miscellaneous industrial uses. The 9 EAs issued to the projects requiring IEE covered housing schemes and commercial buildings (4 EA) and plastic manufacturing (5 EAs). Rawalpindi's sectoral profile reflects its function as a strategic hub for peri-urban commercial development.

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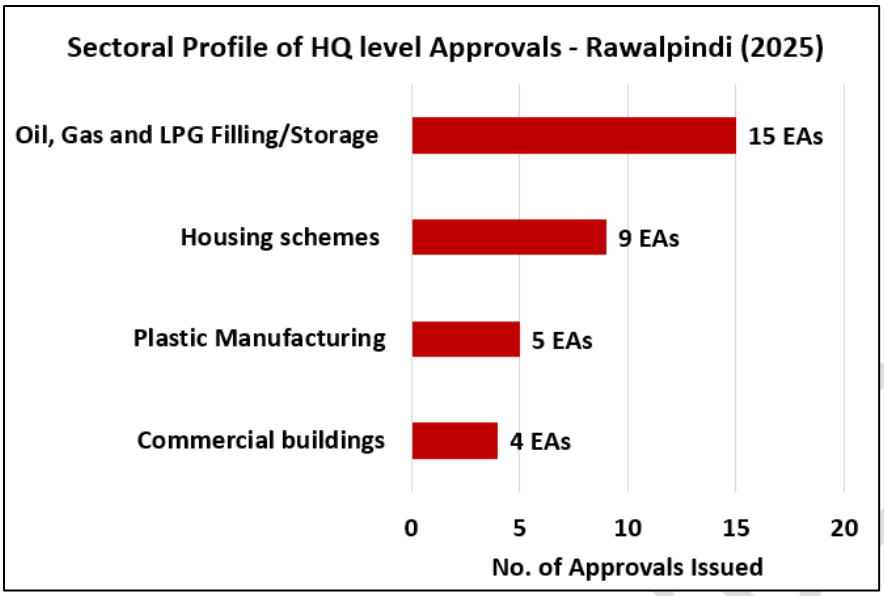

Figure 7.6: EA profile of Rawalpindi

Kasur, with 56 HQ applications (21 EIA and 35 IEE), received 12 EAs cross sectors including food and beverage processing (2), leather and tannery units (1) and oil and gas infrastructure (1) in the EIA categories. The16 EAs issued to the projects requiring IEE consisted of feed mills and poultry units (2 EAs), cables and steel fabrication (2 EAs), energy projects (2 EAs), scrap yards (2 EAs) and food processing (2 EAs). Kasur's profile reflects its dual character, a legacy leather-processing district transitioning towards a more diverse industrial base.

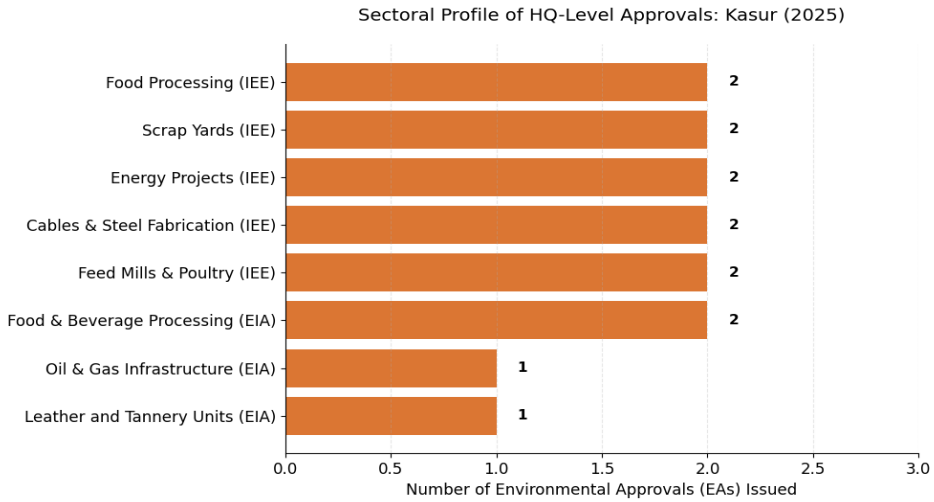

Figure 7.7: EA profile of Kasur

7.5 Divisional-Level Environmental Approvals Matrix

Divisional EACs, constituted under the chairmanship of Commissioners, evaluate a wider spectrum 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 EA matrix for all 10 divisions. Multan Division recorded the highest divisional volume with 144 applications and 108 approvals (75% approval rate), followed by Sargodha's 112 approvals out of 136 applications; 82.4% (the highest approval rate among large-volume divisions) and Sahiwal division with 70.27% approval rate (111 received, 78 approved). Gujranwala (58 approvals with 58 applications) and Gujrat divisions (51 approvals with 51 applications), both achieved 100% approval rates, a performance attributable to the standardized and well-documented nature of their predominantly poultry-sector submissions. At the other end, Rawalpindi Division (32.0% approval rate on 100 cases) and Lahore Division (32.1% on 56 cases) recorded the lowest throughput rates, reflecting the complexity of commercial real estate and large infrastructure projects that dominate these divisions' caseloads.

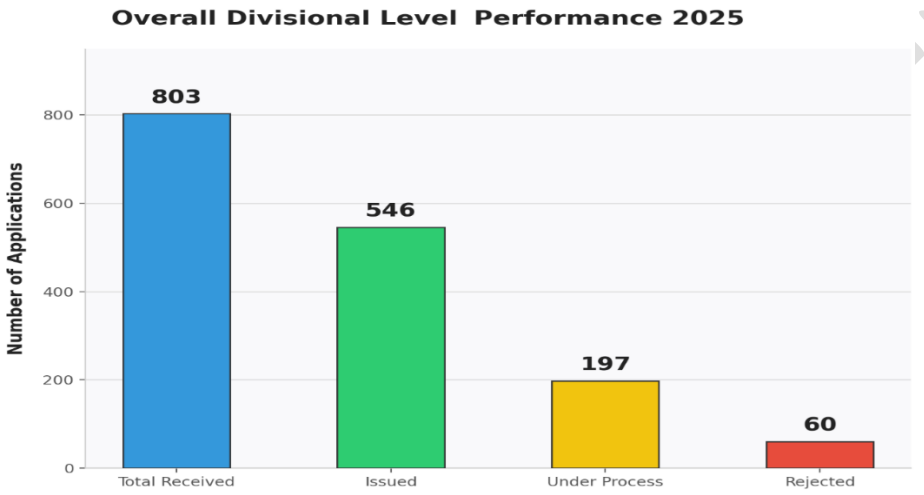

Figure 7.8: Overall divisional level performance

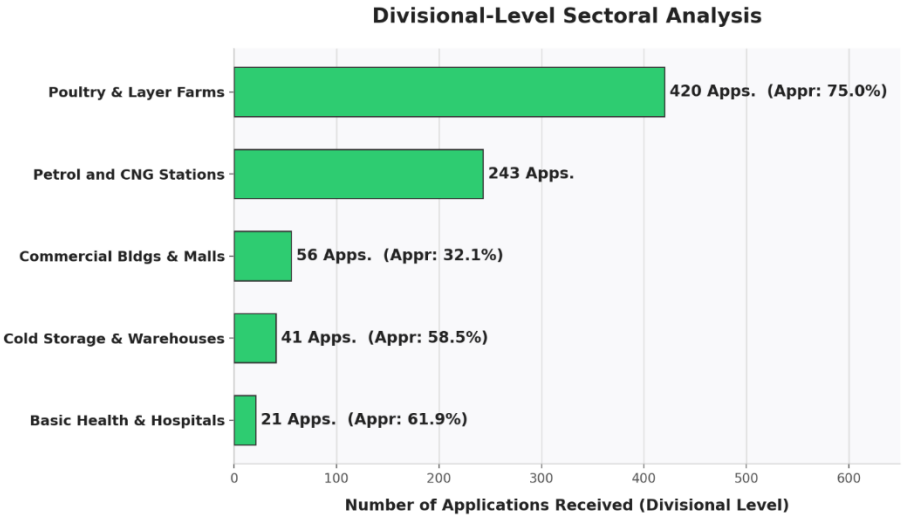

Figure 7.9: Divisional-Level Sector Breakdown

7.6 District-Level Environmental Approvals Matrix

The DEAC tier handles smaller projects under delegated powers, primarily in agro-processing, resource extraction and local commercial development. The complete district-wise EA matrix for cases processed by DEACs during 2025, covering all 38 districts of Punjab reveals that, of the 541 applications received, Mianwali recorded the highest district-level volume with 55 applications, all in the Mining and Mineral Processing category, followed by Bahawalnagar (53), Chakwal (52) and Khushab (50). Bahawalnagar district (50 of 53 approved cases) and Gujranwala (21 of 21 approved) demonstrated near-complete clearance of the cases, reflecting well-prepared submissions in the rice milling and agro-processing sectors. Six districts (Nankana Sahib, Okara, Bahawalpur, Mandi Bahauddin, Hafizabad and Sheikhupura) recorded cases approved in excess of applications received, indicating clearance of prior-year backlogs by their respective DEACs.

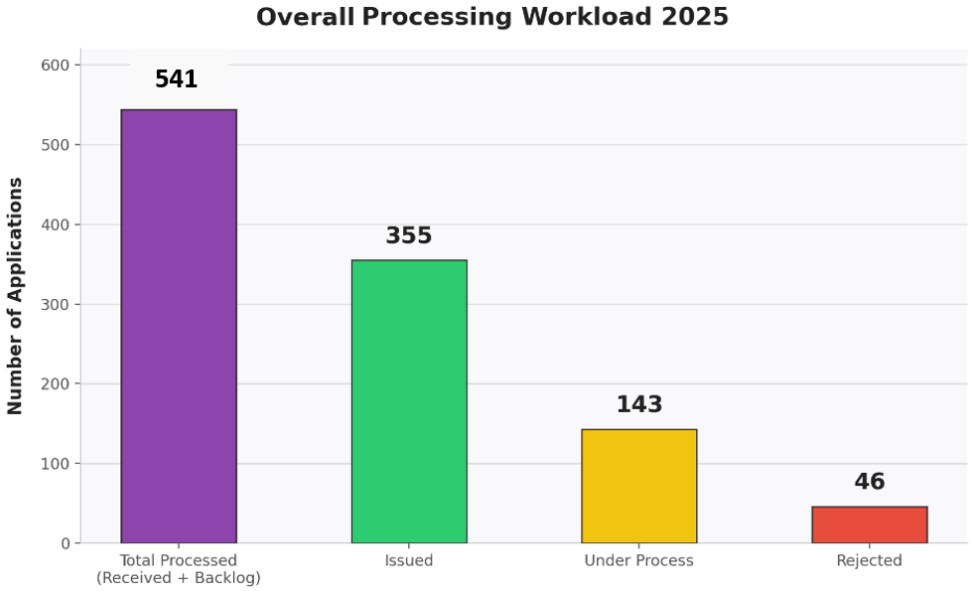

Figure 7.10: Overall district level performance

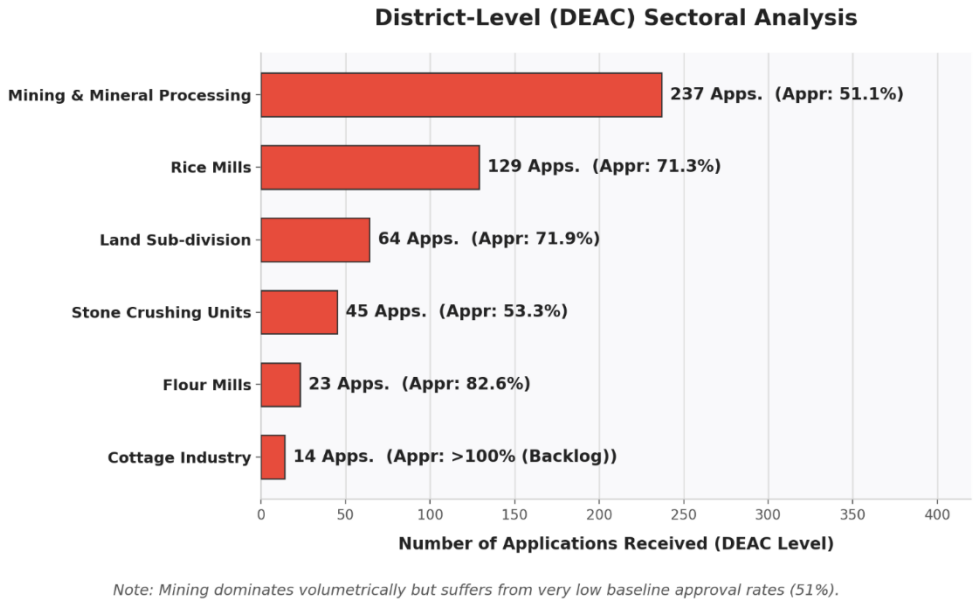

Figure 7.11: District-Level Breakdown

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 district and divisional levels, combined 1,347 applications were received and 901 EAs issued. The 340 cases under process are primarily driven by proponent non-responsiveness and land use clearance interdependencies, consistent with patterns observed in prior years.

7.7 Compliance status of environmental conditions

Environmental Approval granted under Section 12 of the Punjab Environmental Protection Act, 1997 is issued in two distinct phases - Construction phase and the Operational phase.

Environmental Approval for the construction phase is valid for a period of three years from the date of issuance. Upon completion of construction, or at any point within this three-year period if the project is completed earlier, the proponent is required to apply to EPA Punjab for Confirmation of Compliance under Regulation 13 of the Punjab Environmental Protection (Review of IEE and EIA) 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 duly fulfilled and seeks additional information where required. If the compliance status report is found satisfactory, Confirmation of Compliance is issued within fourteen days of receipt of the application, in line with the Government of Punjab's service delivery timelines for business facilitation.

The Confirmation of Compliance serves 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 set of conditions applicable to all project types, EPA Punjab incorporates project-specific conditions tailored to the nature and scale of each development. Construction-phase approvals for all projects require the installation of mist sprinkler systems to suppress dust generation. Housing schemes are required to install three-chamber septic tanks at each household to ensure appropriate domestic wastewater treatment at the source. Industrial units are required to plant between 500 and 2,000 indigenous trees (depending upon the area of the project) of six to seven feet in height within the project premises. Plastic manufacturing units are required to conform to the Punjab Environmental Protection (Manufacturing and Use of Single Use Plastic Products) Regulations 2023. All projects are mandated to plan, design, construct and operationalize a rainwater harvesting system within their premises for the 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, enabling systematic tracking of approved facilities across the Agency's regulatory database. Second, projects generating wastewater discharges or air emissions are now required to provide EPA Punjab with continuous CCTV access to their emission and discharge points, enabling real-time remote monitoring without dependence on periodic physical inspections alone.

During 2025, EPA Punjab has issued 403 Confirmations of Compliance/Environmental Approval for Operational Phase, each following verification of full adherence to all conditions of their respective Environmental Approval. This figure reflects both the volume of projects that successfully completed 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 installed, 164 Wastewater

DRAFT SOE 2025

Treatment Plants commissioned, 141 Rainwater Harvesting Systems installed, 150 Continuous Emission Monitoring Systems deployed, and 472 CCTV camera live accesses granted to EPA offices. Table showing the details is as under:

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**

DRAFT SOE 2025

7.8 Spatio-Temporal Governance

Spatio-temporal governance analysis examines how the EPA performed across space and over time regarding issuance of EAs. It highlights which administrative units processed cases efficiently, where rejections occurred, what caused delays and how 2025 compares with previous years at the Headquarters level.

7.8.1 Three-Year Trend at HQ Level - A Record-Breaking Performance

The most significant governance story of 2025 is the record volume of Environmental Approvals issued at HQ level. Table 6.5 presents the three-year comparison 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 32.4% increase over 2023 (840 EAs). Applications received also reached a record high of 974 in 2025, compared to 701 in 2024 and 740 in 2023, suggesting that the formal EA pathway is increasingly being used by proponents who previously may have operated without clearance.

The 2025 data reveals two concurrent record-breaking achievements at HQ level. First, applications received reached 974, the highest ever, indicating a sustained increase in compliance and regulatory demand. Second, E As issued reached 1,112, demonstrating that EPA HQ has not only absorbed the increased volume but has also cleared a substantial backlog from previous years. EAs issued to projects requiring EIA (536) exceeded EIA applications received (434) by 102, while EAs issued to IEE projects (576) exceeded IEE applications received (540) by 36, confirming that the backlog clearance component was driven primarily by the EIA stream.

The increase in applications received between 2024 and 2025, from 701 to 974, a rise of 38.9%, is particularly significant. This is not an artefact of improved data collection; it reflects a genuine increase in development activity and, importantly, in proponents' compliance with the EA requirement before commencing construction.

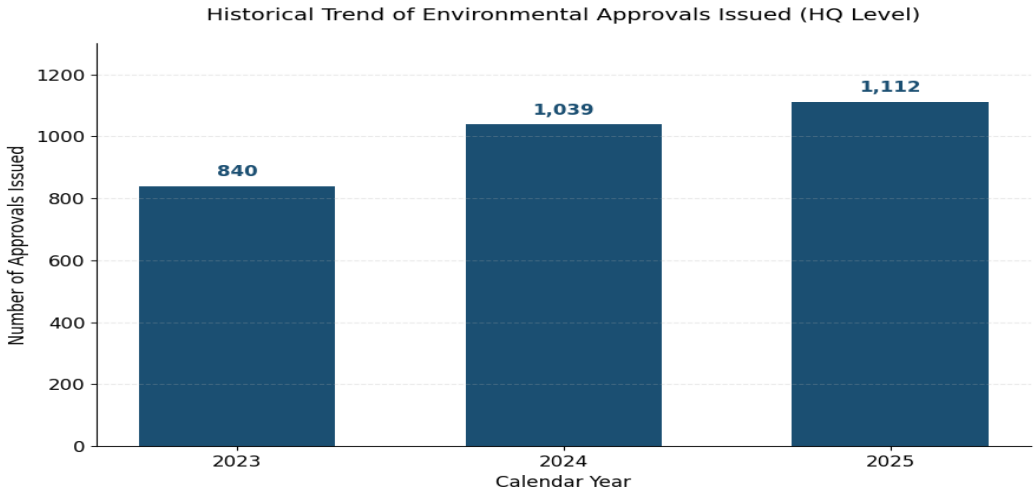

Figure 7. 12: Historical Trend of Environmental Approvals Issued (HQ Level)

7.9 Tier-wise Development Volume

EPA HQ absorbed the largest application volume of 974 applications, comprising of complex EIA projects (434) and smaller IEE projects (540). At Divisional level, 802 applications were received, whereas, the district tier handled 541 applications. In aggregate, Lahore, Sheikhupura and Faisalabad districts collectively contributed 407 HQ-level applications (41.7%), reflecting the industrial and commercial density of the central Punjab urban corridor.

At divisional level, Multan (144), Sargodha (136), Sahiwal (111) and Rawalpindi (100) divisions recorded the highest project developments, together accounting for 61.1% of all divisional cases. While at the district level, Mianwali (55), Bahawalnagar (53), Chakwal (52), Khushab (50) and Vehari (40) recorded the highest caseloads among the 38 districts.

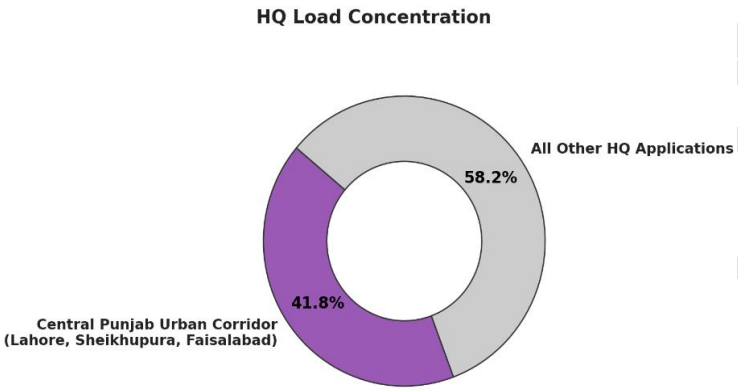

Figure 7.13: Load Concentration for HQ Projects

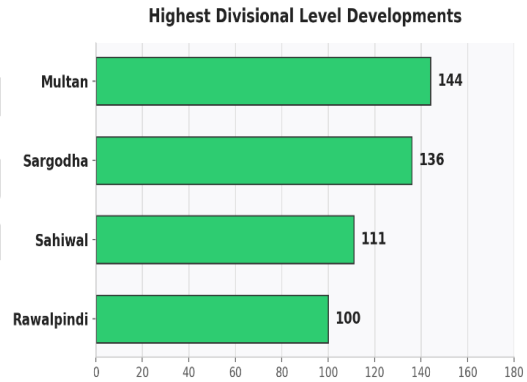

Figure 7.14: Highest Divisional Level Development

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, a contravention of Section 12 read with Section 17 of the Punjab Environmental Protection Act, 1997. The 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; upon payment of the assessed penalty and demonstration of environmental compliance, the units were brought within the regulatory fold and Environmental Approvals were subsequently issued. This enforcement action reflects EPA Punjab's commitment to ensuring that no industrial or commercial facility operates outside the legal framework of environmental oversight.

7.11 Rejection Patterns

The province-wide rejection rate at district and divisional tiers combined is 8.0% (106 rejections from 1,343 applications), indicating a functioning and not merely permissive, regulatory process.

DRAFT 2025

However, rejection rates vary substantially by geography and is due to EPA's refusal to approve unsuitable extraction sites in the Potohar terrain, projects that failed to meet location and safety criteria. This also represents the kind of preventive environmental governance the EA system is designed to provide.

Six divisions (Gujranwala, Gujrat, Bahawalpur, Sargodha, Faisalabad and Lahore) recorded no rejections. This suggests that projects either met the requirements or are still under review.

7.12 Pending Case Analysis

The 340 cases under process at district and divisional level at year-end are majorly due to proponent non-responsiveness, land use clearance interdependency, technical complexities of the cases, complaints and public grievances and referral to PET, whereby, 113 IEE and EIA cases of HQ level have been referred to the Punjab Environmental Tribunal for prosecution upon violation of Sections 12, 13, or 16 of the IEE/EIA Regulations 2022. These involve proponents who commenced construction or operation of their unit without obtaining Environmental Approval, or failed to seek an extension before expiry of their three-year EA validity period.

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 change throughout its operational lifespan. **This section shows the total pollution risk from the 2025 Environmental Approvals and highlights areas where pollution could exceed the environment's capacity.**

i. Sector-Specific Pollution Profiles

The 2025 approval portfolio encompasses several pollution-intensive sectors whose cumulative environmental burden warrants proactive monitoring and post-approval inspection. The following sectors carry the highest pollution significance.

Oil, Gas and LPG Storage, with 85 EIAs approved, is the largest single EIA sector and carries risks of hydrocarbon spills, volatile organic compound emissions, underground fuel contamination and fire hazard. The geographic concentration of LPG and petroleum storage facilities in Rawalpindi, Lahore and Faisalabad creates a cumulative exposure risk that warrants clustered inspection programming by EPA's field enforcement teams.

Textile Dyeing and Printing (37 EIAs) and Chemical Manufacturing (33 EIAs) are process industries generating high organic pollutant loads, heavy metal effluents and particulate matter. Their concentration in the Lahore-Sheikhupura-Faisalabad-Kasur corridor creates one of Punjab's most significant industrial effluent corridors, placing pressure on receiving water bodies including the Ravi and Chenab river systems and their associated groundwater aquifers.

DRAFT SOE 2025

Pharmaceuticals (30 EIAs) generate effluents containing active pharmaceutical ingredients at sub-therapeutic concentrations, which are associated with antimicrobial resistance development in receiving water bodies. Pharmaceutical clusters in Lahore, Sheikhupura, Faisalabad and Rawalpindi require targeted effluent monitoring programmes integrated with EPA Punjab's existing pharmaceutical compliance inspections.

Coal Exploration (56 IEEs) drives water table disruption, acid drainage, dust generation and slope destabilization in the coal-bearing districts of DG Khan, Chakwal and Khushab. The concentration of coal exploration IEEs in DG Khan (20 cases) in 2025 is particularly significant, representing a new frontier of coal development in southern Punjab with potentially significant long-term hydrological and ecological impacts.

Controlled Environment Poultry and Layer Farms (315 Div EAC approvals), with ammonia as the primary pollutant, create cumulative air quality impacts in the poultry-dense divisions of Sargodha and Multan. Litter management, groundwater nitrate contamination and biosecurity-related disease risk are secondary concerns that require standardised post-approval compliance protocols.

Mining and Mineral Processing (121 DEAC approvals) generates dust (PM10 and PM2.5), mine drainage and slope instability, particularly in the Salt Range districts. The relatively low approval rate in this category (51.1%) reflects EPA's stringent review posture, but the 121 approved sites

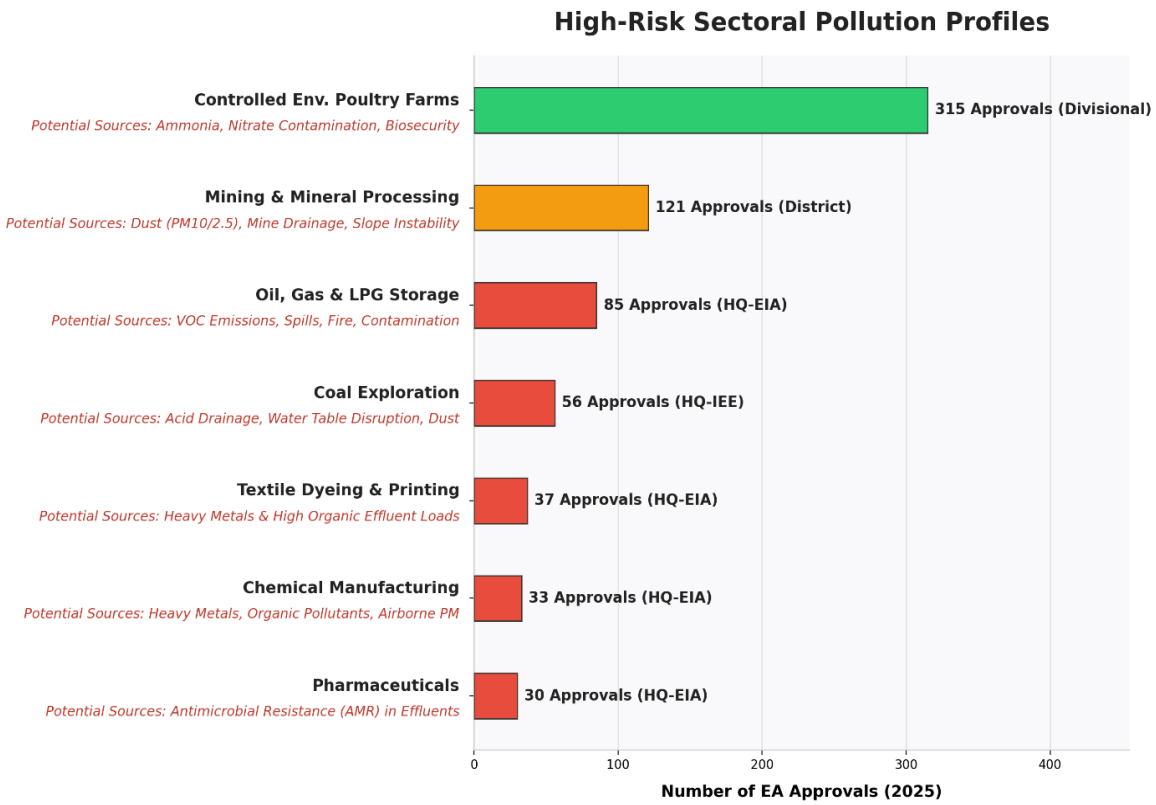

Figure 7.15: High Risk Sectoral Pollution Profiles

represent a significant incremental addition to the existing pollution burden in Mianwali, Khushab and Chakwal.

Table 7.2 presents the estimated annual greenhouse gas emissions from 13 industrial categories using internationally recognised emission factors derived from sources such as the Intergovernmental Panel on Climate Change, International Energy Agency, United Nations Industrial Development Organization and United Nations Environment Programme. The total estimated emissions from 166 industrial units are approximately 3,042.5 kt CO_2e annually, indicating a significant industrial carbon footprint. The analysis shows that a small number of heavy industries contribute the majority of emissions. The cement plant alone accounts for about 900 kt CO_2e, making it the largest contributor, 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 categorised as high-load industries due to their energy-intensive operations and process emissions. Moderate-load industries, including apparel, paper and pulp, glass manufacturing and chemical formulation units, also contribute substantially because of the large number of operational units. In contrast, leather, beverage and dairy manufacturing units show comparatively lower emissions. Overall, the table highlights that industrial emissions are concentrated within a few carbon-intensive sectors, emphasising the need for cleaner production technologies, energy efficiency measures and stronger environmental oversight to support 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	Beverages 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	Fertilizer 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

DRAFT SOER 2025

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 has been balancing the intended pollution load through environmental approval conditionalities in order to manage the cumulative environmental burden arising from the 2025 project portfolio. Given the concentration of pollution-intensive sectors in already stressed districts, the imposition of stringent sector-specific conditions at the approval stage can serve as a proactive tool to offset incremental impacts. These conditionalities included mandatory installation of advanced effluent treatment systems, zero liquid discharge requirements for high-risk industries such as textile dyeing and chemicals, vapor recovery systems for oil and gas storage and standardised waste management protocols for poultry and mining operations. Furthermore, conditional approvals require cumulative impact assessments, tree plantations, groundwater monitoring and periodic environmental audits by agency can ensure that economic development does not exceed the carrying capacity of local ecosystems. The pollution risk of the projects with respect to numbers is tabulated under as a pollution risk index the categorization is between high to moderate risk for projects.

EPA in order to assess spatial redistribution of pollution-intensive projects is aligning its process with the concerned zoning regulations and Punjab Land Use and Reclassification Rules in order discourage further concentration of hazardous industries in already stressed districts and instead guide new developments towards less environmentally sensitive areas, provided adequate safeguards are in place.

In coal and mining regions such as DG Khan, Chakwal and Khushab regulators are now required to submit comprehensive mine closure and land rehabilitation plans, along with groundwater monitoring and slope stabilization measures. In poultry-dense regions like Sargodha and Multan, standardised guidelines for litter management, nutrient recycling and biosecurity will be enforced to minimise cumulative impacts on air and water quality considering the increased. While the Pollution Risk Index highlights the environmental pressures and potential risks associated with development activities, it is equally important to evaluate the socio-economic contributions generated through environmental approvals.

DRAFT SOE 2025

7.15 Socio Economic Benefit from the Environmental Approvals

The Controlled Environment Poultry and Layer Farms sector, with 315 Div EAC approvals, underpins food security and rural economic development. Poultry operations in Sargodha and Multan divisions ensure a steady supply of meat and eggs to urban and rural populations, stabilizing local food markets. The sector generates employment across the value chain, from farm labor and feed production to processing, distribution and retail. By providing income opportunities in rural areas, poultry farming strengthens livelihoods, encourages entrepreneurship and supports ancillary industries such as transport, veterinary services and feed manufacturing, delivering broad socio-economic benefits to communities.

The Mining and Mineral Processing sector, with 121 DEAC approvals, is a key contributor to regional infrastructure and industrial development. Mining operations in the Salt Range districts of Mianwali, Khushab and Chakwal supply raw materials critical for construction, manufacturing and industrial applications. These projects create jobs in extraction, processing and transport while supporting local service sectors. By promoting investment in these regions, the sector contributes to regional economic diversification, infrastructure development and overall 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 EIAs approved in 2025, represents a critical pillar of Punjab's energy infrastructure. These facilities ensure a stable supply of petroleum products and LPG, which is essential for both industrial and domestic use. Beyond energy security, the sector generates significant employment opportunities, ranging from technical roles in facility management and maintenance to logistics and supply chain operations. The geographic concentration of facilities in Rawalpindi, Lahore and Faisalabad also stimulates local economies, supporting ancillary businesses such as transportation, equipment servicing and construction, creating a network of socio-economic benefits that extend beyond the core facilities.

The Coal Exploration sector, represented by 56 IEEs, contributes to Punjab's energy security by expanding domestic coal production, supporting electricity generation and industrial fuel needs. In southern Punjab districts such as DG Khan, Chakwal and Khushab, coal development has created new employment opportunities, including mining operations, logistics and local services. Infrastructure development associated with mining operations such as roads, electricity and water supply further stimulates local economies. As a new frontier of coal development, this sector also attracts investment, offering long-term socio-economic benefits for 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 along Lahore, Sheikhupura, Faisalabad and Kasur. These sectors are vital contributors to export revenues, supporting the country's trade balance and GDP growth. They provide employment for a diverse workforce, from skilled technicians and chemical engineers to semi-skilled laborers involved in production lines. Investment in modern manufacturing technologies within these

DRAFT SOE 2025

sectors fosters innovation, improves productivity and enhances competitiveness in global markets, 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 industry development. By producing essential medicines locally, this sector reduces dependence on imports and strengthens national health security. It offers high-value employment for scientists, laboratory technicians and regulatory professionals, promoting skill development in the knowledge-intensive economy. Concentrated clusters in Lahore, Sheikhupura, Faisalabad and Rawalpindi facilitate efficient supply chains, enhancing both domestic medicine availability and potential export opportunities, thereby contributing to economic resilience and regional prosperity. This is tabulated in the table below:

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

DRAFT SOE 2025

7.16 Recent Developments

The year 2025 also marks a structural transformation in the operational architecture of environmental governance in Punjab. The eBiz portal became operational on 15 January 2026 and is designed to replace the predominantly manual, paper-based and partially digital (due to Business Facilitation Centre) processing system to a fully integrated digital platform through the eBiz Portal. This shift 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 case progress in real time while simultaneously improving internal accountability across reviewing tiers. The portal's embedded timelines and digital communication channels have also contributed to faster query resolution and reduced administrative lag. Under the new system, a structured two-week review cycle has been introduced, reducing the administrative processing target for Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) applications from 45 and 30 days, respectively, to 14 days. In addition, the traditional pay order mechanism has been replaced with a secure **online fee payment system**, allowing applicants to conveniently pay processing fees through digital channels. This not only enhances ease of doing business but also improves financial transparency and record-keeping. eBiz is positioned to become the backbone of a fully digitised, data-driven environmental regulatory regime in Punjab.

7.17 Conclusion

Punjab's environmental governance in 2025 reached its highest performance under the framework of PEPA 1997 and the IEE/EIA Regulations 2022. A total of 2,317 applications were filed across headquarters, divisional and district tiers, with 2,013 approvals issued. Headquarters handled the largest share, processing 974 applications and issuing 1,112 approvals, a record-breaking achievement that also cleared backlogs from previous years. Lahore led in volume with diverse industrial projects, Faisalabad was dominated by textiles, Sheikhupura by plastics and fibre-based manufacturing, Multan by food processing, Rawalpindi by petroleum storage and Kasur by a mix of leather and agro-industrial units. At the district level, mining and rice mills were the most prominent categories, while divisional committees mainly processed poultry farms, fuel stations and commercial buildings.

Development pressures clustered into four zones: the Central Punjab industrial corridor with textiles, chemicals and pharmaceuticals; the Salt Range mineral zone with mining and stone crushing; the southern agro-industrial belt with rice, flour, oil mills and poultry; and peri-urban Rawalpindi and Chakwal with real estate and fuel infrastructure. Sectoral trends showed oil and gas storage, textile dyeing, chemicals, pharmaceuticals and coal exploration as major HQ-level activities, while poultry farms and petrol stations dominated divisional approvals. District

DRAFT SOE 2025

committees struggled with mining proposals due to inadequate baseline data, resulting in a relatively low approval rate.

Spatio-temporal analysis highlighted a steady increase in compliance, with applications rising nearly 39% from 2024 to 2025. Rejections were concentrated in unsuitable mining projects, while pending cases often reflected proponent delays or land clearance issues. The province-wide rejection rate of 8.0% at the district and divisional levels confirms a functioning, non-permissive regulatory process rather than a purely facilitative approval regime. In parallel, 113 units were referred to the Punjab Environmental Tribunal for operating without obtaining the requisite Environmental Approval, demonstrating continued enforcement against non-compliant projects. Pollution load balancing emerged as a critical concern, with oil and gas facilities, textile dyeing, chemical manufacturing, pharmaceuticals, coal exploration, poultry farms and mining identified as high-risk sectors. EPA sought to mitigate these impacts through conditional approvals and stricter monitoring, underscoring the balance between development and environmental safeguards in Punjab's most intensive regulatory year to date.

DRAFT SOE 2025

Chapter No. 8: Pollution Risk Analysis of Ecological Site

8.1 Introduction

Across the developing world, the accelerating pace of industrial growth has intensified a fundamental tension between economic progress and ecological integrity. As nations strive to expand their industrial base and generate employment, the natural systems that underpin long-term human well-being clean water, fertile soils, biological diversity a stable climate face mounting pressure from pollution, habitat fragmentation the unchecked conversion of natural landscapes. The challenge is not simply one of competing interests; it is, at its core, a question of whether short-term industrial gains can be pursued without permanently foreclosing the ecological foundations upon which future generations will depend.

Pakistan, especially Punjab in particular, exemplifies this challenge. As the country's most populous and economically productive province, Punjab hosts a vast network of industrial estates, manufacturing clusters small-scale production units that have expanded considerably over the past two decades. This industrial growth has been vital to employment generation and economic output; however, it has occurred largely without systematic regard for the ecological sensitivities of surrounding landscapes. Rivers, wetlands, forests wildlife habitats many of them carrying national and international conservation significance have been subjected to incremental yet cumulative degradation as industrial pressures encroach ever closer upon their boundaries.

It is within this context that the concept of Ecologically Sensitive Zones (ESZs) has emerged as a critical instrument of environmental governance. ESZs are geographically defined areas recognised for their exceptional biodiversity, ecological fragility, the irreplaceable ecosystem services they provide. They encompass a wide range of environments from river corridors and protected wetlands to reserved forests, groundwater recharge zones nationally designated parks and biosphere reserves. Among the most internationally prominent categories of protected ecological areas are Ramsar Sites, which are wetlands of global significance listed under the Ramsar Convention on Wetlands. Several such sites lie within Punjab's boundaries and are examined in detail in later sections of this chapter.

Despite their recognised importance, Ecologically Sensitive Zones (ESZs) in Punjab have historically lacked the spatially informed regulatory oversight necessary to manage the cumulative pressures arising from surrounding industrial activity. In response, the Environmental Protection Agency (EPA) Punjab has undertaken a strategic initiative to systematically map industrial clusters operating in close proximity to these sensitive ecological areas. This initiative marks a significant transition from reactive, case-by-case enforcement towards evidence-based spatial planning and precautionary environmental governance.

The initiative is grounded in the broader understanding of the ecological, environmental and socio-economic significance of ESZs and the growing need to integrate spatial intelligence into environmental regulation. It further aligns with the regulatory framework governing

DRAFT SOE 2025

Environmental Impact Assessments (EIAs), No Objection Certificates (NOCs) and sustainable industrial planning in Punjab.

Spatial analyses have been conducted for seven major ESZ locations across the province, including internationally recognised Ramsar wetlands, EPA-notified ecologically sensitive areas and protected forest reserves. The findings reinforce that systematic spatial mapping of industrial activity near ESZs represents a foundational step towards strengthening evidence-based environmental governance, precautionary planning and alignment with international sustainability and conservation frameworks.

8.2 Ecologically Sensitive Sites in Punjab

Punjab contains a diverse range of ecologically sensitive sites including wetlands, protected forests, riverine ecosystems, wildlife habitats, biodiversity hotspots and environmentally fragile landscapes. These areas perform critical ecological functions such as groundwater recharge, flood regulation, carbon sequestration, habitat protection and climate regulation. Several of these locations are also internationally recognised under conservation frameworks such as the Ramsar Convention on Wetlands, while others have been notified or protected under provincial environmental, forestry and wildlife management regimes.

Due to increasing industrialisation, urban expansion, land-use change and pollution pressures, these ecologically significant areas require strengthened spatial planning, precautionary environmental regulation and evidence-based environmental governance.

8.3 Criteria for Declaration as Ecological Sensitive Zones

Ecologically Sensitive Zones are geographically defined areas recognised for their high ecological value and heightened vulnerability to environmental degradation. They are characterized by one or more of the following attributes:

- Exceptional biodiversity, including the presence of endemic, rare, threatened, or endangered species of flora and fauna.
- Critical ecosystem functions such as groundwater recharge, flood regulation, carbon storage and soil stabilization.
- Ecological fragility, defined as a low threshold of tolerance for physical, chemical, or biological disturbance.
- High connectivity within ecological corridors essential for wildlife movement and genetic exchange.
- Cultural, spiritual, or scenic significance that is intertwined with natural processes.

DRAFT SOE 2025

- Proximity to protected areas, wetlands of international importance (Ramsar sites), or biosphere reserves.[63]

8.4 Classification of Ecologically Sensitive Zones in Punjab

Punjab, Pakistan's most populous and industrialised province, harbors a diversity of ecologically sensitive landscapes despite its predominantly agrarian and urban character. These include:

- **Riverine and riparian zones:** The Ravi, Chenab, Jhelum, Sutlej and Beas river corridors and their associated floodplains support rich biodiversity and perform critical hydrological functions.
- **Protected forest areas:** Reserved and protected forests across the Pothohar Plateau and Salt Range are fragile ecosystems with limited regenerative capacity.
- **Wetlands and waterbodies:** Sites such as Chashma Barrage, Head Islam and numerous smaller wetlands serve as critical habitats for migratory and resident avifauna.
- **Groundwater recharge zones:** Certain alluvial plains function as primary recharge zones for underlying aquifers, making them sensitive to contamination and land-use change.
- **Peri-urban green corridors:** Natural and semi-natural vegetation belts surrounding urban centres that moderate microclimates and support urban biodiversity.[64]

DRAFT SOE 2025

[63] Guidelines for Sensitive and Critical Area- Pak EPA
[64] The Punjab Protected Areas Act 2020

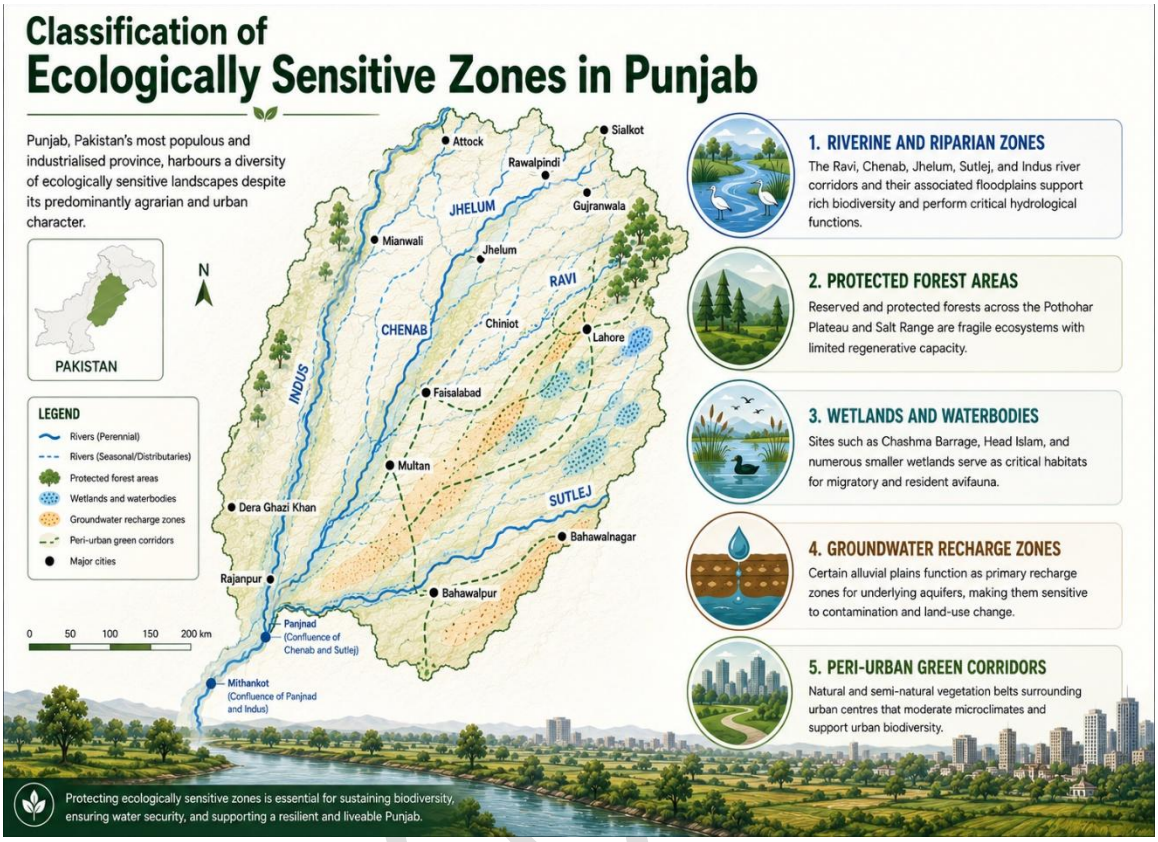

Figure 8.1: Classification of Ecological Sensitive Zones in Punjab

8.5 Significance of the Ecological Sensitive Zones

ESZs function as refugia for species that cannot persist within the altered landscapes of agricultural fields, urban centres, or industrial zones. They sustain genetic diversity within wild populations, preserve evolutionary processes support the ecological networks upon which food security and ecosystem stability depend. In Punjab, where natural habitats have been extensively modified, residual ESZs represent disproportionately high conservation value relative to their geographic extent. Furthermore, the degradation of ESZs carries profound socio-economic repercussions that extend far beyond the immediate ecological loss. Rural and peri-urban communities in Punjab are substantially dependent on ecosystem services for their livelihoods, food security and health outcomes. The contamination of riparian zones by industrial effluents, for example, directly diminishes agricultural productivity, potable water availability and fisheries yields, thereby impoverishing communities that have historically depended on these resources. Additionally, failure to adequately protect ESZs may expose regulatory authorities and industrial proponents to legal liability, challenge the legitimacy of development approvals invite interventions by superior courts, which have increasingly demonstrated willingness to adjudicate on environmental matters.

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8.5.1 Ramsar Sites: Wetlands of International Importance

The Ramsar Convention on Wetlands, formally adopted in the Iranian city of Ramsar in 1971, is one of the oldest and most widely ratified intergovernmental environmental treaties in the world. It provides the principal international framework for the conservation and sustainable use of wetlands, recognising them as ecosystems of extraordinary ecological, economic, cultural and scientific recreational value. A wetland earns designation as a "Ramsar Site" when a signatory government formally lists it under the Convention on the basis of meeting at least one of nine internationally established criteria relating to its ecological, botanical, zoological, limnological, or hydrological significance.

Pakistan acceded to the Ramsar Convention in 1976 and currently maintains nineteen listed Ramsar Sites, collectively covering approximately 1.34 million hectares. These sites span a diverse range of wetland types, including coastal mangroves, high-altitude mountain lakes, and river delta systems inland freshwater and brackish wetlands. Together, they support millions of migratory waterbirds traversing international flyways, serve as breeding and feeding grounds for numerous threatened fish and bird species provide critical water regulation and flood buffering services to the communities that surround them.

Within Punjab, two wetland complexes carry formal Ramsar Site designation and are directly relevant 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 unique brackish-saline chemistry and its function as a critical wintering sanctuary for thousands of migratory birds navigating the Central Asian Flyway. Jahlar Lake, similarly endorheic in character meaning it has no natural outlet provides irreplaceable refuge for the globally endangered White-headed Duck. Both lakes are also designated as EPA-Notified Sensitive Areas under Pakistani environmental law and are examined in detail in Sections 8.6.3 and 8.6.5, respectively.

Ramsar Site designation carries significant regulatory implications under Pakistan's environmental law. It triggers the highest level of scrutiny in the Environmental Impact Assessment process, strengthens the legal basis for EPA-issued NOCs and siting restrictions aligns national environmental governance with Pakistan's binding obligations under international conservation law. For the purposes of EPA Punjab's industrial cluster mapping initiative, Ramsar Sites represent among the highest-priority categories of ESZs warranting proactive monitoring, precautionary buffer management stringent enforcement of existing development prohibitions

8.5.2 EPA Punjab's Initiative: Mapping Industrial Clusters around Ecologically Sensitive Zones

EPA Punjab's decision to undertake systematic mapping of industrial clusters in proximity to ecologically sensitive zones (ESZs) is grounded in the recognition that effective environmental regulation must be spatially informed. Without comprehensive knowledge of the geographic

DRAFT SOE 2025

relationship between industrial pollution sources and ecologically vulnerable receptors, regulatory interventions remain necessarily reactive, piecemeal and insufficient.

The initiative pursues five primary objectives: establishing a comprehensive spatial database of industrial establishments operating within defined buffer zones around identified ESZs across Punjab; characterizing the nature, scale and pollution profile of industrial clusters with respect to effluent generation, emissions, solid waste and land-use intensity; assessing cumulative environmental loads on ESZs attributable to proximate industrial activity; identifying regulatory gaps, including unregistered or non-compliant units operating without valid environmental authorisations; and generating 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 directly enrich the baseline data requirements embedded within EIA processes. Proponents seeking environmental approvals for new or expanded industrial projects near ESZs will be required to consult the ESZ-industrial cluster database as part of their baseline environmental characterization. This will ensure that EIA reports accurately account for existing cumulative pollution burdens, rather than treating the project environment as a pristine baseline a methodological shortcoming that has historically undermined the reliability of EIAs in Pakistan.

ii. **No Objection Certificates (NOCs) and Siting Decisions:** The mapping data will provide a robust empirical foundation for NOC issuance decisions, enabling EPA Punjab to impose location-specific conditions, restrict the establishment of particularly polluting industries within critical buffer zones and apply the precautionary principle with greater precision. Industries seeking to locate within identified sensitive buffer zones will face more stringent scrutiny, enhanced monitoring requirements, where appropriate, outright restrictions on categories of activity deemed incompatible with ESZ integrity.

iii. **Cumulative Impact Management:** One of the initiative's most significant contributions is its potential to enable cumulative impact assessment a dimension of environmental governance that remains markedly underdeveloped in Pakistan. Cumulative impacts arise when the incremental effects of individual projects, each potentially within permissible thresholds, aggregate into significant ecological harm. By maintaining a dynamic, spatially referenced database of industrial activity around ESZs, EPA Punjab will be positioned to identify cumulative pollution hotspots, assess total pollutant loading to ESZ receptors set aggregate emission caps that prevent the progressive deterioration of sensitive ecosystems.

iv. **Compliance Monitoring and Enforcement:** The mapped database will serve as a prioritisation tool for EPA Punjab's inspection and enforcement activities. By identifying industrial clusters in close proximity to ESZs, the agency can allocate its enforcement resources more strategically, directing audits towards facilities whose non-compliance poses the greatest risk to high-value environmental receptors. This risk-based approach represents a meaningful operational improvement over the prevailing ad hoc inspection regime.

DRAFT SOE 2025

8.6 Proximity Assessment: Industrial Impact on Ecological Sensitive Zones

The spatial analysis conducted across Punjab's identified ESZ buffer zones depicting industrial concentration, cluster typology and proximity-based pollution risk are discussed as under:

8.6.1. Lal Suhanra National Park, Bahawalpur

Lal Suhanra National Park stands as a premier conservation site and the first UNESCO-declared Biosphere Reserve in Pakistan. Its global environmental significance is rooted in its rare convergence of three distinct ecosystems. It serves as a "living laboratory" for UNESCO's Man and the Biosphere (MAB) programme, testing sustainable desert management and eco-tourism models. The national park has existing 52 industrial units within 15 Km radius and 216 brick kilns within 25 Km which represents a significant concentration of existing industrial and brick kiln activity. The high concentration of brick kilns in particular poses substantial risks of air and soil pollution to this protected biodiversity zone and requires thorough assessment and strategic planning of new development projects. The map showing the industrial and brick kilns around the park is shown in the figure below:

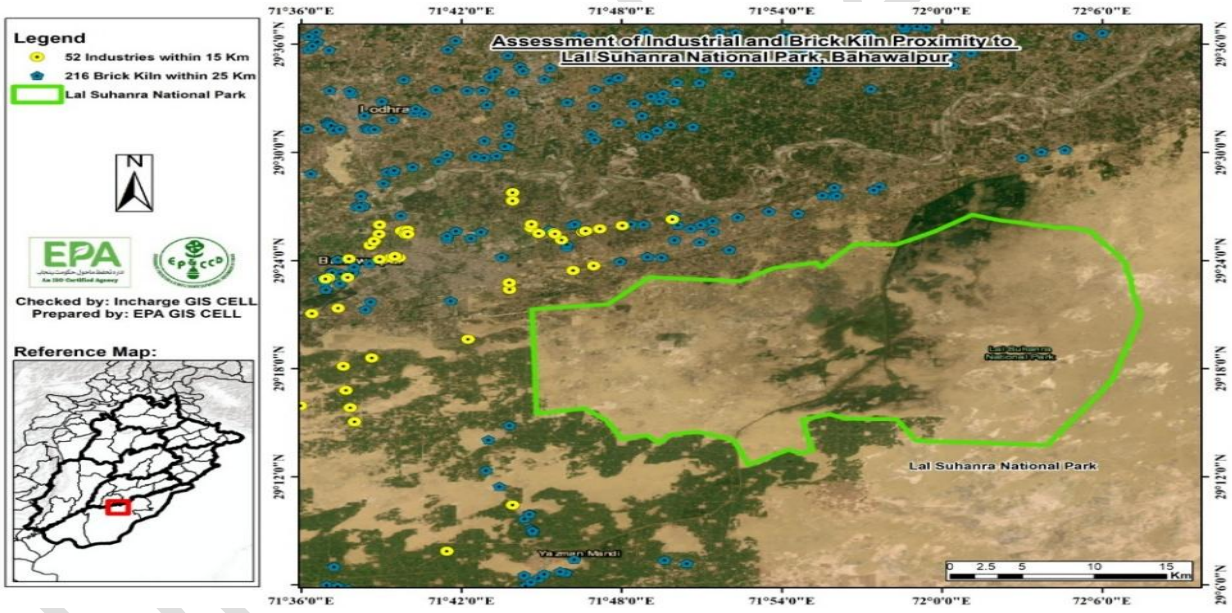

Figure 8.2: Industrial and Brick Kilns Cluster around Lal Suhanra National Park

8.6.2. Changa Manga Plantation Forest, Kasur

The environmental significance of Changa Manga is increasingly defined by its role as a defensive ecological barrier against severe industrial encroachment. Located in the Kasur District, the forest is currently surrounded by 108 industries and 152 brick kilns within a 15-km radius, creating an intense "industrial ring" that subjects the ecosystem to extreme particulate emissions and chemical pollutants. The co-location of these high-emission industries poses an existential threat to the forest

through air pollution, heavy metal deposition in the soil a heightened risk of illegal deforestation for industrial expansion.

To ensure the survival of Changa Manga against the surrounding industrial density, the Punjab Environmental Protection Agency (EPA) enforces a rigorous regulatory framework centred on

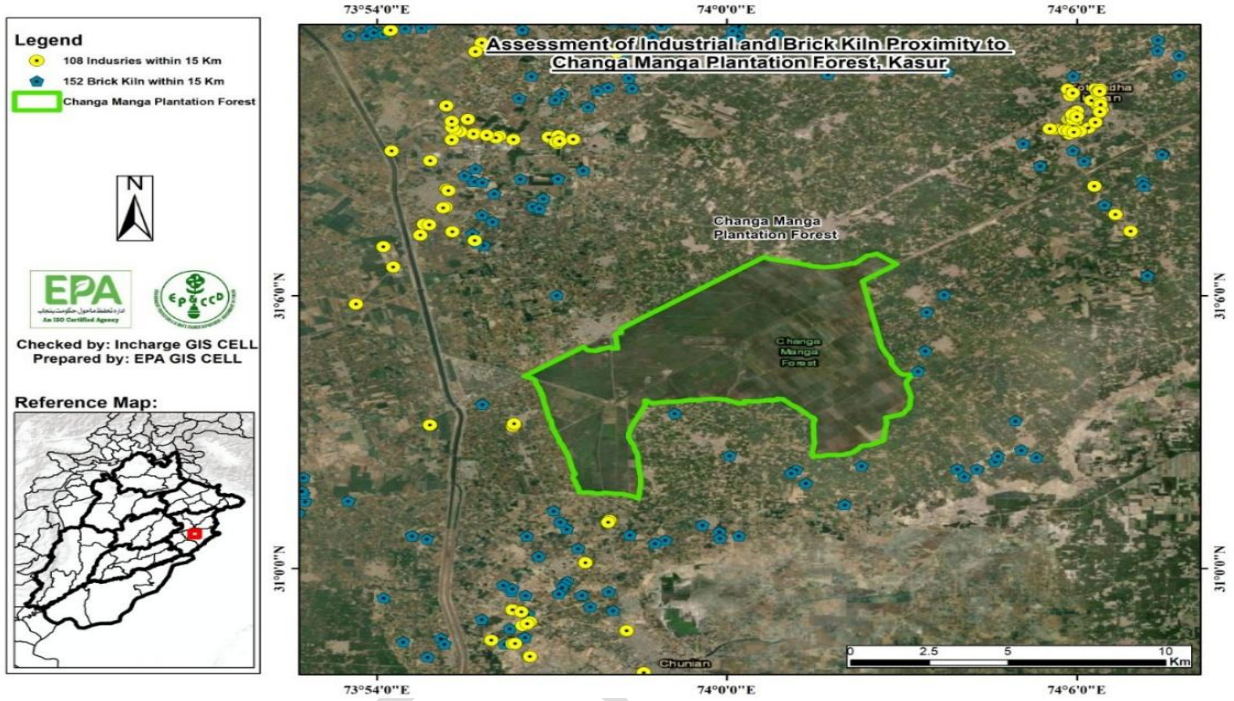

Figure 8.3: Industrial and Brick Kilns Clusters around Changa Manga Plantation Forest

technological mandates and spatial containment. A primary pillar of this strategy is the compulsory conversion of the 152 neighboring brick kilns to Zigzag Technology, a design that optimises airflow to significantly reduce coal consumption and cut emissions. Beyond the kilns, the EPA mandates that the 108 nearby industries adhere to the Punjab Environmental Quality Standards (PEQS) by installing air pollution control systems, such as scrubbers and precipitators, to prevent toxic deposition on the forest canopy. To further mitigate the "industrial ring" effect, the EPA has soon to introduce established Ecological Buffer Zones around clustered industrial units to maintain their own green belts to act as biological filters. The map describing the same is shown below:

8.6.3. Uchali Lake, Soon Valley (EPA-Notified Sensitive Area)

Uchali Lake, a centerpiece of the Soon Valley in Khushab, is an internationally recognised Ramsar Site and a legally protected EPA-Notified Sensitive Area. Its environmental significance is rooted in its role as a vital winter sanctuary for thousands of migratory birds navigating 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 heavy restrictions on agricultural runoff to preserve its delicate brackish-saline chemistry. Because the lake is an endorheic basin meaning it has no natural outlet the EPA treats it as a high-risk zone for toxic

accumulation, utilising real-time monitoring and zoning regulations to balance its hydrological fragility with controlled ecotourism. This status ensures that any proposed project in the vicinity must undergo the most rigorous level of environmental scrutiny to prevent the irreversible degradation of one of Pakistan's most unique high-altitude wetland ecosystems. Currently 7 industrial units exist within 15 Km of radius of the lake which has been geographically mapped as under:

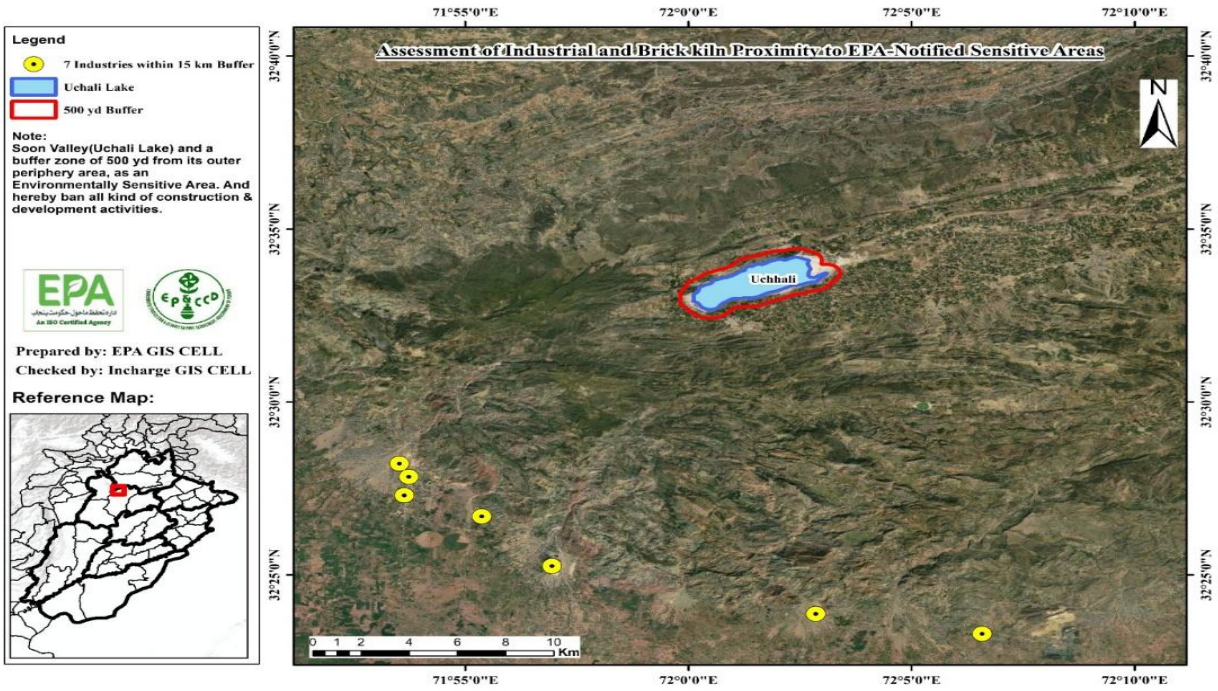

Figure 8.4: Industrial and Brick Kilns Clusters around Uchali Lake

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 preserve its critical ecological and watershed functions. This protective mandate faces significant pressure from an “industrial ring” consisting of 84 units located within a 6-km buffer zone and one unit situated directly on the tehsil boundary. The concentration of these industries necessitates a robust regulatory regime by the Punjab EPA. By freezing development within the tehsil and enforcing a rigorous oversight buffer, the EPA aims to safeguard the region’s natural landscape from the

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cumulative threats of particulate emissions, unauthorised expansion and habitat fragmentation. The map is shown below:

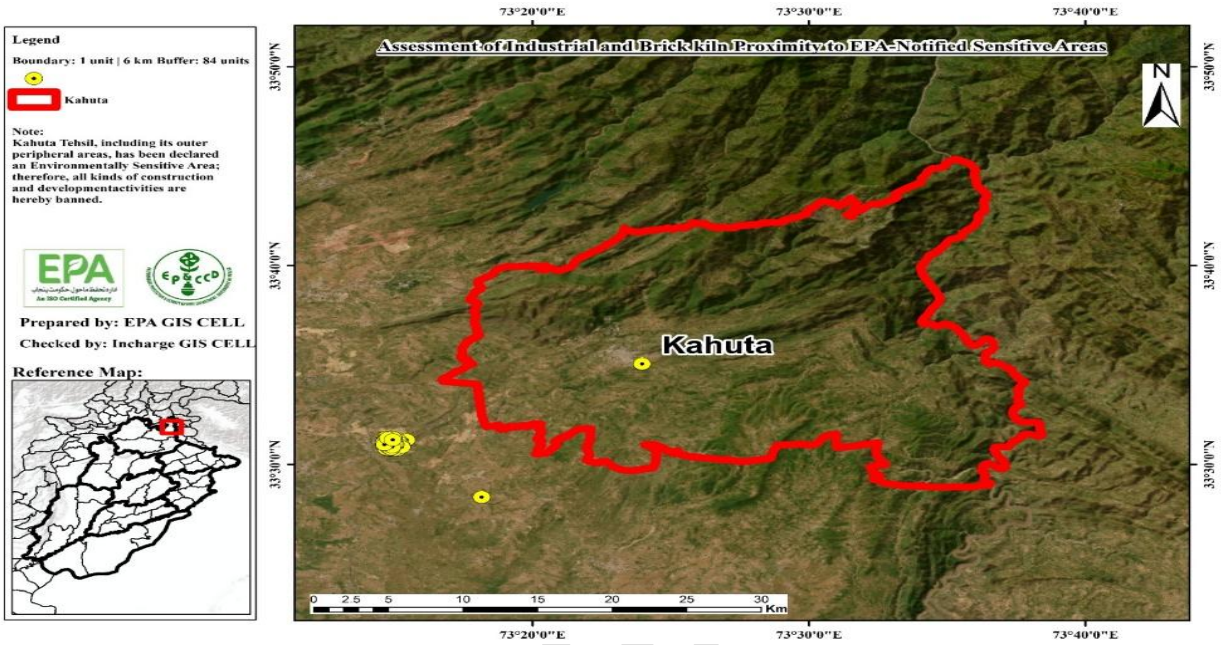

Figure 8.5: Industrial Cluster near Tehsil Kahuta

8.6.5. Jahlar Lake, Soon Valley (EPA-Notified Sensitive Area)

Jahlar Lake, situated within the ecologically fragile Soon Valley, is a highly sensitive brackish wetland protected as both a Ramsar Site and an EPA-Notified Sensitive Area. Currently, the lake exhibits minimal industrial encroachment, with only 2 industries located within its 15-km buffer zone; however, its environmental integrity is strictly guarded by a mandatory 500-yard protected buffer zone where all development is prohibited. Because the lake is an endorheic basin with no natural outlet, even minor industrial or agricultural runoff can lead to catastrophic toxic accumulation, threatening its status as a primary refuge for the globally endangered White-headed Duck. While the current lack of industrial density is a positive indicator, the inherent vulnerability of the surrounding terrain necessitates continued, active surveillance by the Punjab EPA to prevent

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future violations and ensure that this "biological oasis" remains undisturbed by the regional pressures of expansion.

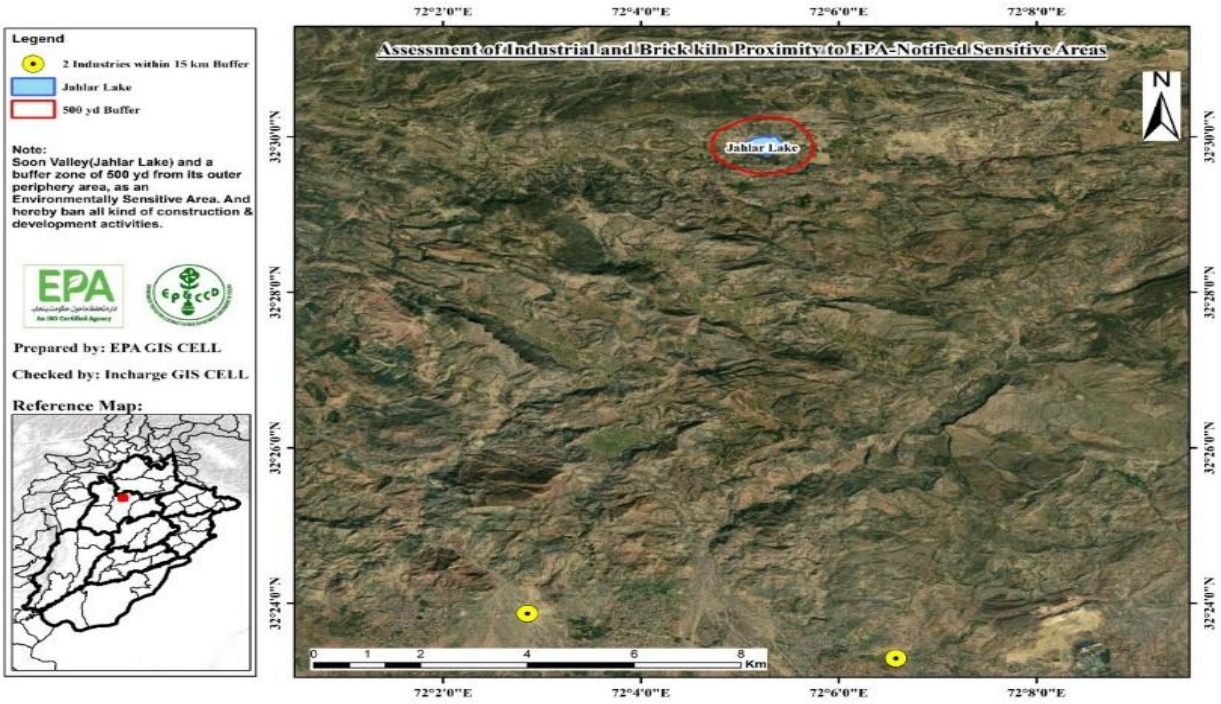

Figure 8.6: Industrial Cluster around Jahlar Lake

8.6.6. River Ravi Corridor – Ravi Syphon to Village Maraka (50 km stretch)

The 50-km environmentally sensitive corridor along River Ravi represents one of Punjab's most strategically important ecological and hydrological zones. Recognizing the increasing environmental pressures within the corridor, EPA Punjab has undertaken a focused spatial assessment to identify industrial and brick kiln clusters operating in proximity to the river ecosystem in order to strengthen evidence-based environmental governance and targeted enforcement interventions.

The spatial analysis identified approximately 1,072 industrial units operating within a 2-km buffer zone and 28 brick kilns located within a 5-km radius of the corridor. The findings highlight the significant industrial footprint surrounding the river system and reinforce the importance of enhanced environmental oversight in the area. River Ravi also serves as an important groundwater recharge zone for Lahore and therefore requires strengthened ecological protection and pollution management measures.

In response, EPA Punjab has initiated regulatory surveillance and enforcement-focused environmental mapping to support compliance monitoring, industrial profiling and identification of environmentally non-compliant activities within the notified sensitive corridor. To further strengthen enforcement mechanisms, EPA Punjab has also constituted a dedicated Special Wastewater Squad tasked with monitoring wastewater discharge, industrial effluent management

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and illegal disposal activities affecting the River Ravi corridor. The squad is supporting targeted inspections, compliance verification and enforcement actions against units contributing to pollution within the ecologically sensitive stretch.

The generated spatial database, coupled with field enforcement operations, is expected to support cumulative pollution assessment, risk-based inspections and future planning decisions related to industrial siting, environmental approvals and ecological risk management. The initiative further demonstrates EPA Punjab's transition towards data-driven environmental regulation, where spatial intelligence, industrial mapping and specialised enforcement mechanisms are being integrated to improve protection of ecologically sensitive areas and critical environmental receptors across Punjab

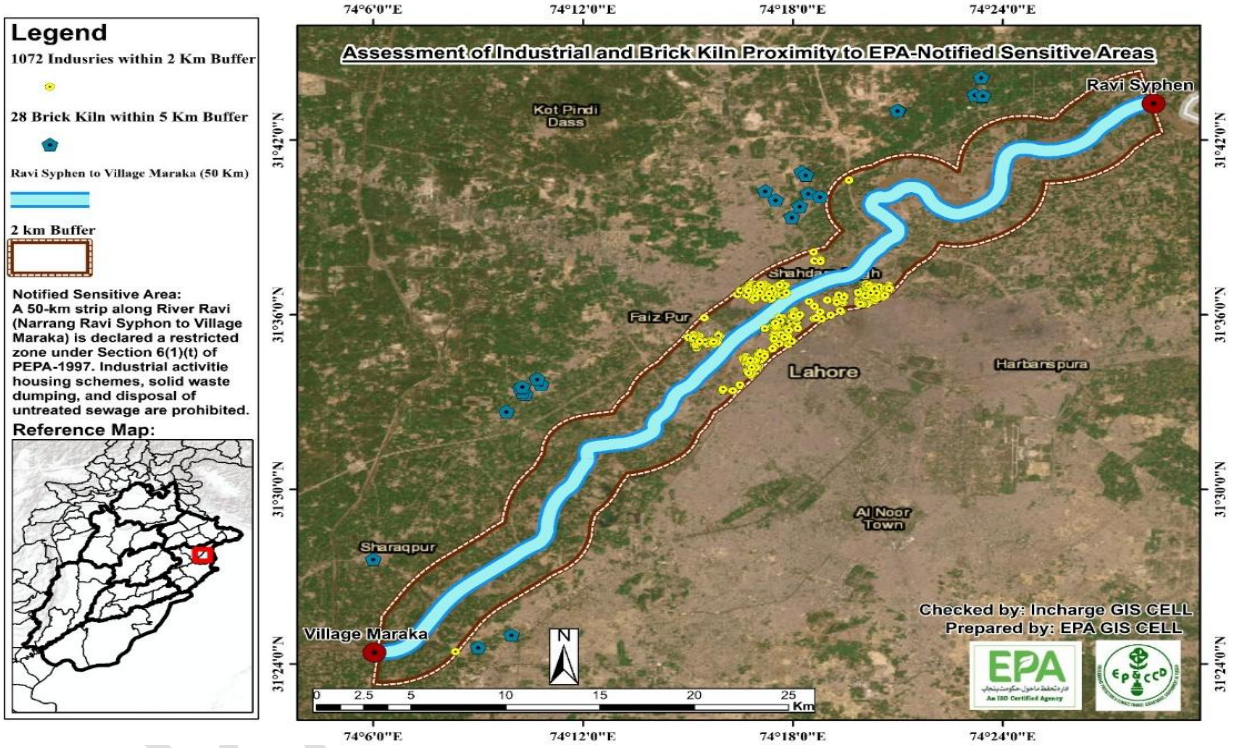

Figure 8.7: Industrial and Brick Kiln Cluster around River Ravi Corridor

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 that serves as a critical hydrological and ecological anchor for the Talagang District. To safeguard its water quality and surrounding habitat, the Punjab EPA enforces a strict 2-km protected buffer zone where development is heavily restricted; however, current data reveals moderate pressure from 7 industries and 10 brick kilns operating within a 10-km radius. While these numbers are comparatively lower than other industrial corridors, the proximity of these polluting sources to a primary freshwater body necessitates targeted enforcement action to prevent sediment runoff and particulate deposition. As of 2026, the lake is managed under a framework of

continuous digital surveillance and geo-fencing, ensuring that even moderate industrial activity is strictly regulated to protect this vital regional water resource and designated wildlife sanctuary

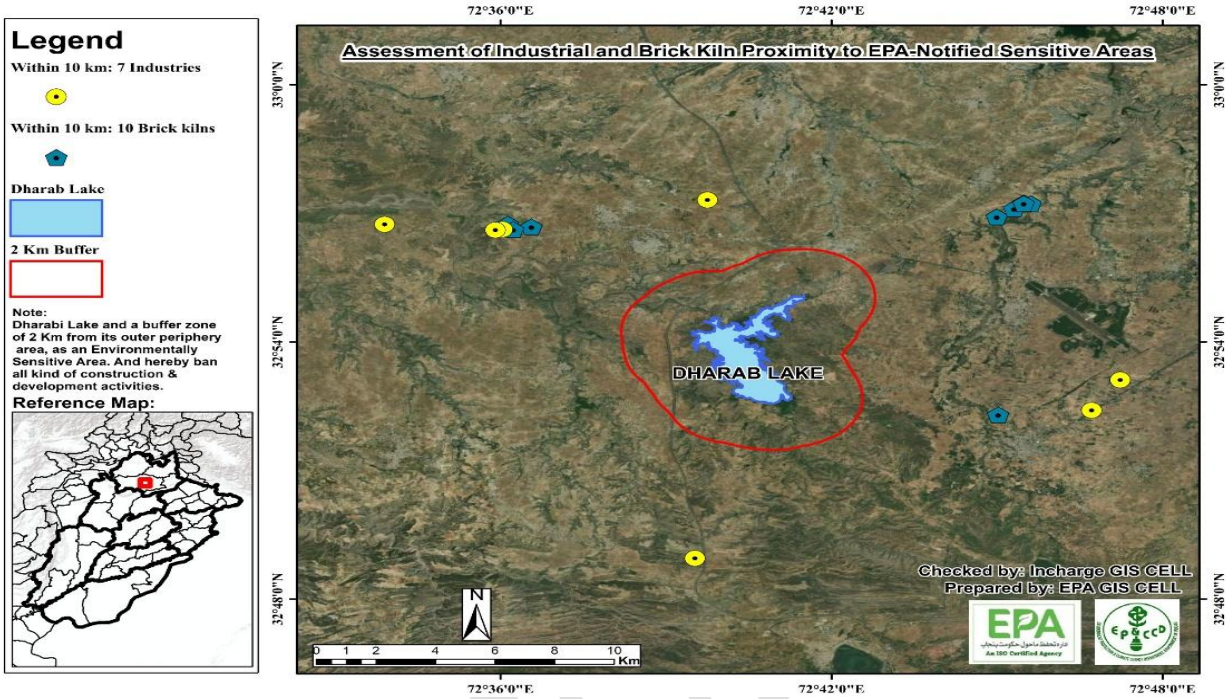

Figure 8.8: Industrial Cluster around Dharab Lake

8.7 Conclusion

EPA Punjab's initiative to map industrial clusters around Ecologically Sensitive Zones marks a critical shift from reactive to proactive environmental governance. The spatial analysis across Punjab's ESZs reveals a consistent and concerning pattern: significant industrial and brick kiln activity operating in close proximity to some of the province's most ecologically vulnerable landscapes.

The findings highlight that many of these ESZs face cumulative pollution pressures that no single EIA or NOC review can adequately capture in isolation. Addressing this challenge requires a sustained, spatially informed regulatory framework one that integrates the ESZ-industrial cluster database into EIA baseline assessments, strengthens NOC siting decisions and enables risk-based enforcement that prioritises ecologically sensitive receptors.

Ultimately, the long-term viability of Punjab's biodiversity, water resources and ecosystem services depends on the institutional will to translate this spatial evidence into enforceable protections. Done consistently, this initiative has the potential to establish a replicable model for evidence-based environmental governance across Pakistan.

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Chapter No. 9: 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[65], with Punjab contributing the largest share due to its 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 remain in the environment for decades and gradually break down into microplastics that enter ecosystems and food chains. Simultaneously, hazardous waste generated from industries, healthcare facilities, laboratories, chemical processes and electronic waste streams poses even greater environmental risks because of its toxic, corrosive, flammable, reactive, or infectious nature. Under the provisions of the Punjab Environmental Protection Act 1997, hazardous waste refers to waste capable of causing significant harm to human health, living organisms, property, or the environment if improperly handled, stored, transported, treated, or disposed of. The absence of scientifically managed treatment and disposal systems further intensifies these risks, particularly in rapidly expanding urban and industrial centres.

Recognizing the growing severity and complexity of the issue, the Environmental Protection Agency Punjab has increasingly adopted a more integrated, regulatory and technology-driven approach towards plastic and hazardous waste management. EPA has strengthened environmental enforcement against environmentally harmful practices while promoting safer waste handling, recycling and recovery, and disposal mechanisms across the province. Regulatory interventions such as 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 Punjab's evolving environmental governance framework. Simultaneously, initiatives such as Extended Producer Responsibility (EPR), scientific landfill planning and recycling facilitation, and cleanliness campaigns like Suthra Punjab are contributing towards the development of a more resilient and sustainable waste

[65] Pakistan generates 3.9m tonnes of plastic waste annually: report

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management system aimed at protecting public health, reducing environmental pollution and ensuring 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 such as polyethylene bags and PET bottles clogged sewerage systems and contributed to recurrent urban flooding. The situation was most critical in the River Ravi, which had turned into an ecologically stressed system due to the large-scale discharge of untreated municipal and industrial waste entered the river without treatment. This led to the accumulation of plastic

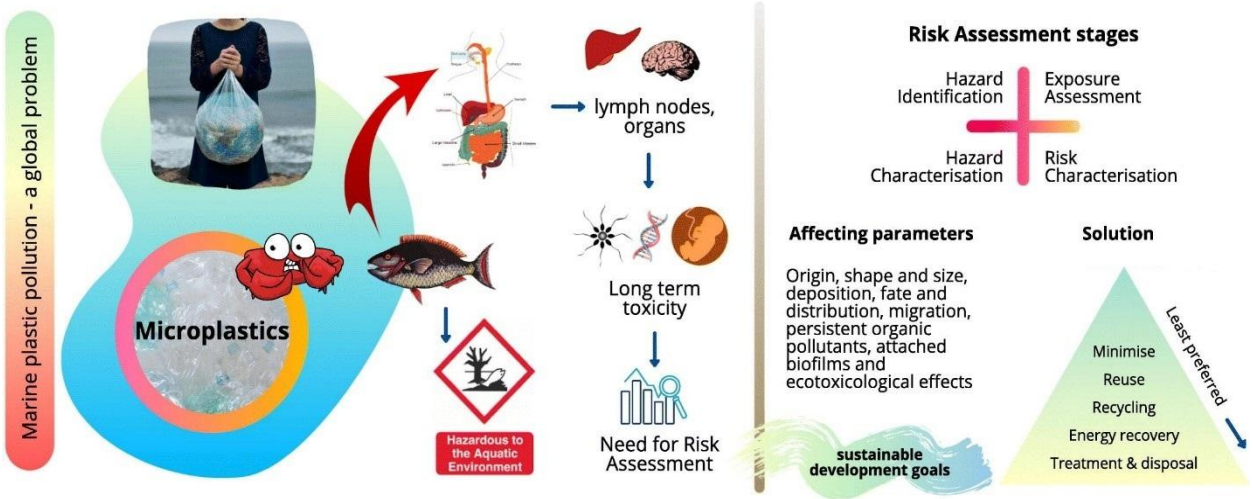

Figure 9.1 Micro Plastic in Food Chain[66]

debris in downstream areas like Head Balloki, effectively transforming the river into a plastic corridor. A major component of this pollution was micro plastics tiny particles primarily composed of polyethylene and polypropylene found in concentrations exceeding 16,000 particles per cubic metre near urban drainage channels. Dominated by fine fibers, these microplastics posed significant ecological and health risks as they were easily ingested by aquatic life and were difficult to remove through conventional treatment systems.[66] Alongside plastic pollution, Punjab is also facing a parallel challenge from hazardous industrial waste generated by rapidly expanding industrial clusters.

[66] 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.

9.1.2. Hazardous Waste and Industrial Vulnerability

The hazardous waste crisis in Punjab spans key urban and industrial hubs, including Lahore, Faisalabad, Sialkot, Gujranwala and Gujrat, creating a province wide ecological challenge where industrial prosperity has come at immense environmental cost.[67] In Sialkot, leather tanneries discharge untreated chromium laden effluents into drains like Aik Nullah, contaminating surrounding soils,[68] while metal finishing units in Gujranwala release lead and mercury that infiltrate local ecosystems.[69] Faisalabad's extensive textile industry contributes significant dye, acid and chemical residues to canals and drainage networks, degrading both soil and water quality.[70] In Lahore, chemical, pharmaceutical and steel recycling industries produce toxic sludge, oils and solvents, much of which is dumped in informal sites or landfills, leaching into groundwater and contaminating surface waters such as the River Ravi.[71] Across these industrial clusters, the historical absence of centralised Treatment, Storage and Disposal Facilities (TSDFs), coupled with unlined landfills and weak regulatory enforcement by the Punjab Environmental Protection Agency, has allowed hazardous substances to migrate through soils and aquifers, creating persistent ecological and public health hazards. This combined effect threatens the province's agricultural productivity, urban sustainability and the well-being of millions of residents, underscoring the urgent need for integrated hazardous waste management and stronger industrial governance.

9.2. The Regulatory Shift and Future Outlook

To strengthen long-term sustainability, Punjab is gradually shifting from conventional waste management practices towards integrated circular economy approaches. Punjab has pioneered several initiatives like the Suthra Punjab (Clean Punjab) campaign and the stricter enforcement of the Punjab Environmental Protection Act. The province is currently pushing for Extended Producer Responsibility (EPR), where manufacturers are held accountable for the end-of-life disposal of their plastic packaging. Furthermore, the integration of the informal sector the thousands of waste pickers who currently handle the bulk of Punjab's recycling into a formal, protected workforce is essential. Moving forward, the focus is shifting towards Waste to Energy plants and the establishment of scientific sanitary landfills that can safely sequester hazardous materials away from the province's precious groundwater tables. Building upon these regulatory reforms and sustainability objectives, Punjab intensified its plastic reduction commitments during 2025.

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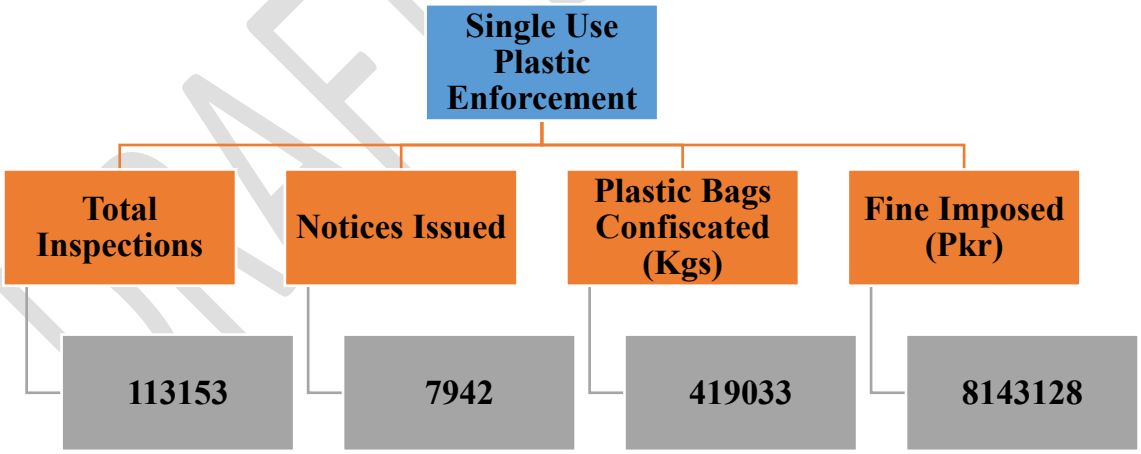
[67] Urbanunit.gov.pk | Regional Development Plan of Gujranwala.pdf
[68] Assessment of various heavy metals level in groundwater and soil at tannery manufacturing areas of three mega cities (Sialkot, Lahore and Karachi) of Pakistan – Science Direct
[69] Comparative analysis of heavy metals toxicity in drinking water of selected industrial zones in Gujranwala, Pakistan | Scientific Reports
[70] 12339297_03.pdf
[71] EIA River Training.pdf

9.2.1. Plastic Reduction Commitments and Strategies

Government of Punjab advanced its Plastic-Free Punjab vision as a comprehensive environmental and socio-economic reform agenda in 2025. Under the leadership of the Chief Minister, the Mission Zero Plastic initiative evolved beyond policy into an implementation focused movement aimed at eliminating non-biodegradable single use plastics while promoting a circular economy. A key development during the year was the introduction of the Green Credit Program, which encouraged public private partnerships to install plastic collection machines in major cities and educational institutions. These systems provided financial incentives reaching up to Rs. 1,000 for bulk deposits to motivate citizen 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 public infrastructure.[72]

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 fully enforced across the province. These regulations prohibited the manufacture, sale and distribution of plastic bags below 75 microns in thickness and size smaller than 12x16 inches.[73] A major institutional advancement was the mandatory implementation of the Plastic Licence Management Information System (PLMIS), requiring all producers, collectors and recyclers to register and obtain environmental approvals. By early 2025, strict enforcement led to the significantly improving regulatory oversight and bringing previously informal operations into the compliance net.



[72] Green Credit Program
[73] Punjab launches "Plastic-Free Punjab Pledge" campaign

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To ensure effective implementation at the grassroots level, District Plastic Management Committees were made operational across all districts. Working under 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. Additionally, EPA Punjab issued 7942 notices and imposed fine of more than 8.1 million to the violators.[74] 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 and imprisonment for serious environmental violations.[75] As part of these reforms, EPA Punjab introduced mandatory registration mechanisms to improve transparency and accountability across the plastic supply chain.

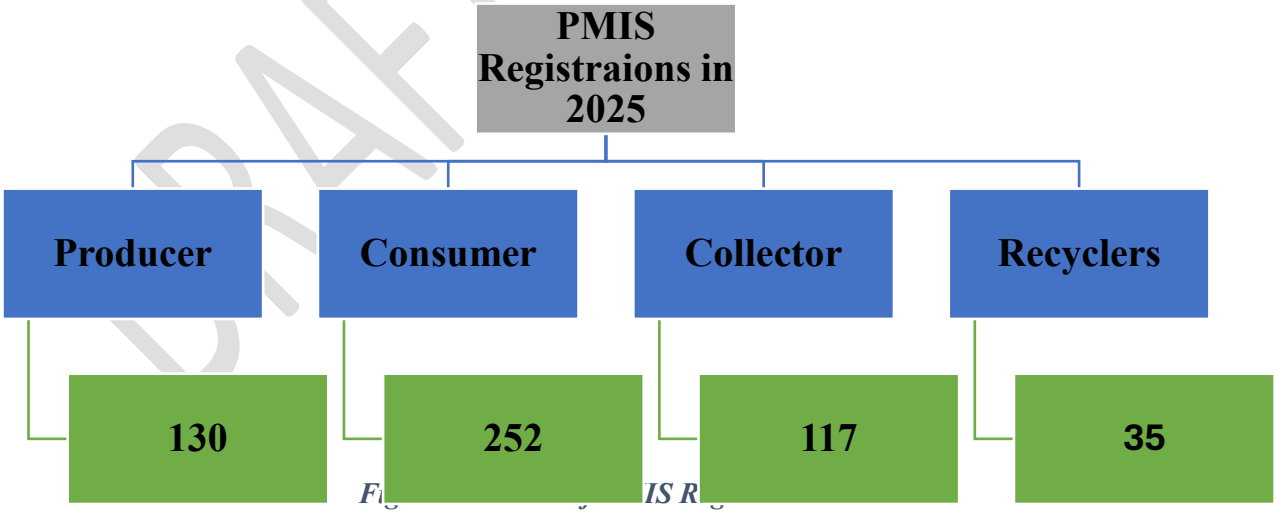
9.2.2 Producer Responsibility & Mandatory Registration

A major regulatory milestone in 2025 was the enforcement of mandatory registration of all

Figure 9. 2: Single Use Plastic Enforcement

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 outline recovery mechanisms as a prerequisite for legal operation.

As a result of this initiative, a total of 130 producers, 252 consumers, 117 collectors and 35 recyclers were registered in the system. Additionally, 361 licences were issued, while 173



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[74] Daily Situation Report - EPA Punjab
[75] The Suthra Punjab Authority Act 2026

applications remained under process. This reform significantly enhanced transparency and enabled the Environmental Protection Agency (EPA) Punjab to map the entire plastic supply chain across the province.

To facilitate compliance, EPA Punjab conducted stakeholder engagement sessions and training workshops in key industrial cities such as Lahore, Faisalabad, Gujranwala and Multan. The PMIS framework played a crucial role in formalizing the previously undocumented sector, strengthening enforcement capacity and laying the foundation for future Extended Producer Responsibility (EPR) mechanisms. By linking registration data with enforcement strategies, authorities were better able to identify high risk operators, reduce illegal plastic flows and promote a more accountable and traceable system of plastic production and recycling.

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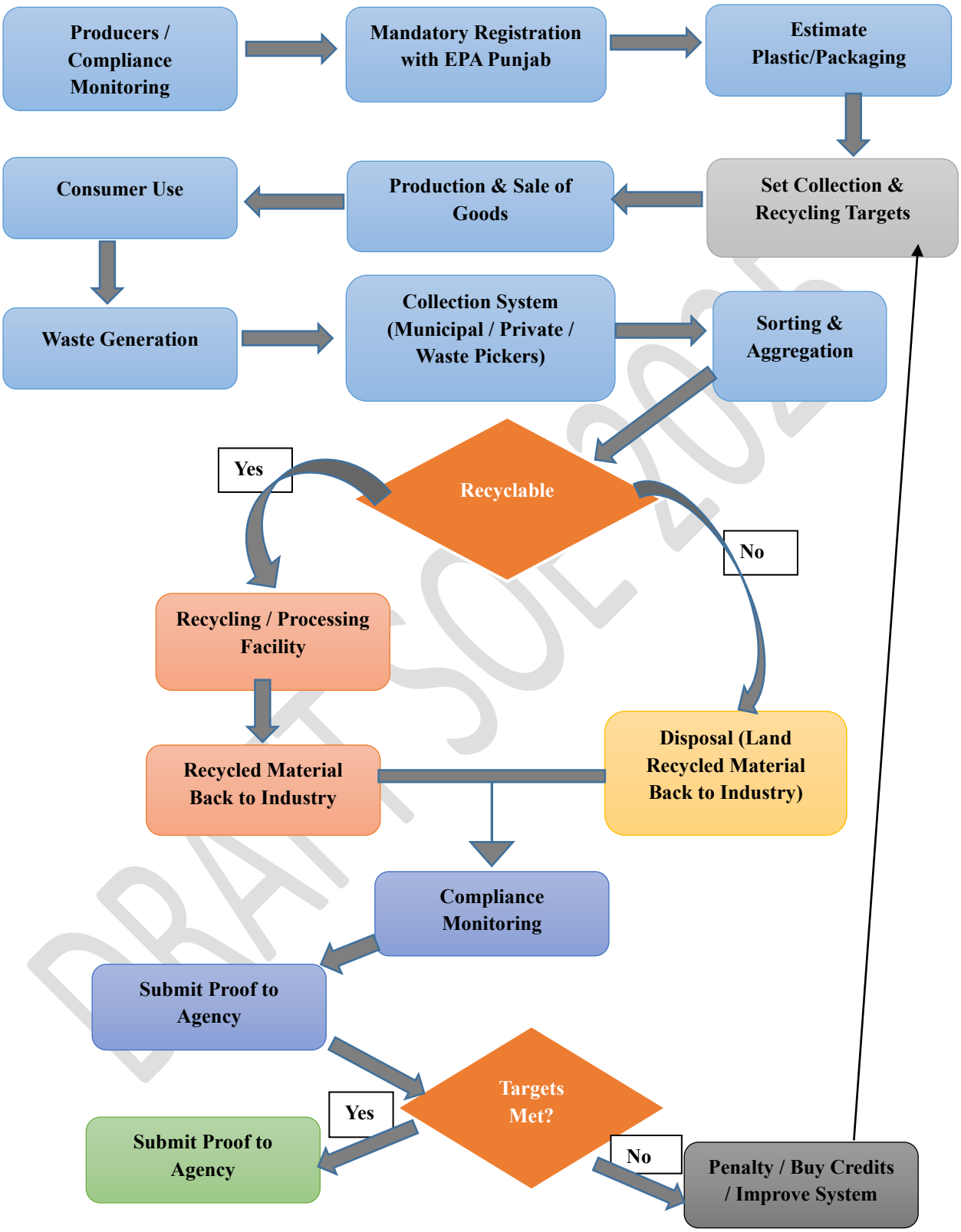

Figure 9.4: EPR Mechanism under Punjab Environmental Protection (Production and Consumption of Single-Use Plastic Products) Regulations, 2023[76]

9.2.3 Transition from Plastic Waste to Circular Economy

While the implementation of PMIS and mandatory stakeholder registration significantly strengthened regulatory oversight and traceability within 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 focused on waste recovery, recycling and public participation. In this context, the province gradually shifted from a purely compliance-based approach towards incentive-driven environmental governance aimed at encouraging behavioural change among citizens, businesses and local communities. This transition laid the foundation for innovative initiatives designed to integrate environmental responsibility with economic incentives, thereby promoting plastic waste recovery and resource circulation 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-driven mechanism designed to operationalize sustainable behaviour among both citizens and institutional actors. The CMPGCP establishes a quantifiable reward system where verified environmental actions are converted into Green Credits, each valued at PKR 10,000, with a per-participant ceiling of PKR 100,000 per programme cycle.[77] The programme's scope encompasses a multi-dimensional sustainability framework, incentivizing activities.

CMPGCP 2025 initiative aimed at promoting public participation in sustainable practices.[78] The programme encourages citizens, institutions and communities to adopt environmentally responsible actions such as tree plantation, waste recycling, renewable energy adoption, rooftop gardening and environmentally friendly transportation through a green credit incentive mechanism.[79]

It also supports climate resilience, cleaner urban environments and Punjab's broader sustainable development objectives by encouraging long-term environmental responsibility and public stewardship. Among its most impactful interventions is the Cash for Bottle Initiative, which operationalizes the Green Credit Program's circular economy objectives through a targeted plastic recycling mechanism.

DRAFT SOE 2025

[76] Plastic Regulations 95 of 2023
[77] CM Punjab Green Credit Program 2026 – Earn Up to Rs100,000
[78] CM Punjab Green Credit Program | CM Special Monitoring Unit
[79] CM Punjab Green Credit Program 2025 – Full Guide

9.2.3.1 Cash for Bottle Initiative under Green Credit Program, 2025

As a flagship intervention under the CMPGCP, the Cash for Bottle Initiative introduced a technology-driven approach to plastic recovery by formalizing a Memorandum of Understanding (MoU) with ISP Environmental Solutions Ltd., enabling the systematic deployment of Reverse Vending Machines (RVMs) across urban centres and transforming plastic collection into a structured, traceable and incentive-linked recycling system.

Figure 9. 5: MoU Signing Ceremony of CMPGCP with ISP Environmental Solutions Ltd on Reverse Vending Machine

Within the plastic waste management component of the CMPGCP, programme adoption was accelerated through targeted initiatives such as the Bottle-for-Cash drive in Lahore, leveraging the Reverse Vending Machine (RVM) network established under the MoU with ISP Environmental Solutions Ltd. These RVMs enabled users to deposit post-consumer plastic bottles, authenticate their participation via mobile number registration and receive immediate Green Credit allocations or financial rewards, thereby operationalizing a real-time, traceable recycling workflow.

By September 2025, out of 4 RVMs, two RVM units had been deployed at strategic high-traffic locations, including University of Central Punjab, Lahore and Superior University Lahore, with a third unit planned for installation within the Walled City of Lahore. Each deployment is coupled with awareness campaigns and capacity-building workshops, designed to train participants on credit verification procedures, system utilisation and compliance with programme guidelines, thereby ensuring both operational transparency and participant accountability. This integrated RVM approach not only optimises plastic collection efficiency but also establishes a data driven feedback loop to monitor environmental impact and programme performance metrics.[80]

The recovered plastic collected through these systems contributed significantly to Punjab's circular economy objectives. In cities like Lahore, where plastic waste generation reached substantial volumes, collected materials were redirected to processing facilities and repurposed into eco-friendly products such as eco bricks, pavement tiles and construction materials. This integration of incentivized collection with resource recovery demonstrated a shift from conventional waste disposal towards value-added recycling. Overall, the Green Credit Program complemented regulatory enforcement efforts by fostering behavioural change, enhancing recycling infrastructure and strengthening public engagement in achieving a sustainable, plastic-free Punjab.[80]

Figure 9. 6: Inauguration of Reverse Vending Machine by Senior Minister Marriyum Aurangzeb

Green Credit Program generated impacts that extended far beyond plastic recycling by fostering a broader culture of environmental responsibility across Punjab. Through financial incentives tied to sustainable actions, the initiative encouraged citizens to reduce waste, adopt cleaner transportation options and participate in activities such as tree plantation and community clean-up campaigns, reflecting a growing shift in public behaviour towards sustainability. At the same time, the programme attracted private sector involvement in recycling operations and green technology deployment, strengthening infrastructure and innovation in waste management. It also created economic opportunities for informal waste collectors and individuals from diverse socio-economic backgrounds by integrating them into structured recycling networks, thereby expanding the reach of plastic recovery systems. Collectively, this incentive-based model supported Punjab's transition towards a circular economy by promoting the re-valorization of waste as a resource rather than its disposal, aligning environmental protection with economic and social benefits. Building on these behavioural and institutional gains, Punjab's environmental strategy extended its focus towards a more structured and systemic approach to plastic waste management, establishing dedicated frameworks for recovery, recycling and resource valorization at the provincial level.

[80] 'Cash for Plastic Bottles': Punjab unveils unique scheme under Green Credits Program - Pakistan Today - Pakistan Today

9.3. Plastic Recycling in Punjab

Plastic recycling in Punjab moved beyond basic collection measures towards a structured circular economy framework under the supervision of the EPA Punjab. These recovery efforts were closely linked with provincial enforcement operations, where confiscated plastic materials were redirected towards regulated recycling and repurposing streams. Rather than treating plastic waste as residual refuse, policy direction emphasised its classification as a recoverable resource, integrating recycling objectives into broader environmental governance and sustainable production strategies adopted during the year.

Figure 9.7: Plastic Waste to Recycled Products; EPA Punjab Cycle[73]

Beyond enforcement and seizures, districts also pursued education and registration 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. Across all districts, wider public awareness drives, fine structures (from thousands to tens of thousands of rupees), confiscations, sealing of non-compliant sites and coordination with law enforcement reflected a comprehensive and sustained provincial effort to implement the plastic ban and strengthen compliance throughout 2025.

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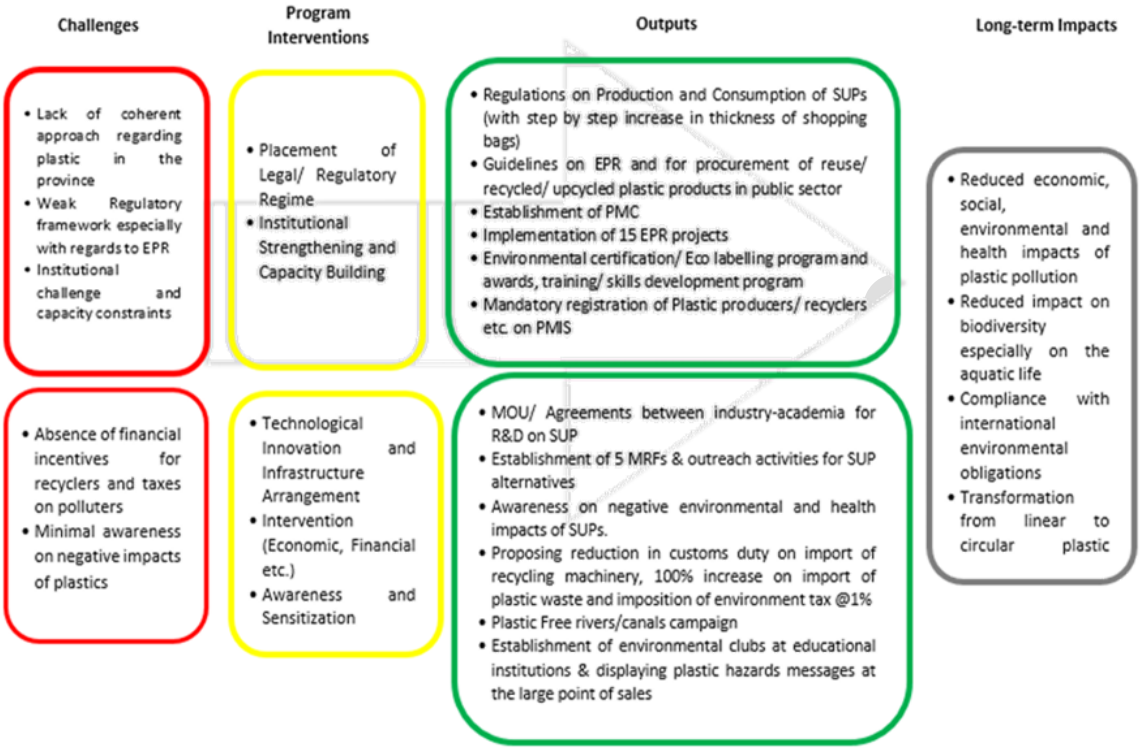

Figure 9.8: Theory of Change Diagram for Plastic Management Strategy[81]

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 for disposal, Punjab adopted a recovery-oriented approach aligned with circular economy principles. Punjab implemented an integrated recovery framework, instead of relying solely on traditional disposal methods such as landfilling or incineration which can generate secondary environmental hazards like soil contamination or toxic emissions.[81] This framework ensured that confiscated plastics were treated as a recoverable resource, aligning with the province's broader circular economy goals and long-term environmental strategy.

[81] the-plastic-management-strategy-punjab-pdf.pdf

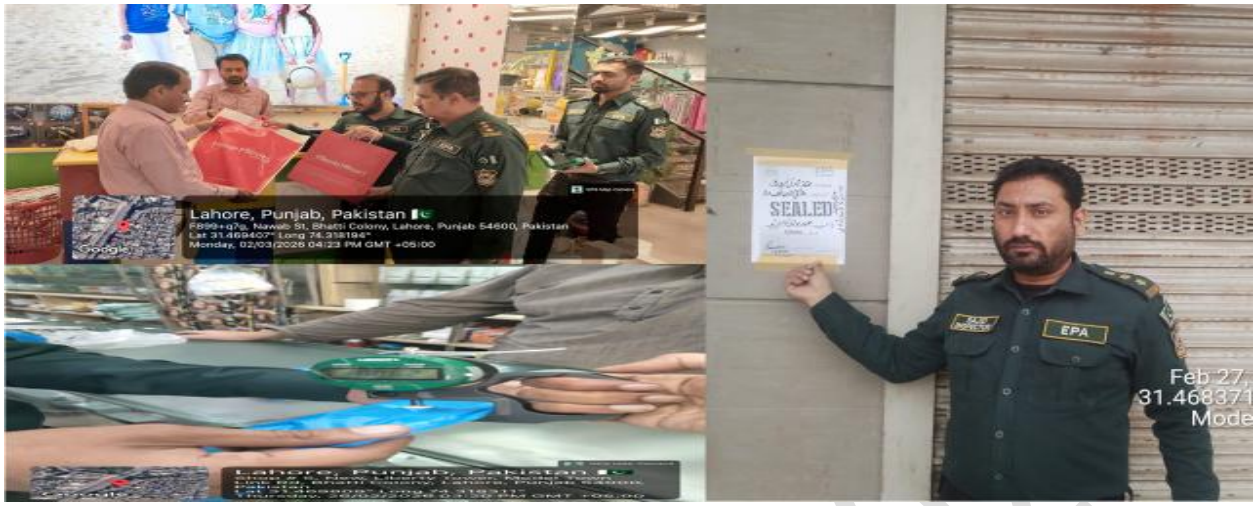

Figure 9. 9: Single Use Plastic Inspection and Confiscation Activities

The first step in the process involved systematic segregation and characterization of seized plastics. Materials were sorted based on type (e.g., polyethylene, polypropylene) and contamination levels to determine the most suitable recycling or repurposing pathway. Contaminated or mixed waste streams were carefully processed in controlled facilities to minimise health risks and ensure environmental safety. This step not only improved the efficiency of subsequent recycling operations but also enhanced the quality of recovered materials, making them suitable for conversion into durable goods and construction inputs.

Recovered plastics were then repurposed into a variety 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 Sahianwala, Faisalabad, further highlighting the social impact of these initiatives.[82]

Figure 9. 10: Plastic into Chairs

[82] Directorate of EDH, EPA Punjab

These efforts served multiple objectives simultaneously: reducing the volume of waste sent to landfills, supporting local infrastructure projects and generating tangible social benefits for communities. By integrating seized plastics into infrastructure development, Punjab effectively linked enforcement activities with urban improvement and public welfare initiatives, demonstrating a practical application of circular economy principles.

To ensure accountability and transparency, Punjab established digital tracking and reporting mechanisms that monitored the movement of confiscated plastics from seizure to final utilisation. This system allowed enforcement units, district administrations and recycling partners to coordinate closely, reducing material loss or diversion and ensuring full regulatory compliance. Training and capacity building programmes were introduced for enforcement personnel and recycling facility operators, emphasising safe handling, proper segregation techniques and documentation procedures. Such initiatives were particularly critical for handling mixed or contaminated waste streams, which pose greater environmental and occupational hazards.

Figure 9.11: Playground Structure made of Recycled Plastic Installed by EPA in a Public Park

Additionally, post confiscation handling was linked with public engagement and awareness efforts. Local communities, educational institutions and NGOs were encouraged to participate in recovery initiatives, contributing to 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 societal value of proper waste management, fostering long-term behavioural change.

While enforcement actions, recovery mechanisms and recycling initiatives significantly strengthened Punjab's plastic waste management framework, long-term environmental sustainability required a broader societal transition towards responsible consumption and behavioural change. Recognizing that regulatory interventions alone could not fully address the

growing challenge of plastic pollution, Punjab increasingly focused on 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 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 key efforts to reduce 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 setting district-wise targets and tracking performance over time, the programme ensures structured implementation and accountability. The categorization of districts based on size allows for realistic goal setting while promoting equitable participation. Overall, these efforts contribute significantly to improving waste management practices and advancing circular economy objectives in the region.

Figure 9.12: Plastic Pledge and Public Awareness Campaign by EPA Punjab

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) showed particularly strong engagement, reflecting active participation from communities and institutions. Other districts, including Bahawalpur (3,045), Sargodha (2,315), Sheikhupura (1,638) and Vehari (1,220), also contributed significantly to the province-wide efforts. Together, these seven districts accounted for 21,900 plastic pledge activities, representing over half of the total efforts and demonstrating where initiatives have gained the most traction. Across Punjab, EPA

conducted a total of 41,238 plastic pledge activities, surpassing expectations and indicating a strong commitment to reducing single use plastic at both local and provincial levels. The widespread participation highlights the effectiveness of awareness campaigns, community mobilization and institutional support in promoting plastic free practices. Overall, these achievements reflect meaningful progress towards fostering behavioural change, strengthening sustainable waste management practices and advancing Pakistan's broader goals of environmental sustainability and circular economy development.

9.4. Plastic-Free Zones

Data from different districts of Punjab shows considerable progress in the establishment of single use plastic free shopping malls, demonstrating growing participation of 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 such as 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 demonstrate the increasing awareness among commercial stakeholders regarding the environmental impacts of plastic pollution and their willingness to support sustainable consumption practices.

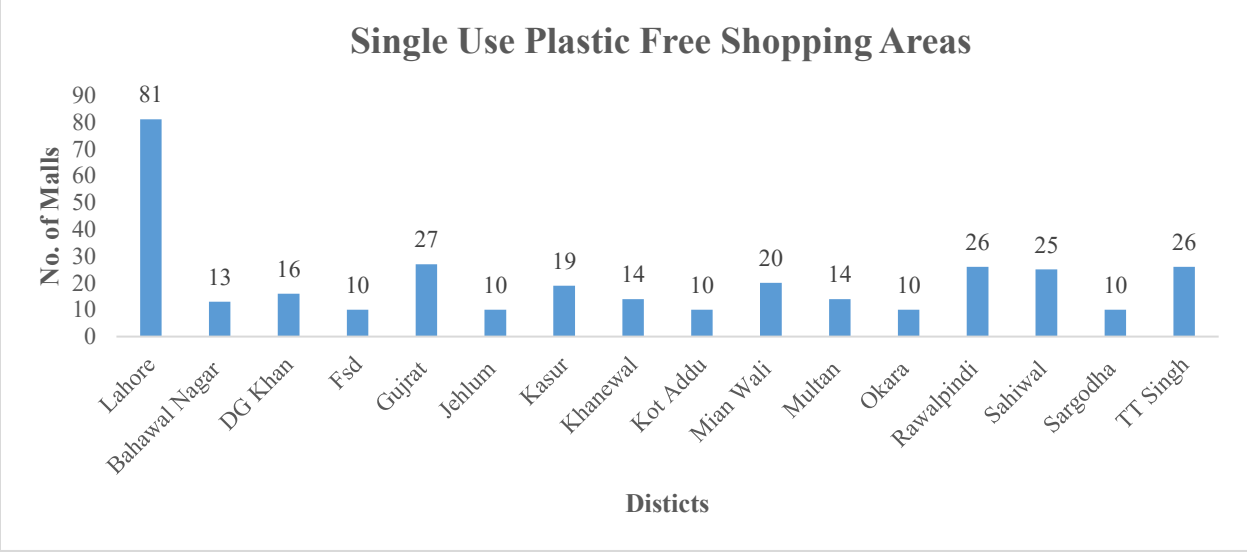

Figure 9.13: Single Use Plastic Free Shopping Areas across Punjab

Beyond commercial shopping centres, these initiatives were also extended to high-footfall motorway service areas across Punjab. Across major motorways (M-2, M-3, M-4 & M-11) corridors in Punjab 14 service areas have been designated as single use plastic free zones. Among these, five service areas are located along the M-2 motorway, which connects Lahore and

Islamabad and serves as one of the busiest transportation routes in the country. Similarly, five service areas on the M-3 motorway, which connects Lahore to Faisalabad, have also adopted plastic free practices. Furthermore, two service areas each on the M-4 and M-11 motorways have been designated as plastic free zones. These initiatives target areas with high consumer activity, thereby significantly reducing the distribution and disposal of single-use plastic items such as plastic bags, disposable cutlery and packaging materials.

The establishment of plastic free malls and motorway service areas contributes directly to reducing plastic waste generation and promoting sustainable consumption patterns. By encouraging businesses and service providers to replace disposable plastics with biodegradable or reusable alternatives, these initiatives help minimise plastic leakage into drainage systems, landfills and natural ecosystems. Moreover, such measures support broader environmental objectives by reducing micro plastic contamination in soil and water resources and lowering the environmental burden associated with plastic waste management. In conclusion, 438 shopping malls/centre, 14 points on motorways and 37 Sahulat Bazar were declared as single use plastic free zones as shown in below given figure.

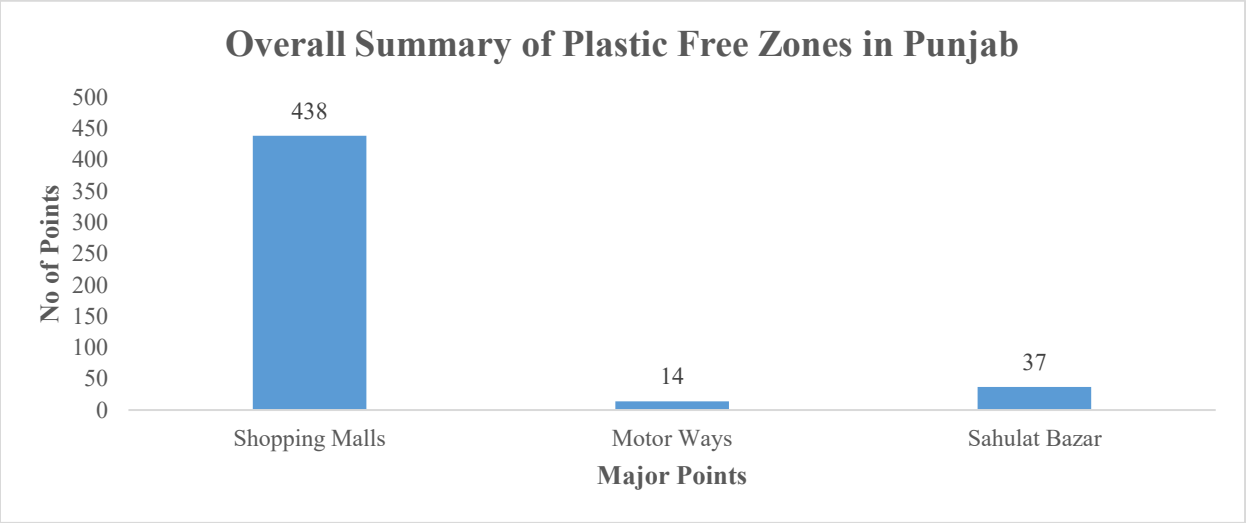

Figure 9.14: Overall Summary of Plastic Free Zones in Punjab

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.[83] Voluntary commitments have been widely recognised in international environmental policy as an important complementary mechanism to regulatory enforcement for addressing plastic pollution and advancing sustainable consumption patterns.[84] These voluntary commitments were further strengthened 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 have been declared as plastic free across Punjab. 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, while Faisalabad saw similar initiatives in areas like Jhang Road and Millat Road. This plastic free markets campaign expanded across the entire province in 2025. These efforts were implemented with active support from district administrations, in collaboration with local market associations and trader unions. Retailers participating in these initiatives were encouraged to adopt sustainable practices, including the provision of reusable shopping bags and discouraging the use of conventional single-use plastics, thereby promoting environmentally responsible consumer behaviour. Awareness campaigns targeting shopkeepers and consumers were conducted to highlight the environmental impacts of plastic waste and promote environmentally responsible purchasing behaviour.[85] Community participation played a critical role in these initiatives, particularly through engagement with schools, universities and civil society organisations that promoted responsible waste management practices and sustainable consumption at the household level.[86]

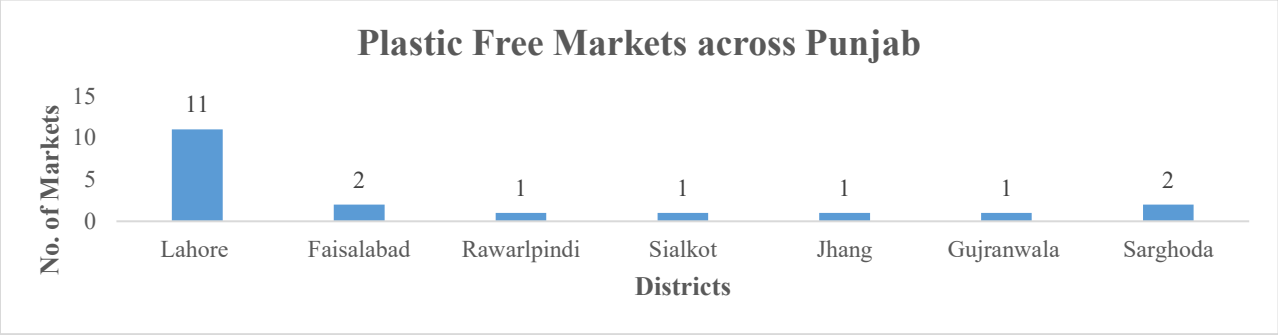

Figure 9.15: Plastic Free Markets across Punjab

[83] Welcome to Environment Protection Department | Environment Protection Department
[84] Intergovernmental Negotiating Committee on Plastic Pollution | UNEP - UN Environment Program
[85] Ministry of Climate Change and Environmental Coordination
[86] Punjab Government Takes Historic Step to Combat Plastic Pollution | Punjab Portal

9.4.3 Integrated Plastic and Waste Management Approach

EPA Punjab's 2025 plastic management initiatives reflected a multi-faceted strategy focused on regulatory enforcement, recovery mechanisms, 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 converted into useful products such as construction materials and public infrastructure components. Simultaneously, initiatives including plastic pledges, plastic-free zones, voluntary environmental commitments and awareness campaigns strengthened public participation and encouraged sustainable consumption practices across Punjab. These measures collectively improved transparency, enhanced institutional coordination, reduced landfill burden 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. Therefore, alongside plastic management interventions, the Agency also expanded its focus towards broader waste management practices, including waste segregation, recycling awareness and institutional engagement programmes aimed at promoting environmental responsibility within communities and educational institutions. Looking ahead, Punjab aims to further strengthen recycling infrastructure, adopt advanced recovery technologies, enhance public-private partnerships and expand 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 embed sustainable waste management practices within the educational sector, targeting schools as catalysts for long-term environmental behavioural change. Recognizing that schools play a critical role in shaping environmental habits, the campaign aimed to implement a structured programme for source-based

Figure 9. 16: Waste Wise Certification of Schools by EPA

DRAFT SOE 2025

waste segregation, proper disposal and recycling practices among students and staff. Ten model schools across Punjab were selected as pilot institutions, functioning as demonstration hubs to showcase scalable best practices.[87] The primary objectives were to enhance operational efficiency in waste handling, reduce contamination of recyclable materials and instill practical knowledge of organised waste management within the school environment.

9.5.1. Integrated Waste Wise Management Implementation across Schools

The programme's foundation was solidified when EPA Punjab officially notified the "Waste Wise Management" framework, a regulatory mandate designed to standardise environmental practices across educational institutions. This notification served as the catalyst for change, transforming waste management from a voluntary suggestion into a structured, compulsory initiative. By formalizing these guidelines, the EPA provided schools with a clear roadmap for compliance, ensuring that every participating institution operates under the same rigorous environmental benchmarks to reduce the province's ecological footprint.

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 maximise the impact of this infrastructure, the bins were strategically placed in high-traffic areas such as classrooms, laboratories, cafeterias and playgrounds. This ensures that segregation is integrated into the daily flow of school life, making it nearly impossible for students and staff to miss the opportunity to dispose of waste responsibly.

To complement the physical bins, the initiative introduced a comprehensive visual learning layer. Schools received environmental education boards and instructional signage that clearly illustrated the "hows" and "whys" of waste segregation. These tools served as constant reminders of the Waste Wise Management protocols, turning the act of throwing away trash into a conscious, educational moment. This visual cues-based approach proved essential for shifting the behavioural habits of the youth towards long-term sustainability.

The initiative combined infrastructure, education and monitoring to strengthen waste management across 41 districts. A total of 7,246 waste bins were installed (with 4,476 in public schools and 2,770 in private schools), demonstrating strong implementation in all districts across Punjab.

DRAFT SOE 2025

[87] 'Waste wise management bins': Coca-Cola Pakistan partners with EPA - Business & Finance - Business Recorder

To complement these bins, a visual learning component was introduced in 4,177 certified schools, benefiting 4,475 students enrolled in waste wise activities. Districts such as Faisalabad (331 schools), Gujranwala (264 schools) and Lahore (83 schools) highlighted how the programme integrated both infrastructure and awareness. While in Sahiwal (297 schools) and Kasur (165 schools) were certified as per waste wise management and the use of instructional boards and signage helped students understand proper waste segregation practices. On the operational side, schools were equipped to manage and temporarily store segregated waste effectively, ensuring that collection efforts remained meaningful. Teachers and administrative staff in all districts were assigned supervisory roles. They maintained daily records of waste collection and disposal, ensuring accountability.

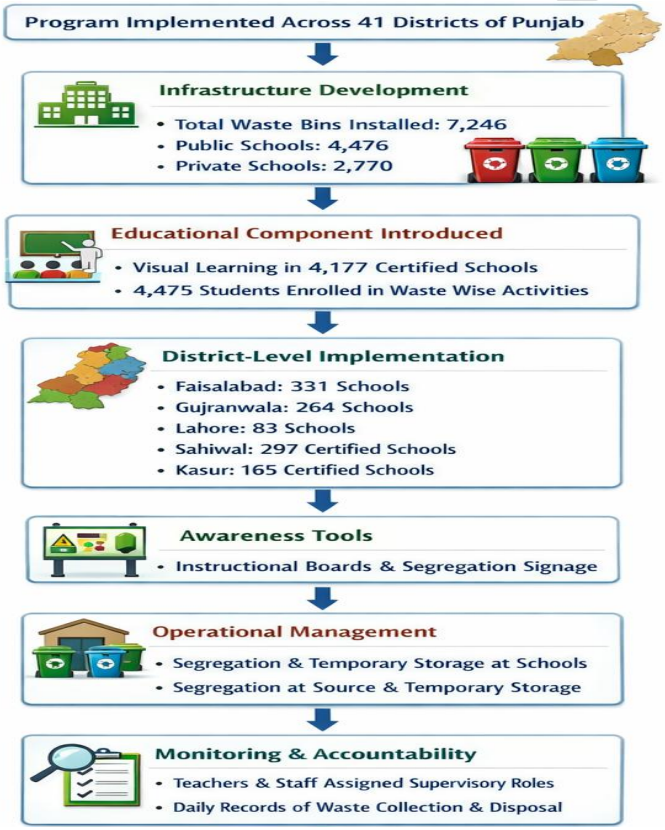

Figure 9. 17: Integrated Waste Wise Management Implementation

Together, these educational and operational measures helped institutionalize responsible waste management practices within schools.

9.5.2. Operational and Environmental Benefits

The campaign generated multiple tangible operational benefits. Proper segregation at the source allowed schools to streamline collection and minimise mixing of recyclable and non-recyclable waste. This improved the efficiency of municipal recycling processes and reduced the volume of waste requiring disposal in landfills. Schools also reported reduced contamination in recyclable

streams, leading to higher quality recovered materials and cost savings for waste management authorities. Moreover, by practicing structured segregation in a controlled environment, schools created a model that can inform institutional and healthcare waste practices, showing how operational rigor and monitoring can lead to improved compliance and sustainability outcomes.[88]

9.5.3. Public Health and Community Linkages

While focused on schools, the campaign also had broader public health and community implications. By introducing structured waste handling processes, students learned how segregation reduces the risk of contamination, odours and pests associated with poorly managed waste. These practices, when carried into homes and communities, supported provincial objectives for cleaner neighborhoods and safer environmental conditions. The programme demonstrated the value of educational institutions as operational testbeds for waste management initiatives, bridging municipal programmes with community engagement and reinforcing principles that are central to healthcare waste protocols, including safe handling and traceable disposal.

Figure 9. 18: Waste Wise Certified School

9.5.4. Outcomes and Future Prospects

Participating schools documented measurable improvements in waste segregation and material recovery, as the mandated installation of five colour-coded waste bins (for paper, glass, organic, metal and plastic) under the Smart Waste Management / Waste Wise Management initiative issued by the Punjab Environmental Protection Agency (EPA) and required for all public and private institutions by 30 September 2025 enabled more effective sorting at the source and routing of recyclables to appropriate streams. Schools complying with the EPA directive were eligible for

[88] 'Waste wise management bins': Coca-Cola Pakistan partners with EPA

"Smart Waste Certified" status, which reinforced adherence to protocols such as regular monitoring of waste fractions and proper disposal practices.[89]

Operational logs maintained by education authorities and EPA field officers indicated higher compliance with designated disposal protocols post-implementation. These logs showed increased capture rates of segregated paper, plastic and metal, reflecting improved recovery performance compared with pre-campaign baseline periods where mixed waste was the norm (EPA inspections commenced 1 October 2025 following the government order).[90]

In turn, municipal collection teams coordinated through mechanisms such as the Punjab Waste Management Helpline (1139) and supported by the provincial Suthra Punjab integrated waste services framework reported enhanced collection efficiency for segregated streams, reducing contamination of recyclables and optimizing transport logistics to recycling parks and processing facilities.[91] The campaign established a replicable operational framework for scaling to additional educational settings across both rural and urban schools in Punjab. This framework aligns with broader provincial objectives under the Smart Waste Management Process and the Suthra Punjab programme, which integrates modern waste collection systems and recycling infrastructure across 36 districts and 141 tehsils, supporting systematic segregation and recovery at source.[92]

Moving forward, EPA Punjab intends to integrate lessons learned from the Waste Wise School Campaign with wider provincial waste initiatives, leveraging structured operational engagement in educational environments to support sustainable waste management practices. This integration is expected to complement municipal and healthcare waste protocols, strengthen compliance with official waste management regulations and contribute to lasting environmental and public health benefits through reduced landfill pressure, improved resource recovery and enhanced sustainability education among students and staff.[91] Beyond educational institutions, similar waste management principles were increasingly adopted within Punjab's healthcare sector to address high-risk medical waste streams.

9.6. Hospital Waste Management and Compliance

The management of risk waste in Punjab has become a critical component of public health governance, particularly within the healthcare sector. Biomedical and hazardous waste, if improperly handled, poses serious risks to healthcare workers, patients and the surrounding environment. Punjab, with its dense population and large network of hospitals, clinics and laboratories, generates substantial volumes of both infectious and non-infectious waste daily. Over time, a structured system has evolved, incorporating legal regulations, operational protocols,

[89] Educational institutions: EPA makes placement of waste segregation bins mandatory - Pakistan - Business Recorder
[90] CM Maryam launches 'smart waste management' drive in Punjab schools - Pakistan Today - Pakistan Today
[91] Punjab schools ordered to install colour-coded bins
[92] Suthra Punjab – Clean Punjab Program, Services, Portal, Billing & Jobs

certified waste management firms, and, more recently, digital tools for monitoring and compliance. By 2025, the province has taken steps to formalize procedures, strengthen accountability and integrate innovative technologies to ensure safer and more sustainable 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 a crucial role in providing preventive care, basic treatment and maternal and child health services.[93]

At the secondary and tertiary levels, the system included 128 Tehsil Headquarters Hospitals (THQs) and 29 District Headquarters Hospitals (DHQs), which acted as key 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 medical 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.[93]

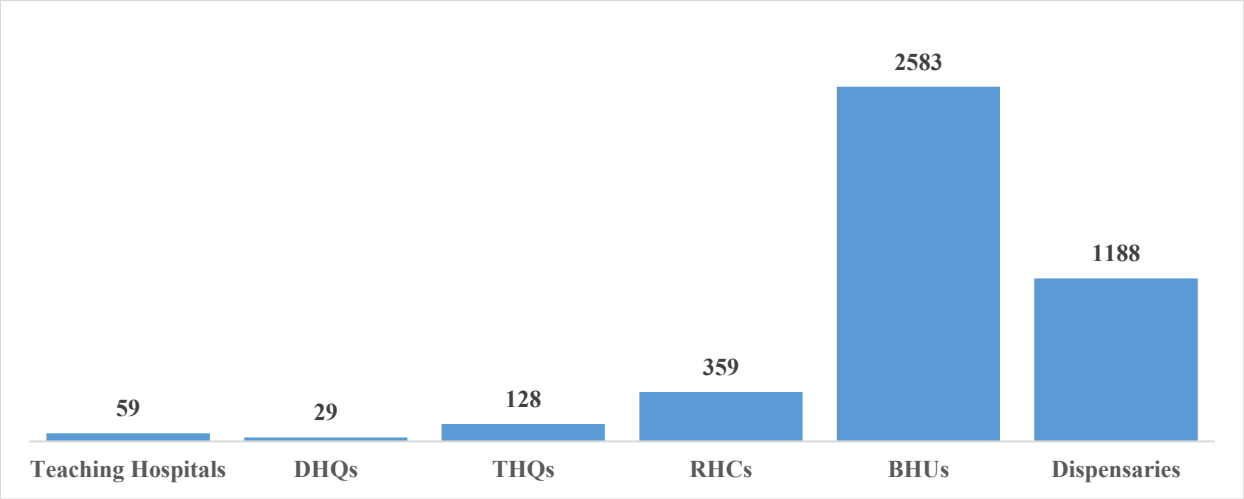

Figure 9.19: Network of Healthcare Facilities across Punjab[93]

[93] Hospital_Waste_Study_EDH

The scale of these facilities resulted in substantially generate almost 46,542 kg of biomedical waste on daily basis, including infectious materials, sharps, pathological waste and pharmaceutical residues. This posed significant challenges for safe handling, treatment and disposal, with potential risks to public health and the environment.

Recognizing these challenges, the Environmental Protection Agency (EPA) undertook proactive measures in line with the Hospital Waste Management Rules (HWMR) 2014. Through effective regulation, monitoring and capacity building initiatives, the EPA promoted proper waste segregation, adoption of colour-coded systems and use of modern treatment technologies. These efforts significantly improved hospital waste management practices, demonstrating the EPA's strong commitment to protecting public health 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 set clear definitions for risk and non-risk waste

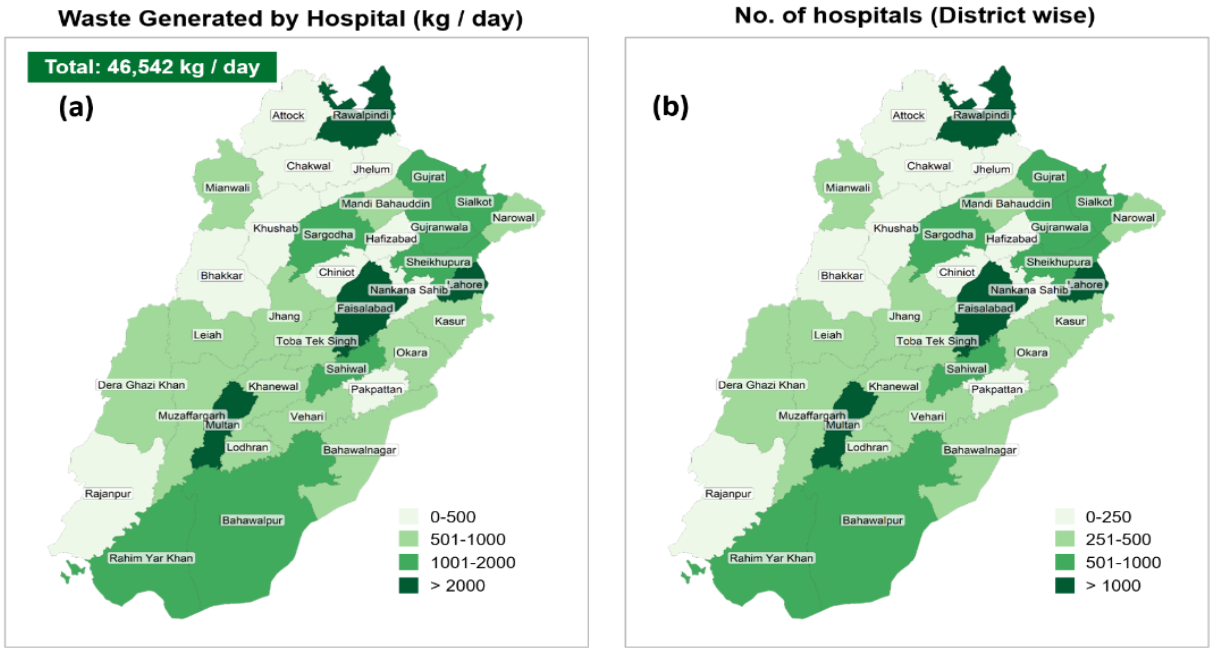

Figure 9. 20: District-wise (a) Infectious Waste Generated by Hospitals (b) Density of Hospital Facilities across Punjab[93]

categories and outline responsibilities across the healthcare ecosystem. 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.[94]

Risk waste classification 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 containers, enabling targeted treatment such as autoclaving, chemical disinfection, or incineration. Non-risk waste is separated for routine disposal without specialised treatment.

As illustrated in Figure 9.21, the composition of hospital waste during the last year remained predominantly non-hazardous, accounting for approximately 85% of the total waste stream. Infectious waste constituted around 10%, while chemical and radioactive (hazardous) waste represented about 5%. This distribution remained critical for mitigation planning, as it highlighted that although the majority of waste was general and relatively low-risk, a smaller proportion continued to pose significant health and environmental risks.

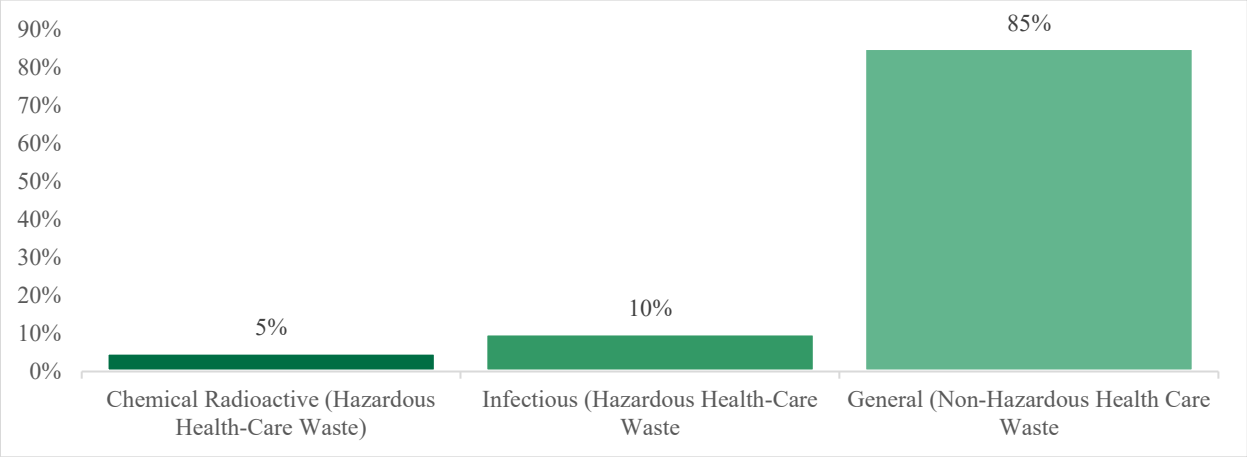

Figure 9.21: Waste Composition in Healthcare Facilities[93]

By summarizing risk waste into these categories, hospitals can protect healthcare workers, optimise treatment processes, reduce environmental impact and maintain regulatory compliance, forming the foundation for a safe and efficient healthcare waste management system. In 2025, EPA Punjab strengthened this framework by introducing digital compliance platforms, enabling real time monitoring and reporting. This shift not only enhanced enforcement transparency but also allowed for early detection of non-compliance patterns, reducing reliance on periodic manual inspections. Clear legal standards foster consistency across hospitals of varying capacities and help smaller facilities meet safety requirements without ambiguity.[94]

[94] Hospital Waste Management Rules (2014)

9.6.3. Segregation and On-Site Handling

Segregation of risk waste at the point of generation remained the most critical measure for preventing contamination and minimising environmental hazards across healthcare facilities in Punjab. In accordance with the Punjab Hospital Waste Management Rules 2014, hospitals were required to separate waste into clearly defined categories using colour-coded and labeled bins: yellow for infectious waste, Blue for sharps, red for chemical or pharmaceutical waste. Segregation had to occur immediately at the site of generation including wards, operation theatres, laboratories and diagnostic centres to ensure that high-risk materials were never mixed with general or recyclable waste.

Figure 9. 22: Segregation of risk waste

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As illustrated in Figure 9.23, segregation began with the use of colour-coded containers (red, yellow, white), ensuring proper classification of waste at the source. The process then progressed through safe collection by designated staff using Personal Protective Equipment (PPE), followed by weighing, sealing and labeling of infectious waste bags prior to transport. Infectious waste was subsequently transferred to designated yellow rooms, which were temperature-controlled (maintained between 3–8°C) to prevent decomposition and contamination. The figure further showed that waste disposal teams regularly collected this waste, typically within 24 hours and transported it to incineration facilities, where it was again weighed before final treatment.

Figure 9. 23: Flow Chart of Hospital Waste Management Practises in Punjab

This structured, step-by-step workflow demonstrated that segregation operated as part of a continuous and integrated system, significantly reducing contamination risks and enhancing the efficiency and safety of downstream waste treatment processes during the last year.

Effective segregation also provided measurable operational and environmental benefits. By ensuring that only truly infectious waste entered energy intensive treatment streams such as incineration, hospitals reduced volumes of high-risk waste, optimised storage requirements and improved the efficiency of collection and transport operations. Cost savings were realised through decreased demand for specialised treatment processes, while the risk of environmental contamination or occupational exposure was significantly lowered. 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 to minimise human and environmental exposure. Hospitals and healthcare facilities continued to maintain dedicated storage areas, commonly referred to as "yellow rooms," for temporary containment of infectious waste, at a maintained temperature conditions between 3°C and 8°C, which helped prevent microbial growth and ensured safe storage before disposal. In line with the Punjab Hospital Waste Management Rules 2014, these storage areas were required to be secure, well-ventilated and clearly marked with biohazard signage. Facilities maintained detailed records of all waste, documenting type, quantity, point of generation and storage duration to ensure traceability and compliance with the 24-hour maximum storage guideline for infectious waste.[94]

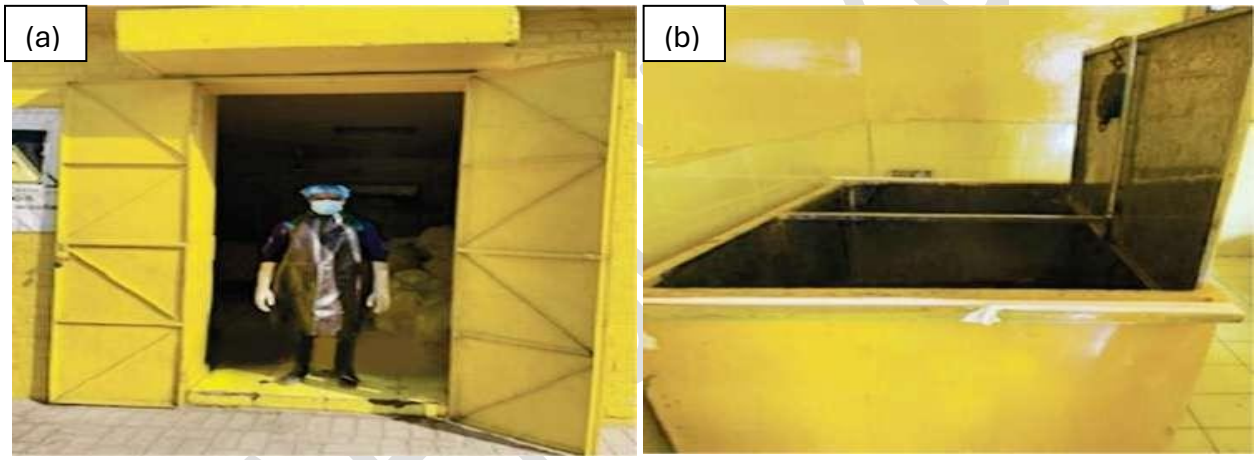

Figure 9.24: Hospital Waste Storage (a) Yellow Room & (b) Waste Trolley

EPA Punjab and other provincial health authorities reinforced these requirements by implementing enhanced monitoring protocols in 2025. Temperature and humidity in storage areas were continuously tracked, reducing the risk of pathogen proliferation or chemical degradation. Physical security measures, including restricted access and CCTV monitoring, were strengthened to prevent unauthorised entry and ventilation systems were improved to mitigate odours and airborne contaminants. Hospitals reported increased adherence to these standards, supported by staff training and internal audits that emphasised both technical compliance and behavioural practices in handling risk waste.

Transportation of risk waste was formalized across all healthcare facilities, ensuring accountability at each stage of the collection and transfer process. Vehicles used for off-site movement were equipped with sealed compartments to prevent leakage or spillage and GPS tracking systems allowed real time monitoring of waste movement. Staff handling the waste continued to follow strict personal protective equipment (PPE) protocols and digital consignment notes provided a

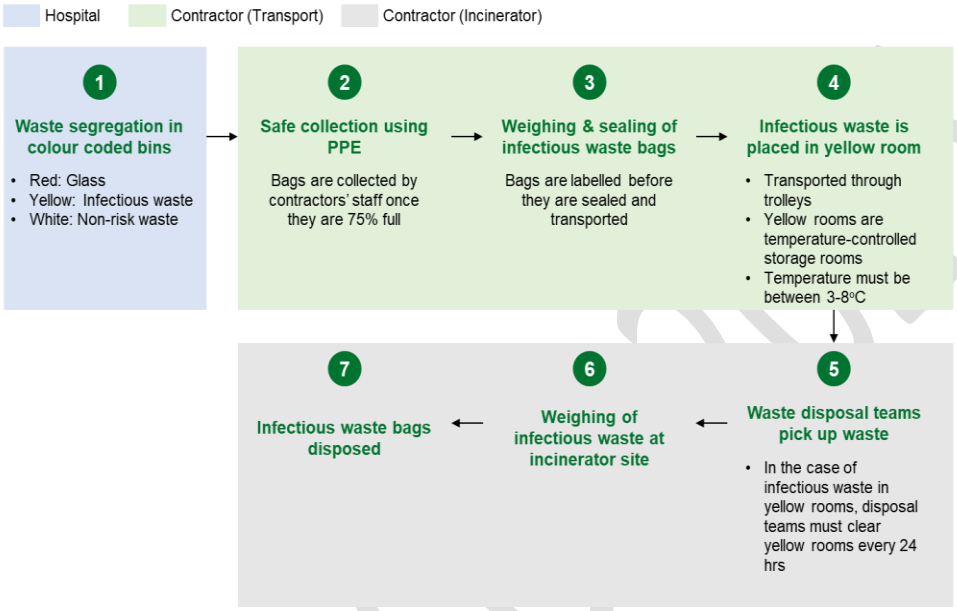

Figure 9. 25: Process for disposing infectious hospital waste

traceable record of the chain of custody. These measures directly aligned with the 2014 rules' stipulation that waste must be securely transported in dedicated containers while maintaining proper documentation.

Waste generated from medical activities represents a real problem of living nature. Proper medical waste disposal involves segregating waste at the point of generation, using colour-coded waste bins for specific waste types and transporting and storing it in designated areas and treatment via incineration for safe disposal. An estimated average of 21,256 kg of hospital waste is generated daily from the public health sector of Punjab, including 3,188.9 kg of infectious waste. There is a total of 48 public incinerators in Punjab having incineration capacity of 4,450 kg per hour. Out of 48 incinerators, 8 are non-functional; however, the installed capacity remains sufficient for public sector infectious waste.[95]

[95] Source: Punjab Health Statistics, 2024

Treatment practices in 2025 expanded beyond conventional incineration to include autoclaving, microwave-based systems and chemical disinfection, enabling hospitals and certified waste management firms to apply methods tailored to specific waste categories. This approach reduced environmental emissions, improved energy efficiency and provided more sustainable alternatives for managing infectious, sharps and chemical waste.[94]

Punjab had achieved measurable improvements in risk waste management throughout the year 2025. The combination of the 2014 Hospital Waste Management Rules and updated operational

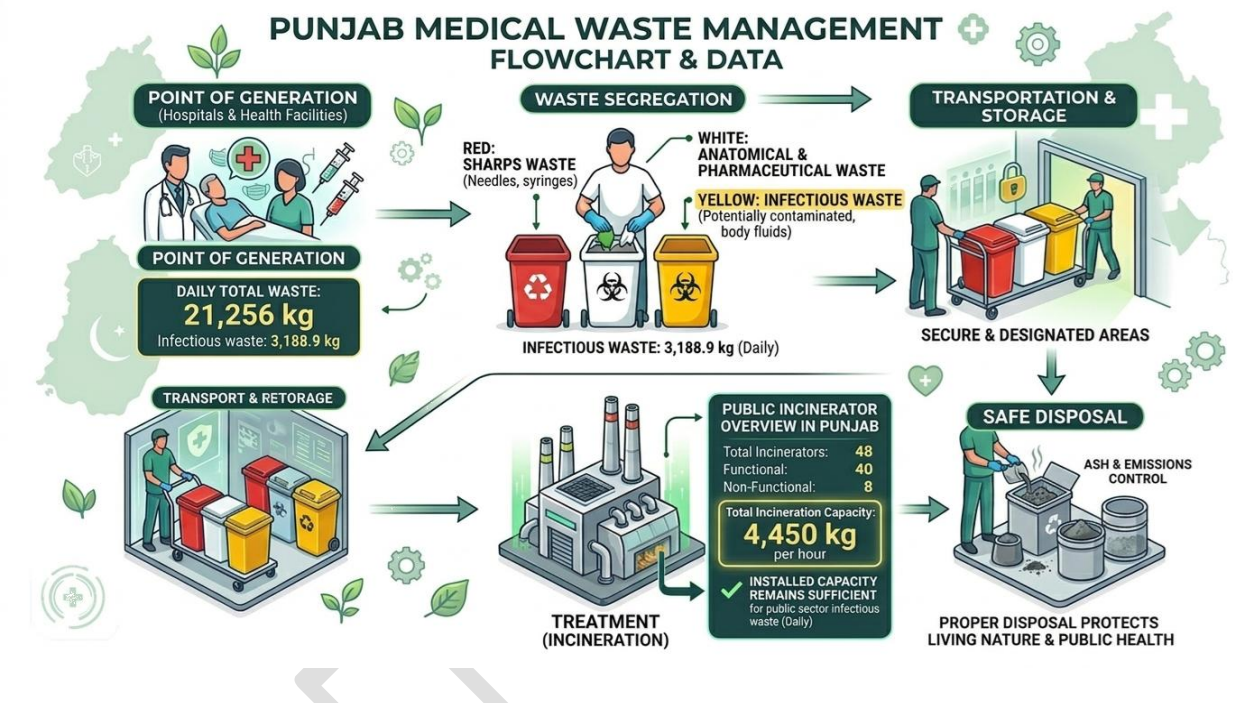

Figure 9. 26: Flowchart and Data of Medical Waste Management in Punjab

protocols ensured that storage, transportation and treatment practices were safer, more accountable and increasingly technology driven. These developments reduced occupational and environmental risks, strengthened regulatory compliance and laid the foundation for further enhancements in healthcare waste management across the province.

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.

Environmental Protection Agency (EPA) Punjab in 2025, introduced a structured and formal certification system for hospital waste management firms, marking a major step towards institutionalizing safe and compliant practise 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.[96]

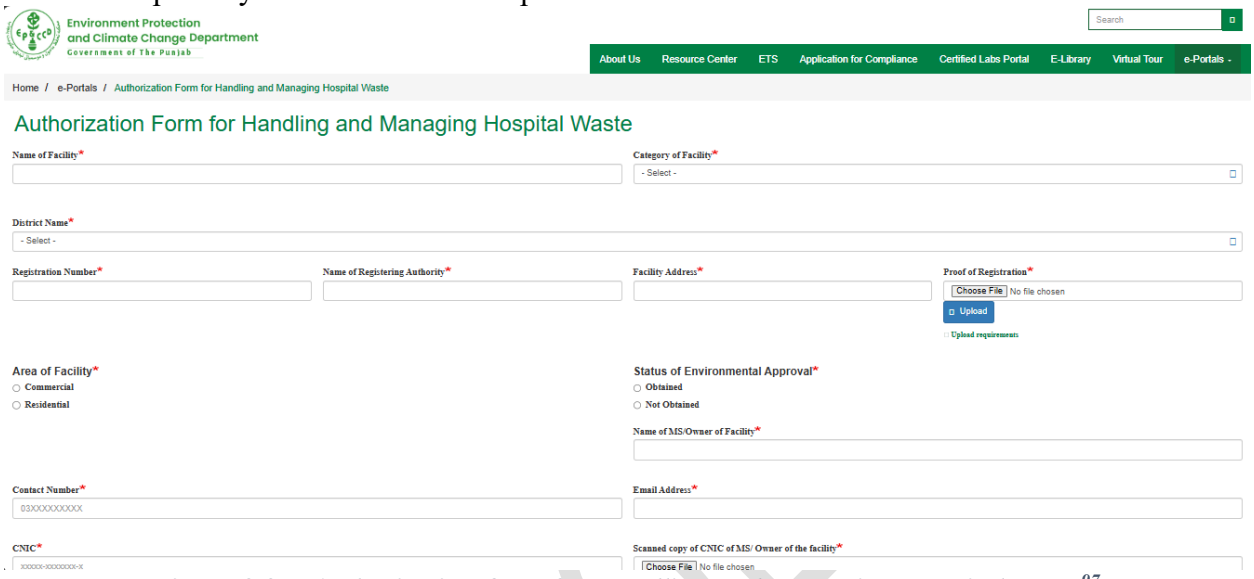

Figure 9.27: Authorisation form for Handling and Managing Hospital Waste[97]

This initiative is closely aligned with Rule 28 of the Punjab Hospital Waste Management Rules (PHWMR) 2014, which emphasizes the authorisation, monitoring and regulation of waste management service providers by the EPA. The rule provides a legal framework for ensuring that only qualified and approved entities handle hazardous healthcare waste, thereby strengthening accountability and standardisation across the province.

The certification system has significantly contributed to the professionalization 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 incentivized to maintain high standards of performance and compliance.

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[96] Authorisation Order under Rule 28 of PHWMR 2014.pdf
[97] 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 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.

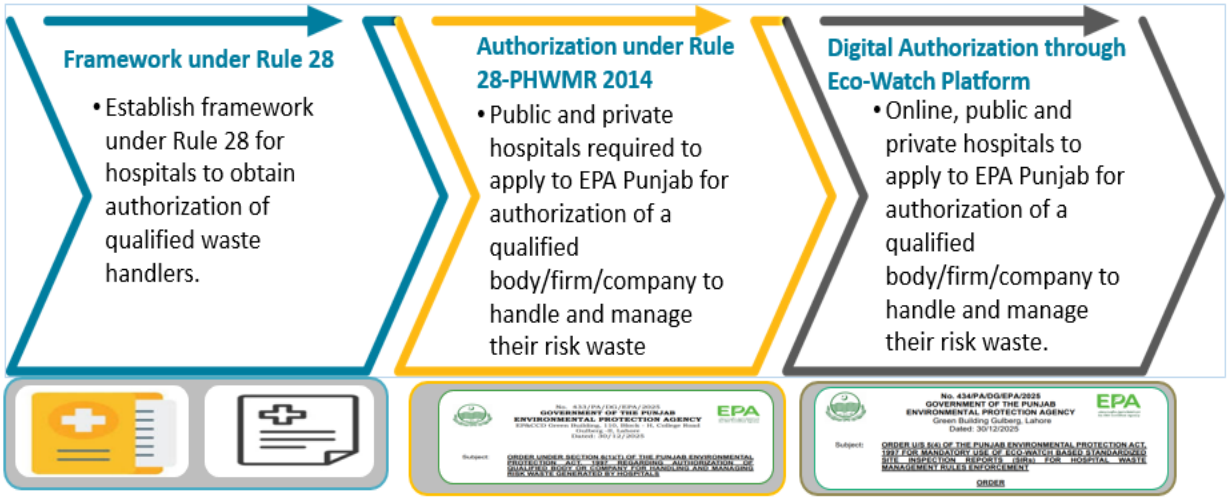

Figure 9.28: Authorisation under Rule 28 of PHWMR, 2014

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 significantly 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.

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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. 29: Hospital Waste Management Practises in Punjab

Figure 9.29 highlighted 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 facilities-maintained 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 grow in line with population and healthcare service expansion. Public hospitals alone produced approximately 19,467 kilograms of infectious waste daily, while private hospitals contributed about 27,076 kilograms, 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 illnesses, further intensify waste volumes. Additionally, patient load, specialised procedures and high turnover surgical or diagnostic services contribute to

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variations in daily waste generation, posing operational challenges for timely collection, storage, treatment and disposal.

However, increasing demand and operational complexities 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

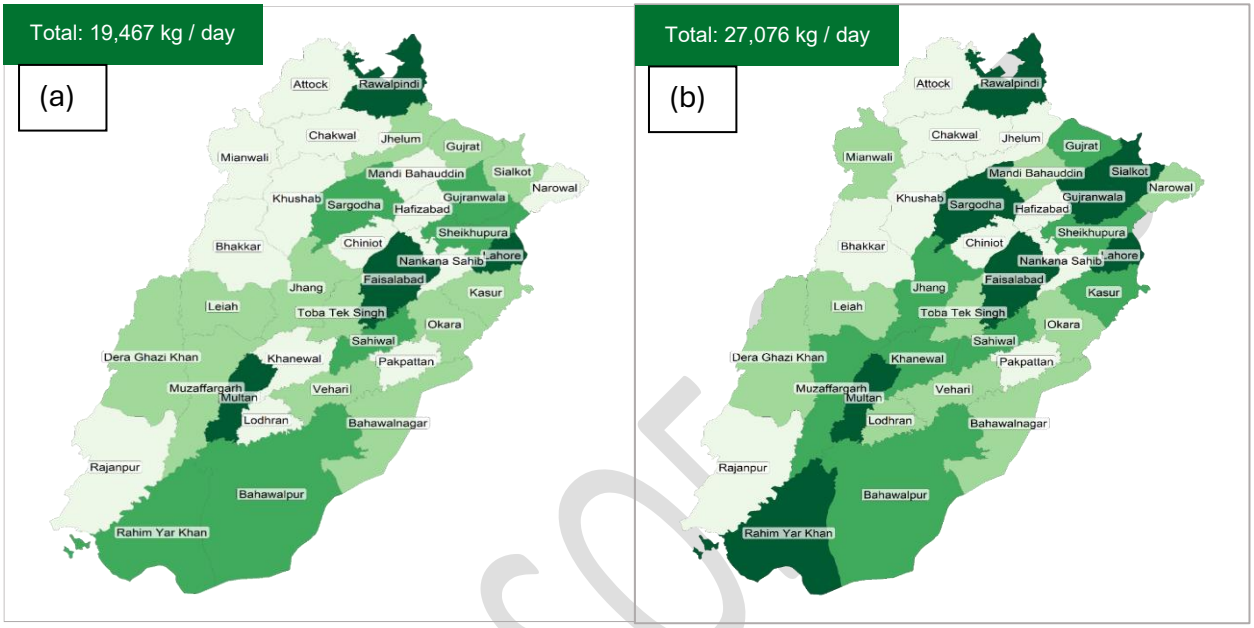

Figure 9.30: Infectious Waste Generation in kg/day by (a) Public Hospitals and (b) Private Hospitals

higher future volumes. This included ensuring that storage facilities had sufficient capacity to temporarily hold infectious waste without exceeding safe limits, that treatment plants had the throughput to handle peak loads and that transport fleets were adequately resourced and tracked for timely collection.

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 consistent compliance with regulatory requirements, even under 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.

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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 are supplemented by guidance and support rather than punitive measures alone.

This dual approach combining enforcement with education ensures that healthcare personnel understand the rationale behind procedures, reducing errors and improving adherence. 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.

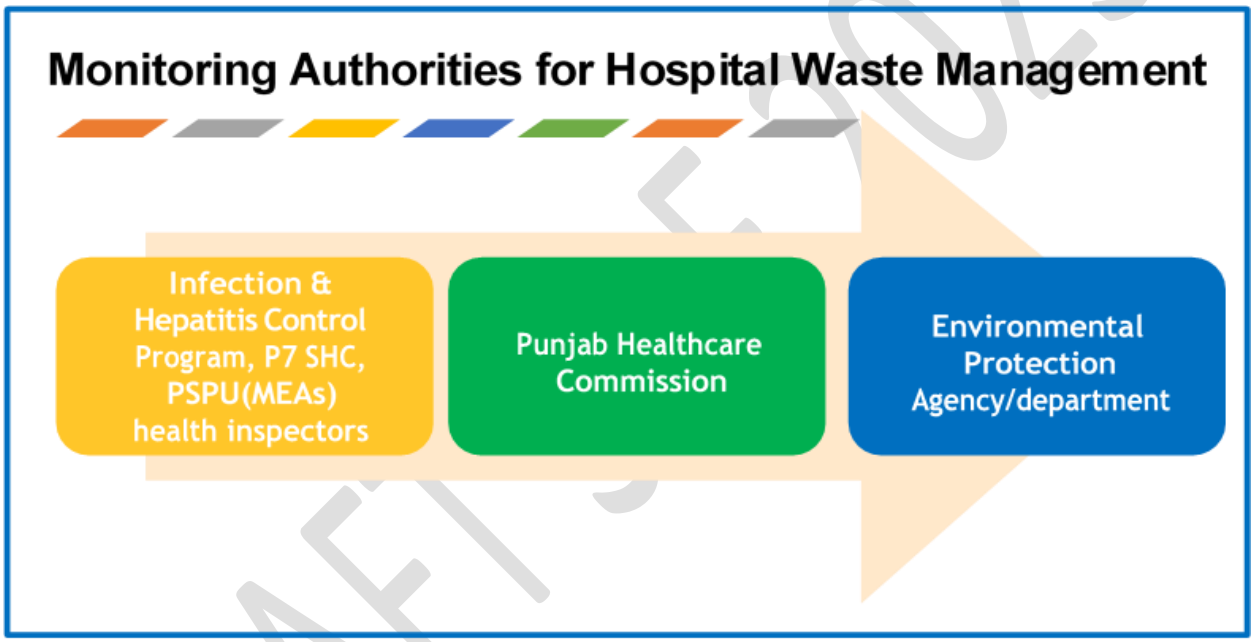

Figure 9.31: Monitoring Authorities for Hospital Waste Management [93]

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 support from institutions, practices are gradually improving across many districts. Training programmes are helping doctors, nurses and waste handlers better understand proper waste segregation and handling, while new infrastructure such as improved storage facilities and treatment equipment is being introduced. Monitoring systems are also becoming more organised, which is helping authorities keep better track of waste management activities and ensure accountability.

Although challenges still exist, 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. If this momentum is maintained,

Punjab can successfully overcome current gaps and build a strong, safe and environmentally friendly 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 centeredon 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.

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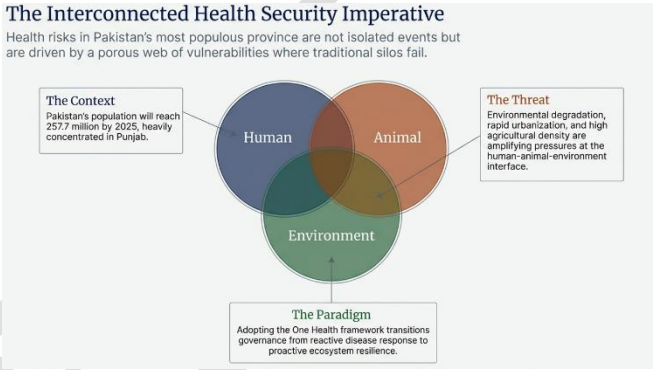
Chapter No. 10: One Health and Environmental Risk Nexus in Punjab

10.1 Introduction and Background

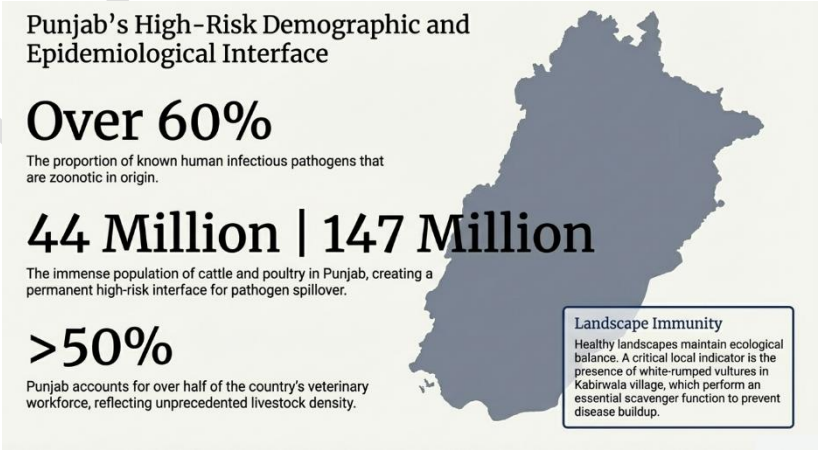
One Health is an integrated, unifying approach that aims to sustainably balance and optimise the health of people, animals and ecosystems. It recognises that the well-being of humans, domestic and wild animals, plants and the wider environment are closely linked and interdependent.[98]



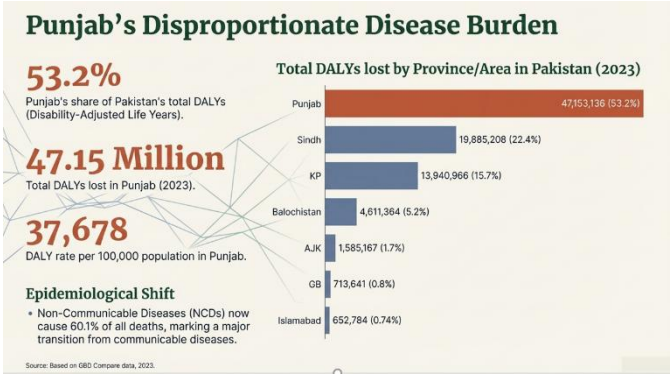
This framework has become increasingly critical due to rising global health threats, such as antimicrobial resistance (AMR), zoonotic diseases and food safety hazards. The application of a One Health approach is essential for achieving the United Nations Sustainable Development Goals (SDGs).[99] It has direct relevance to goals such as 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 can lead to improved global health security, poverty alleviation and the protection of biodiversity.[100]

10.2 Punjab's Disease Burden and Epidemiological Context

Punjab is Pakistan's most populous and economically vibrant province, housing approximately 127.7 million people in 2023 (56% of the national total).[101] The province exhibits the highest population density in the country at 643.4 people per km², reflecting heavy population concentration that drives rapid urbanisation and land-use changes.[102]



[98] Operational-framework-for- strengthening-human-animal-and-environmental-public-health-systems-at-their-interface
[99] Revised-Public-World-Bank-One-Health-Framework-2018.
[100] Pakistan JEE report 2023
[101] National-Census-Report-2023.pdf
[102] UHC Monitoring Report 2024



This demographic pressure correlates with the highest burden of disease (BoD) in Pakistan; Punjab accounts for 53.2% of the national share, with a staggering 47.15 million Disability-Adjusted Life Years (DALYs) lost in 2023. The province is undergoing an epidemiological transition where non-communicable diseases (NCDs) such as cardiovascular disease, diabetes and cancers now account for over half of total deaths, yet entrenched infectious diseases (TB, hepatitis, malaria) and neonatal disorders remain significant threats.[103]

10.3 Conceptual Framework: Human, Animal, Ecosystem and Climate

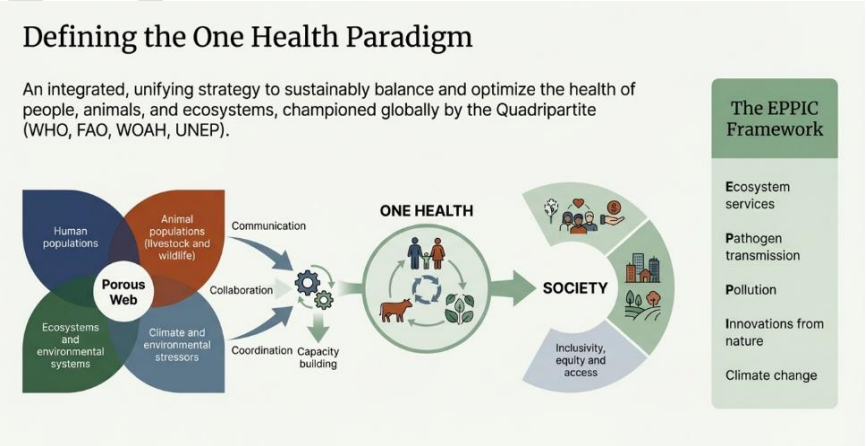
The One Health framework conceptualizes health risks as emerging from **interactions between four key domains**:

1. Human populations
2. Animal populations (livestock and wildlife)
3. Ecosystems and environmental systems
4. Climate and environmental stressors

The One Health approach in Punjab is defined as an integrated, unifying strategy to sustainably balance and optimise the health of people, animals and ecosystems. In this regional context, health risks are not isolated events but are driven by a "porous web of vulnerabilities" where traditional silos between sectors often fail to address root causes.

These dynamics create a complex nexus of environmental and health risks, where ecological changes can amplify disease emergence and environmental degradation can undermine both human and animal health.[104]

Recognizing these interconnected challenges, international organizations including World Health Organization, Food and Agriculture Organization of the United Nations, World Organization for Animal Health and United Nations Environment Programme



[103] Level of Readiness of PHC in Pakistan Beta 2025
[104] One Health ChJekel Epi& Public Health

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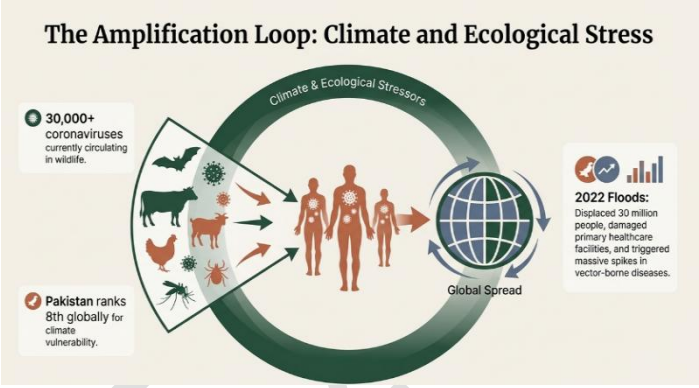
collectively known as the Quadripartite have called for stronger global adoption of the One Health approach.[105] The One Health framework also contributes directly to achieving several United Nations Sustainable Development Goals, particularly those related to health, water, climate action and biodiversity protection.[106]

10.3.1 The Animal-Human Interface:



Pakistan is the fifth most populous nation, with its population projected to reach 257.7 million by 2025 Punjab, bearing 56% of this population, faces intense urbanisation and land-use change, which act as primary stressors on natural habitats. Punjab's status as a massive livestock and poultry hub creates a permanent "high-risk interface". The province accounts for over half of Pakistan's veterinarians and para-veterinarians, yet the high animal density means pathogens can easily pass between species. Approximately 60% of known infectious diseases and 75% of emerging ones are zoonotic, originating in animals.[107]

10.3.2 Animal and Livestock Density: Agriculture and livestock are the backbones of Punjab's economy; the province hosts a significant portion of the country's **44 million cattle and 147 million poultry**. This high density creates a permanent "high-risk interface" for pathogen spillover.[108]

10.3.3 Ecosystem Resilience: Healthy landscapes provide "landscape immunity," where interactions remain in balance. A critical indicator in Punjab is the presence of white-rumped vultures in Kabirwala village, which perform an essential scavenger function by removing carcasses, thereby preventing disease buildup.

10.3.4 Climate Change as a "Threat Multiplier": Pakistan ranks 8th globally for climate vulnerability. Climate change exacerbates environmental stressors, shifting the distribution of disease vectors and increasing the frequency of extreme events like the 2022 floods, which displaced millions and triggered massive outbreaks of malaria and dengue.[109]

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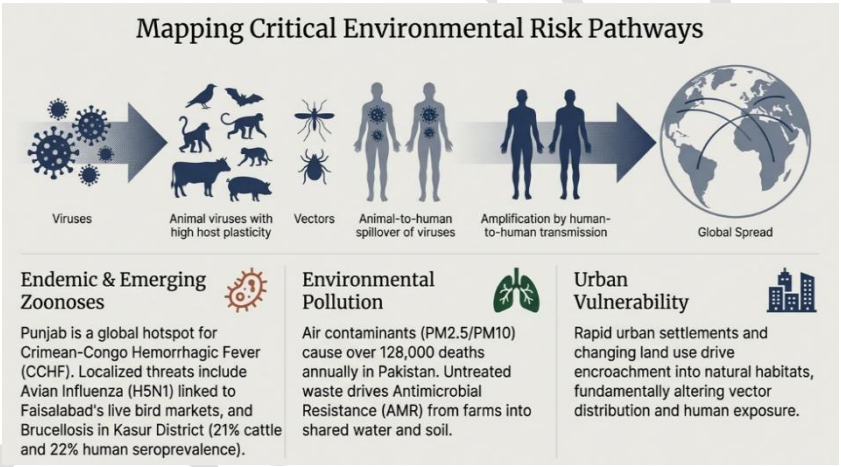
[105] One Health and The United Nations
[106] One Health Joint Action Plan
[107] Pakistan Multisectoral Health workforce Strategy PMHWS (2025-35)
[108] World Health Organization, Joint External Evaluation of IHR Core Capacities of The Islamic Republic Of Pakistan. 2016.
[109] Pakistan Universal Health Coverage Monitoring_Report_2024

10.3.5 Coordination Mechanism: From the livestock perspective, One Health coordination in Punjab remains formally recognised but only partially operational. At present, coordination between livestock and human health is primarily routed through formal government structures, particularly through the One Health Secretariat and official interdepartmental meetings.

10.4 Environmental Risk Pathways Affecting Health

The disease burden at the human-animal-environment interface is significant, with approximately 60% of known human infectious pathogens being zoonotic in origin. Environmental risk pathways include water and soil contamination, which can spread antimicrobial-resistant germs through communities and the food supply.[110]



Stress itself is a critical risk amplifier; for instance, wildlife stressed by habitat loss becomes more susceptible to infection and more likely to shed pathogens.[111] A healthy landscape provides "landscape immunity," where balanced ecosystem dynamics buffer against disease spillover. COVID-19 is the latest example of a pandemic caused by a zoonotic pathogen. Several other zoonoses (e.g. Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS-CoV), zoonotic influenza (H5N1, H7N9, H1N1), Mpox and Ebola virus diseases) are examples of diseases originating from an animal reservoir with the potential to cause epidemics and pandemics in humans.[112]

Pollution from pesticides, industrial waste and air contaminants poses direct toxicity risks and can serve as a mediator for increased susceptibility to infectious diseases. Risks in Punjab travel through three critical pathways: disease burden, environmental pollution and urban vulnerability.

10.4.1 Disease Burden: Endemic and Emerging Zoonoses Punjab is a global hotspot for **Crimean-Congo Hemorrhagic Fever (CCHF)**, with outbreaks peaking during festivals like Eid al-Adha. Specific local threats include:

[110] World Bank's 2018 One Health Operational Framework
[111] WWF's "One Health Approach to Conservation
[112] ECDC One Health Framework One-Health-Framework-Directors

- **Brucellosis:** Outbreaks in **Kasur District** highlight the vulnerability of smallholder dairy farmers. Seroprevalence is recorded as high as 21% in cattle and 22% in high-risk human populations.
- **Avian Influenza**: Since 1994, Punjab has faced recurring outbreaks of H5N1, with cases in [113]**Faisalabad** linked to semi-commercial broiler production and live bird markets.[114]
- ***Neglected Zoonotic Diseases (NZDs):*** Rabies causes 2,000–5,000 deaths annually in Pakistan, primarily from dog bites, with 78% of the population remaining unaware of treatment options.[115]

10.4.2 Environmental Pollution*: Air, Water and Soil* Punjab's industrial activity and agricultural burning create severe systemic health hazards.

- ***The Smog Crisis:*** Major cities like **Lahore, Faisalabad and Gujranwala** consistently rank among the most polluted globally. Air pollution (PM2.5/PM10) is linked to over **128,000 deaths annually** in Pakistan.[116]
- ***Toxic Bioaccumulation:*** Pollutants like heavy metals and pesticides used in food systems enter aquatic ecosystems and bioaccumulate in cattle and fish, eventually impacting human health.

10.4.3 Economic Burden*:* Macroeconomic Losses and Future Projections: Environmental degradation and climate change pose an existential threat to Pakistan's economic stability.

- **Immediate Disaster Costs:** The 2022 floods alone caused over USD 40 billion in damages.
- Specifically within the health sector, these floods resulted in USD 134 million in losses and damages
- **Long-term GDP Impact:** Climate risks, environmental pollution and the degradation of ecosystems are anticipated to cause GDP reductions of 18% to 20% by 2050 if current trends are not reversed
- **Agricultural Vulnerability:** As a cornerstone of the economy, the agricultural sector is highly susceptible to climate shifts. For example, the 2022 floods destroyed 3 million acres of crops and killed more than 1.2 million livestock, severely impacting the livelihoods of the rural poor

10.4.4 Antimicrobial Resistance (AMR): The overuse of antibiotics in livestock and the subsequent spread of resistant genes through manure and wastewater into soil and water creates a "silent pandemic". [117]

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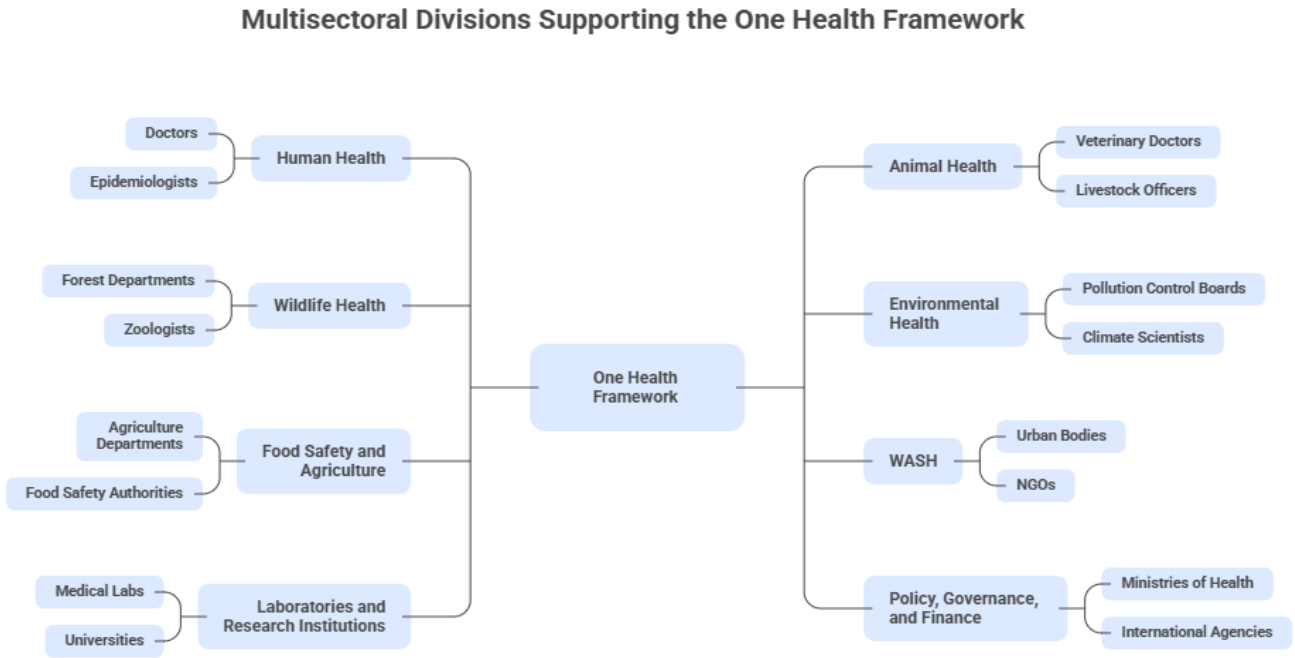
[113] National Bridging Workshop on the International Health Regulations (IHR) and the OIE Performance of Veterinary Services (PVS) Pathway,2017
[114] Pakistan Multisectoral Health workforce Strategy PMHWS (2025-35)
[115] One Health Zoonotic Disease Prioritisation & One Health Systems Mapping and Analysis Resource Toolkit™ For Multisectoral Engagement
[116]WHO Environmental Health Report, 2023
[117] Pakistan Multisectoral Health workforce Strategy PMHWS (2025-35)

10.4.5 Urban Vulnerability and Habitat Change Urban vulnerability is heightened in densely populated areas where unplanned urbanisation leads to poor waste management and increased contact with pest animals. For example, contaminated water sources used for drinking and recreation can lead to widespread outbreaks affecting both humans and livestock.[118]

System Failure: High population density combined with weak **WASH (Water, Sanitation and Hygiene)** infrastructure facilitates the spread of cholera and typhoid.[119]

10.5 Multisectoral Divisions Supporting the One Health Framework

The **One Health framework** operates through the integration of multiple specialised divisions, moving away from isolated sectoral approaches to a unified system that addresses 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 all institutions that hold a part of the wider health, environmental and disease-prevention system. In Punjab, effective One Health implementation depends on the coordinated contribution of departments responsible for human health, animal

[118] OneHealth-SimpleGuideforPolicyandPractise.pdf
[119] About One Health WORD.pdf

health, environmental protection, food safety, agriculture, water and sanitation, laboratories, 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 help monitor and control animal diseases; environmental institutions address pollution, waste, water quality and ecological risks; while food safety, agriculture and WASH systems reduce exposure to contamination and prevent the spread of infectious diseases.

Laboratories, universities and research institutions provide the evidence base required for diagnosis, antimicrobial resistance monitoring, pathogen detection and risk assessment. At the same time, governance and finance institutions create the policy direction, coordination mechanisms and resources needed to sustain multisectoral action. Together, these institutional functions form the operational foundation for a stronger One Health framework in Punjab.

Strengthening this framework requires improved coordination, shared data systems, joint planning and clear responsibilities across departments. By linking these sectors through a common health security agenda, Punjab can move from fragmented responses toward 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 support early detection of infectious diseases, vaccination, infection prevention and response to outbreaks. Surveillance systems are important for identifying unusual patterns of fever, respiratory illness, diarrhoeal disease and other public health threats that may indicate emerging risks.

10.5.2 Animal Health

The animal health sector is essential for preventing and controlling zoonotic diseases that may spread from animals to humans. Veterinary services, livestock departments, dairy and poultry institutions support disease monitoring, vaccination, farm biosecurity and animal health reporting. Strong animal disease surveillance provides an 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 One Health because many emerging infectious diseases originate in wildlife populations. Forest, wildlife and ecological institutions contribute by monitoring high-risk species, identifying disease hotspots and reporting unusual

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wildlife deaths. Strengthening wildlife surveillance can help detect early signs of spillover risk before diseases affect livestock or human communities.

10.5.4 Environmental Health

Environmental health provides the foundation for One Health by addressing the ecological and environmental conditions that influence disease transmission. Environmental institutions monitor air quality, water quality, pollution, waste disposal, ecosystem degradation and climate-related risks. Effective environmental management reduces exposure to pollutants, limits disease-supporting conditions and supports healthier ecosystems for humans and animals.

10.5.5 Food Safety and Agriculture

Food safety and agriculture sectors protect public health by managing risks across the food chain, from production to consumption. Agriculture departments, food safety authorities and farming institutions help prevent contamination from pathogens, pesticides, heavy metals and unsafe production practices. Strong food safety regulation and agricultural biosecurity 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 infectious disease transmission. Safe drinking water, effective sanitation, solid waste management and wastewater treatment reduce the spread of diseases such as cholera, typhoid and diarrhoeal infections. Wastewater management is also important for limiting the environmental spread of antimicrobial resistance and protecting community health.

10.5.7 Laboratories and Research Institutions

Laboratories and research institutions provide the diagnostic and evidence base for One Health decision-making. Medical, veterinary, environmental and academic laboratories support pathogen detection, antimicrobial resistance monitoring, 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 must work through clear legal frameworks, defined responsibilities and dedicated budgets. Governance tools such as joint assessments, preparedness reviews and performance monitoring can help identify gaps and guide investment in integrated health security.

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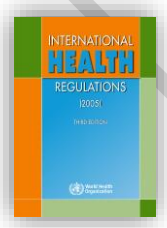
Overall, these sectoral components show that One Health in Punjab requires coordinated institutional action rather than isolated departmental activity. Strengthening linkages between these sectors will improve disease prevention, environmental management, surveillance capacity and emergency preparedness across the province.

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 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 building the necessary systems to prevent, detect and respond to public health emergencies. Progress towards these commitments has been periodically reviewed 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 tackling infectious disease threats. Pakistan became a member in 2015 and reinforced its engagement in 2020 by joining the GHSA Steering Group.



The International Health Regulations, developed by the World Health Organization, serve as a legally binding framework that guides countries in developing essential capacities for managing health threats. Through the JEE process, countries receive an independent assessment of their preparedness levels and recommendations for strengthening national health systems.

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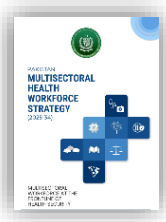
Pakistan's most recent JEE in 2023 provided an updated assessment of the country's health security landscape. While the evaluation acknowledged existing strengths, using established tools like the **IHR Joint External Evaluation (JEE) has been done in 2023 and from that Stakeholder Mapping done at national and provincial** thorough analysis of all relevant actors including government agencies, NGOs, academia and the private sector will help clarify roles and responsibilities.

Pakistan introduced the **National Action Plan for Health Security (NAPHS) 2024–2028**, a strategic roadmap designed to improve the country's preparedness and response capabilities. The plan focuses on expanding workforce capacity across human, animal and environmental health sectors, strengthening health infrastructure and enhancing multisectoral coordination to address emerging health threats more effectively.

The 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 indeed in the region this landmark effort highlights Pakistan's leadership in advancing health security through workforce development.



10.6.2 Punjab's Current Regulatory Landscape: Challenges and the Need for Integration

Punjab has developed a series of important legislative acts aimed at addressing various public health and safety concerns. These include laws focused on infectious disease control, dengue management, animal health, disaster relief and food safety.

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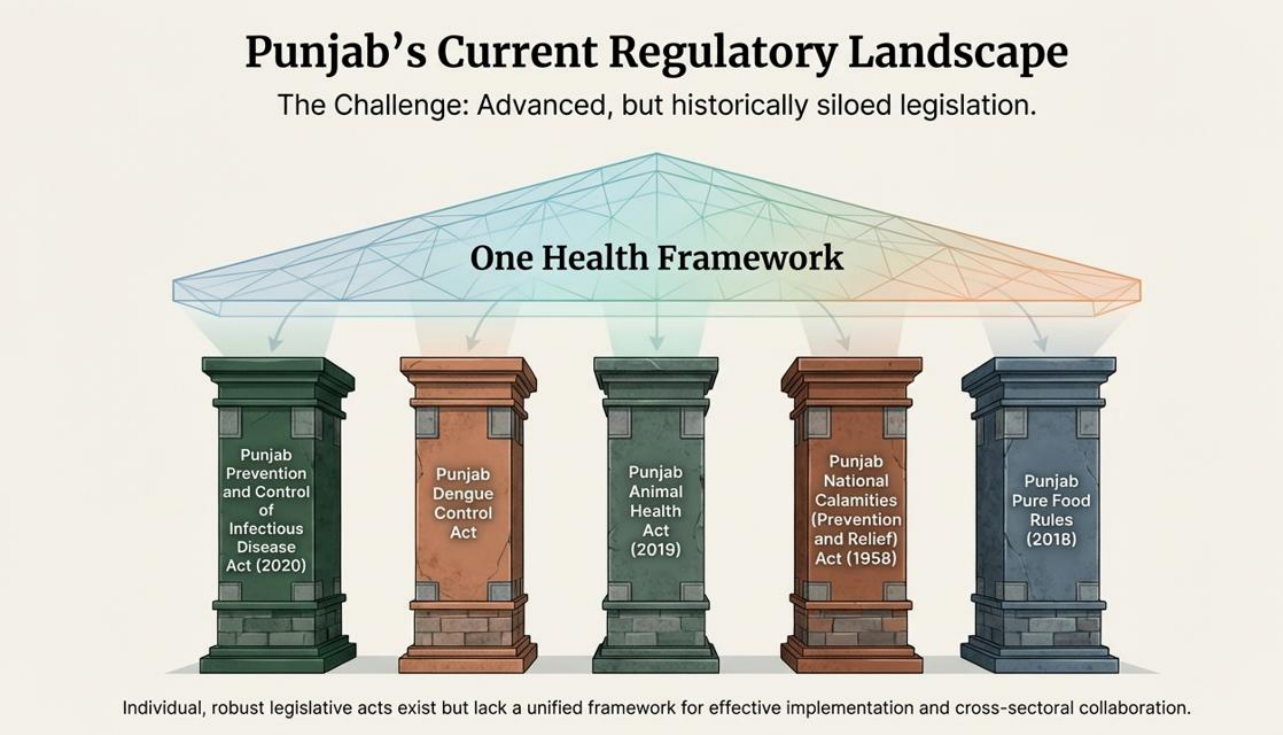

Individually, these acts are robust and demonstrate advanced regulatory thinking. For example, the Punjab Prevention and Control of Infectious Disease Act (2020) targets the containment of infectious diseases, while the Punjab Dengue Control Act specifically addresses dengue fever prevention. Additionally, the Punjab Animal Health Act (2019) focuses on veterinary and zoonotic disease management, the Punjab National Calamities (Prevention and Relief) Act (1958) governs disaster response and the Punjab Pure Food Rules (2018) set standards for food safety.

However, despite the strength of these individual laws, a significant challenge remains: these legislative frameworks operate in isolation, or in "silos." This siloed approach limits their overall effectiveness because it prevents seamless collaboration between sectors such as human health, animal health, environmental safety and disaster management. Each act functions independently, with minimal coordination, which can lead to duplication of efforts, gaps in response and inefficiencies in implementation.

In 2025, Punjab demonstrates relatively strong institutional capacity for implementing International Health Regulations (IHR 2005) functions, with an overall IHR capacity index of 46.8%. This represents a gradual transition from foundational capacity towards a more structured and institutionalized preparedness framework.

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10.6.3 EPA Punjab as a regulatory bridge

EPA Punjab serves as an important regulatory interface within the One Health framework by linking environmental governance with wider public health risk management. Its core functions, including environmental monitoring, pollution control, environmental impact assessment, industrial effluent regulation, air quality management and compliance enforcement, directly contribute to reducing environmental conditions that may increase health risks.

Rather than acting as a direct health or livestock agency, EPA Punjab's role is to regulate and monitor environmental determinants that influence disease emergence, antimicrobial resistance and community exposure to pollutants. Poor waste management, contaminated water, untreated industrial discharge, air pollution and unsafe disposal practices can all create pathways for human, animal and environmental health risks.

Strengthening EPA Punjab's regulatory capacity and coordination with health, livestock, local government and agriculture departments can improve early identification 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, compliance 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 connect public health, livestock, environmental protection and related sectors. Rather than working only through separate departmental mandates, emerging governance arrangements provide a basis 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 structures help improve information-sharing between sectors and create opportunities for coordinated decision-making at provincial and district levels.

However, further institutional strengthening is required to ensure that these mechanisms are fully operational, adequately resourced and consistently linked with field-level implementation. Clear roles, regular data-sharing, joint monitoring and district-level coordination will be essential for

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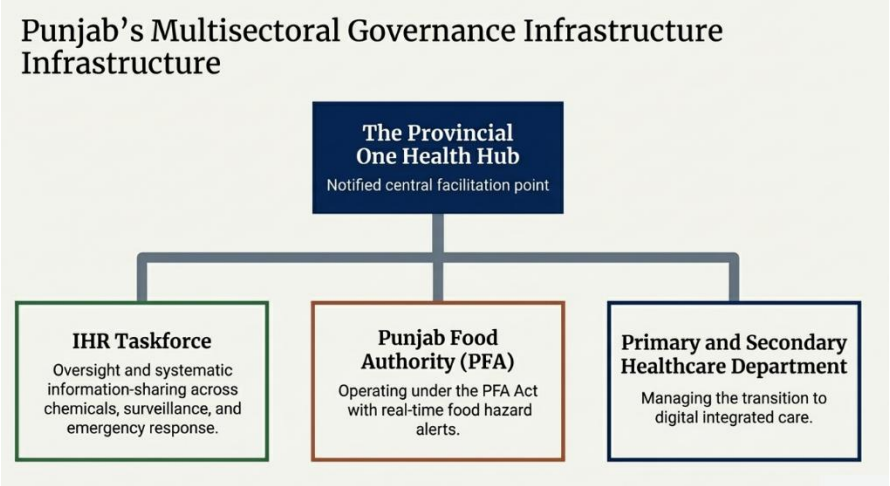
translating Punjab's One Health governance infrastructure into measurable public health and environmental outcomes.

10.7.1 One Health Hub:

A provincial One Health hub has been officially 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, 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 legislation, including the **Punjab Prevention and Control of Infectious Disease Act (2020)**, the Punjab Dengue Control Act and the **Punjab Animal Health Act (2019)**. Comprehensive mapping of public health laws is currently "under process" to further align them with multidisciplinary IHR requirements.

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

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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, often paper-based, disease reporting systems to a modern, web-based digital platform known as **DHIS2** (District Health Information System 2). This platform enables real-time collection, analysis and reporting of health data. The adoption of DHIS2 across Punjab is complete, allowing daily and weekly monitoring of 34 priority diseases. This digital transformation ensures timely data flow, enabling public health authorities to detect outbreaks quickly, make informed decisions and deploy interventions efficiently.

10.8.2 Integrated Data Flow and Response System

The DHIS2 platform integrates data inputs from multiple sources local clinics, EPA labs and the Food Authority into a single system that facilitates rapid analysis and coordinated response. This integrated data flow enables continuous monitoring of priority diseases and environmental health indicators, which informs public health response and policy decisions.

10.8.3 Laboratory Networks

Complementing digital surveillance is a tiered laboratory network designed to support diagnostic testing and environmental monitoring. This network operates through several key components:

- The **Provincial Public Health Reference Laboratory (PHRL)**, which serves as a central hub for disease diagnosis and confirmation.
- **Environmental Protection Agency (EPA) certified labs** that monitor industrial effluent and other environmental factors that can impact public health.
- **Food Authority diagnostic setups** that ensure food safety by analyzing potential contaminants.
- Together, these labs provide comprehensive diagnostic capabilities, supporting surveillance data and contributing to evidence-based public health actions.

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

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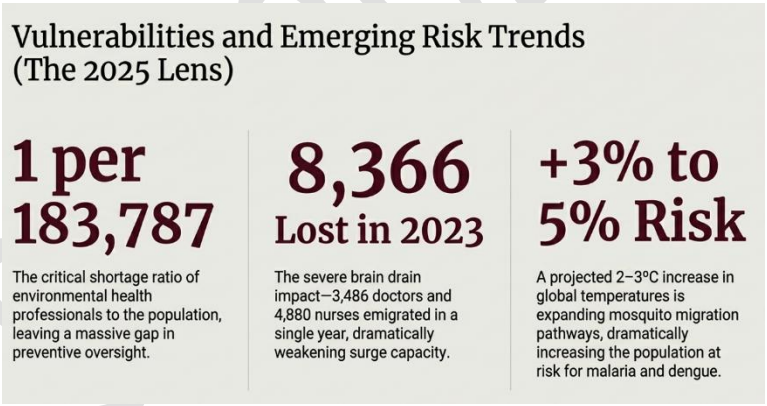
supports improved coordination between human, animal and environmental health sectors, including upgrades to the Animal Disease Reporting and Surveillance (ADRS) system. This represents an important step toward operationalizing the One Health approach by improving early detection, reporting and response 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 reflects a significant public health achievement and indicates the province's capacity to implement large-scale preventive health programmes. Maintaining and further improving this coverage remains essential for reducing vaccine-preventable diseases, strengthening child health outcomes and supporting 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 of multi-drug resistant organisms remains at **a low level of capacity,** indicating an urgent need for stronger stewardship Programmes.

10.9.2 Workforce Disparities:

While Punjab has the largest share of physicians and specialists, rural areas remain under-resourced. There is a critical shortage of environmental health professionals, with only one available for every **183,787 people**.

10.9.3 Financing:

IHR implementation financing is the biggest challenge, as dedicated and sustainable provincial budget lines for health security have not yet been fully institutionalized.

10.9.4 Infection Prevention and Control (IPC):

Programmes are currently struggling to improve and need systematic monitoring of healthcare-associated infections to reach higher operational maturity.

10.9.5 Rising Vector-Borne Threats:

Climate models predict that a **2–3ºC increase in global temperature** will expand mosquito migration pathways, increasing the risk of malaria and dengue in the region

DRAFT 2025

10.10 Strengthening One Health Frameworks in Punjab

Strengthening the **One Health** framework in Punjab requires a shift from broad policy commitment 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 suited to Punjab's environmental, livestock, public health and governance context.

First, Punjab should establish a formal provincial One Health coordination mechanism involving environment, health, livestock, agriculture, food safety, local government and disaster management institutions. This mechanism should support joint planning, shared risk assessment 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 between departments would help identify emerging risks earlier and support evidence-based decision-making at provincial and district levels.

Third, district-level One Health coordination should be operationalised through multisectoral committees that can translate 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 improved through joint training programmes for environmental inspectors, public health officials, veterinarians, laboratory staff and local

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government officers. A skilled multisectoral workforce is essential for implementing One Health beyond policy documents.

Finally, Punjab should introduce clear monitoring and evaluation indicators to track progress. These may include improvements in disease surveillance, response time, interdepartmental coordination, laboratory capacity, AMR monitoring, environmental compliance and community-level risk reduction. These priorities would help Punjab move toward a more integrated, preventive and resilient One Health system.

10.10.1 Align with National and Global Health Security Frameworks

Punjab should adopt national-level strategies and use technical assessments such as the Joint External Evaluation (JEE) to identify gaps in health security. Provincial policies should align with global commitments like the International Health Regulations (IHR) to ensure preparedness for emerging health threats.

10.10.2 Establish Strong Governance and Coordination

A high-level inter-ministerial coordination mechanism should be created to oversee collaboration between the health, environment, livestock and agriculture sectors. A dedicated One Health coordination unit can help manage risk assessments, share data and coordinate responses during outbreaks.

10.10.3 Develop Policy and Legal Frameworks

Punjab should develop a clear provincial One Health strategy aligned with national health security plans. Legal mandates should define responsibilities and enable coordinated disease surveillance, risk assessment and emergency response across sectors.

10.10.4 Strengthen Integrated Surveillance and Workforce Capacity

Integrated surveillance systems should collect and share data from human, animal and environmental health sectors. Standard operating procedures for joint outbreak investigations and multi-sectoral training programmes such as Field Epidemiology Training Program (FETP) can build a skilled workforce capable of implementing the One Health approach.

10.10.5 Focus on Prevention and Community Engagement

Strategies should address upstream drivers of disease emergence, including climate change, habitat destruction and agricultural intensification. Engaging local communities ensures that prevention efforts are practical, equitable and sustainable.

10.10.6 Monitor Progress with Measurable Indicators

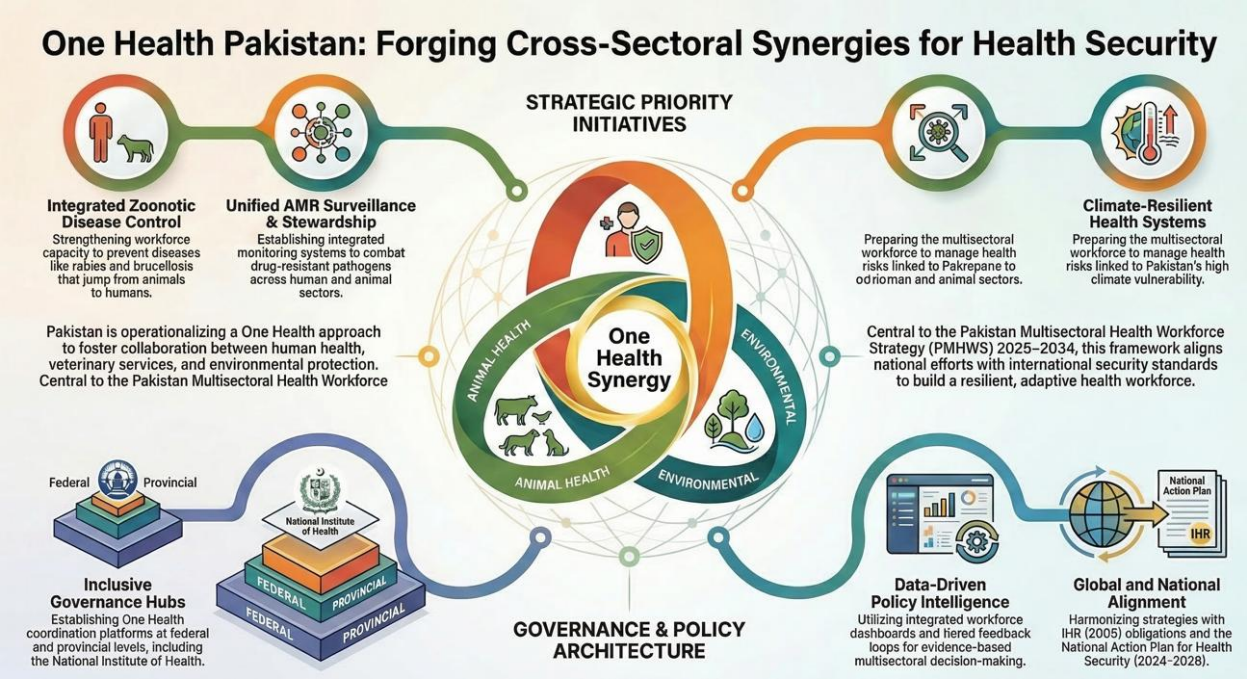
Punjab should implement a monitoring and evaluation framework with SMART indicators, including the functionality of a One Health coordination body, updated JEE assessments, the

DRAFT SOE 2025

number of joint surveillance activities and the proportion of professionals trained in One Health principles.

10.11 Conclusion

This chapter has examined the growing importance of strengthening the One Health (OH) framework in Punjab to address complex health risks emerging 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 shown that these risks cannot be managed effectively 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 help strengthen provincial preparedness and improve coordination between sectors. However, policy alignment alone is not sufficient. Effective implementation requires clear institutional responsibilities, functional coordination platforms, integrated data-sharing systems and district-level mechanisms that translate 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 directly linked with public health risk reduction. Strengthening regulatory governance can therefore help operationalise One Health by connecting environmental monitoring with disease prevention, risk assessment and emergency response. District-level coordination structures, including multisectoral workforce committees, can further improve 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 will 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 necessity. 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.

DRAFT SOE 2025

Chapter No. 11: Bird Strike Risk Reduction

11.1 Introduction

Bird strikes collisions between aircraft and birds are among the most serious safety threats in aviation. They occur most commonly during takeoff, landing and low-altitude flight. A single strike can cause catastrophic engine failure, windshield damage, or loss of aircraft control, putting lives at risk.

Globally, bird strikes cause hundreds of millions of dollars in aircraft damage every year. Several fatal crashes have been directly linked to bird ingestion into engines. The risk is not theoretical it is a well-documented hazard that airports worldwide manage through active 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 areas provide food, while ponds, wetlands and drainage systems attract waterfowl. Trees, shrubs, buildings and tall grass offer shelter and nesting opportunities. These attractants increase bird activity near airports and raise the risk of bird strikes, making effective wildlife and habitat management essential for aviation safety.

For Lahore, the concern is particularly acute. The city's dense urban environment characterized by slaughterhouses, open garbage dumps, unauthorised poultry farms and widespread bird-feeding at shrines and public spaces draws large concentrations of birds towards flight paths near Allama Iqbal International Airport. This makes bird hazard management a direct aviation safety priority, not a secondary environmental concern.

According to civil aviation sources, from 2018 to 2022, 198 incidents of bird strikes were reported at the Allama Iqbal International Airport while 622 were reported across the country. In 2022, 57 PIA flights were affected by bird strikes, with the highest number reported from Lahore, where five planes were damaged. In the first six months of 2024, 38 PIA planes collided with birds across the country, of which 14 incidents were reported in Lahore, where 28 more incidents took place between 2024 and 2025.[120]

The problem is further compounded by rapid urban expansion around the airport. As commercial and residential activity grows near flight corridors, human-generated food waste and bird-attracting land use continues to increase. Without regulatory intervention, bird density near the airport will rise and so will the probability of a serious incident.

To address this, the Wildlife & Parks Department, Punjab declared seven localities surrounding the airport as No Bird Zones. In response to this declaration, EPA Punjab issued a formal order in

[120] Bird strikes threaten aviation safet | The Express Tribune

DRAFT SOE 2025

July 2025, establishing a comprehensive set of enforceable control measures across all seven zones to address the environmental and urban factors driving bird concentration near the airport.

11.2 Enforcement by EPA Punjab

EPA Punjab issued a formal order on 9 July 2025 for the control of bird hazards near Allama Iqbal International Airport. It covers seven No Bird Zones spanning 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 is rooted in aviation safety: Lahore's urban environment generates the conditions that concentrate birds near flight paths, heightening the risk of bird-aircraft collisions that can cause catastrophic engine failure and loss of life.

The EPA Punjab prohibits a defined set of activities within these zones:

- Open dumping of garbage, offal and slaughter remains
- Unauthorised poultry farms or bird breeding facilities
- Feeding of birds at public gatherings or religious shrines
- Slaughterhouses, tandoors and bakeries operating without waste management
- Unregulated rooftop grain scattering and bird or animal feeding
- Use of uncovered waste collection bins

Beyond these operational bans, the EPA Punjab imposes a complete freeze on processing environmental approval applications for poultry farms, hatcheries, tanneries, meat shops, slaughterhouses and organic waste storage facilities within the designated zones. Non-compliant units are liable to be sealed and violators face legal action carrying 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

DRAFT SOP 2025

11.3 Enforcement Data (2025)

EPA Punjab conducted an enforcement campaign, “No Bird Zones” in 2025. Field teams issued notices to violators and removed bird cages across five areas. The table below shows the results:

During this enforcement campaign 634 notices were issued and 128 bird cages were removed. Icchra recorded the highest activity 257 notices and 71 cage removals followed by Chah Miran with 227 notices and 33 removals. Chungi Amar Sadhu saw 81 notices and 23 removals. Manwan Hospital and PKLI together accounted for 69 notices and only 1 cage removal, reflecting relatively lower levels of non-compliance in those 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 the numbers. Pigeon and bird cages kept on rooftops and in commercial areas sustain a permanent resident bird population within the zones. Their removal directly reduces the bird density. The 128 cages removed in less than two months indicate meaningful early progress.

This intervention is significant because it demonstrates EPA's capacity to act at the intersection of environmental law and public safety reframing bird hazard control not as a niche aviation concern, but as a direct consequence of waste mismanagement and unregulated urban activity, both of which fall squarely within the EPA's regulatory mandate.

DRAFT SOE 2025

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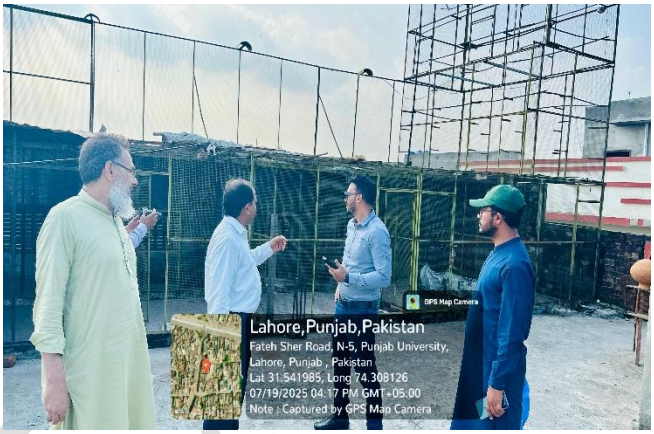
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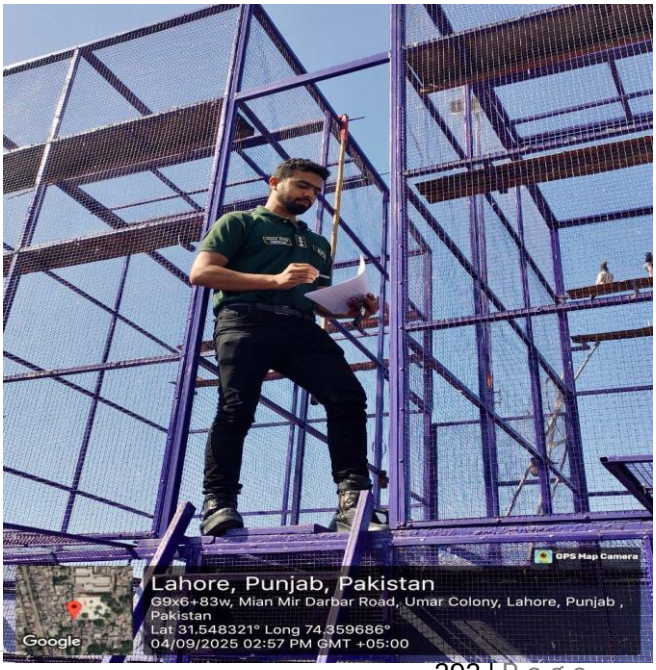
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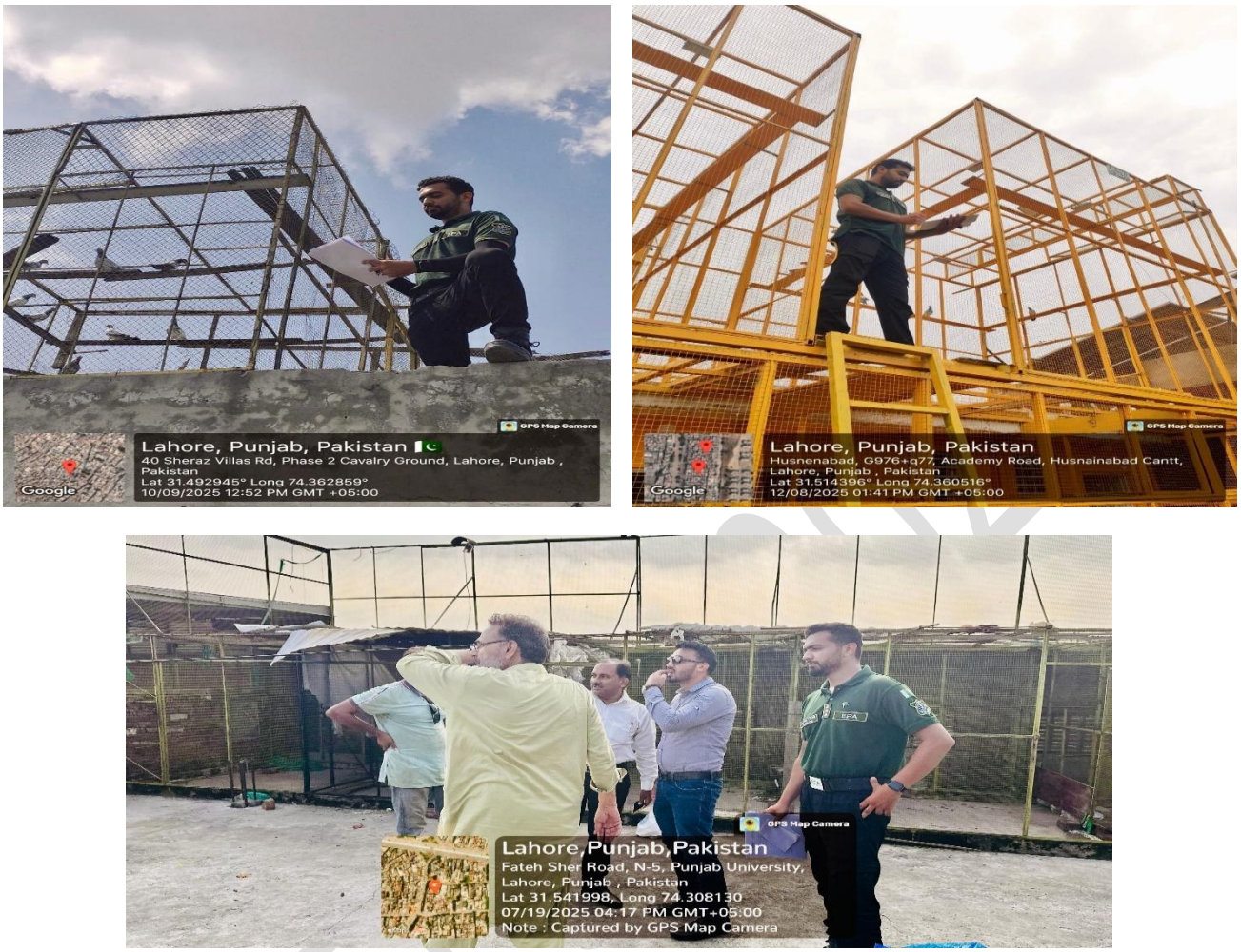

Figure 11.1: Enforcement Activities by EPA Punjab

11.4 Conclusion

Bird strike risk reduction around Allama Iqbal International Airport represents a coordinated regulatory response to a well-established aviation safety hazard. The Wildlife & Parks Department's No Bird Zone declaration, backed by EPA Punjab's enforcement and active field operations, has set a clear legal and operational framework. Early enforcement data 634 notices and 128 cages removed across five zones in under two months shows the initiative is being actively implemented on the ground.

Sustained results will depend on continued enforcement, inter-agency coordination between EPA, local government, airport management and wildlife authorities and public awareness about the consequences of bird-attracting activities near airports. The legal framework is in place; consistent implementation is what will determine whether bird strike risk around the airport is meaningfully and durably reduced.

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Chapter No. 12: Stubble Burning and Smog Mitigation

12.1 Overview

Punjab's land use pattern reflects an overwhelming agricultural orientation, with approximately 60% of its 20.6-million-hectare geographical area dedicated to cultivation, translating to roughly 12.5 million hectares of cultivated land. The Indus Basin Irrigation System, one of the world's largest contiguous irrigation networks, irrigates over 80% of this cultivated area. Major crops dominate the landscape: wheat occupies approximately 9 million hectares, rice covers about 4.5 million hectares, cotton spans roughly 2.5 million hectares and sugarcane extends across approximately 1.3 million hectares. In contrast, forest cover remains critically limited at only 3% (approximately 0.5 million hectares), while urban areas are expanding rapidly, currently occupying around 12% of the land with major cities like Lahore alone sprawling over 400,000 hectares. Rangelands and barren lands constitute approximately 10% and 5% respectively of the remaining land use categories. This intense agricultural focus underscores the intricate relationship between land use patterns and environmental challenges in the province.

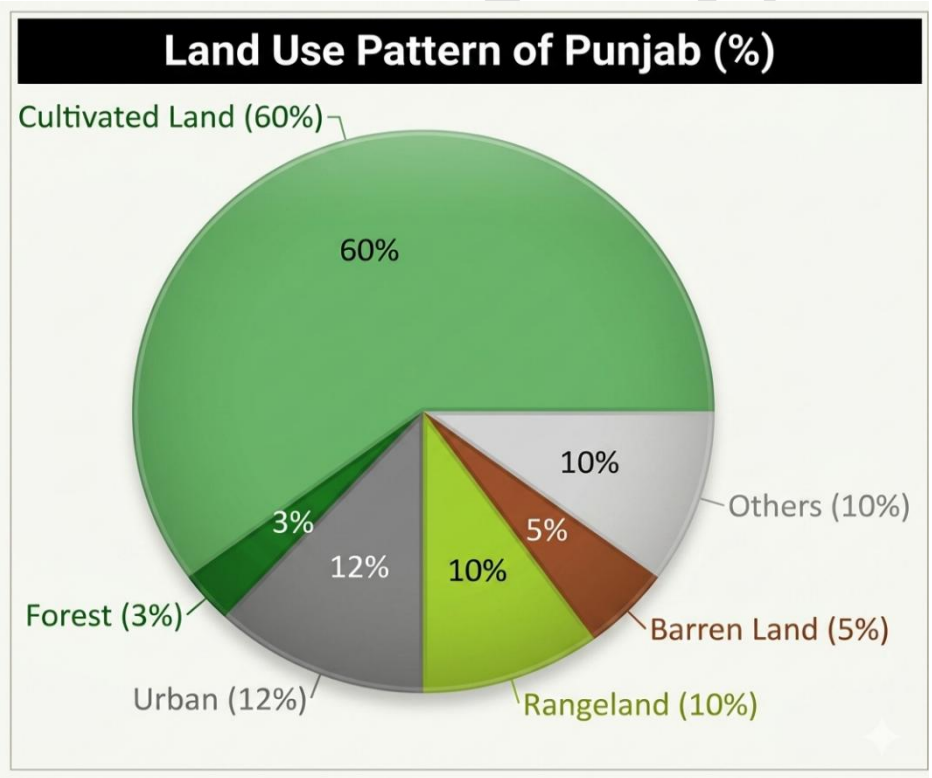

Figure 12.1: Land Use Distribution of Punjab

Source: Bureau of Statistics, Punjab (2023). *Land Utilisation Statistics.*

This land use distribution highlights the dominance of agriculture in Punjab and provides the context for understanding how crop residue management practices influence seasonal air quality

Within this agricultural landscape, smog has emerged as a persistent environmental challenge in Punjab, particularly during the post-harvest period of the agricultural cycle, when practices such as stubble burning significantly worsen air pollution. The province's agricultural cycle consists of two main cropping seasons: Kharif (April to September) and Rabi (October to March. The close transition between these two seasons creates a narrow window for farmers to clear fields after rice harvesting and prepare land for wheat sowing. In central Punjab, where most farmers practise crop rotation between rice and wheat, rice is sown in May and wheat in November. To expedite field preparation for wheat and other crops requiring fine seedbeds, many farmers resort to burning the leftover stubble from paddy harvesting. This practise has intensified alongside the increasing cultivation of rice in the region, significantly contributing to deteriorating air quality.

The scale of this practise is reflected in official estimates and satellite-based observations of seasonal burning incidents and established a direct linkage in contribution of Smog. According to the Smog Commission Report 2017, stubble burning contributes approximately 20% to 25% of the total smog concentration during peak months. Punjab has a rice cultivation area of approximately 4.5 million acres and each year a substantial volume of crop residue is burned in the open. As per the anomalies reported by SUPARCO (2024), a large number of stubble burning incidents were recorded, especially along major motorways, highlighting the urgency of targeted interventions. Given Punjab's extensive cultivated area and the documented contribution of stubble burning to smog formation, the serious health, environmental and economic impacts of smog necessitate the adoption of a dedicated, resource-backed mitigation strategy aimed at reducing seasonal burning and improving air quality across the province

12.2 Environmental Impacts of Stubble Burning

The recurring practise of stubble burning during crop harvesting seasons has become a major source of multifaceted environmental pressure in Punjab contributing to severe smog, environmental degradation and health hazards. Immediate impacts include severe air pollution, with particulate matter (PM2.5 and PM10) reaching hazardous levels that pose significant health risks to vulnerable populations. This practise also contributes to greenhouse gas emissions, soil degradation through loss of organic matter and reduction in soil microbial activity. Long-term consequences include declining soil fertility, increased dependency on chemical fertilisers and contribution to regional climate change patterns.

Controlling this pressure requires more than simple prohibition. The continued practise of residue burning shows that farmers are often working within difficult structural and economic limits. For many, the quickest and cheapest option is not the most environmentally sustainable one. This makes it necessary to design policies that combine enforcement with practical support, access to suitable technology and gradual changes in farming behaviour. In this context, farmer awareness and capacity building become essential **first steps,** as meaningful change depends on helping farmers understand the impacts of burning and adopt practical alternatives in the field.

DRAFT SOE 2025

12.2.1 Farmer Awareness and Capacity Building Campaigns

Recognizing importance of awareness and Capacity building, an extensive multi-channel Information, Education and Communication (IEC) campaign was launched titled **"Piloting the Solutions for Environmentally Sound Management of Crop Residues in Punjab."** Executed through a collaboration between the EP&CCD, EPA Punjab and the SP&IU, the initiative was launched with a Rs. 300 million allocations for the 2025-26 fiscal year.

The campaign was designed to promote sustainable alternatives to stubble burning, such as biochar production, waste-to-value energy generation and industrial biomass utilisation, while educating farmers and stakeholders on the health and environmental risks of traditional burning. While the project initially considered including subsidies and surveillance, the scope was refined following inter-departmental consultations to avoid duplicating existing efforts, such as the Agriculture Department's machinery distribution and the CM Punjab Green Credit Program.

Figure 12.2 Capacity building Workshop & demonstration of Biochar making Plant from the Crop Residue

Consequently, the project transitioned to a specialised focus on farmer orientation, capacity building and facilitating direct interaction between growers and industrial residue users. This strategic pivot ensured that resources were dedicated to driving long-term behavioural shifts through education rather than replicating pre-existing financial support mechanisms.

12.2.2 Community Engagement through Seminars and Screenings

The community engagement strategy was built around a series of seminars, field visits and practical demonstrations across Punjab's primary rice-growing districts. These initiatives provided farmers with direct exposure to waste-to-energy projects and alternative residue management technologies, bridging the gap between theory and field application.

A centrepiece of this outreach was a purpose-built **docudrama** detailing the environmental and health consequences of stubble burning. Screened in over 100 high-cultivation villages, the film was paired with interactive dialogues featuring agricultural and environmental specialists. These sessions served as a platform for farmers to share experiences and address the practicalities of transitioning to non-burning 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 major rice-growing districts, bringing together progressive farmers, extension workers, district administration officials and technical experts to discuss strategies for expanding the adoption of sustainable residue management practices and addressing implementation challenges.

12.2.3 Awareness through Mass Media and Digital Communication Campaigns

The campaign leveraged mainstream media channels including radio, television and print media to reach broader audiences beyond direct farming communities, creating general public awareness about the smog problem and stubble burning's contribution to it. Targeted digital media awareness campaigns were launched on social media platforms, utilising the growing influence of these platforms to engage younger demographics and urban populations who could serve as advocates for environmental protection.

Digital poster and video competitions were organised on social media to encourage public participation in climate awareness content creation. The IM4Climate programme was launched as an innovative initiative that incentivized content creators to develop and disseminate climate awareness materials, creating a community-driven awareness ecosystem. Digital streamers were displayed in main cities across Punjab to reach urban populations and create widespread awareness about the environmental challenge.

All project activities (seminars, field visits, exhibitions and workshops) were extensively highlighted through digital, social (Facebook) and mainstream media channels. This multi-channel

DRAFT SOE 2

approach ensured maximum reach and engagement across diverse audience segments, from rural farming communities to urban populations and policymakers.

12.2.4 Information, Education and Communication Materials

Extensive Information, Education and Communication (IEC) materials were produced and distributed to ensure consistent messaging across all communication channels. The campaign produced 2,000 banners for display in strategic locations across rice-growing areas, 2,000 streamers for visibility in public spaces and along roadways, 20,000 flyers in four different types providing targeted information on specific aspects of residue management, 10,000 trifold brochures offering comprehensive information on alternatives to burning and 30 roll-up standees for use at seminars, workshops and public events.

These materials were strategically designed to communicate key messages in accessible formats suitable for diverse audiences, from farmers with limited literacy to educated urban populations. The use of visual communication through banners and streamers ensured that messages reached even those who might not engage with text-based materials. All materials emphasised awareness, capacity building and orientation towards non-burning options for sustainable crop residue management.

DRAFT SOE 2025

Figure 12.4 Social Media Outreach Material for Anti Crop-Residue Burning Campaign

The IEC materials were distributed and displayed during all seminar and screening events across the 100 selected villages, creating 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 Robocalls	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 helped communicate the risks of stubble burning and promoted behavioural change, prevention also required practical instruments that farmers could use 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, in collaboration with the Agriculture Department, implemented a major initiative for the distribution of Super Seeders and rice straw shredders to farmers as an alternative to the traditional method of burning rice straw. Super Seeders enable farmers to sow wheat directly into fields with standing rice stubble, incorporating the residue into the soil. This technology improves soil health by adding organic matter, reduces the need for burning and saves time during the critical transition period between crop seasons.

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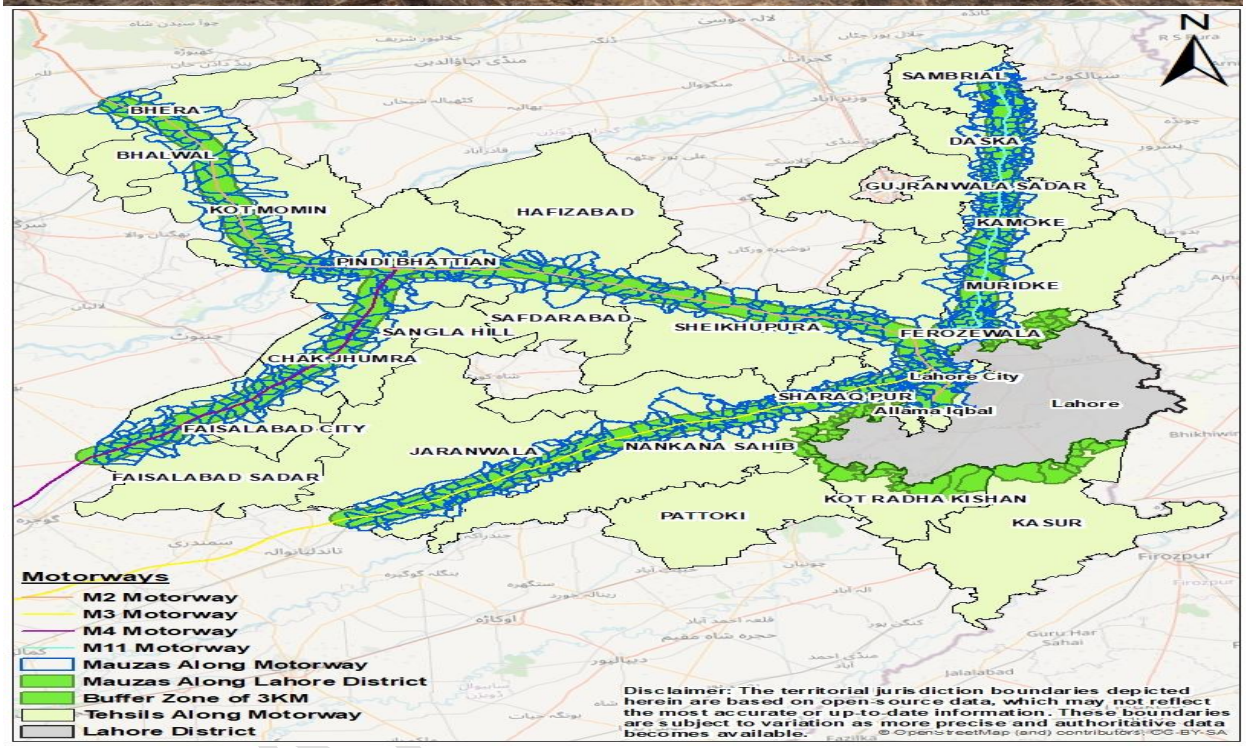


Figure 12.5 Super Seeder Distributed by the Government of Punjab Clean Air Programme

Rice straw shredders complement this approach by breaking stubble into manageable pieces that can be easily decomposed or integrated into the soil. The shredded material decomposes faster, enriching soil organic content and improving soil structure for subsequent crops. The distribution programme was strategically targeted at hotspot areas along major motorways (M-2, M-3, M-4 and M-11) identified based on the frequency of stubble burning incidents in previous years. Details are depicted in **Figure 12.6**. A total of 5,000 Super Seeders were distributed among farmers during 2024 and 2025, with 301 machines deployed in priority areas and plans for deploying the remaining units by November to ensure comprehensive coverage of targeted regions.

Figure 12.6 Hotspot Area along Motorways and sensitive tehsils around District Lahore

12.3.2 Impact of Preventive Measures

The deployment of Super Seeders and rice straw shredders, combined with comprehensive farmer training, yielded measurable results. The programme covered approximately 356000 acres of rice fields, directly preventing stubble burning on these lands. The use of Super Seeders allowed farmers to incorporate rice straw into the soil, eliminating the need for burning while simultaneously improving soil quality through recycling of organic matter.

The widespread adoption of these technologies, facilitated by training programmes, resulted in an estimated 40 to 50 percent reduction in stubble burning incidents in areas where Super Seeders were deployed. By incorporating rice straw into the soil, the programme promoted better soil fertility and reduced environmental degradation previously caused by burning. With full deployment of planned equipment, projections indicated potential reduction in stubble burning incidents by 50 to 60 percent in hotspot areas, resulting in cleaner air and healthier soils across Punjab.

12.3.3 Phased Delivery Strategy

The distribution of Super Seeders and rice straw shredders was implemented through a strategically phased approach. This phased delivery strategy was designed to ensure systematic coverage of priority areas while building implementation capacity and responding to emerging needs based on field experience.

The delivery plan was structured across three primary phases, with an additional focused allocation for motorway corridors where stubble burning incidents were most concentrated and visible. Phase-I focused on initial deployment in identified hotspot districts, delivering 1,000 units to establish operational infrastructure and demonstrate the viability of the technology. This initial phase served as a proof of concept, allowing the programme to refine distribution mechanisms, training protocols and farmer support systems based on early implementation experience.

Phase-II represented a significant scaling up of the programme, with 2,000 units distributed to expand coverage across additional rice-growing areas. This phase benefited from lessons learned during Phase-I and achieved more efficient deployment through established distribution networks and trained extension personnel. The doubling of delivery capacity in Phase-II reflected growing farmer demand for the technology and increased administrative capacity to support widespread adoption.

Phase-III delivered 1,163 units, targeting areas that were identified as requiring additional support based on monitoring data from previous phases and ongoing assessment of stubble burning patterns. This phase emphasised filling coverage gaps and ensuring that all priority areas had adequate access to alternative residue management technologies.

Recognizing the particular visibility and environmental significance of motorway corridors, where stubble burning incidents along major transportation routes contribute significantly to smog formation and create hazardous driving conditions, a dedicated allocation of 602 units was made

DRAFT SOE 2025

specifically for areas along motorways M-2, M-3, M-4 and M-11. This targeted deployment in motorway zones ensured intensive coverage in areas where burning incidents had the greatest public visibility and impact on regional air quality.

Across all phases and the motorway-specific allocation, a total of 4,819 Super Seeders and rice straw shredders were delivered to farmers on subsidized rates. This substantial deployment represented a significant public investment in providing viable alternatives to stubble burning and demonstrated the Government of Punjab's commitment to addressing the smog challenge through preventive rather than purely punitive measures. The subsidized pricing model was crucial to ensuring accessibility for small and medium-scale farmers who might otherwise be unable to afford the technology.

The phased delivery approach provided several strategic advantages. It allowed for systematic capacity building among implementing agencies and farmers, enabled adaptive management based on feedback from earlier phases, facilitated quality control and monitoring of equipment performance and ensured efficient utilisation of budgetary resources across multiple fiscal periods. The concentration of additional units along motorways reflected data-driven targeting based on SUPARCO anomaly reports and surveillance squad observations, ensuring that resources were deployed where they could achieve maximum 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 and the motorway-specific allocation represented approximately 95 percent of the total distribution target of 5,000 Super Seeders mentioned in programme objectives. This high delivery rate demonstrated effective programme implementation and strong administrative coordination among implementing agencies. The remaining units were planned for deployment in subsequent distribution cycles based on ongoing assessment of farmer demand and emerging hotspot areas.

Table 12.3: Impact of Super Seeder Distribution Program

DRAFT SOE 2025

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

Although awareness campaigns and preventive instruments were introduced to discourage stubble burning, the persistence of incidents across hotspot areas indicated that preventive measures alone were not sufficient to ensure compliance at the field level. In many areas, crop residue burning continued due to operational convenience, limited adoption of alternative practices, weak ground-level oversight and the narrow time window between harvesting and sowing cycles. The situation was particularly critical in areas located near major motorways and urban settlements, where even localised burning could rapidly affect visibility, traffic movement and ambient air quality. These conditions highlighted the need for an active monitoring and enforcement mechanism capable of identifying incidents in real time, verifying field conditions and ensuring immediate response in high-risk areas. Consequently, the Environmental Protection Agency, Punjab established a structured monitoring and surveillance framework designed to combine field monitoring, technological surveillance, public reporting and coordinated enforcement into an integrated operational response system.

12.5 EPA's Monitoring Framework

Building on this targeted approach, the Environmental Protection Agency, Punjab established a monitoring and surveillance framework in 2025 to control stubble burning in priority areas. The Environmental Protection Agency Punjab adopted a six-layer strategic surveillance and response framework for the control of stubble burning in priority areas. The strategy began with the identification of hotspot areas based on rice cultivation intensity, historical burning trends and proximity to major motorways and urban settlements. Following hotspot identification, surveillance squads were deployed for continuous field monitoring and incident detection. To strengthen reporting coverage, EPA incorporated public participation through the Green Punjab App, Helpline 1373 and community-based reporting mechanisms. For timely field response, Quick

DRAFT SOE 2025

Response Centres (QRCs) were established at strategic locations, supported by Quick Response Units (QRUs) equipped for immediate firefighting and intervention. In parallel, EPA also developed an inter-departmental coordination mechanism involving district administration, Agriculture Department, Police and other relevant departments to ensure coordinated enforcement and operational support. Together, these components formed an integrated strategic surveillance and response framework for stubble burning control.

12.5.1 Surveillance Squad Deployment

A total of Nine surveillance squads were strategically deployed across designated beats along motorways. These beats were strategically designed to provide comprehensive coverage of hotspot districts, with each beat assigned to specific sections of major transportation corridors:

DRAFT SOE 2025

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

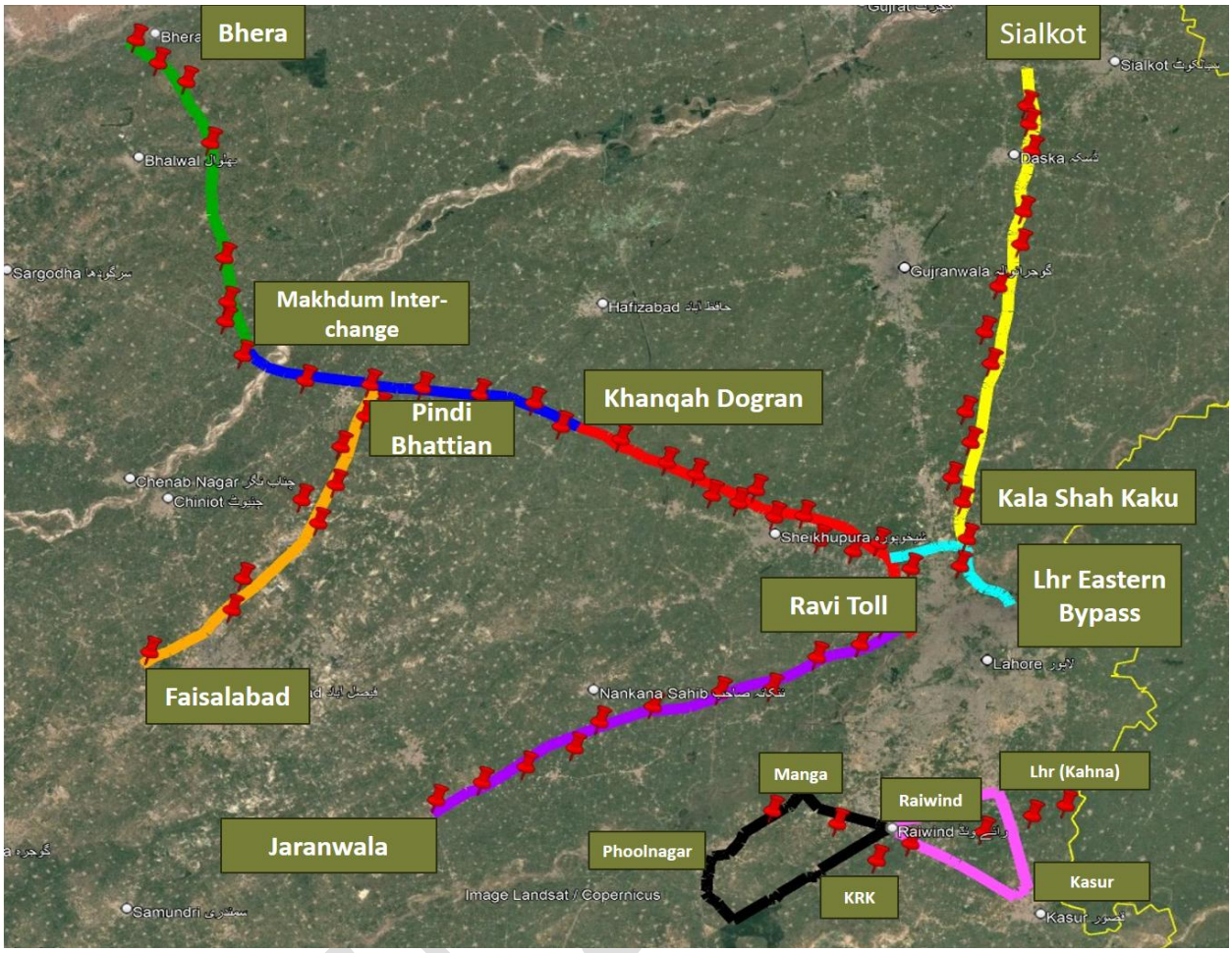


Figure 12.7 Geographic Alignment of Surveillance Beats along Motorways

Each surveillance squad consisted of one Inspector, one Field Assistant and a driver equipped with a vehicle to patrol its respective beat. The inspectors and field assistants worked in rotating shifts to ensure round-the-clock monitoring of agricultural fields. While field squads provided direct ground-level surveillance, remote sensing and digital tools were integrated to strengthen detection, verify field observations and extend monitoring coverage beyond physical patrol route

12.5.2 Remote Sensing and Technology Integration

EPA integrated satellite-based monitoring through SUPARCO's anomaly detection system, which provided real-time data on fire incidents across the province. These anomalies are shared daily with the Deputy Commissioners of all districts across Punjab via an official WhatsApp group, enabling immediate access and resolution by designated authorities. The integration of remote

sensing data with ground-level surveillance created a robust, multi-layered monitoring system capable of detecting incidents across vast agricultural areas. To complement official surveillance, the framework also incorporated public reporting mechanisms, enabling citizens and local communities to share timely information on suspected stubble burning incidents.

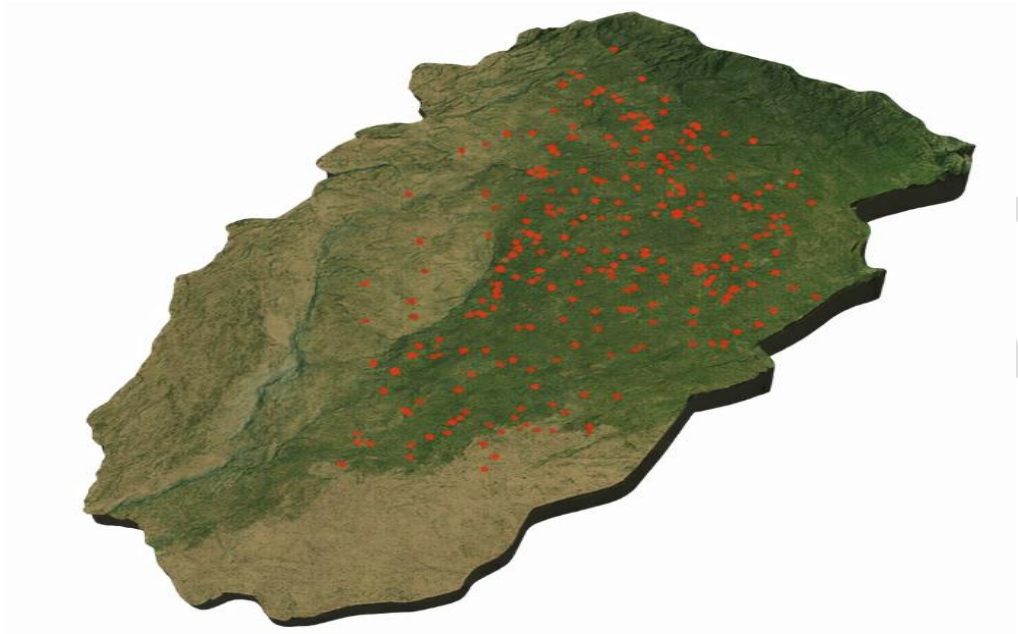


Figure 12.8 Stubble Burning Alerts Facilitated by SUPARCO & NASA Fire Maps

12.5.3 Public Reporting Mechanisms

EPA established multiple channels for public participation in monitoring efforts. The Green Punjab App was launched as a comprehensive platform for citizens to report complaints about air pollution and stubble burning incidents. Additionally, a dedicated helpline (1373) was established to receive and register complaints from citizens about stubble burning incidents on a round-the-clock basis.

Figure 12.9 1373 Helpline System for Public Reporting

An innovative approach involved the registration of 13,600 school teachers stationed within rice cultivation hotspot Districts. Recognizing that teachers are uniquely positioned to serve as community observers due to their local presence and influence, this network was engaged through automated Robo-calls. Issued twice daily, these calls prompted teachers to report stubble burning by selecting a 'Yes' or 'No' response via their keypad (pressing 1 or 2). Affirmative responses automatically triggered the lodging of a formal complaint for immediate field verification by enforcement teams. This community-based surveillance model significantly expanded monitoring coverage and enhanced early detection through proactive grassroots participation.

Figure 12.10 Teacher-based Robo-call reporting system

In this way, the teacher-based Robo-call system converted local community presence into a structured reporting channel. However, the value of these reports depended on timely verification, field response and enforcement action, which required close coordination among EPA, district administration, agriculture authorities and other relevant departments.

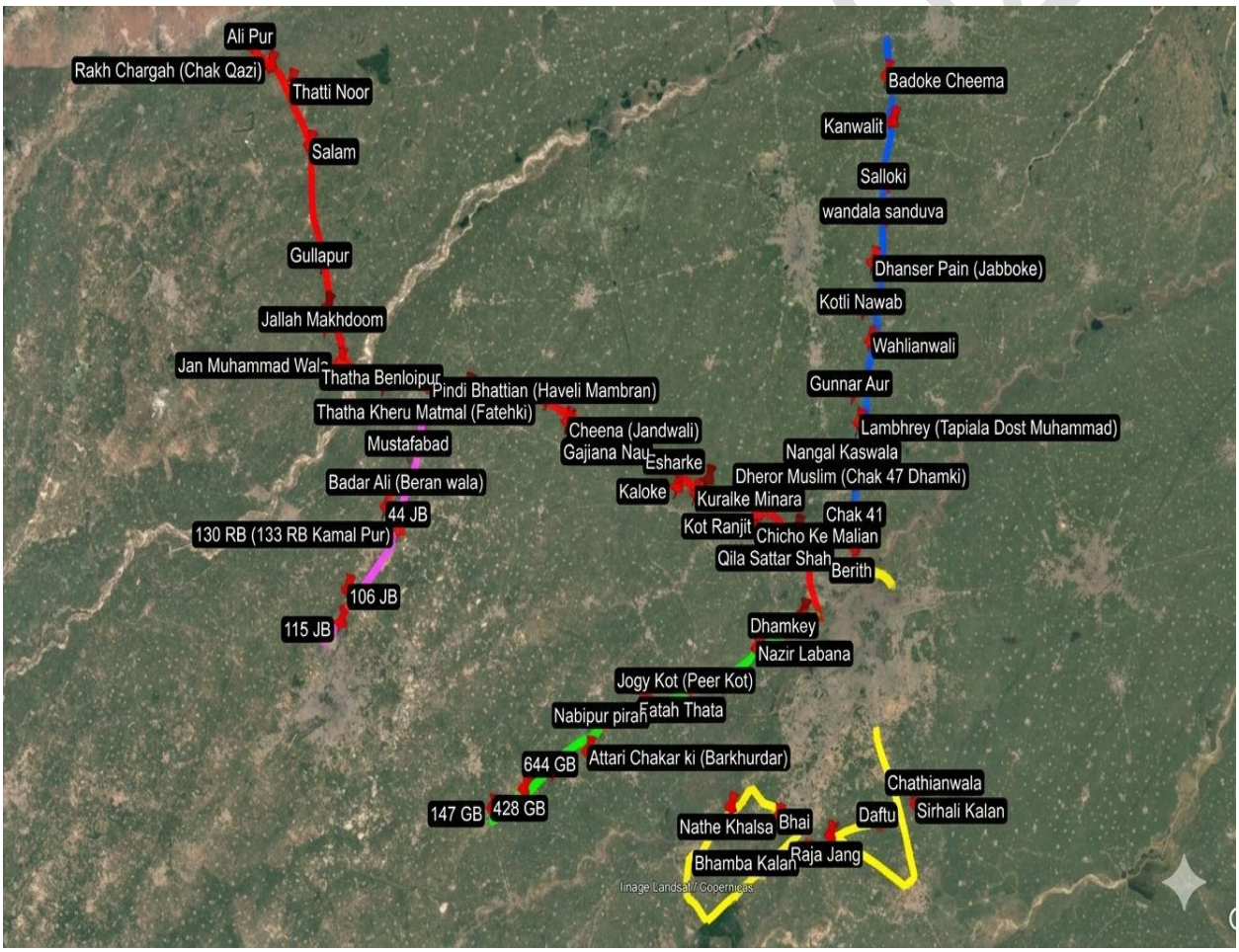
However, effective control of stubble burning required more than incident reporting and surveillance alone. The increasing volume of field alerts generated through surveillance squads, Helpline 1373, the Green Punjab App, teacher-based reporting and satellite anomaly detection highlighted the need for an operational response mechanism capable of timely field intervention and coordinated enforcement. To address this requirement, EPA established a broader implementation framework under the project titled *"Establishment of Environmental Protection Force in 10 Zones of Punjab."* The project integrated surveillance, rapid response, technological monitoring and inter-departmental coordination into a unified operational system aimed at controlling stubble burning across identified hotspot districts along motorways and the periphery of Lahore.

12.5.4 Quick Response Centres (QRCs)

A total of sixty-seven Quick Response Centres were strategically established **(Figure 12.11)** within a 3-kilometre radius along motorways (M-2, M-3, M-4 and M-11) and in adjoining areas of Lahore. Each QRC was positioned in or near a Union Council office of the Agriculture Department, ensuring accessibility to infrastructure and coordination with agricultural extension services.

Each Quick Response Centre was equipped with essential firefighting equipment, including one tractor paired with a water bowser having a capacity of 5,000 to 6,000 liters. This Quick Response Unit (QRU) enabled direct response to fires identified by surveillance teams. Each QRC was staffed by a Field Assistant from EPA serving as the focal person, along with firefighting personnel. The QRC squads were equipped with motorcycles (125cc) for quick field assessment and mobility.

Figure 12.11 Locations of 67 Quick Response Centres (QRCs)



The QRCs operated in two shifts (day and night) to ensure continuous availability and capability to respond to stubble burning incidents at any time. The Agriculture Department coordinated the identification of suitable sites for QRCs and identified nearby tube wells for water refilling operations, ensuring that response units had sustained access to water resources necessary for fire suppression.

12.5.5 Incident Reporting and Response Mechanism

A streamlined incident reporting and response protocol was established to ensure rapid mobilization of resources. When a surveillance squad identified an incident of stubble burning, they immediately reported the incident, including GPS coordinates, to the nearest Quick Response Centre. Upon receiving the report, the QRC squad swiftly mobilized, deploying the water bowser and firefighting staff to the incident location to extinguish the fire and prevent further damage.

This rapid response mechanism ensured timely intervention, minimising the duration and extent of stubble burning incidents. The coordination between surveillance squads and QRCs created an effective early warning and response system capable of addressing incidents within critical time windows.

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 various channels (the Green Punjab App, Helpline 1373, teacher reports and SUPARCO satellite anomalies) were consolidated and displayed on the Green Punjab App Dashboard. The dashboard provided real-time visualization of complaint locations, status of complaint resolution, deployment of surveillance squads and QRUs and patterns and trends in stubble burning incidents.

12.6 Inter-departmental Coordination & Enforcement

Recognizing that effective stubble burning control requires coordinated action across multiple departments and administrative levels, EPA established a comprehensive inter-departmental coordination framework. This framework facilitated seamless collaboration among key stakeholders and ensured 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) in suitable locations, ensuring their strategic placement for effective response. The department identified and coordinated the use of Union Council offices for housing QRCs and identified nearby tube wells to support water refilling operations. This collaboration ensured that QRCs had access to essential infrastructure and resources necessary for rapid fire suppression. Extensive coordination meetings were held at high administrative levels between the Environment Department and the Agriculture Department to finalize operational strategies and ensure effective implementation of crop-residue burning control measures, which also helped define clear roles and responsibilities and ensured a unified direction for field operations across districts.

Figure 12.13 High-Level Coordination Meetings between Environment and Agriculture Departments for Crop Residue Burning Control

Joint teams comprising EPA and Agriculture Department personnel conducted field operations within designated clusters, combining regulatory enforcement with farmer engagement and technical support. This integrated approach facilitated both immediate action against violations and longer-term adoption of alternative residue management practices.

12.6.2 District and Tehsil-Level Coordination Mechanisms

EPA activated District and Tehsil-level Anti-Smog Committees to ensure localised coordination and implementation of anti-stubble burning mechanisms. These committees brought together

representatives from agriculture, environment, police and district administration to develop integrated response strategies tailored to local conditions. Regular meetings of these committees ensured continuous monitoring, information sharing and coordinated action against violators.

In collaboration with district administration, thirty sub-tehsil tier clusters were notified along motorways, each encompassing 30-35 villages. These clusters served as operational units for prevention and control activities, with joint teams from the Agriculture Department and EPA operating within their designated areas of responsibility.

12.6.3 Police Department Coordination

EPA coordinated with the Provincial Police Officer to direct all District Police Officers to obtain sureties from previous years' violators, ensuring commitments that they would not burn stubble during the current season. This preventive measure leveraged enforcement records to proactively reduce recidivism among known violators. Police support also proved crucial in facilitating access to remote locations and ensuring the safety of surveillance and quick response teams during field operations.

12.6.4 Centralised Coordination through Smog War Room

The EPA established a Smog War Room to serve as the central command and coordination hub for all anti-stubble burning operations. To ensure seamless inter-departmental synergy, focal persons from the Agriculture Department and other key stakeholders were deputed to the War Room. These representatives were mandated to attend on a regular basis throughout the stubble burning season, facilitating real-time data sharing and ensuring that field activities were synchronized across all administrative levels. The War Room facilitated real-time monitoring of the Green Punjab App Dashboard, tracking of complaint resolution, coordination of quick response Units deployments and strategic decision-making based on emerging patterns and trends.

All complaints received through various channels (the Green Punjab App, Helpline 1373, teacher reports via Robo-calls and SUPARCO anomalies) were consolidated and displayed on the Green Punjab App Dashboard. Access to this dashboard was provided to Deputy Commissioner offices, with designated System Network Administrators (SNAs) serving as district focal persons. This centralised information system enabled coordinated response across jurisdictions and ensured accountability in complaint resolution.

12.7 Environmental Outcomes

The comprehensive anti-stubble burning strategy implemented by EPA, integrating preventive measures, surveillance systems and rapid response mechanisms, yielded significant environmental outcomes during the 2025 paddy harvesting season.

DRAFT SOE 2025

12.7.1 Reduction in Fire Anomalies

The rice stubble burning season officially commenced on September 28, 2025. Following this, satellite data from SUPARCO demonstrated a substantial reduction in fire anomalies during October 2025 compared to October 2024. The timely induction of surveillance squads and coordinated interventions with the Agriculture Department, district administration and police resulted in a 65 percent reduction in reported anomalies during October (Figure 12.14). This significant decrease reflected the effectiveness of the integrated approach combining prevention, monitoring and enforcement.

The reduction in fire anomalies was particularly pronounced in areas where Quick Response Centres were operational and Super Seeders were distributed. The convergence of alternative technologies, farmer training, enhanced surveillance and rapid response capabilities created a synergistic effect that substantially reduced the incidence of stubble burning in targeted hotspot areas.

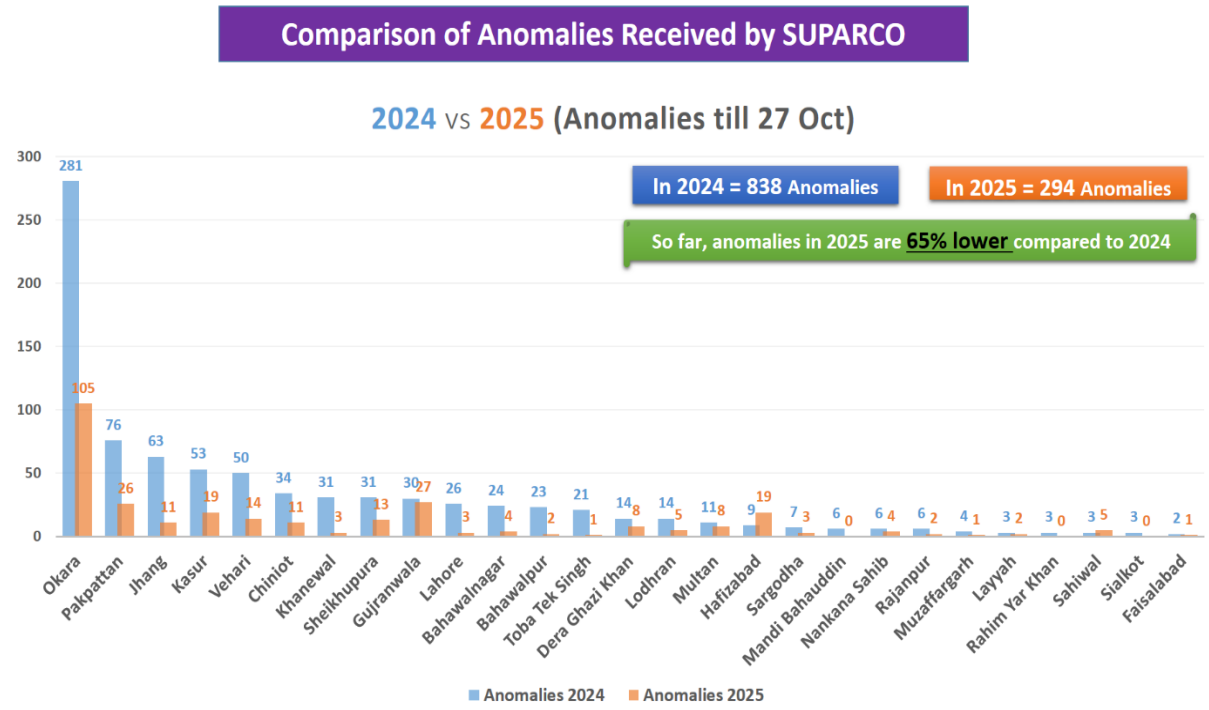


Figure 12.14: Comparison of Anomalies 2024 vs 2025

12.7.2 Emergency Response Performance

The Quick Response Units 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 motorways and the Lahore periphery. Notably, in two specific hotspot districts and in their respective beats, no fire extinguishing

activities were required as rice harvesting had already been completed prior to the QRUs arrival. Despite the late-season start, this rapid response capability proved the efficacy of the deployment strategy, demonstrating that timely intervention can effectively suppress stubble burning before incidents escalate.

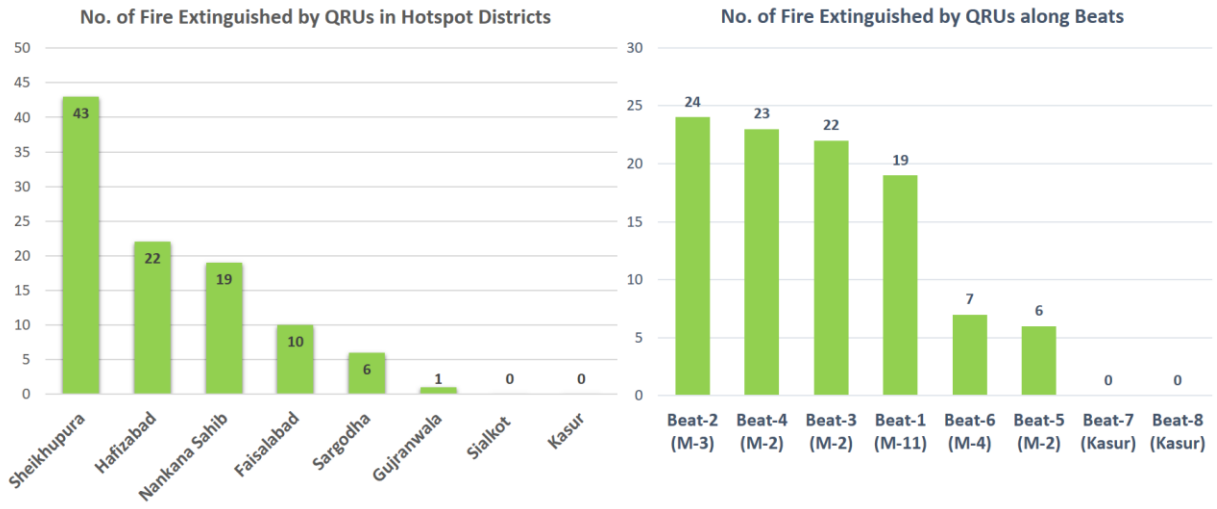


Figure. 12.15 Operational performance of Quick Response Units (QRUs) showing district-wise and beat-wise distribution of fire incidents addressed in priority intervention zones

The successful extinguishment of 101 fires within two weeks represented a significant achievement in preventing air pollution that would have otherwise resulted from uncontrolled burning of crop residue. Each extinguished fire prevented the release of particulate matter, carbon monoxide, methane and other pollutants that contribute to smog formation and pose 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 Super Seeder deployment and extinguishing 101 fires through rapid response, the programme prevented the release of significant quantities of air pollutants. The reduction in particulate matter (PM2.5 and PM10) concentrations in areas with intensive interventions contributed to decreased respiratory health risks for local populations and reduced the contribution of agricultural burning to regional smog formation.

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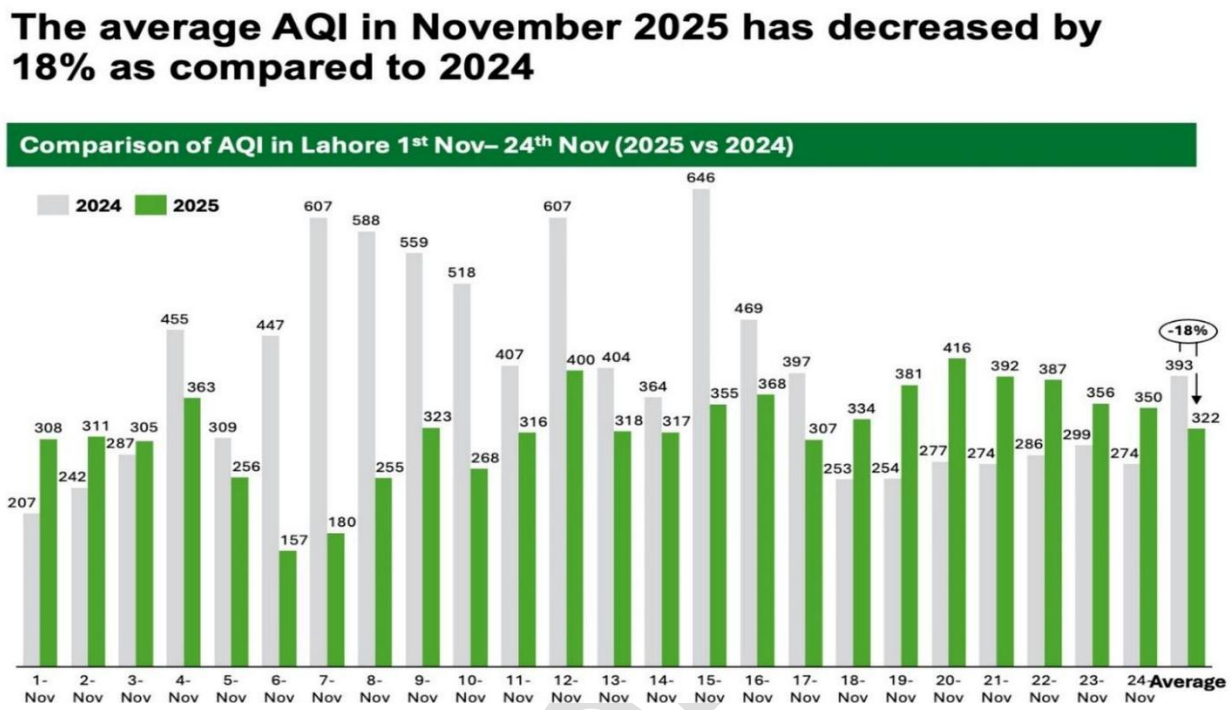

Figure: 12.16 Daily and average Air Quality Index (AQI) values in Lahore from 1–24 November, comparing 2024 and 2025, showing an overall 18% reduction in average AQI in 2025.

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 yielded significant soil health benefits. By incorporating rice straw into the soil rather than burning it, farmers added organic matter to their fields, improving soil structure, water retention capacity and nutrient cycling. Over time, these improvements in soil health are expected to enhance agricultural productivity and reduce dependence on chemical fertilisers, creating both environmental and economic benefits for farming communities.

12.7.5 Behavioural Change and Long-term Sustainability

The comprehensive approach combining technology provision, training, surveillance and enforcement contributed to gradual behavioural change among farming communities. The training of farmers created awareness about the environmental and agricultural impacts of stubble burning and demonstrated viable alternatives. This awareness-building, combined with the availability of Super Seeders and the credible threat of enforcement through surveillance systems, created conditions for sustainable adoption of alternative residue management practices.

The establishment of inter-departmental coordination mechanisms and community-based monitoring networks created institutional capacity that will support continued progress in stubble

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burning control. The success of the 2025 interventions provides a foundation for scaling up preventive and response measures in subsequent years, with potential for further reductions in stubble burning and associated environmental impacts.

12.8 Way Forward

The anti-stubble burning initiatives implemented during 2025 demonstrated that a comprehensive, multi-faceted approach integrating preventive instruments, advanced surveillance technology, rapid response capabilities, and inter-departmental 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 more than 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 highlights several critical success factors, most notably the importance of targeted deployment in hotspot areas, the value of integrating preventive measures with enforcement, the effectiveness of technology-enabled monitoring systems, and the creation of a foundation for long-term behavioral change through direct farmer engagement.

Moving forward, sustaining and building upon these achievements will require continued investment in alternative agricultural technologies, expansion of Quick Response Centre coverage, and the strengthening of surveillance and monitoring systems. The comprehensive framework established during the 2024–2025 cycle provides a highly replicable model for addressing stubble burning that can be scaled across additional districts and refined based on ongoing operational experience. Ultimately, the environmental outcomes achieved, including improved air quality, enhanced soil health, reduced greenhouse gas emissions, and decreased public health risks, demonstrate that effective environmental management in the agricultural sector requires the seamless integration of regulatory enforcement with the provision of viable alternatives and capacity building for farming communities. The Punjab experience in stubble burning control offers valuable lessons for addressing similar agro-environmental challenges in other regions facing the dual imperative of agricultural productivity and environmental sustainability.

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Part III Digital Transformation & Coordinated Environmental Governance

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Chapter No. 13: Digital Environmental Governance

13.1 Introduction

A defining moment in the evolution of environmental governance unfolded in 2025, as Environmental Protection Agency initiated a bold and far-reaching digital transformation across Punjab. Confronted with escalating environmental pressures and the complexity of managing forty-one districts, the agency recognised that its traditional, paper-based systems were no longer sufficient. These legacy processes not only slowed regulatory response but also limited transparency and weakened enforcement capacity. The need for a decisive shift towards a more agile, data-centric framework became both urgent and unavoidable.

In response, the EPA embraced a forward-looking approach centeredon digital integration, real-time monitoring and streamlined operations. By replacing fragmented workflows with interconnected systems, the agency sought to enhance the speed, accuracy and accountability of its regulatory functions. This transformation reflects a strategic commitment to strengthening institutional performance while addressing the dynamic environmental challenges facing the province.

This transformation extended well beyond the digitization of legacy records; it represented the development of a comprehensive and interconnected digital ecosystem. By incorporating AI-driven industrial monitoring, real-time analytical dashboards and electronic adjudication platforms, the Environmental Protection Agency has fundamentally restructured its operational framework. These innovations have replaced time-consuming manual procedures with streamlined, transparent and automated systems, enabling quicker regulatory responses and ensuring greater consistency in enforcement across Punjab.

Today, these initiatives have established EPA Punjab as a leader in smart regulation, setting a new benchmark for environmental governance in Pakistan.

13.2 EPA Punjab's Digital Transformation Framework

EPA Punjab views its digital transformation through three interconnected strategic priorities: strengthening regulatory oversight, improving ease of doing business and enhancing internal accountability. Rather than treating digitization as a purely administrative exercise, the agency designed its new framework to support faster enforcement actions, transparent regulatory decision-making and citizen-centric service delivery. Under this approach, digital dashboards and analytical systems were introduced to strengthen regulatory checks and real-time monitoring; online applications and systematic approval mechanisms were developed to facilitate ease of doing business by reducing procedural delays and improving transparency; while internal accountability mechanisms, performance tracking systems and centralised monitoring platforms were established to ensure institutional efficiency and operational oversight across all districts. Together, these three pillars form the foundation of EPA Punjab's evolving digital governance model and provide the

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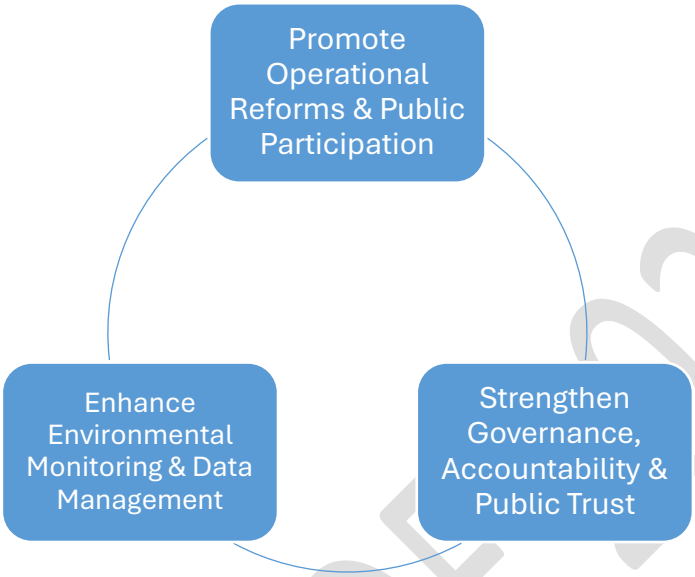
operational basis for the interconnected systems, dashboards, applications and public response platforms discussed in the following sections.

Figure 13.1: Three Strategic Priorities of new Framework



13.3. Digital Monitoring System and Dashboards

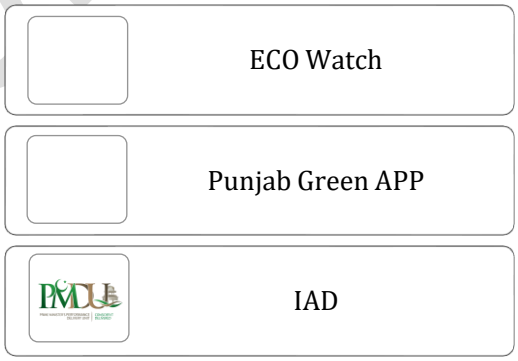


Figure 13.2: Some EPA's Digital Monitoring Systems – LOGOs

The strategic rollout of digital dashboards, including the ECO Watch Dashboard, Internal Accountability Dashboard and Industrial Directory Dashboard, together with applications such as the Green Punjab App and ECO Watch App, has strengthened the digital governance capacity of EPA Punjab. Rather than functioning only as information-display platforms, these systems have created a more transparent, traceable and performance-oriented regulatory framework. The shift from manual reporting to live digital monitoring has improved the ability of EPA Punjab to identify violations, track inspections, allocate field teams and review enforcement performance through real-time data.

A major governance improvement is the reduction in delays between violation 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 quickly than traditional inspection-based systems. This means that EPA Punjab can assess industrial activity continuously instead of relying only on periodic site visits. The effectiveness of this system can be measured through indicators such as average response time to detected violations, number of live-monitored industrial units, number of violations detected through digital surveillance, and percentage of cases where enforcement action was initiated within a defined timeframe. For example, EPA Punjab should report whether the dashboard has reduced the average

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complaint or violation response time from [insert previous response time] to [insert current response time].

The dashboards have also improved operational efficiency in field inspections. Inspectors can now upload inspection reports, photographs, geotagged evidence and compliance observations in real time. This reduces duplication, limits paperwork delays and minimises the risk of inaccurate or incomplete manual records. Key performance indicators should include the number of inspections uploaded digitally, percentage of inspections completed with geotagged evidence, reduction in manual file processing time, and number of inspections reviewed by senior officers through the Internal Accountability Dashboard. These indicators would demonstrate whether the digital system has genuinely improved administrative efficiency rather than simply introducing new technology.

The Industrial Directory Dashboard further supports evidence-based regulation by creating a structured database of industries, their locations, compliance status and risk profiles. This enables EPA Punjab to move from routine schedule-based inspections towards targeted, risk-based enforcement. Industries with repeated violations, high-emission activities or incomplete compliance records can be prioritised for inspection. The effectiveness of this risk-based approach should be assessed through indicators such as percentage of high-risk industries inspected, number of repeat violations identified, compliance improvement rates after enforcement action, and reduction in pending inspection cases.

Overall, the digital monitoring system has the potential to improve environmental governance by making enforcement more data-driven, transparent and accountable. However, its success should not be judged only by the existence of dashboards or mobile applications. It should be evaluated through measurable outcomes, including faster response times, higher inspection coverage, improved compliance rates, reduced backlog of complaints, increased detection of violations and visible improvements in environmental quality. Therefore, future reporting by EPA Punjab should include a performance dashboard showing baseline figures, current results and annual targets so that the real governance impact of digital monitoring can be objectively assessed.

DRAFT SOE 2025

13.3.1. AI-Driven Smart Monitoring

The Smart Industrial Monitoring Dashboard represents a significant leap in continuous industrial surveillance, leveraging CCTV cameras enhanced with artificial intelligence and machine learning capabilities to automatically detect and flag regulatory violations as per “Ringelmann Scale”. Unlike conventional inspection methods that depended on periodic site visits, this platform provides uninterrupted visual monitoring of industrial operations, with AI algorithms trained to recognise abnormal smoke patterns, unauthorised discharges and operational anomalies.

The Monitoring mechanism is structured as follows. It ensures a prompt and systematic response to any detected emissions or environmental violations. Through automated alerts and coordinated actions, the system facilitates timely intervention and effective regulatory enforcement

It begins with the detection of emissions or visible smoke from industrial units. Upon detection, the system automatically generates an alert, triggering an immediate response through the EPA

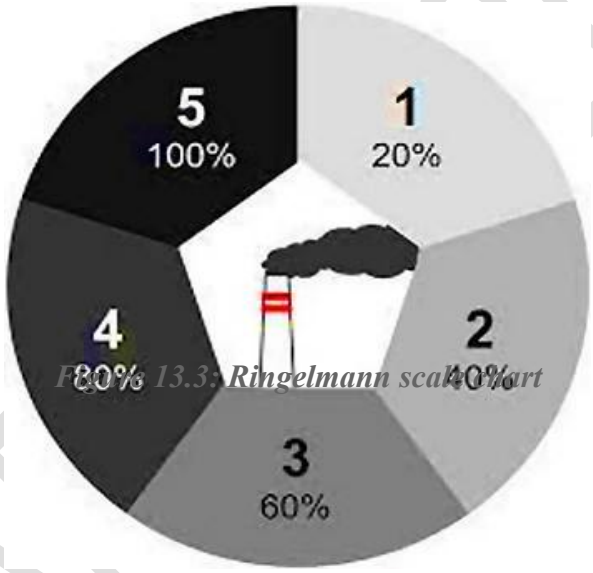

Figure 13.3: Ringelmann scale chart

helpline (1373), whereby the concerned industry owner is contacted and informed of the violation. This rapid communication ensures that the issue is addressed at the earliest possible stage, minimising environmental impact and encouraging prompt corrective action by the operator.

If the issue is resolved following the initial intervention, the case is closed within the system. However, in instances where the violation persists, the system escalates the matter to the respective district office for further action. This leads to on-ground field enforcement, where compliance is enforced through inspections and necessary regulatory measures. If required, the process culminates in legal action, supported by digital evidence collected through the system. This structured, stepwise approach ensures transparency, accountability and a shift towards proactive environmental governance.

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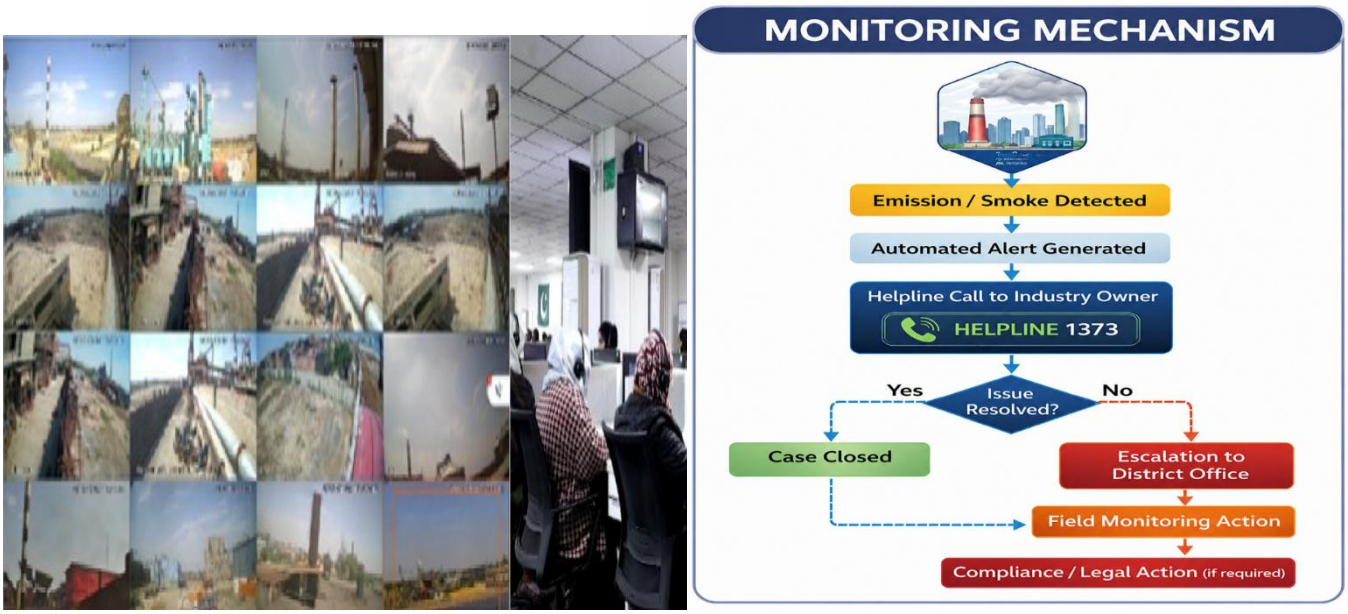

Figure 13.4: Online Industrial Monitoring and Response from 1373

While smart monitoring and automated enforcement mechanisms strengthened EPA Punjab's real-time regulatory oversight, the agency simultaneously recognised that environmental governance could not rely on enforcement alone. An equally important challenge was the modernization of environmental approvals and regulatory clearances, which traditionally involved lengthy procedures, fragmented documentation and operational delays. To address these structural limitations and to facilitate responsible industrial growth through a transparent and efficient regulatory process, EPA Punjab introduced the Environmental Approval Management System (EAMS) as a dedicated digital platform for streamlining environmental approvals across Punjab.

13.3.2. Environmental Approval Management System (EAMS)

Environmental approvals constitute a highly important regulatory subject that requires a clear, dedicated and well-structured approach to ensure that future environmental impacts are properly assessed, managed and mitigated. At the same time, an effective approval system must also facilitate responsible industrial and business development by providing 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 streamline and modernize the environmental approval process across Punjab.

EAMS has significantly transformed the traditional approval mechanism by digitizing the submission and processing of Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) cases across all 41 districts of Punjab. Under the conventional system, proponents were often required to visit Lahore Headquarters physically for submission and follow-up of their cases, resulting in delays, inconvenience and unnecessary procedural burdens. Applicants can now submit their cases at district level on EAMS from anywhere in the province,

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thereby reducing travel, saving time and making the approval process more accessible for businesses and project proponents.

One of the most important strengths of EAMS is its transparency and user-oriented design. The system provides step-by-step alerts through email at every stage of case processing, allowing proponents to remain informed from the moment a case is submitted until its final disposal. This has made file tracking considerably easier and more reliable, as applicants no longer need to rely on manual correspondence or repeated office visits to determine the status of their applications. For the first time, final environmental approvals are also generated through the system and communicated directly to the proponent through automated email alerts, which has enhanced both efficiency and institutional credibility.

In addition to improving case handling, EAMS has also created a digital footprint for each industry and project entering the approval regime. This digital record enables regulators to maintain a structured history of submissions, approvals, conditions and follow-up actions in a centralised system. As a result, industrial compliance has become more reviewable, traceable and manageable over time. The system also supports quarterly monitoring and compliance review by linking environmental approvals with subsequent oversight functions, thereby strengthening post-approval governance rather than limiting regulation to the issuance of permits alone.

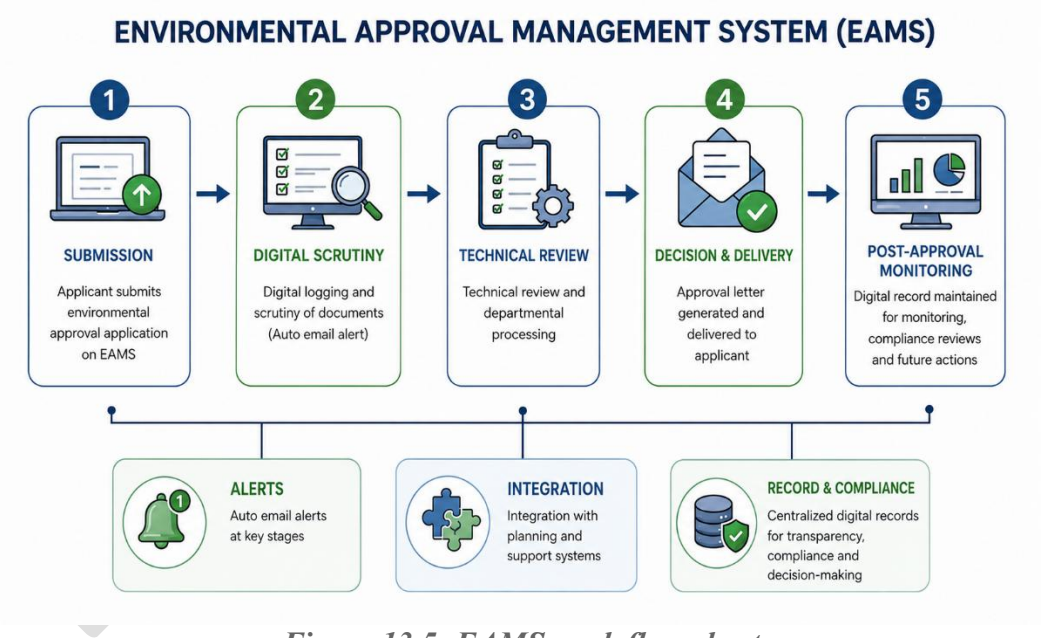

Figure 13.5: EAMS work flow chart

Furthermore, EAMS is integrated with the broader Planning Support System under the Environmental Management System framework, which enables informed decision-making by connecting environmental approvals with geospatial, planning and regulatory data. This integration helps ensure that approval decisions are not made in isolation, but are instead supported by comprehensive environmental and spatial information. Such an approach improves the quality,

consistency and defensibility of regulatory outcomes while also reducing overall processing timelines.

The operational process of EAMS follows a clear digital sequence. First, the proponent submits the EIA or IEE case at district office without need to visit Lahore Headquarters. Once submitted, the case is digitally logged and becomes traceable within the system. The proponent then receives automated email alerts as the case moves through different stages of scrutiny, technical review and departmental processing. During the review stage, the concerned officers examine the submitted documents, observations are recorded where necessary and the case is processed in accordance with regulatory requirements. Upon completion of the scrutiny and approval process, the final environmental approval is generated through the system itself and delivered to the proponent electronically through email notification. Thereafter, the case remains part of the digital record, enabling future compliance reviews, monitoring and traceability of the concerned industrial or development unit.

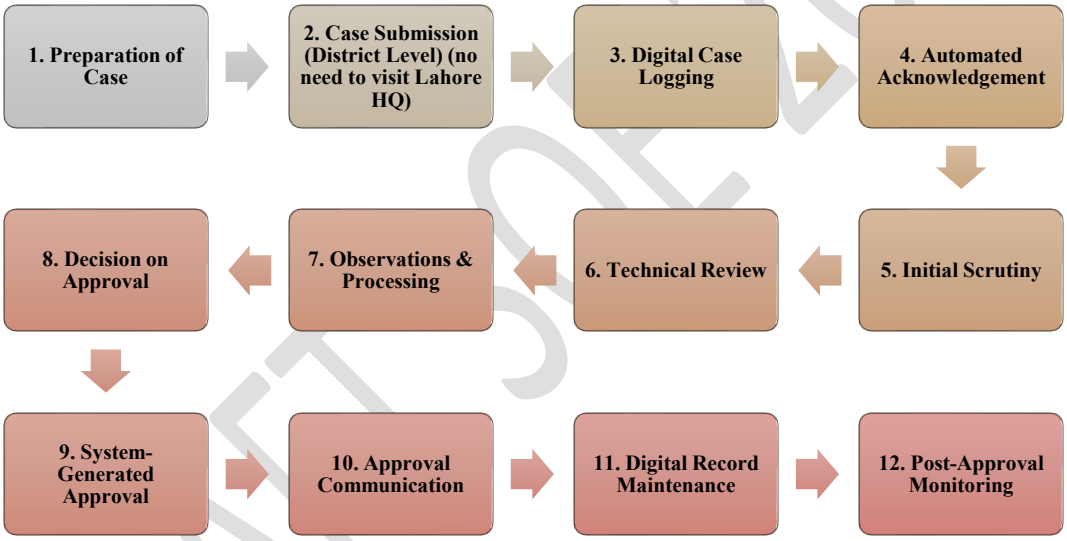

Figure 13.6: EAMS Process Flow

In 2025, a total of 541 cases were successfully uploaded on EAMS, out of which approximately 65 percent were approved. These figures reflect not only the growing operationalization of the platform but also its practical value in supporting transparent, efficient and technology-enabled environmental governance in Punjab.

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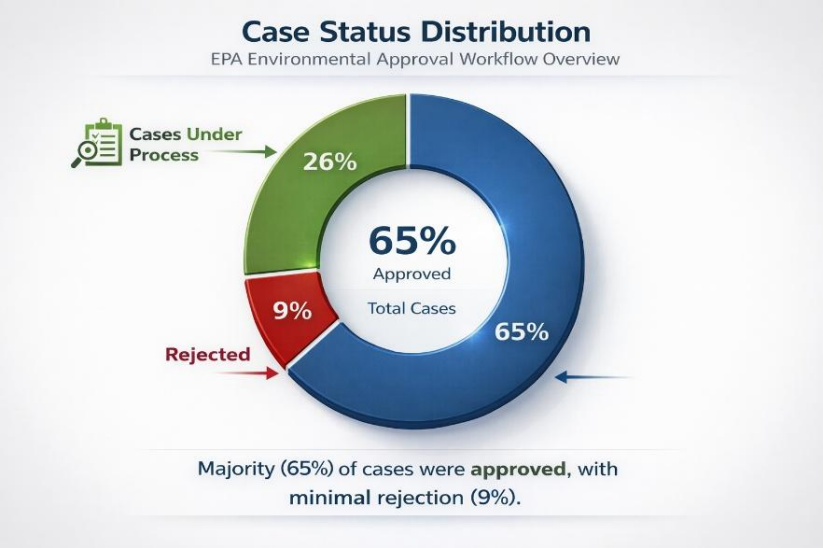

Figure 13.7: 2025 EAMS cases status distribution

13.3.3. Unique Identification System and E-Mapping of Industries

Following the launch of the Environmental Approval Management System (EAMS), a strategic initiative was undertaken by the Punjab Environmental Protection Agency (EPA) to significantly strengthen its regulatory framework, with a particular focus on improving industrial tracking, historical traceability and data standardisation across the province. During the initial assessment, it was identified that a substantial number of industrial units operating in Punjab were either completely unregistered or lacked a structured digital record, despite in many cases possessing environmental approvals. This fragmentation of data and absence of a centralised inventory created gaps in regulatory oversight, limiting the Agency's ability to effectively monitor, evaluate and enforce environmental compliance. Furthermore, inspection practices were largely unstructured, often resulting in selective monitoring where certain sectors received repeated attention while others remained overlooked due to the lack of a comprehensive tracking mechanism.

DRAFT SOE 2025

To address these systemic challenges, EPA Punjab developed and implemented a province-wide digital Unique Identification (UID) and E-Mapping system, aimed at bringing all industrial units—both registered and previously untracked—into a unified, transparent and traceable regulatory framework. This initiative was complemented by the development of a comprehensive digital industrial inventory, ensuring complete coverage of industrial establishments across all districts. A key component of this system was the standardisation of industrial 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"—allowing for uniform classification, easy identification and consistent data management across the province. In addition, districts were assigned standardised short codes and industries within each district were sequentially numbered, enabling the creation of a structured and meaningful UID format.

Figure 13.8: UIDs Generation Mechanism

The generation of the Unique Identification Number follows a systematic and rule-based mechanism that incorporates five critical data elements to ensure accuracy, uniqueness and traceability. These include the name of the industrial unit, its precise geographic coordinates (latitude and longitude), its sector classification, its sub-sector categorization 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 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 system-compatible, enabling quick identification while maintaining database integrity.

The implementation process involved extensive groundwork, including field-level 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 exercise, more than 14,000 industrial units were successfully identified, categorised and brought into the digital inventory, marking a significant milestone in environmental data management

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within the province. The integration of E-Mapping further strengthened this system by embedding each industrial unit within a Geographic Information System (GIS), allowing regulatory authorities to visualize spatial distribution, assess environmental risk zones and plan inspections more effectively based on geographic and sectoral clustering.

Moreover, each UID is linked to a comprehensive digital profile of the industrial unit, serving as a centralised repository of all relevant information, including inspection history, compliance status, notices issued, enforcement actions and environmental approval records such as NOCs and permits. This unified platform replaces fragmented manual record-keeping with a real-time, transparent and easily accessible system, 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 complete coverage of industrial units and supports data-driven decision-making. This system not only enhances regulatory effectiveness and inspection planning but also promotes transparency, consistency and sustainable environmental governance across the province.

The next 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 (Attached at Annexure 1 for reference) This enabled the identification of pollution hotspots at the district level and facilitated the development of cluster-based classifications a

Building upon this geospatial intelligence, Punjab was further divided into three major industrial zones based on cluster distribution. This classification was subsequently utilised for optimised deployment of human resources, ensuring that regulatory staff placement aligned with the density and type of industrial activity in each region.

13.3.4. EPA Punjab Industrial Directory

Following the successful implementation of the Unique Identification (UID) system, the next critical challenge was to ensure that industrial inspections and field visits were managed in a more intelligent, efficient and targeted manner. At the same time, it was essential to promote environmental awareness among industrial stakeholders, encouraging them to voluntarily adopt compliance measures, recognising that environmental protection is a shared and collective responsibility.

To address this, a comprehensive digital record management system was developed for all industries assigned a Unique ID. Under this system, detailed profiling of each industrial unit was conducted at the time of initial field visits, capturing extensive information across approximately 30 standardised parameters. This ensured that the complete operational and environmental profile

DRAFT SOE 2025

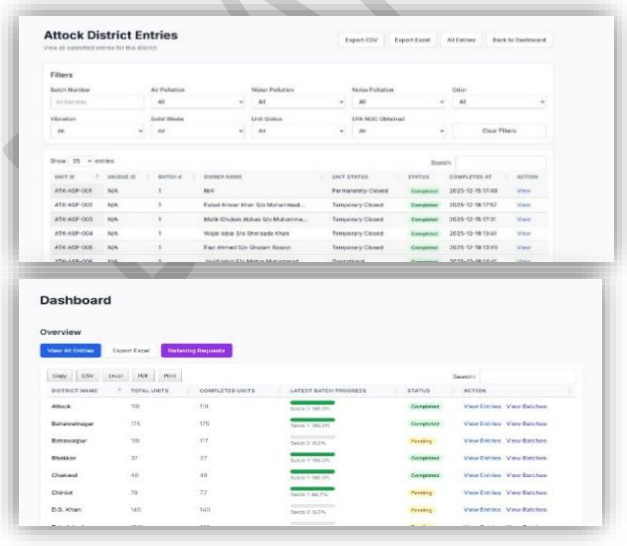
of each industry was recorded only once, eliminating the need for repetitive data collection in subsequent inspections.

The primary objective of this initiative was to develop a province-wide environmental profiling of industries. This enabled the identification of sector-wise and district-wise industrial patterns, including differentiation between seasonal industries and those operating throughout the year. As a result, inspection planning became more focused and risk-based, allowing regulatory efforts to be directed towards environmentally sensitive and high-risk industries, while avoiding unnecessary disruption to low-risk or seasonal units.

The primary purpose of the District Industrial Profiling initiative was to develop a centralised digital record system through which all industrial data could be securely stored and easily accessed whenever required for legal or regulatory proceedings. This approach ensures that data does not need to be collected repeatedly, reducing duplication of effort and minimising delays in enforcement actions. By maintaining complete and verified digital records, the need for repeated field visits is significantly reduced, allowing authorities to rely on readily available information for decision-making. Overall, the system enhances efficiency, saves time and supports more effective, transparent and evidence-based regulatory operations.

This approach significantly improved stakeholder confidence in government processes, as industries observed a shift towards transparent, data-driven and non-intrusive regulatory practices. Consequently, many industrial units began voluntarily sharing their data, further strengthening the system.

The digital profiling system has greatly enhanced the EPA's capacity for smart monitoring. The Agency now possesses a comprehensive and continuously evolving database of environmentally critical industries across Punjab, enabling more informed decision-making and targeted enforcement.



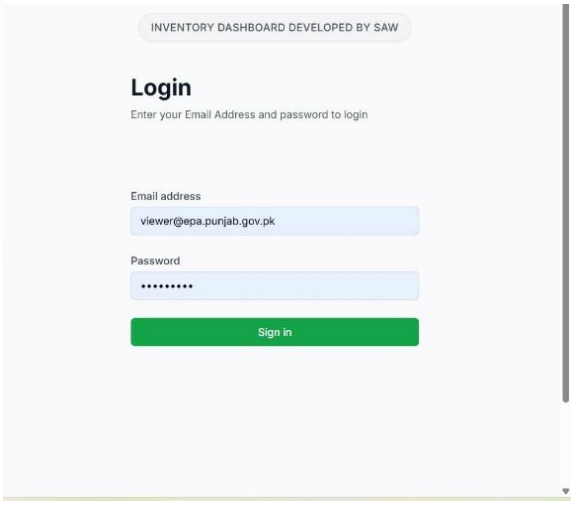


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Figure 13.9: Industrial Directory Dashboard View

Operationally, the process is fully integrated with the Environmental Approval Management System (EAMS). Whenever a new industrial unit obtains construction approval through EAMS, it is automatically assigned a Unique ID. Upon issuance of the UID, its complete digital profile is created through a one-time data collection process. Additionally, through special surveys, including drone-based assessments, any previously unmapped industrial units are identified, assigned a Unique ID and immediately incorporated into the digital profiling system.

This dynamic and continuously updated system ensures complete industrial coverage across the province, forming the backbone of a modern, data-driven and efficient environmental regulatory framework in Punjab.

13.3.5. Certified Private Laboratory Digital Portal

Following the strengthening and establishment of reference-grade laboratories, the Punjab Environmental Protection Agency (EPA Punjab) further enhanced its regulatory framework by integrating certified private laboratories into a structured and digitally monitored system. The purpose of this reform was to ensure credible third-party verification of industrial emissions while improving transparency, accountability and coordination between EPA Punjab, private laboratories and industrial units.

Previously, private laboratories conducted environmental testing for industries and submitted reports through manual or paper-based procedures. This created several regulatory weaknesses, including fragmented record-keeping, limited visibility over sample collection, inconsistent reporting formats and weak monitoring of laboratory testing capacity. There was also no centralised mechanism to verify whether laboratories were conducting tests within their approved scope, whether monthly sample limits were being followed, or whether reports were directly linked with the relevant industrial units.

To address these gaps, EPA Punjab introduced a dedicated Certified Private Laboratory Digital Portal. Through this portal, certified laboratories are digitally connected with EPA Punjab's wider regulatory ecosystem, including the UID-based industrial database and central dashboard system. Each laboratory is first subjected to a formal departmental certification process, during which its technical capacity, equipment, staff expertise and testing capability are assessed. Once approved, the laboratory is certified for specific environmental testing parameters and assigned monthly testing limits according to its verified capacity.

After certification, the laboratory is digitally onboarded onto the portal. From this point onward, laboratory operations are managed through the system. Laboratories receive sample requests online, upload test results electronically, manage their certification status and submit reports directly through the portal. This replaces paper-based laboratory reports with a secure electronic reporting mechanism, reducing the risks of delayed submissions, missing records, manual manipulation and inconsistent documentation.

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A key strength of the portal is its integration with the Unique Identification Number (UID) system. Every test report uploaded by a certified laboratory is mandatorily linked with the UID of the relevant industrial unit. This ensures that emission data is automatically mapped to the correct industrial profile, allowing EPA Punjab to maintain a complete compliance history for each industry. The system also enables regulators to review past testing records, identify repeated violations, monitor laboratory workload and verify whether testing has been conducted within the laboratory's approved scope.

The portal also improves regulatory accountability by creating a complete digital audit trail. Each stage of the process, including sample request, testing, report submission and compliance review, can be tracked through the system. This strengthens the reliability of third-party verification and reduces dependence on informal or manually submitted reports. It also supports fairer enforcement because regulatory decisions can be based on digitally recorded, traceable and verifiable laboratory evidence.

Overall, the Certified Private Laboratory Digital Portal represents an important institutional reform in EPA Punjab's digital transformation. By linking certified laboratories with the central dashboard and UID-based industrial database, the Agency has improved data reliability, reporting transparency and regulatory oversight. The system not only strengthens industrial compliance monitoring but also ensures that private laboratories operate within defined technical limits, making third-party environmental testing more credible, accountable and aligned with evidence-based environmental governance.

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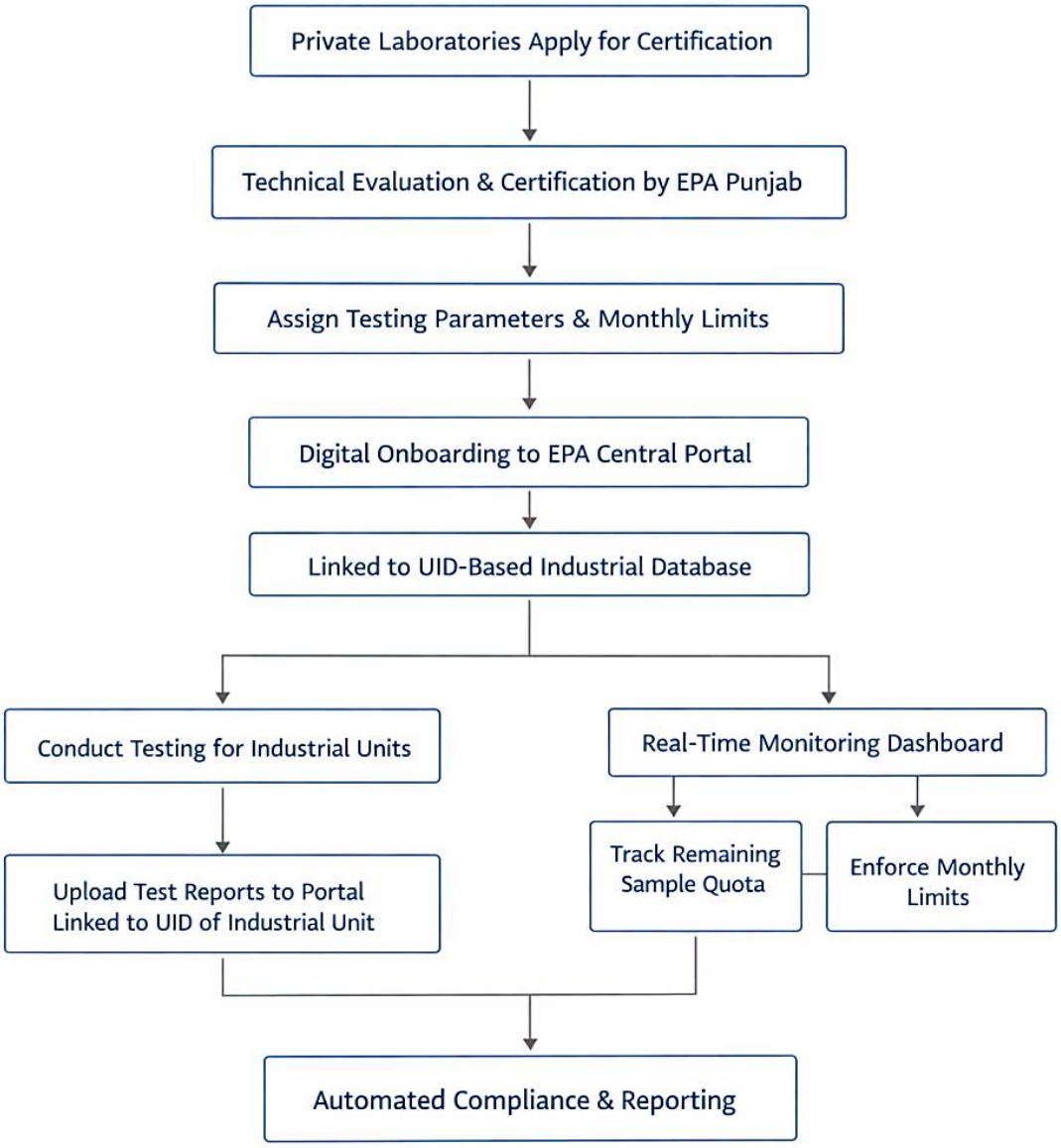

Figure 13.10: Private Lab Certification Process

A key strength of this system lies in its real-time monitoring and control mechanisms. Laboratories are able to continuously track their remaining monthly sample quota against each approved parametre through the dashboard. As soon as the assigned limit for any parametre is reached, the system automatically restricts further submissions for that parameter, thereby enforcing strict adherence to certified capacities. This automated control eliminates the possibility of over-reporting or unauthorised testing, which was a major limitation in the previous manual system.

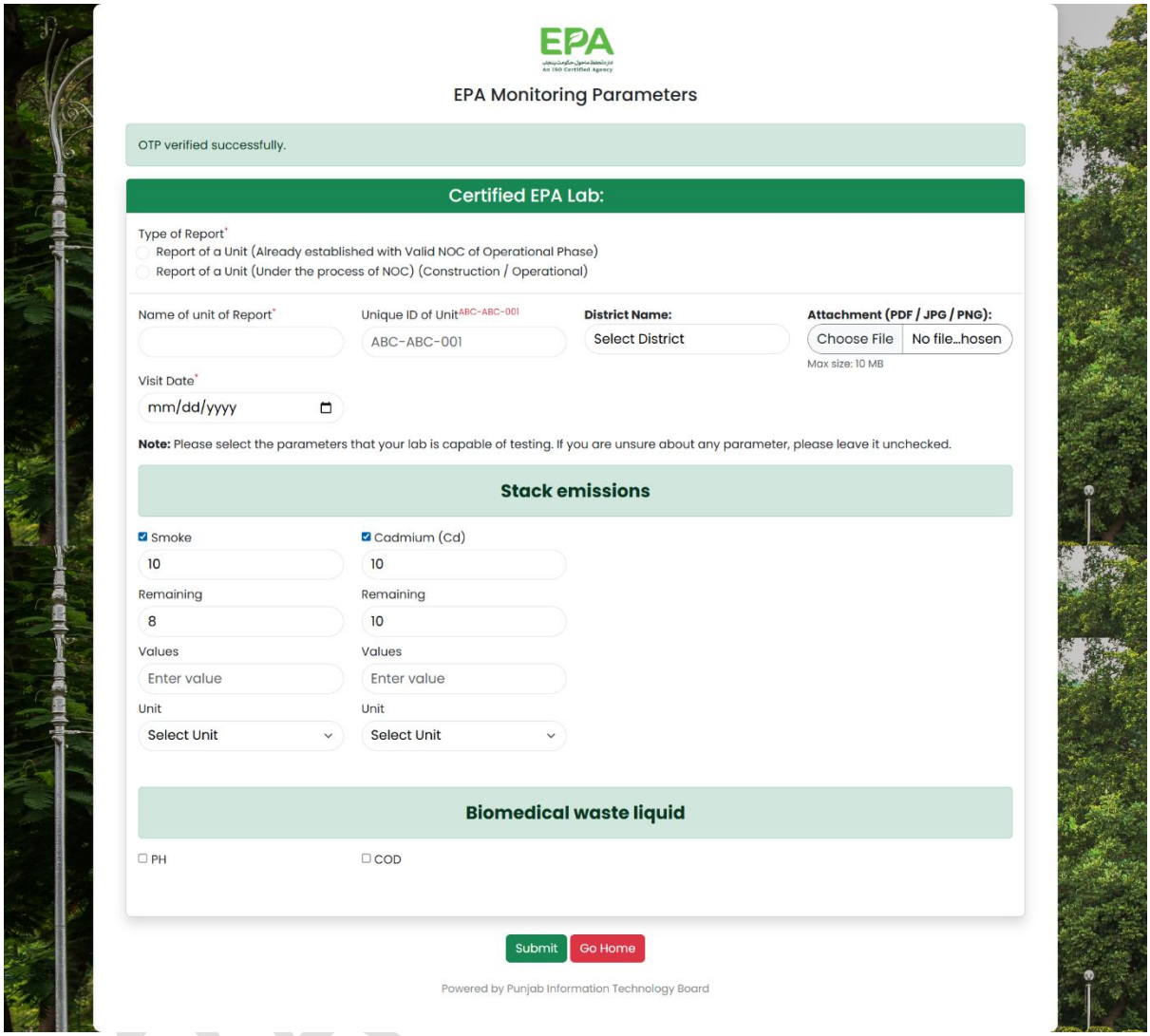

Figure 13.11: Monitoring parameters – Private Laboratory Digital Portal

Furthermore, all submitted laboratory reports are instantly accessible to the concerned field officers and regulatory authorities through the system. This removes the need for physical submission of reports and significantly reduces administrative delays. It also ensures that data is available in real-time for verification, inspection planning and enforcement actions, thereby strengthening regulatory responsiveness and decision-making. In year 2025 more than 1500 reports have been added into this system the district-wise categorization is as follows:

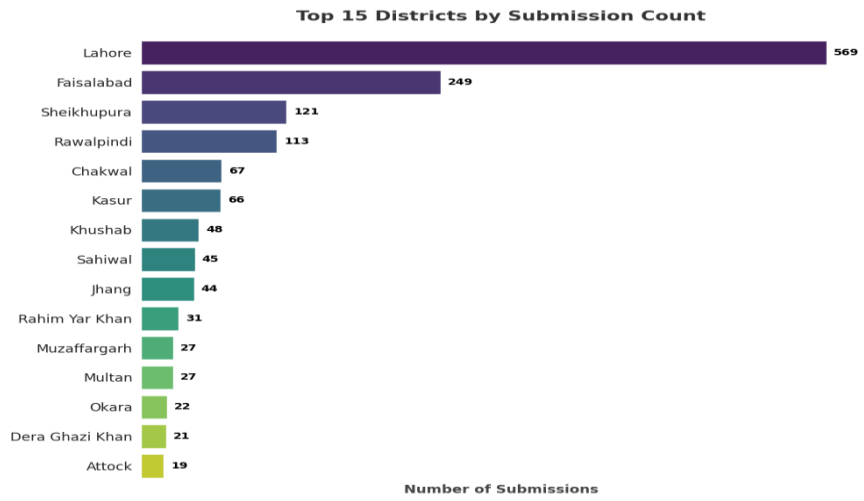

Figure 13.12: 15 Districts Submission count – Private Laboratory Digital Portal

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 movement towards smart monitoring, a critical gap remained in the availability of reliable, reference-grade air quality data. Without scientifically credible monitoring data, digital systems could improve administrative efficiency but could not fully support evidence-based environmental regulation, pollution control planning or targeted enforcement.

Until 2024, the Punjab Environmental Protection Agency (EPA Punjab) had only three reference-grade air quality monitoring stations across the entire province, all located in Lahore. This limited infrastructure restricted the Agency's ability to understand the actual causes, concentration levels and spatial distribution of air pollution across other districts. As a result, decision-making remained heavily dependent on limited localised data, complaint-based information and general assumptions about pollution sources rather than a province-wide evidence base.

Recognising this gap, a major breakthrough was achieved in 2025 with the expansion of the Air Quality Monitoring System (AQMS). EPA Punjab significantly enhanced its monitoring capacity by installing a network of reference-grade monitoring stations across multiple districts. This initiative marked an important milestone, as EPA Punjab became the first government agency in Pakistan to provide publicly accessible, real-time data from its own reference-grade monitoring network. The system now operates through 41 monitoring stations across 18 districts, continuously capturing pollutant concentrations on an hourly basis.

However, the value of this expanded monitoring network depends not only on the number of stations installed but also on the reliability, accuracy and usability of the data generated. Therefore, EPA Punjab must ensure strong data quality assurance and quality control mechanisms. These should include regular calibration of monitoring equipment, standard operating procedures for data collection, periodic maintenance of sensors and analysers, validation of abnormal readings, and

DRAFT SOE 2025

technical audits to ensure that reported pollutant levels are accurate and scientifically defensible. Without such safeguards, there is a risk that inaccurate or unverified readings could weaken policy decisions, enforcement actions and public trust.

The AQMS should also be supported by clear data validation protocols. Hourly air quality readings should be checked for missing values, instrument errors, extreme outliers and inconsistencies between nearby stations. Any corrected or invalidated data should be transparently marked so that policymakers, researchers and the public can understand the reliability status of the information. This is particularly important because real-time air quality data can influence public health advisories, industrial enforcement decisions and emergency smog-control measures.

In addition, the generated data should be actively used for policy formulation and enforcement rather than remaining limited to public display. EPA Punjab can use AQMS data to identify pollution hotspots, assess seasonal pollution trends, evaluate the contribution of industrial clusters, support targeted inspections and measure the effectiveness of anti-smog interventions. For example, areas showing repeated exceedances of permissible pollutant limits can be prioritised for enforcement visits, fuel-quality checks, industrial audits and traffic or construction-control measures. Similarly, long-term AQMS data can support the development of district-level air quality management plans and evidence-based regulatory standards.

Overall, the expansion of AQMS represents a major step towards modern, evidence-based environmental governance in Punjab. Nevertheless, its institutional impact will depend on the strength of calibration systems, data validation mechanisms, quality assurance protocols and the practical use of generated data in policy and enforcement. To maximise the value of this investment, EPA Punjab should regularly publish data quality reports, maintenance records, calibration schedules and analytical summaries showing how AQMS findings are being used to guide environmental decision-making

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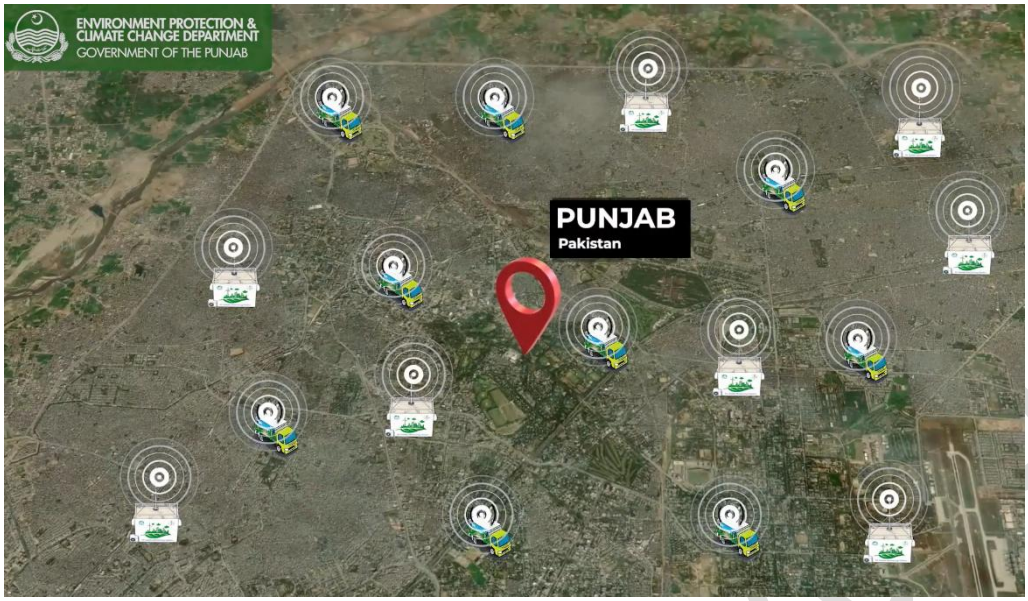

Figure 13.13: AQI Monitoring Stations – 18 Districts

These stations continuously capture high-resolution environmental data, including concentrations of key pollutants and meteorological parameters. The data from all stations is transmitted in real time to a centralised dashboard known as **AQI Punjab**, accessible through the official platform at **aqi.punjab.gov.pk**, ensuring uninterrupted data flow, centralised monitoring and enhanced regulatory oversight.

Figure 13.14: AQI Mobile Van

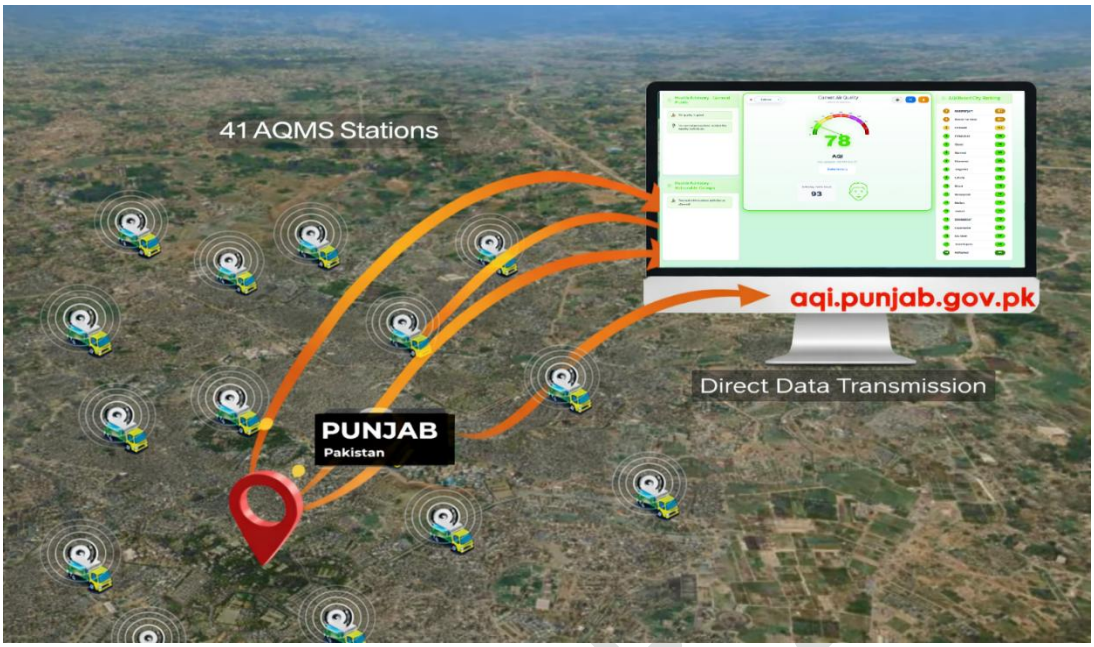

Figure 13.15: Air Quality Monitoring System — Province-Wide Station Network

13.3.6.1 Features of AQI Punjab Dashboard

i. Current AQI

At its core, the system provides **real-time AQI monitoring**, where continuous pollutant concentrations from all connected stations are streamed and displayed dynamically. This includes all major criteria pollutants such as $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO and O_3, along with simultaneous meteorological parameters. The integration of weather stations ensures that each AQMS does not only report pollution levels but also captures localised atmospheric conditions, which are essential for understanding pollutant behaviour and dispersion. The platform is built on a centralised architecture where all incoming data is processed and visualized instantly, enabling province-wide situational awareness.

Figure 13.16: Current hour Air Quality Index — EPA Punjab

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ii. Health Advisory System

A key feature of the system is the health advisory engine, which automatically translates AQI values into human-readable guidance. The advisory framework is based on AQI ranges (Good, Moderate, Unhealthy, etc.) and is directly linked to public health recommendations. The system categorizes users into different sensitivity groups and dynamically updates precautionary measures such as limiting outdoor exposure, reducing physical activity, or using protective measures. This ensures that the dashboard is not just a monitoring tool but also a public health communication system

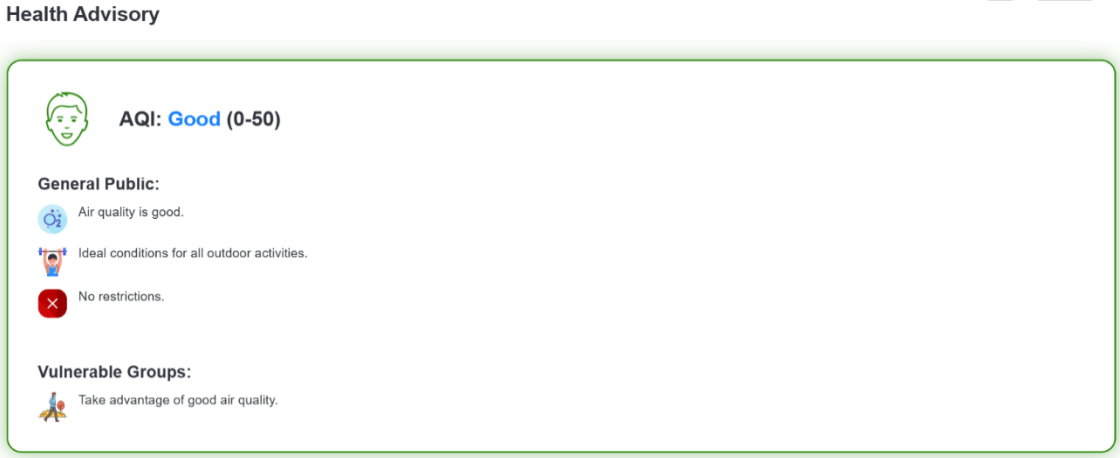

Figure 13.17: Health Advisories – AQI Punjab

iii. Forecast

The platform includes a **forecasting and predictive analytics module**, particularly for Lahore, where 24-hour AQI forecasts are generated. These forecasts are not simple extrapolations but are based on machine learning models that integrate multiple datasets. Real-time AQMS data is combined with meteorological inputs and further enhanced through satellite observations, enabling highly localised and accurate predictions. Advanced atmospheric parameters such as mixing layer height are incorporated to understand vertical dispersion of pollutants, which significantly improves forecast reliability, especially during smog episodes.

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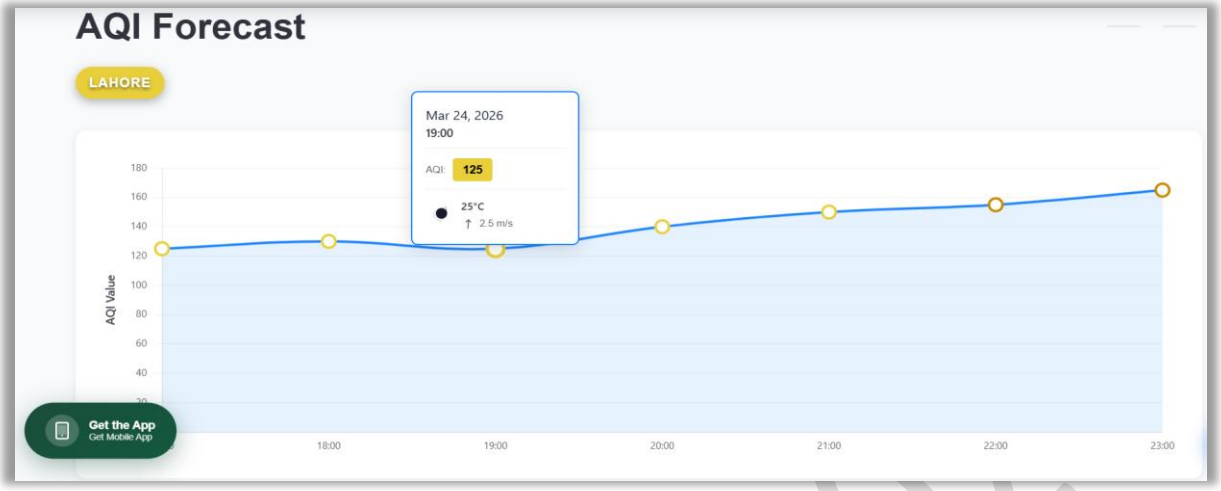

Figure 13.18: Forecasted AQI for next 24 hours — EPA Punjab

iv. Trends

Another important analytical layer is the **trend analysis system**, which presents air quality patterns over time. The dashboard provides weekly trends using standardised colour coding aligned with environmental policy frameworks. These visual indicators allow quick interpretation of whether air quality is improving or deteriorating. The use of consistent colour bands ensures alignment with regulatory thresholds and enhances usability for both policymakers and the general public.

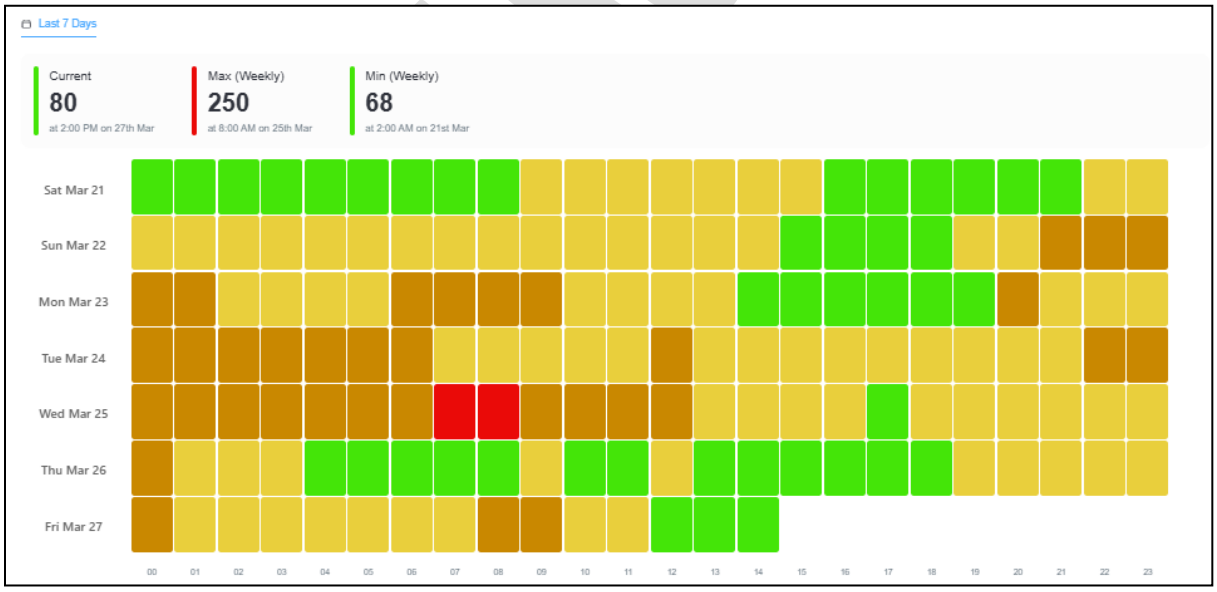

Figure 13.19: AQI Trends — EPA Punjab

v. Town-Wise

The system offers advanced spatial analysis through town-wise and city-wise data segmentation, particularly in cities with multiple AQMS stations where data is further disaggregated for micro-

level environmental assessment. This approach enables the accurate identification of localised pollution hotspots and supports targeted interventions instead of broad, city-wide measures. Each station provides pollutant-specific data, allowing detailed source analysis and sector-focused policy actions. Additionally, AQMS stations are equipped with localised weather monitoring systems that capture key parameters such as wind speed and direction, helping to understand pollutant dispersion patterns and how variations in the Air Quality Index (AQI) are influenced by specific 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.

DRAFT SOER 2025

Figure 13.21: Town wise AQI — EPA Punjab

vi. Map

A major visualization component of the dashboard is the interactive geospatial map, where all AQMS stations are displayed in real time. Each station reflects current AQI, pollutant concentrations and weather parameters. This spatial interface allows users to compare multiple locations simultaneously and understand regional pollution distribution. The integration of ground-based weather systems with AQMS enhances the analytical capability of the map, making it useful for both operational monitoring and forecasting validation

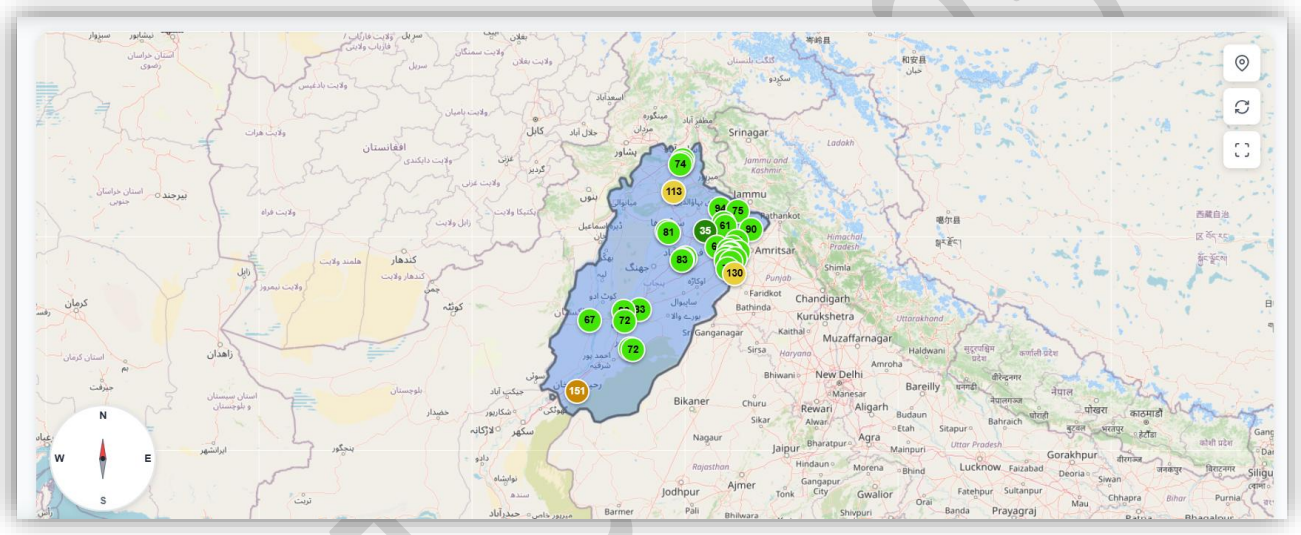

Figure 13.22: Station-wise Local Wind Map — EPA Punjab

The platform also includes temporal analytics feature in the form of AQI calendars and historical datasets. These provide a day-wise record of AQI values across the year, enabling long-term trend analysis, seasonal pattern identification and performance evaluation of environmental policies. Historical data availability ensures that the system is not limited to real-time monitoring but also supports research, reporting and evidence-based decision-making.

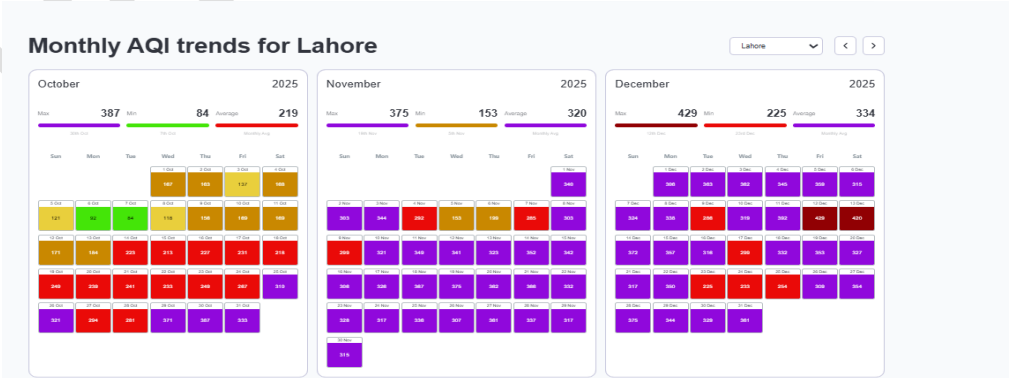

Figure 13.23: Monthly AQI trends for Lahore

13.4 Digital Transformation of Field Operations

Following the development of centralised dashboards and digital monitoring systems, EPA Punjab further strengthened its field operations through the expansion and operational enhancement of the Eco Watch Application. The platform was transformed into a comprehensive field surveillance and oversight mechanism designed to improve real-time monitoring, inspection management and operational accountability across Punjab. Through Eco Watch, field formations were enabled to conduct inspections digitally, record violations on-site, upload geo-tagged evidence and maintain centralised activity records accessible at the provincial level. The application also shifted operational oversight from conventional manual reporting towards a live digital monitoring framework, allowing senior management to track field performance, enforcement activities and inspection status in real time. This transition significantly improved coordination, transparency and responsiveness within EPA Punjab's regulatory operations.

13.4.1 Revamping of the Eco Watch Application

The Eco Watch Application, in its earlier version, was primarily limited in scope and functionality, as it focused mainly on industrial inspections with a narrow set of parameters. The system lacked a comprehensive revisit mechanism, meaning there was no structured way to track follow-up inspections, monitor compliance progression, or maintain a continuous environmental history of facilities. Additionally, the absence of sectoral diversification restricted its effectiveness in addressing the broader environmental challenges across Punjab. As EPA Punjab expanded its regulatory focus to multiple domains, it became evident that the existing application architecture was insufficient to support integrated, traceable and scalable operations.

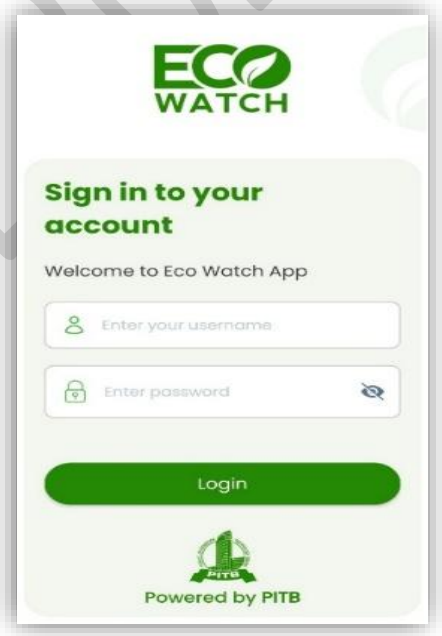

Figure 13.24: ECO Watch – Revamp

DRAFT SOP 2025

In response to these limitations, a complete restructuring of the Eco Watch Application was undertaken to align it with modern regulatory requirements and digital governance objectives. The revamped system was designed to incorporate multi-sectoral operations, introduce a robust revisit and compliance tracking mechanism and ensure that all environmental interventions are interconnected through a unified digital platform. This transformation laid the foundation for a more comprehensive, transparent and data-driven environmental monitoring system, capable of supporting EPA Punjab's evolving field operations across Punjab.

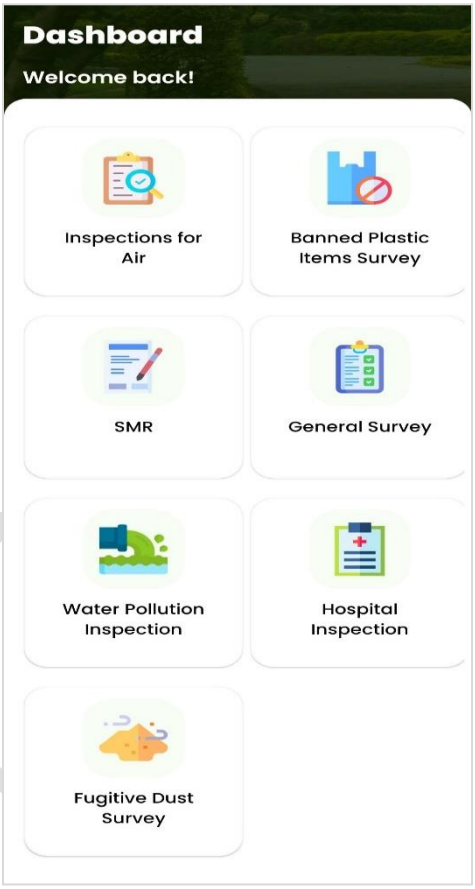

Figure 13.25: ECO Watch Dashboard

A key component of this transformation is the development and deployment of seven dedicated operational modules within the Eco Watch system, each designed to address a specific environmental domain. These 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 has been equipped with customized digital inspection forms, standardised parameters and structured reporting formats. All inspection activities, observations and violations recorded under these modules are linked to unique facility IDs, ensuring that every industrial entity has a complete and continuously updated environmental compliance profile. This enables regulators to track pollution trends, review historical violations and take informed enforcement actions with greater precision and consistency.

The application has also been integrated with a robust **ePay system**, reinforcing EPA Punjab's commitment to transparency and a fully cashless regulatory environment. Through this integration, all penalties are digitally generated, recorded and tracked in real time. Each financial transaction is linked to the respective violation and facility, ensuring complete auditability and eliminating the risks associated with manual handling of payments. This not only enhances financial transparency but also improves efficiency in compliance enforcement and revenue tracking

One of the most significant outcomes of the Eco Watch revamp is the complete digitization of field operations across Punjab. All inspection activities are now conducted, recorded and monitored through the application, effectively eliminating the legacy manual system. Over the past year alone, more than 150,000 field operational activities have been logged digitally, demonstrating large-scale adoption and institutionalization of the system. Field officers are now able to perform

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inspections, issue notices, record violations and update compliance status in real time, ensuring immediate availability of data at both district and headquarters levels.

Furthermore, the system has been integrated with district profiling and performance monitoring mechanisms. This allows EPA Punjab to analyse sector-wise inspection coverage, identify underperforming areas and ensure balanced regulatory focus across all environmental domains. Based on these insights, a structured weekly progress review mechanism has been introduced, replacing the traditional monthly review approach. More than 50 weekly performance reports have been generated, enabling KPI-based ranking of districts and fostering a culture of accountability and competition within the field formations.

13.4.2 Plastic Confiscation Verification System

Building upon the comprehensive digitization of field operations and the integration of sector-specific modules within the Eco Watch Application, EPA Punjab further strengthened transparency and accountability by introducing a QR code-based plastic confiscation system. While plastic inspections were already being conducted through Eco Watch, there was a critical gap 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 publicly verifiable.

Under this system, uniquely QR-coded challan books were designed, printed and issued to field officers through a user-based allocation process within Eco Watch. Each challan is system-generated, securely linked to a specific officer and strictly non-transferable, thereby ensuring individual accountability. During field operations, when a challan is issued for plastic confiscation, the officer is required to upload photographic evidence through the application. This data is then digitally mapped to the QR code printed on the challan, creating a complete and traceable enforcement record.

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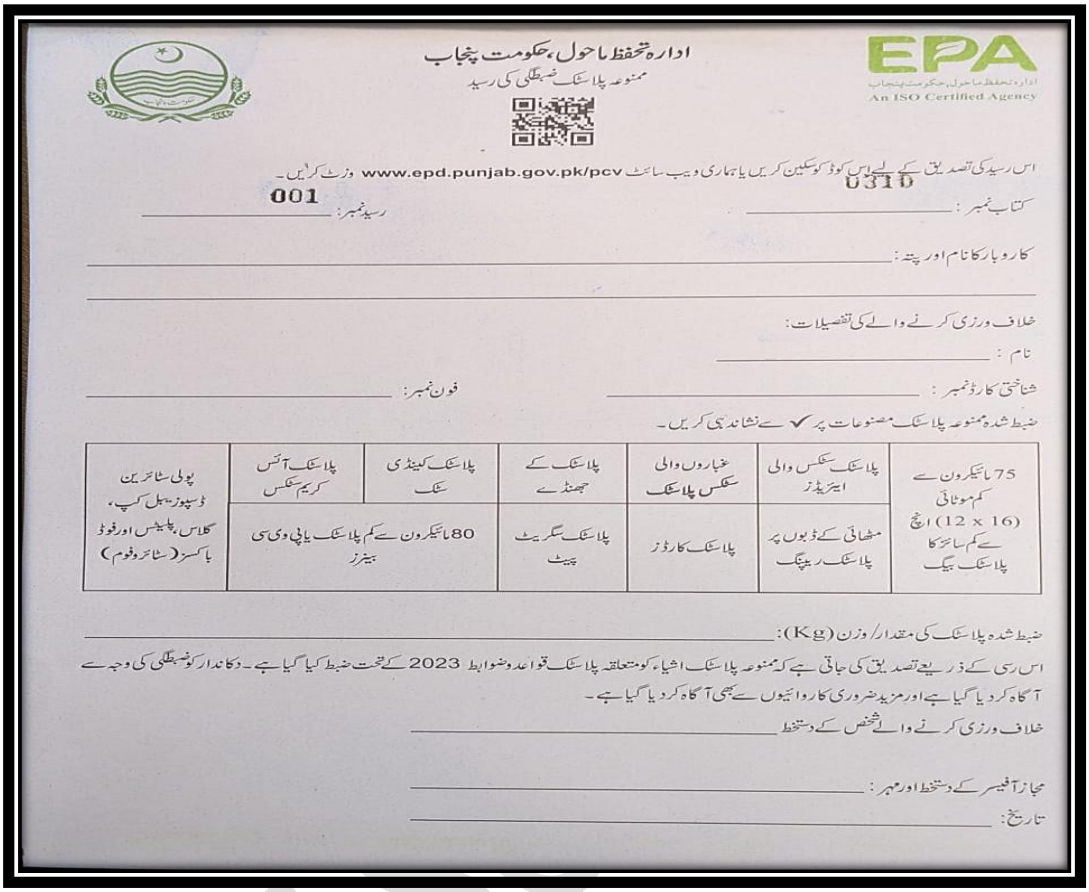

Figure 13.26: Plastic Confiscation QR coded book

This initiative has introduced a new level of public empowerment by enabling citizens to verify confiscation actions in real time. By scanning the QR code, the public can access relevant details of the violation and associated evidence, ensuring that enforcement activities are transparent and credible. Additionally, a dedicated helpline (1373) has been integrated into the system to facilitate complaints, feedback and verification, further enhancing citizen engagement.

As a result of this intervention, a structured and reliable digital record of plastic confiscation activities has been established for the first time. This data-driven repository has enabled EPA Punjab to analyse enforcement trends, monitor field performance and identify policy gaps.

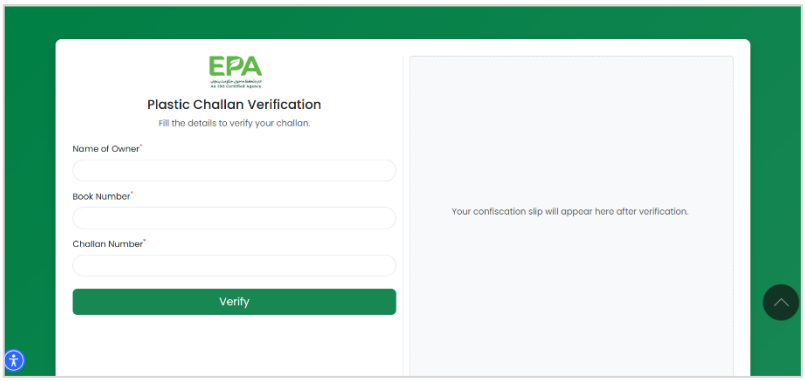

Figure 13.27: Plastic Verification System – EPA Punjab

Consequently, more informed and targeted policy decisions have been undertaken to strengthen plastic regulation across the province. This initiative complements the

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broader Eco Watch framework by reinforcing transparency, improving accountability and advancing the transition towards a fully digital, citizen-centric environmental governance system.

13.4.3 Revamping of the 1373 Helpline

The digitization of EPA Punjab's operational ecosystem through the Eco Watch Application created a need to strengthen public interaction and engagement mechanisms. While the 1373 helpline existed as a basic complaint registration facility, it was not aligned with modern digital systems and lacked real-time, data-driven capabilities. In response, it was transformed into a CRM-based intelligent complaint management and public facilitation system, fully integrated with EPA Punjab's digital framework.

Under this revamp, the 1373 helpline now serves as a centralised platform for complaint handling and public engagement. Complaints related to smoke emissions, illegal industrial activities and other environmental violations are digitally logged, categorised and automatically routed to relevant departments for prompt action, ensuring improved efficiency and accountability.

The system has also been enhanced 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, improving transparency and accessibility.

To ensure service quality, all helpline agents underwent structured refresher trainings aligned with EPA Punjab's digital systems, operational protocols and communication standards. Additionally, the helpline has been used for awareness campaigns, including over 13,000 automated robocalls to educators for crop residue burning awareness.

The transformation has significantly improved service delivery, reducing 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 through the 1373 helpline, reflecting strong public engagement. A majority of complaints, 44,959, were related to the Emission Testing System, followed by smoke (7,151), encroachment (2,441) and fire incidents (2,303). Other categories included general complaints (1,143), dust (1,111), smell (723), illegal petrol machines (662), green lockdown violations (518), school timing violations (511), plastic violations (279), Punjab Green School Certificate (236) and animal abuse (157).

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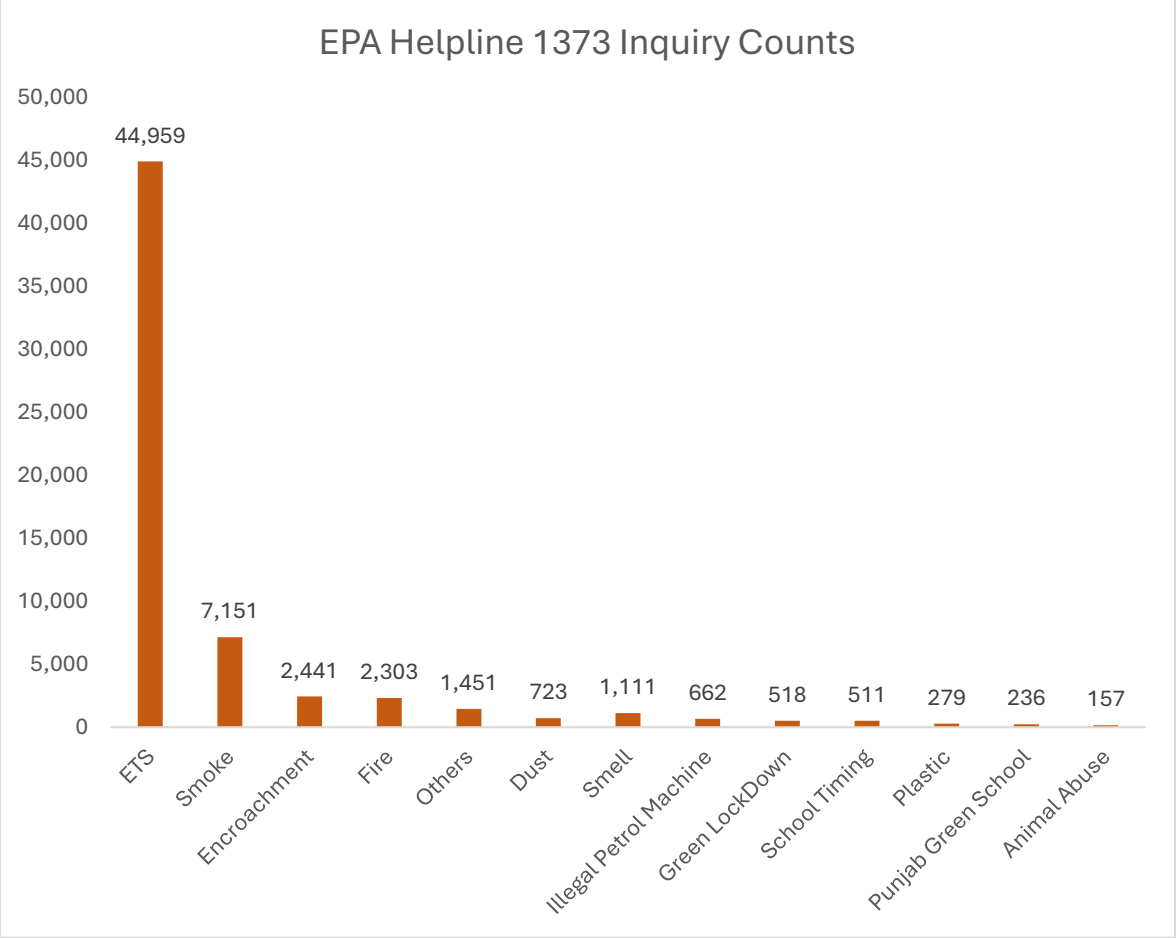


Figure 13.28: Environmental Enquiry Statics

13.4.4 Revamping of the Green Punjab Application

The Green Punjab Application, originally launched as EPA Punjab's first citizen-facing digital platform, was designed to centralize public complaints and establish a direct linkage with the 1373 helpline for streamlined grievance redressal. However, in light of the broader digital transformation across the Agency, it became essential to revamp the application to expand its functionality beyond complaint lodging and transform it into a comprehensive citizen engagement and environmental monitoring platform. This restructuring positioned the application as a key interface between the public and EPA Punjab, enabling real-time reporting, enhanced transparency and active citizen participation in environmental governance.

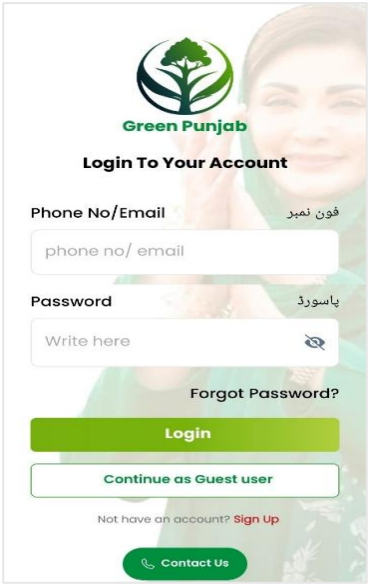


Figure 13.29: Green Punjab App

A major advancement 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) are digitally inspected using gas analysers, with emission readings, live photographs of vehicles and supporting evidence recorded and uploaded in real time. Each inspection is conducted through uniquely assigned, geo-fenced IDs linked to specific testing booths, ensuring location authenticity and eliminating the possibility of fraudulent entries. The verification mechanism has been further strengthened by linking the system with the official EPD Punjab website, enabling public validation of testing records.

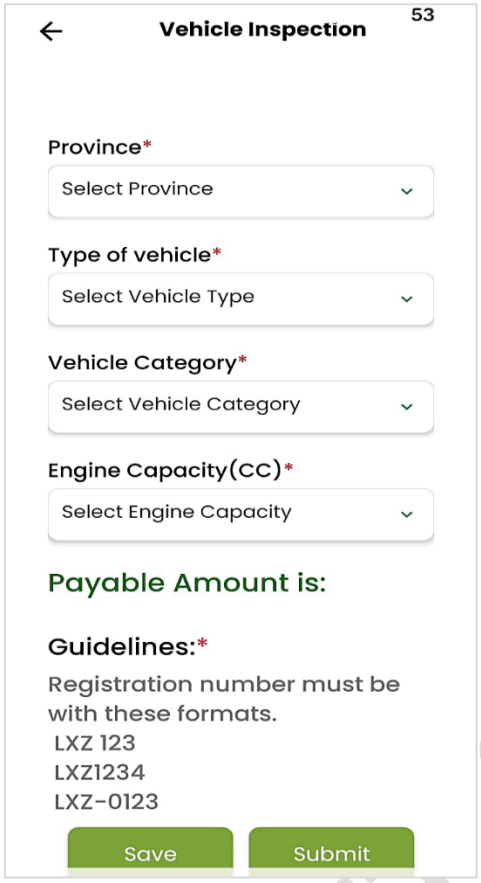


Figure 13.30: Vehicle Inspection form

To ensure financial transparency and eliminate manual handling of fees, the application has been integrated with the ePay system, allowing emission testing charges to be paid digitally through system-generated PSIDs. This integration has reinforced a fully cashless, transparent and auditable mechanism for service delivery. In addition to its operational role, the Green Punjab App has also contributed significantly to research and policy development. As part of a province-wide study, more than 250 automobile workshops were registered through the system to conduct a correlation analysis of different emission testing technologies available in the market, providing valuable insights for regulatory standardisation.

Figure 13.31: Vehicle Inspection – Green

The system's robustness is further reflected in its institutional integrations, as it has been linked with Safe City authorities and the Transport Department, enabling real-time data sharing and inter-departmental coordination. To date, more than 300,000 vehicle inspections have been conducted through this platform, with

Figure 13.32: Green Sticker – Vehicle Inspection

complete digital records including emission results, photographic evidence and payment details readily available. This large-scale digitization has not only eliminated the traditional manual inspection system but has also significantly enhanced public trust by ensuring transparency, reliability and ease of access.

Overall, the revamped Green Punjab Application has evolved into a powerful tool for participatory governance, combining citizen reporting, digital enforcement, financial transparency and inter-agency collaboration into a single integrated platform.

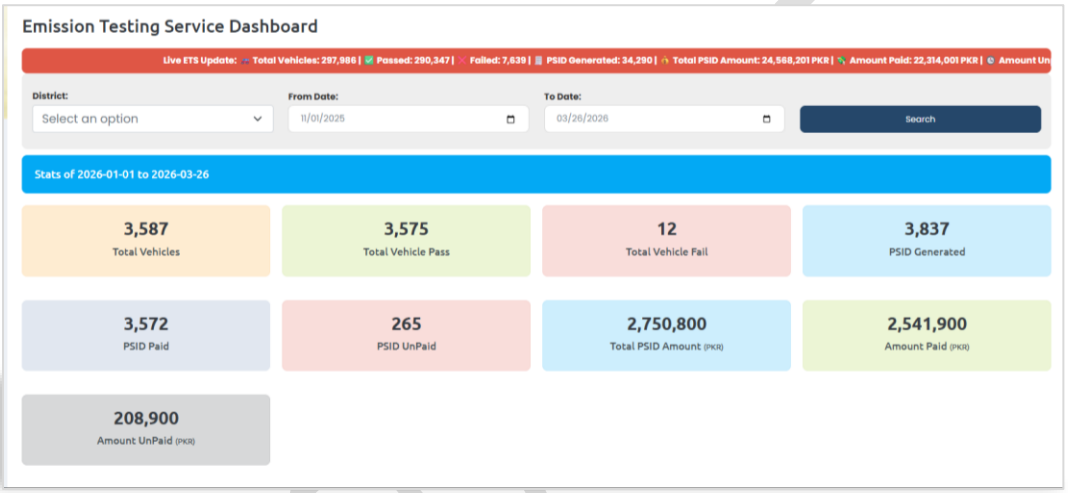


Figure 13.33: ETS Dashboard – EPA Punjab

13.5 Digital Institutional Reforms

The digital transformation of EPA Punjab represents a comprehensive programme of institutional reform that extends beyond the introduction of standalone applications. It has 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-driven enforcement mechanisms, the Agency has improved procedural efficiency, reduced operational delays and created a more traceable record of administrative and regulatory actions.

These reforms have also strengthened internal oversight by standardising workflows and enabling real-time performance monitoring. Digital systems allow senior management to review inspection activities, track pending cases, monitor staff performance and assess regulatory actions through structured data. This has supported more consistent decision-making and reduced the risks linked with manual reporting, missing documentation and delayed approvals. In this way, EPA Punjab's digital reforms have contributed to a more transparent and accountable institutional framework.

However, the increasing dependence on digital systems also creates new governance risks that must be addressed. Cybersecurity, data privacy and information security are now central to the sustainability of EPA Punjab's digital reform agenda. The Agency's platforms collect and process

sensitive information, including inspection records, industrial compliance data, enforcement decisions, geotagged evidence, staff records and public complaints. If these systems are not protected through strong access controls, encryption, audit trails and regular security reviews, there is a risk of data leakage, unauthorised access, manipulation of records or misuse of confidential information.

System resilience is another important institutional concern. 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 handling and enforcement actions. Therefore, the Agency should develop clear disaster recovery and business continuity arrangements. These should include regular data backups, secure cloud or server infrastructure, defined recovery timelines, incident response protocols and periodic testing of system recovery procedures.

Overall, EPA Punjab's digital institutional reforms have created a more efficient, transparent and future-oriented governance framework. Nevertheless, the long-term success of these reforms depends not only on technological adoption but also on the strength of digital risk management. To ensure credibility and continuity, EPA Punjab should integrate cybersecurity safeguards, data protection standards, system resilience planning and disaster recovery mechanisms into its institutional reform strategy. This would ensure that the digital governance model remains secure, reliable and capable of supporting environmental regulation under changing administrative and technological conditions.

13.5.1 Human Resource Management Information System (HRMIS)

Following the successful implementation of multiple digital initiatives, including EAMS, Unique ID system and smart monitoring mechanisms, the need for strengthening internal human resource management became increasingly evident. It was essential to move away from outdated manual record-keeping practices, eliminate bureaucratic delays and bring transparency and efficiency into HR processes.

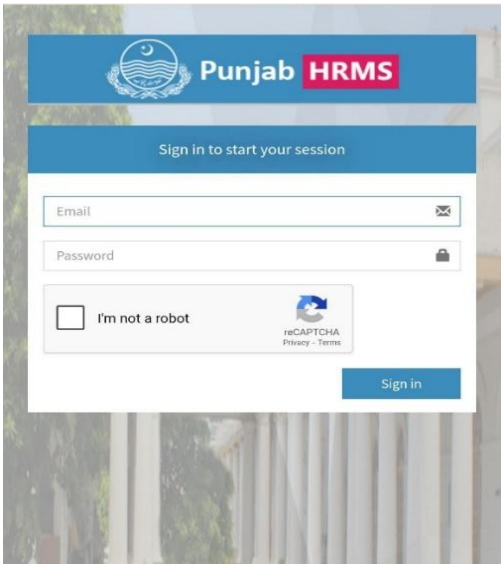


Figure 13.34: PUNJAB HRMS

In this regard, EPA Punjab leveraged the Government of Punjab's Human Resource Management Information System (HRMIS) to digitally transform its entire human resource framework. The Agency undertook a comprehensive digitization of employee records, including service history, leave management and other HR-related processes, transitioning from conventional archive-based systems to a fully integrated digital platform.

DRAFT SOE 2025

A significant milestone achieved under this initiative was the digitization of pension cases, making EPA Punjab the first attached department in the province to process pension-related matters through HRMIS. This step not only streamlined the process but also reduced delays and improved transparency for employees nearing retirement.

Building on this progress, EPA Punjab further enhanced transparency and accountability by integrating Performance Evaluation Reports (PERs) into HRMIS. Immediate reporting officers are now required to record employee evaluations directly within the system, ensuring timely completion, proper documentation and real-time tracking of performance assessments.

This transition has resulted in a substantial improvement in employee confidence and morale. With greater transparency, clarity in evaluation processes and reduced procedural delays, employees feel more secure and motivated. Consequently, there has been a noticeable increase in productivity, ownership and overall performance across the organisation.

By fully adopting HRMIS, EPA Punjab has not only modernized its internal operations but has also reinforced a culture of accountability, efficiency and merit-based evaluation, aligning its workforce management practices with modern governance standards.

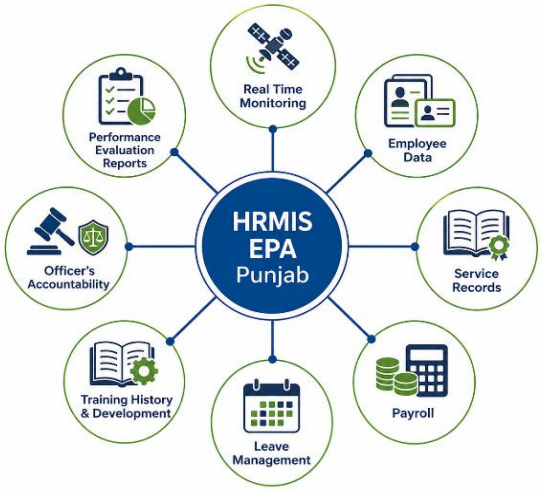


Figure 13.35: Punjab HRMIS Platform

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 modernization of its internal workflows. This comprehensive migration digitizes file movements, internal notes, drafts and formal approvals, replacing slow, paper-intensive processes with a secure and efficient digital environment. By automating these functions, the agency has accelerated internal response times, reduced administrative delays and eliminated the risk of lost documentation.

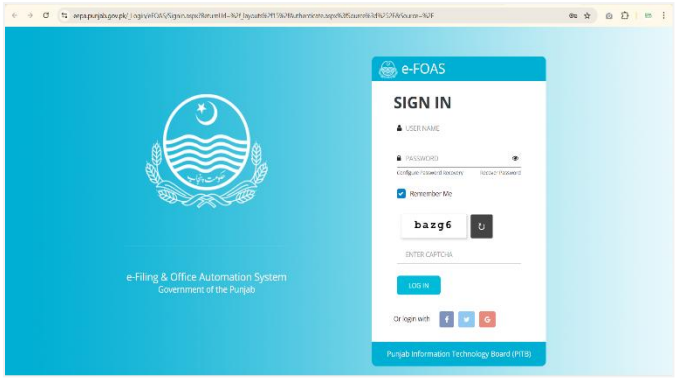


Figure 13.36: e-FOAS

A key innovation within this system is the introduction of QR-coded No Objection Certificates (NOCs), which allow for instant digital verification of environmental approvals. This feature enhances transparency, ensures secure authentication and prevents the circulation of fraudulent permits, enabling stakeholders to verify the authenticity of any EPA-issued certificate with a simple scan. Through e-FOAS and QR-coded NOCs, EPA Punjab demonstrates its commitment to digital innovation, efficient service delivery and accountable regulatory practices, setting a new standard for internal governance and operational efficiency across the province.

13.5.3 Digital Compliance Verification System

The Digital Compliance Verification System, developed in close integration with the Online Adjudication Hub, represents a significant reform in EPA Punjab's enforcement mechanism, particularly under the regulatory framework of smog and environmental protection rules. Traditionally, while enforcement actions were taken against violators, there was no structured, transparent and time-bound mechanism to provide a formal hearing opportunity or to digitally verify compliance before finalizing actions. Recognizing that effective enforcement must balance regulatory authority with procedural fairness, EPA Punjab institutionalized a system whereby every violator is provided an opportunity to be heard before final action is concluded.

Under this system, whenever action is initiated against any industrial unit or facility on this, the violator is required to apply for a hearing through the EPD Punjab website. Upon submission, a verification email is automatically generated, activating the digital compliance verification workflow. Within 24 hours, the system schedules and communicates an online hearing to the applicant. This ensures that the matter is addressed promptly and in a legally structured manner. During the hearing, both the regulatory perspective and the violator's response are evaluated, ensuring that decisions are taken transparently, fairly and in accordance with environmental laws and due process.

Following the hearing, compliance verification is conducted digitally within a defined timeframe, allowing cases to be finalized efficiently. Once compliance is confirmed, the system enables timely closure of cases and, where applicable, facilitates the reopening of industrial units in a controlled and lawful manner. This has significantly reduced unnecessary operational downtime for industries while maintaining strict environmental safeguards.

DRAFT SOE 2025

Action initiated on this form: epd.punjab.gov.pk/application-for-compliance-of-standards

Figure 13.37: Digital Compliance Verification System

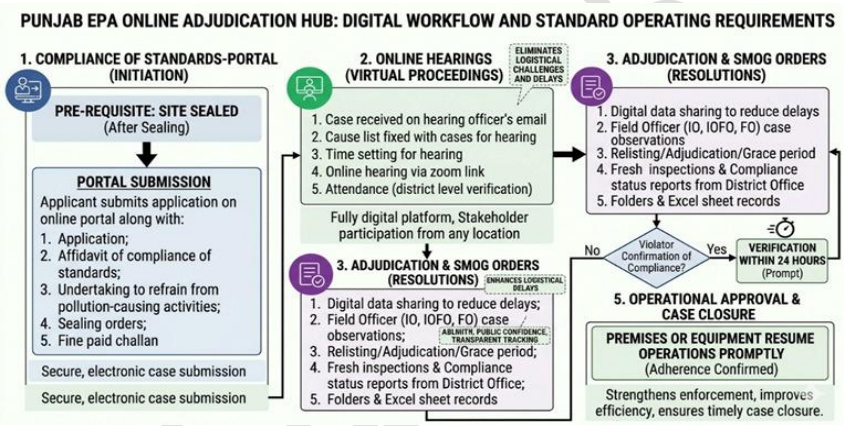
The introduction of this system has been widely accepted by stakeholders, particularly the industrial community, as it provides a transparent and accessible alternative to prolonged legal proceedings. Instead of approaching courts directly, stakeholders have increasingly preferred to present their cases before the competent authority through this digital platform, with confidence in a fair and accountable process. The system has also reinforced institutional credibility, as EPA Punjab has ensured that no arbitrary or unjustified actions are taken against any unit.

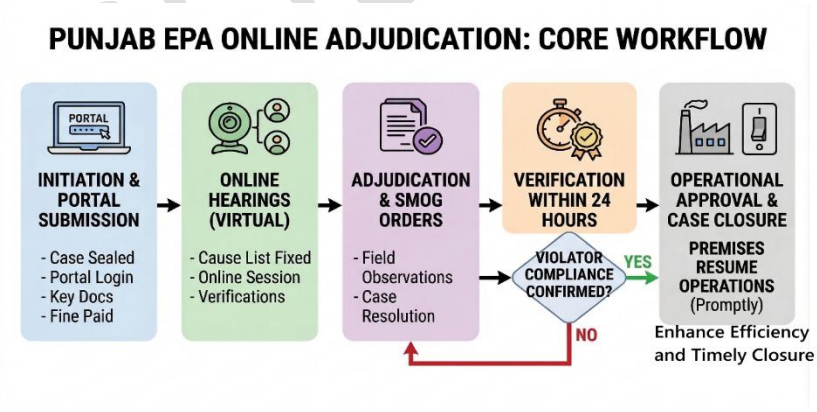
To date, more than 1,000 compliance cases have been processed through this system, with most cases being addressed and finalized within a week, significantly improving efficiency in enforcement proceedings. Importantly, the system has also generated a structured digital record of compliance across districts, enabling EPA Punjab to analyse compliance ratios and trends. This data is now being utilised as a key performance indicator (KPI) in evaluating district-level performance, strengthening internal accountability and promoting a results-driven regulatory culture.

DRAFT SOE 2025

13.5.4 Online Adjudication Hub

Previously, an online hearing mechanism did exist within EPA Punjab; however, it operated in isolation without a structured linkage to a compliance verification system. This gap limited its effectiveness, as hearings could be conducted but there was no integrated, time-bound digital process to verify compliance and finalize cases efficiently. To address this, the online hearing system was fully integrated into the Online Adjudication Hub, creating a unified and end-to-end digital workflow. This integration has also significantly improved accessibility, as applicants from remote areas no longer need to travel to EPA Headquarters in Lahore. Instead, they can participate in hearings from their respective district offices, where attendance is verified locally, making the system more inclusive, efficient and citizen-friendly. The entire process has been designed to ensure transparency, with every step digitally recorded, traceable and auditable.





The Punjab EPA Online Adjudication Hub now operates through a fully digitised, structured workflow designed to ensure transparency, efficiency and timely resolution of environmental cases. The process is initiated once a site is sealed due to a violation, after which the applicant submits a case through the online portal along with all required documents, including the application, affidavit of compliance with environmental standards, undertaking to refrain from pollution-causing activities, sealing orders and proof of fine payment. This ensures a secure and complete electronic case submission, forming the basis for further proceedings. Following submission, the case transitions into the online hearing phase, where virtual proceedings are conducted to eliminate logistical delays and ensure accessibility. The case is received by the hearing officer, listed for hearing and scheduled within a defined timeframe. Hearings are conducted digitally via video conferencing, with verified attendance from relevant district authorities, enabling stakeholder participation from any location while maintaining district-level facilitation.

Figure 13.38: Online Adjudication Hub Workflow - Digital Hearing Platform

Subsequently, the adjudication and decision-making phase is carried out through integrated digital data sharing. Field officers provide inspection reports, observations and compliance updates, which are evaluated alongside fresh inspections and district-level compliance status reports. The system also accommodates relisting of cases, adjudication decisions and provision of grace periods where applicable, all of which are documented through structured digital records.

A critical component of this workflow is the compliance confirmation stage. If the violator successfully meets the required environmental standards, the system ensures verification within 24 hours, enabling prompt action. In cases where compliance is not confirmed, the matter proceeds for further enforcement measures. Once compliance is verified, the system moves towards operational approval and case closure, allowing premises or equipment to resume operations promptly.

13.5.5 Internal Accountability Dashboard

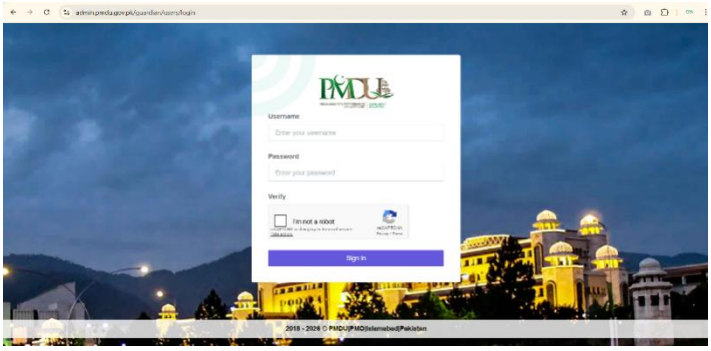


Figure 13.39: IAD Dashboard

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) exists across various departments of the Government of Punjab, it has traditionally remained an internal monitoring tool, inaccessible to the public. EPA Punjab, however, demonstrated institutional confidence and commitment to transparency by integrating its IAD with the Prime Minister Delivery Unit (PMDU), thereby making officer performance and complaint handling visible at a

DRAFT SOER 2025

broader, public level. This initiative has transformed internal performance tracking into a citizen-facing accountability mechanism, strengthening trust and reinforcing 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.

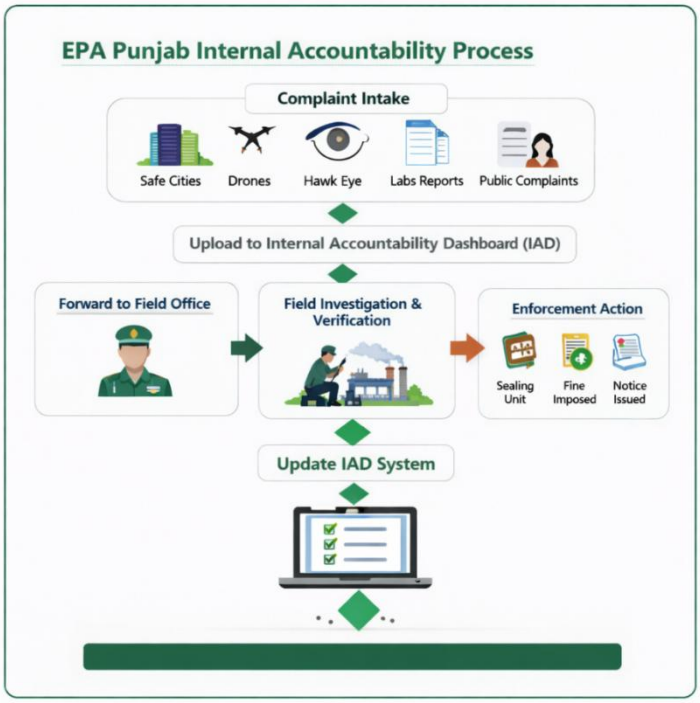


Figure 13.40: Internal Accountability Process

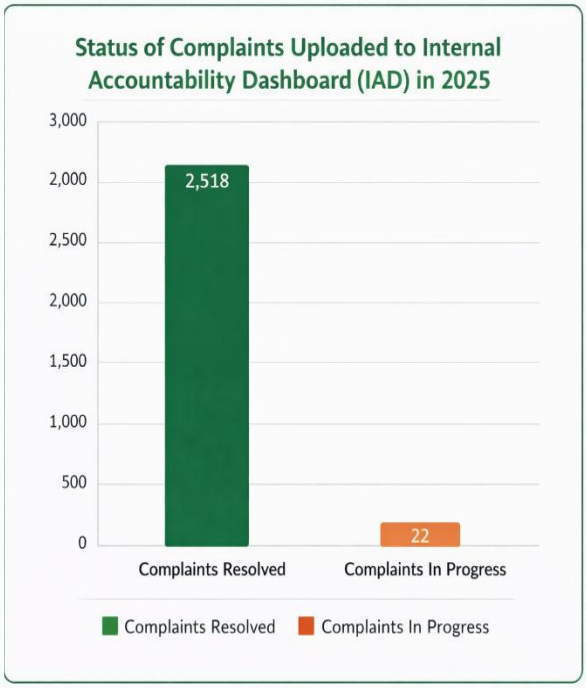


Figure 13.41: IAD Complaints graph 2025

This multi-source integration ensures that environmental violations are captured from both 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 and 22 remained in progress, demonstrating the system's effectiveness in managing, tracking and ensuring accountability for environmental compliance issues.

Once a complaint is received, it is uploaded to the central IAD system and immediately forwarded to the relevant field office, ensuring that no complaint remains unattended or delayed. The next stage involves field officer investigation, where on-site verification is conducted to assess the validity and severity of the complaint. This step ensures that all actions are evidence-based and grounded in actual field conditions. Following verification, appropriate legal or administrative actions are initiated, which may include sealing of units, imposition of fines, or issuance of notices, depending on the nature of the violation.

After enforcement action is taken, the responsible officer is required to update the IAD system with complete details of the action, including observations and outcomes. This real-time updating

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ensures that every step of the process is documented, traceable and visible within the system. Finally, once all necessary actions are completed, the complaint is formally closed within the system.

This end-to-end digital workflow has established a clear chain of responsibility and accountability, where each complaint is tracked from initiation to resolution. By linking this system with PMDU and making performance data more transparent, EPA Punjab has not only improved operational efficiency but has also set a new benchmark in 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) was a critical and timely intervention aimed at safeguarding, sustaining and streamlining the Agency's rapidly expanding digital ecosystem. As EPA Punjab transitioned towards a fully digitised operational model, it became evident that without a centralised technical structure, the growing number of digital systems could face challenges related to maintenance, coordination, duplication and long-term sustainability. To address this paradigm shift and ensure continuity of digital reforms, a dedicated in-house IT Support Unit was established to serve as the backbone of all existing and future technological interventions, ensuring institutional control, consistency and long-term sustainability of digital initiatives.

In line with this need, the primary objective of the Unit is to centralize and channelize all digital initiatives, ensuring that systems are developed, managed and scaled in a coordinated and standardised manner. By doing so, it minimises duplication of efforts, optimises resource utilisation and ensures interoperability of all 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 a cohesive, integrated and efficient ecosystem that supports effective governance and regulatory functions.

As per its Terms of Reference (TORs), the IT Support Unit serves as the focal point for coordination with PITB for the development, implementation and maintenance of digital systems, including mobile applications, dashboards and other IT-driven initiatives. It is responsible for establishing and managing a centralised data repository to facilitate planning, monitoring, reporting and evidence-based decision-making at the highest level. The Unit provides continuous technical support and advisory services to all wings, field formations and directorates, while also identifying emerging requirements 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 works in close coordination with strategic units such as SAW.

In terms of its working, the IT Support Unit functions as a centralised technical hub responsible for the smooth operation, maintenance and continuous improvement of all digital systems across

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EPA Punjab. Beyond system oversight and troubleshooting, it plays a pivotal role in capacity building and digital empowerment of staff by providing training on digital tools, workflows and systems. Acting as a one-window solution for technical support, it offers real-time assistance, issue resolution and guidance to both field and office staff. Furthermore, the Unit is actively promoting advanced digital competencies, including AI-based awareness and skill development, ensuring that EPA Punjab remains adaptive to emerging technologies. Through this structured approach, the IT Support Unit has significantly enhanced the resilience, efficiency, coordination and responsiveness of EPA Punjab's digital systems, enabling transparent, accountable and data-driven environmental governance.

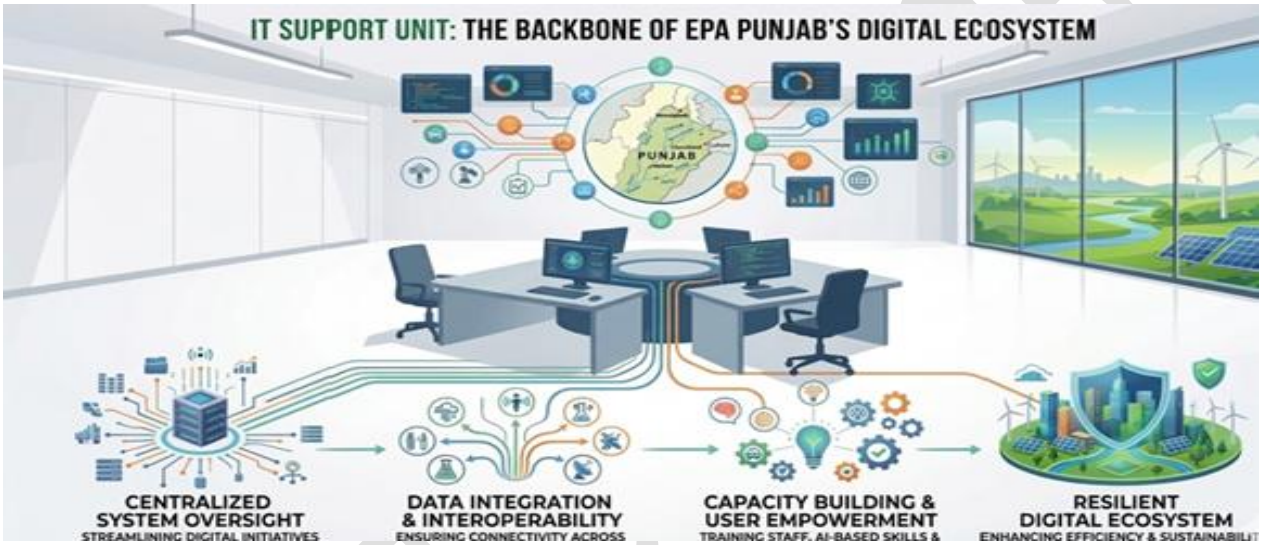

Figure 13.42: IT Support Unit Responsibilities – EPA Punjab

13.6 Conclusion

The digital transformation of EPA Punjab represents an important step towards more transparent, accountable and data-driven environmental governance. Through the introduction 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 developed a stronger digital footprint across monitoring, inspection, enforcement and public engagement functions. These systems have improved the availability of real-time information and created a more structured basis for evidence-based decision-making.

However, the success of this transformation should not be assessed only through the existence of dashboards and applications. Its real value depends on whether these systems have produced measurable improvements in governance performance. Therefore, EPA Punjab's digital transformation should be evaluated through indicators such as reduced response time to complaints and violations, increased number of digitally recorded inspections, improved compliance rates among industries, reduced backlog of pending cases, stronger traceability of enforcement actions and better public access to environmental information.

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The transformation has also strengthened institutional accountability by combining centralised oversight with decentralised field-level implementation. Real-time inspection uploads, geotagged evidence, automated monitoring and internal review mechanisms allow senior authorities to track field performance more effectively. This reduces the risks associated with manual reporting, delayed verification and inconsistent enforcement. Similarly, citizen-focused platforms have made environmental governance more participatory by enabling the public to report environmental concerns and monitor the responsiveness of the Agency.

Overall, EPA Punjab's digital governance model has created a strong foundation for modern environmental regulation. It has the potential to improve transparency, operational efficiency, regulatory fairness and public trust. Nevertheless, for the digital system to remain effective and credible, EPA Punjab should regularly publish performance-based results, including baseline data, annual targets and progress indicators. This would ensure that digital transformation is not only technological in nature but also produces clear environmental, administrative and governance outcomes.

Chapter No. 14: Inter-departmental & International Coordination

14.1. Introduction

Environmental governance today demands engagement far beyond conventional regulation requiring dynamic global connectivity, local institutional anchoring and sustained investment in future environmental stewards. For EPA Punjab, this understanding has shaped a governance philosophy that unites international representation, institutional collaboration and youth-centered academic engagement into a coherent framework of environmental action.

Through its growing presence in international environmental forums, EPA Punjab has emerged as a visible and credible sub national voice within the global environmental architecture. Participation in multilateral platforms, technical working groups and regional cooperation mechanisms under the 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 doing so, the province has contributed meaningfully to global conversations 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 has been complemented by a deliberate strengthening of Punjab's internal institutional ecosystem. EPA Punjab has progressively built a web of partnerships with public sector bodies, regulatory authorities, technological institutions, chambers of commerce and civil society organizations, allowing environmental considerations to be woven into the fabric of governance, commerce and urban development. These collaborations have expanded the reach of environmental regulation, fostered inter agency ownership of sustainability goals and enabled environmental priorities to shape decision making across transport, industry, infrastructure and

DRAFT SOE 2025

public services. In this way, environmental protection has evolved from a specialized regulatory function into a shared provincial responsibility.

Yet the most enduring investment of this integrated model lies in its engagement with young people and academia. Recognizing that environmental resilience is ultimately secured by informed and empowered citizens, EPA Punjab has forged lasting partnerships with universities, research centers and student communities across the province. Through Memoranda of Understanding, structured internship programs, policy dialogues, climate simulations and knowledge generation initiatives, students have been invited into the very process of environmental governance. They are not merely recipients of awareness campaigns, but active participants in data collection, policy analysis, fieldwork, innovation and advocacy learning by doing and shaping the environmental future of Punjab even as they prepare to inherit it.

This chapter traces how international representation, institutional partnerships and youth driven academic engagement have come together to form a distinctive and forward-looking model of environmental leadership in Punjab. Together, these strands reflect 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 people.

14.2. International Engagements by EPA Punjab

In 2025, EPA Punjab expanded its international engagements through global platforms and technical partnerships, enhancing institutional capacity in air quality monitoring, climate resilience and sustainable policy development.

DRAFT SOE 2025

14.2.1 World Economic Forum 2025

The World Economic Forum (WEF) Annual Meeting serves as a premier global platform where governments, international organizations and private sector leaders shape policy dialogue on economic development, environmental sustainability and climate resilience. Punjab's participation at the WEF Annual Meeting 2025, held in Davos from 20–25 January 2025, marked a significant

Figure 14. 1: Participation of DG EPA Punjab Imran Hamid Sheikh in Pakistan Business Sumit 2025

step in positioning the province within the international climate and sustainability framework.

Building on the momentum generated at COP29 in Baku, where EPA Punjab showcased 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 organized on the sidelines of WEF. During the session titled "Environment & Climate Change," EPA Punjab presented Punjab's air quality management reforms, industrial decarbonization initiatives, waste management systems and climate resilience strategies. Dr. Imran Hamid, Director General EPA Punjab articulated the province's long-term vision for a Green Punjab, highlighting institutional strengthening and alignment with global climate goals.

Punjab's engagement attracted interest from expatriates, academia and international stakeholders, opening pathways for research collaboration and technical cooperation. EPA Punjab officers also

participated in thematic WEF sessions on sustainable and climate resilient urban development, reinforcing the relevance of international best practices to Punjab's own policy priorities.

Punjab's participation at WEF 2025 demonstrated active role as sub-national unit, strengthening provincial credibility and expanding partnership opportunities 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 major step in its international engagement through participation in a high-level global forum on air quality and public health held in Cartagena, Colombia. The Raja Jahangir Anwar, Secretary, EP&CCD, Dr. Imran Hamid Sheikh, Director General, Environmental Protection Agency (EPA) Punjab and Dr. Wajid Ijaz, Deputy Director (Monitoring & Evaluation), participated in the international conference titled "Clean Air for All: Addressing Pollution in South Asia for a Healthier Future." The conference was organized by the World Bank and held alongside the Second High Level World Health Organization (WHO) Conference from 21 to 26 March 2025, providing a global platform for advancing policy dialogue on air pollution, public health and climate responsive environmental governance.

The forum brought together policymakers, public health specialists, environmental regulators and development partners from across the world to address the interlinked challenges of air pollution, climate change and human health, with particular emphasis on the South Asian region. EP&CCD Punjab's participation signaled the growing international recognition of Punjab's institutional capacity in air quality management, emissions regulation and environmental governance. Through this platform, EPA Punjab presented its experience in regulatory reforms, real time monitoring systems and enforcement frameworks, while simultaneously engaging with global best practices in pollution control, health-based air quality standards and climate responsive policy design. Beyond technical exchange, the Cartagena engagement strengthened institutional linkages with the World Bank and the World Health Organization, creating new pathways for cooperation in air quality management. This participation thus marked a meaningful consolidation of Punjab's position as a proactive and credible sub national actor within the global environmental and public health community.

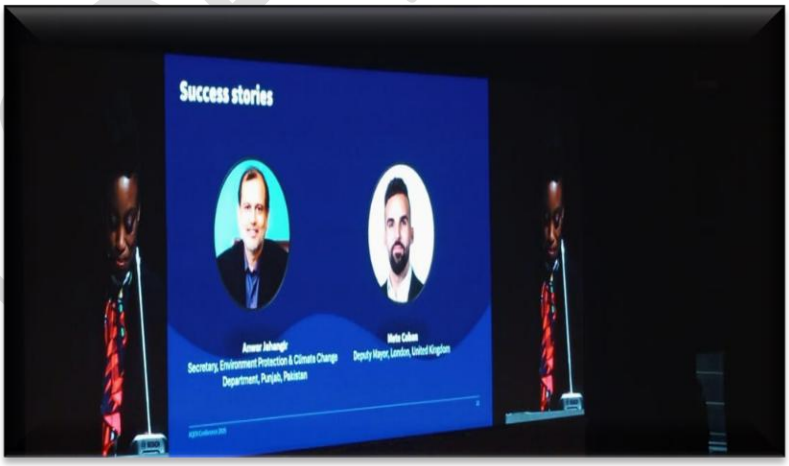

Figure 14.2: Secretary EP&CCD as panelist

DRAFT 2025

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), EPA Rawalpindi, represented EPA Punjab at the Technical Committee of the Science, Policy and Finance Dialogue (SPFD) on Air Quality Management held in Kathmandu, Nepal under the joint auspices of ICIMOD and the World Bank. This high-level regional engagement was convened to operationalize the Thimphu Outcome (June 2024), through which Bangladesh, Bhutan, India, Nepal and Pakistan collectively acknowledged the transboundary nature of air pollution across the Indo-Gangetic Plain and Himalayan Foothills (IGP-HF) and committed to addressing it through a structured regional cooperation framework.

The deliberations led to the comprehensive regional institutional architecture, comprising an Executive Body, an Advisory Committee, three Thematic Working Groups covering air quality monitoring and emissions, pollution mitigation solutions and air quality finance and a Secretariat to be hosted by ICIMOD with technical support from the World Bank. EPA Punjab provided technical input during the Science–Policy Dialogue under the IGP-HF initiative, contributing to regional discussions on transboundary air quality management and collaborative approaches for improving 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, Strategy and Analysis Wing, represented EPA Punjab at the Regional Training Workshop on Air Quality Data Analysis held from 30 June to 04 July 2025 at the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal. The program was organized to strengthen the capacity of sub national partners to monitor air quality, analyse air quality datasets and understand the linkages between air pollution, social dimensions and gender impacts, with particular emphasis on the use of programming tools such as Python and R for evidence-based analysis

Through this engagement, EPA Punjab's capacity for evidence-based air quality management was strengthened. The training enhanced EPA Punjab's ability to apply modern analytical tools and programming-based techniques to transform raw monitoring data into actionable intelligence for smog control, health risk assessment and climate responsive environmental planning, in line 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, Environmental Protection Agency (EPA) Punjab represented the Environment Protection & Climate Change Department, Punjab in a high-level regional engagement under the South Asia Cooperative Environment Programme (SACEP), held at the Asian Institute of Technology (AIT), Bangkok, from 2 to 5 September 2025.

DRAFT SOE 2025

The participation formed part of Pakistan's formal representation in 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 back-to-back SACEP sessions. The delegation comprised Mr. Imran Hamid Sheikh, Director General, EPA Punjab; Mr. Khalid Mehmood, Director, Pakistan EPA; and Mr. Salman Mehmood, Section Officer (IC), MoCC&EC. In recognition of Punjab's strong performance in environmental governance, institutional strengthening and regional cooperation, Mr. Imran Hamid Sheikh was designated as 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 focused on the review and finalization of the revised Articles of Association (AoA) of SACEP. The workshop reviewed and validated the revised draft incorporating feedback from the first review workshop and subsequent written comments, sought consensus on outstanding issues among member states, and ensured that the revised AoA reflected the shared vision, priorities, and aspirations of the region. The process also aimed to strengthen SACEP's institutional framework to enhance its effectiveness in delivering its regional mandate and to finalize the revised Articles of Association for submission to the Governing Council for formal adoption. The discussions emphasized the growing importance of sub-national environmental regulators, such as EPA Punjab, in delivering regional and global environmental commitments. A significant outcome of Punjab's active engagement at the SACEP Articles of Association review was the successful advocacy for the inclusion of clauses formally recognizing sub-national units and provinces within SACEP's governance framework.

DRAFT SOE

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 examined emerging environmental risks, governance gaps and opportunities for collective action in areas such as air pollution, plastic waste, biodiversity, digital environmental governance and climate resilience.

Figure 14.4: Director General EPA at Strategic Planning workshop

Through the leadership of the Director General, EPA Punjab as Team Lead, Pakistan presented practical and field-tested institutional models, including Punjab's experience in environmental enforcement, plastic regulation, air quality management and digital monitoring systems. This engagement reinforced Punjab's standing as a leading sub national environmental authority in South Asia and strengthened Pakistan's contribution to the evolving regional architecture for environmental cooperation, sustainability and climate action.

Figure 14.5: Participants of Strategic Planning Workshop Organized by SACEP

14.2.6. Transformative Action to End Open Burning of Waste in South Asia

In September 2025, Mr. Farooq Alam, Director (Multilateral Environmental Agreements), EPA Punjab, represented EPA Punjab at the Regional Dialogue on "Transformative Action to End Open Burning of Waste in South Asia", held from 04 to 07 September 2025 at the Malla Hotel, Kathmandu, Nepal. The regional dialogue was convened under the IGES–UNEP Climate and Clean Air Coalition (CCAC) initiative, in collaboration with the Ministry of Forest and

Figure 14.6: Representation of EPA Punjab at the Regional Dialogue

Environment, Nepal, GAIA and HECAF360, to address the growing crisis of open waste burning as a major driver of air pollution, black carbon emissions and climate change across South Asia

The dialogue brought together governments, international organizations and regional experts to review and refine the draft Regional Roadmap for Asia to End Open Burning of Waste, with a focus on policy enforcement, institutional coordination and regional collaboration, financing mechanisms and data driven monitoring and inspection systems. Through this engagement, EPA Punjab contributed 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 the 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 Honorable Chief Minister Punjab, Ms. Maryam Nawaz Sharif, the provincial delegation brought together senior political leadership and technical expertise from across government. Punjab's presence at COP-30 was not symbolic; it was a strategic engagement aimed

at protecting 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; to showcase its flagship initiatives, particularly Suthra Punjab, as globally relevant models; to deepen partnerships with international organizations, donors and research institutions; to build the province's institutional capacity for climate diplomacy and negotiations; and to position Punjab as a sub national leader capable of contributing substantively to global climate solutions. This marked a shift from passive participation toward active climate diplomacy. Rather than simply attending, Punjab sought to contribute substantively to the discussions, bringing evidence, demonstrable results and implementation credibility to the table, and positioning itself as a sub-national government with a track record worth sharing.

The scale and visibility of Punjab's presence reflected this ambition. The Chief Minister's engagements at the Pakistan Pavilion in the UNFCCC Blue Zone placed Punjab at the center of international climate discourse. Through a sequence of high-profile events, launches and bilateral meetings, Punjab's leadership articulated the province's reform trajectory in air quality, waste management, climate resilience, mobility and digital governance. The Chief Minister's diplomatic engagements underscored that sub national governments, when equipped with political leadership and institutional capacity, can play a transformative role in advancing global climate action.

One of the prominent engagements was the meeting with the former Prime Minister of New Zealand, Rt. Hon. Jacinda Ardern, held on 10 November 2025. In this interaction, Punjab's eco-friendly governance reforms, digital monitoring systems, smog control measures and large scale community engagement initiatives were acknowledged as a "unique sub national example from the Global South."

Figure14. 7: CM Punjab Meeting with Former PM of New Zealand at COP-30

DRAFT SOE 2025

A defining moment of Punjab's COP-30 presence 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, handling tens of thousands of tonnes of municipal waste daily through a province wide, AI-enabled operational framework supported by over 150,000 sanitation workers and 30,000 vehicles. Its launch at COP-30 demonstrated Punjab's ability to translate political commitment into real world service delivery, environmental enforcement and digital transparency. The initiative aligns with global priorities on circular economy, pollution reduction and urban resilience and its presentation at COP-30 allowed Punjab to share a scalable, implementation ready model with partners from across the world.

Figure 14.8: International launch of Suthra Punjab at COP-30

Beyond political and symbolic milestones, EPA Punjab played a substantive technical and diplomatic role throughout COP-30. Under the leadership of Dr. Imran Hamid Sheikh, Director General EPA Punjab, the Agency represented the Government of the Punjab in nine major panel discussions, thematic dialogues and expert level sessions convened by international organizations, research institutions and multilateral bodies. These platforms enabled Punjab to present its environmental reforms not as abstract policy aspirations but as operational systems backed 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 a trajectory toward one hundred stations, alongside the deployment of AI-enabled AQI forecasting that strengthened seasonal preparedness. Punjab's establishment of Pakistan's first Environmental Protection Force 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), electric mobility transition and fuel quality enforcement regime further illustrated how environmental regulation had moved from paper-based compliance to technology enabled governance.

Punjab's engagement also extended into the domain of climate finance and institutional planning. The delegation presented the Climate Resilient Punjab Vision & Action Plan 2024, enhanced

climate budget allocations and the integration of climate objectives into infrastructure, waste systems and urban planning. Through these presentations, Punjab positioned itself as not merely a project implementer but as a province capable of managing climate finance, monitoring results and delivering bankable, scalable climate investments.

A historic institutional milestone of COP-30 was EPA Punjab's first ever formal entry into UNFCCC negotiation rooms as observers. By attending contact groups, technical negotiations sessions, EPA Punjab officers gained first hand exposure to how international climate positions are negotiated, shaped and finalized. This experience laid the groundwork for institutionalizing negotiation preparedness within EPA Punjab, enabling the province to contribute evidence-based inputs to Pakistan's national positions in future climate negotiations. It marked a transition from external advocacy to procedural participation in global climate governance

The China Pavilion engagement further underscored Punjab's rising profile. Invited to deliver a keynote on "Low-Carbon Technology Innovation and Industrial Practice," the Director General EPA Punjab presented Punjab's alignment with scalable Chinese technologies in renewable energy, electric mobility, digital MRV systems and green industrialization. The discussion emphasized technology transfer, bilateral cooperation and the role of transparent, 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 underscored its acute vulnerability to climate shocks, drawing on the devastating floods of 2022 and 2025. By presenting institutional reforms, budgetary increases and community level verification systems, Punjab reinforced that Loss & Damage finance must translate into direct resilience and livelihood restoration for frontline communities.

DRAFT 2025

Punjab's youth focused climate engagement also attracted international recognition. Through sessions at the GAUC Pavilion and interactions with the Yale School of the Environment, Punjab presented its youth centric climate governance model, including digital platforms, university partnerships, climate internships and community-based monitoring initiatives. These engagements positioned Punjab 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 the Punjab was represented by the Director General EPA Punjab in the panel *"Unlocking the Local Benefits of Renewable Energy,"* organized by the University of Oxford and the Smith School of Enterprise & Environment at the WWF Pavilion. Punjab highlighted the centrality of equitable benefit-sharing in renewable energy development, drawing on community-driven micro-hydro models 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 Enterprise & Environment at the WWF

Key initiatives included the deployment of 1,500 electric buses, Pakistan's first Vehicle Emission Testing System for light duty vehicles, digital enforcement of traffic and emissions, expansion of the 41-station air quality monitoring network, strengthened fuel quality regulation and the launch of CM Green Credits to accelerate EV adoption. Together, these measures form an integrated clean transport system linking regulation, technology and market incentives to deliver measurable reductions in pollution and emissions.

On the strength of these reforms, the Director General, EPA Punjab, was invited to present Punjab's experience at the UN DESA session at the SDGs Pavilion and to represent 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 translating global transport goals into province wide implementation.

Figure 14.12: Panelist at UN Decade of Sustainable Transport (2026-2035) at SDGs Pavillion

Collectively, COP-30 produced significant dividends: Punjab was recognized as an emerging climate leader in South Asia in waste governance, air quality and digital enforcement; and Punjab's standing as a technically credible sub-national actor was affirmed across multiple UN and international platforms.

By the close of COP-30, Punjab had achieved a decisive transformation: from a provincial environmental regulator to a recognized participant in global climate diplomacy. Its reforms, institutions and leadership were no longer confined to domestic narratives; they had entered the global arena as part of the evolving architecture of climate action. Punjab's presence at COP-30 thus represents not merely participation, but a structural repositioning of the province within the international climate system, laying the foundation for sustained global partnerships, negotiation capacity and long-term climate investment.

14.2.8. Strengthening Regional Capacity for Wastewater and Environmental Surveillance (WES) in Public Health Systems of IsDB Member Countries

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 organized by the Islamic Development Bank (IsDB) in

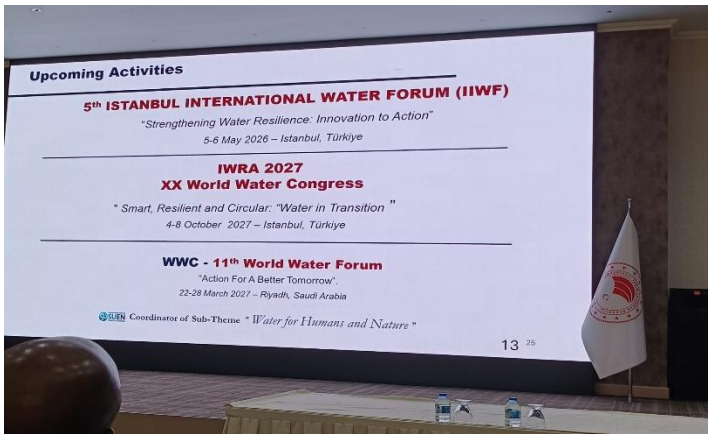

Figure 14.13: International Workshop on "Strengthening Regional Capacity for Wastewater and Environmental

collaboration with the Gates Foundation, the European Commission (HERA) and the Turkish Water Institute (SUEN), with participation from WHO and other international partners and was convened to support the institutionalization of wastewater and environmental surveillance as a core public health and environmental monitoring function.

The program combined high level policy dialogue with practical exposure to operational surveillance systems. Plenary sessions and country showcase highlighted international experiences in integrating wastewater surveillance into public health decision making, mobilizing 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, Pendik provided first hand insight into sampling protocols, pathogen detection, laboratory workflows and biosafety practices and inter institutional coordination mechanisms linking wastewater treatment infrastructure with public health surveillance functions.

Through this international engagement, EPA Punjab strengthened its understanding of how wastewater and environmental monitoring can be embedded within provincial surveillance and regulatory frameworks, reinforcing the strategic convergence between environmental protection, public health preparedness and data driven risk management, in line 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, EPA Punjab, represented EPA Punjab as a panelist in an ICIMOD-organized session during Clean Air Week 2025, convened by 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 and focused on strengthening regional harmonization in air quality management through robust sub national clean air strategies linked to regional cooperation frameworks The session promoted South learning, peer-to-peer exchange and standardized regional approaches.

DRAFT SOE 2025

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 aligning country level clean air actions with emerging regional cooperation architectures for South Asia and the wider 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 pipeline of technical partnerships, Memorandum of Understanding and bilateral cooperation frameworks that have been initiated as a direct result. These prospective institutional arrangements, currently at various stages of finalization, reflect EPA Punjab's growing credibility and will translate presence into structured long-term collaboration 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 formalizing 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 will institutionalize collaboration in air quality monitoring, regional data sharing, scientific capacity building and policy-relevant research within the IGP-HF framework. ICIMOD's convening role in the SPFD platform and its technical support to the IGP-HF airshed governance mechanism position this partnership as foundational to Punjab's regional environmental science architecture.

(ii) Technical Partnership with CRAES and MoU (In Pipeline)

DRAFT SOE

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 is currently providing technical assistance across different ongoing projects of both EPA Punjab and the Environment Protection & Climate Change Department (EP&CCD), encompassing 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 institutionalize this collaboration is currently in the pipeline. The CRAES engagement represents direct access to the scientific foundations of China's own transformative air quality improvement a 35–45% reduction in PM2.5 across major cities between 2013 and 2023 (MEE China, 2023) providing Punjab with 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 foremost academic and research institutions, ranked among the top 100 universities globally and a leading centre for environmental science, climate research and sustainability policy expressed strong interest in establishing structured cooperation with EPA Punjab. This prospective partnership would open pathways for collaborative research in air quality, climate adaptation, urban environmental governance and circular economy, and would connect Punjab's environmental practitioners with environmental research ecosystems. USP's expertise in tropical and sub-tropical environmental systems, industrial ecology and community-based resilience is directly relevant 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 the Republic of South Africa is currently under process. South Africa's DFFE is the principal environmental regulatory authority responsible for biodiversity conservation, pollution and waste management, climate change adaptation and environmental impact assessment functions closely paralleling EPA Punjab's mandate. Once finalized, 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 strengthens its environmental impact through strategic partnerships with different government institutions, academic institutions, the private sector and civil society. These collaborations promote shared responsibility and community-driven solutions, extending regulatory reach and fostering innovation, public awareness and long-term stewardship.

DRAFT SOE 2025

14.3.1. Memorandums of Understanding with Local Authorities

EPA Punjab has pursued a whole of government and whole of society approach to environmental governance by entering into a wide range of strategic collaborations with key provincial institutions, the private sector and academia. A central pillar of this approach is its partnership with the Punjab Safe Cities Authority (PSCA), through which advanced surveillance, command and control infrastructure and real time data feeds are leveraged to support environmental enforcement, traffic related emission control and compliance monitoring in major urban centers. In parallel, EPA Punjab coordinates with the Ravi Urban Development Authority (RUDA) to ensure that large scale urban development projects incorporate environmental safeguards and regulatory compliance.

Figure 14.15: EPA & PSCA MOU Signing Ceremony

At the same time, 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, creating a direct institutional interface with the industrial and business community. These desks are designed not only to streamline regulatory guidance and approvals but also to promote voluntary compliance, cleaner production practices and awareness of evolving environmental standards.

Figure 14.16: EPA & PITB MOU Signing Ceremony

Complementing these outreach and enforcement mechanisms, EPA Punjab has strengthened its partnership with the Punjab Information Technology Board (PITB) to institutionalize digital environmental governance. This collaboration underpins the development and operation of key digital platforms, including the e-FOAS, Eco-Watch, digital inspection and laboratory management systems, and the integration of environmental complaint management through the Punjab Government's 1373 Helpline through a formal agreement. Together, these initiatives have enhanced regulatory efficiency, improved public access to environmental grievance redressal, and enabled technology-driven environmental monitoring and enforcement across the province.

DRAFT SOE

These institutional partnerships have yielded tangible improvements in collaborative enforcement and real-time environmental monitoring across Punjab. Under the Safe City Alliance, EPA Punjab now operates 24x7 across five key domains, with dedicated focal persons stationed at five major Punjab facilities, enabling continuous surveillance and enforcement at a scale and intensity previously unattainable. The deployment of Safe City cameras has introduced an additional and significant layer of monitoring and enforcement capacity province-wide. EPA Punjab's coordination with the Ravi Urban Development Authority (RUDA) in the northern areas of Lahore has similarly yielded measurable improvements in industrial compliance, with smart camera monitoring enabling round-the-clock oversight that was previously unavailable. This has proven particularly effective in curbing late-night and off-hours industrial emissions a persistent enforcement challenge by extending regulatory visibility into periods when violations were historically most frequent. Through its MOU with the Punjab Information Technology Board (PITB), EPA Punjab has integrated the 1373 platform into its core operations, streamlining agency functions well beyond a conventional call centre or public helpline. The platform now facilitates all institutional interactions and underpins smooth implementation of enforcement actions. For instance, under the CCTV camera initiative, communications with industrial proponents are routed exclusively through the platform rather than through direct personal contact, systematically eliminating the risk of individual bias and enhancing transparency. This model of system-mediated, third-party communication has added measurable efficiency and accountability to EPA Punjab's enforcement operations. The 1373 platform further underpins generating automated alerts and coordinating multi-stakeholder responses, enabling EPA Punjab to perform multiple monitoring, enforcement and stakeholder engagement functions through a single integrated digital system.

EPA Punjab, in partnership with Coca-Cola Pakistan, implemented the Waste Wise Management Process to promote modern waste segregation in educational institutions across the province. Under this initiative, ten model schools were equipped with five stream, color coded bin systems

Figure 14.17: EPA Punjab with Coca-Cola Pakistan for Waste Wise Management Process

to enable effective recycling and environmentally responsible disposal. Supported by environmental education materials, the program strengthens waste literacy among students and fosters a culture of sustainability, positioning youth as active contributors to Punjab's transition toward a cleaner and more resilient future.

Another important initiative was the Conference of Directors General of Environmental Protection Agencies, convened by EPA Punjab in collaboration with UNICEF, marked a significant institutional milestone toward strengthening inter-provincial environmental governance in Pakistan. By bringing together the heads of all federal and provincial EPAs on a single platform, the Conference created a rare space for strategic dialogue, peer learning and collective problem-solving at the highest executive level of environmental administration. Through structured presentations by each Director General, followed by a plenary deliberation, the forum enabled provinces to share operational experiences, regulatory innovations and policy challenges. The

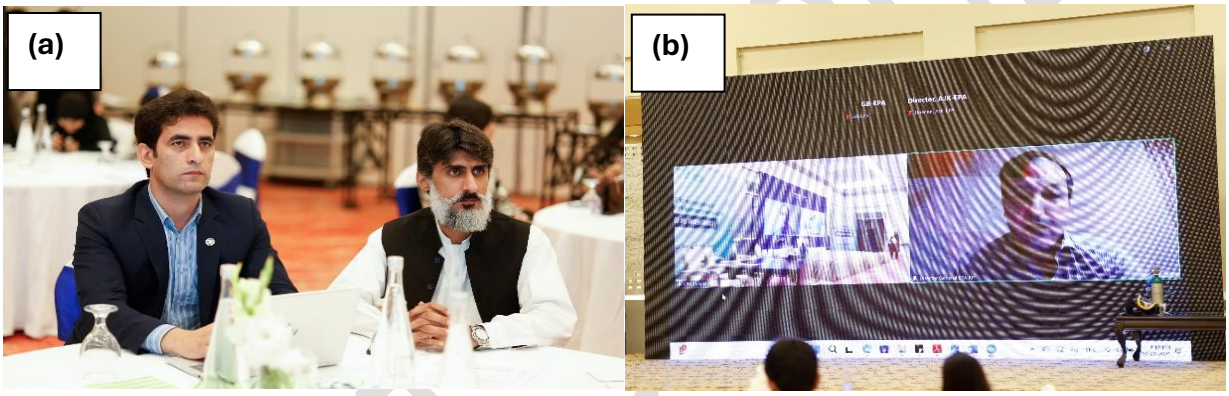

Figure 14. 18: (a) Participants from Baluchistan EPA (b) Online Participation from AJK EPA

proceedings culminated in the consolidation of joint recommendations and the articulation of a structured mechanism for sustained coordination, thereby laying the foundation for a more coherent, cooperative and harmonized national environmental governance framework.

The Conference yielded concrete inter-provincial coordination outcomes that extended well beyond the event itself. All provinces appreciated the efforts of EPA Punjab and has agreed to develop a coordination mechanism for 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 consciously placed youth at the centre of its environmental governance and climate action framework, recognizing young people as both inheritors of the future and active partners in the present. This vision was formally institutionalized through the signing of a Memorandum of Understanding (MoU) with the Lahore University of Management Sciences (LUMS), creating a structured platform for collaboration in environmental awareness, academic exchange, research engagement and policy dialogue. The MoU signified a strategic shift from isolated outreach activities toward a sustained, institutional relationship with academia, ensuring that environmental governance in Punjab is continuously enriched by intellectual inquiry, innovation and youth participation.

Building upon this foundation, EPA Punjab launched the "COP in My City" series as a flagship youth engagement and climate-simulation initiative. The platform was specifically designed to immerse students in the dynamics of international climate negotiations by allowing them to participate in simulated COP processes, policy role-playing, negotiation exercises and evidence-based climate dialogues. Through this approach, young participants were not merely informed about climate diplomacy but were actively engaged in understanding how scientific evidence and climate justice considerations are reconciled within global climate frameworks.

Under this initiative, COP-style simulations and youth engagement sessions were conducted at LUMS, Government College University and the College of Earth and Environmental Sciences, University of the Punjab, among other institutions. These events enabled students to step into the roles of negotiators, scientists, policymakers and civil society actors, thereby gaining practical insight into the workings of the UNFCCC process and the complexity of climate governance. By linking these simulated negotiations to Punjab's own climate challenges, the program helped

DRAFT SOE

young participants connect global climate commitments with local environmental realities and 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 exercise but a structured investment in the next generation of climate-aware citizens and environmental professionals in Punjab.

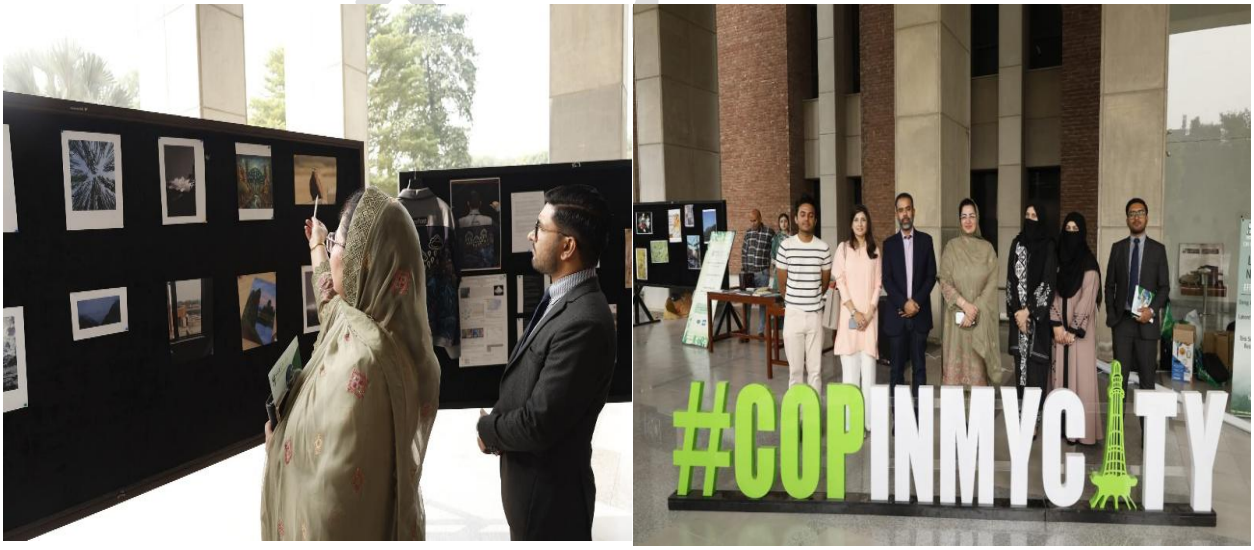

Figure 14.21: COP in my City at LUMS

Figure 11. 22: COP in my City at CEES PU

To ensure that awareness was reinforced by practical experience, EPA Punjab simultaneously expanded a province-wide internship and youth placement program, opening its institutional framework to students from universities and colleges across Punjab. During 2025, more than 100 students completed structured internships within the Agency, gaining exposure to air quality management, environmental monitoring, regulatory compliance, data analysis and public communication. This engagement enabled young scholars to witness first-hand the functioning of environmental governance, nurturing a generation equipped with both academic insight and operational understanding.

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Complementing these initiatives, EPA Punjab also invested in the creation of enduring educational resources for young audiences. In this context, the Agency developed and published its first youth-focused environmental book, “Our Earth, Our Responsibility.” The publication presents environmental challenges, climate risks and sustainability principles in a clear and engaging manner, inspiring young readers to see themselves as stewards of the environment and active participants in climate action.

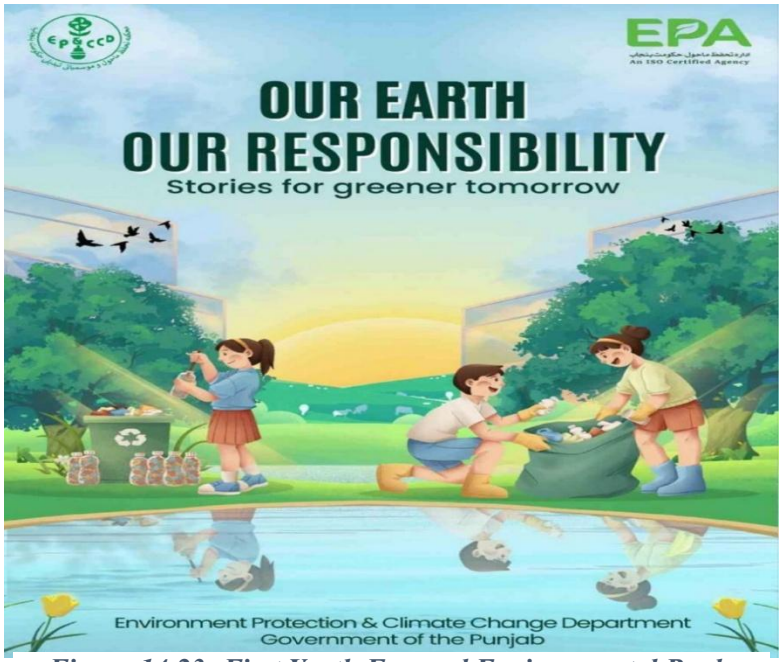

Figure 14.23: First Youth Focused Environmental Book, “Our Earth, Our Responsibility”

14.4 Conclusion: From Engagement to Endurance

EPA Punjab's work in 2025 reflects a significant step forward in how the agency operates both internationally and at home. Rather than treating global engagements as an events, EPA Punjab used each platform to build practical capacity, establish lasting partnerships and bring concrete knowledge back to Punjab.

At the international level, participating in COP-30 in Belém for the first time gave EPA Punjab officers direct experience of how climate negotiations actually work from technical discussions to drafting sessions. This exposure is important because it builds the agency's ability to engage meaningfully in future negotiations rather than simply observing from the sidelines. Alongside this, new technical partnerships with institutions such as CRAES, ICIMOD, the University of São Paulo and South Africa's environment department, as well as stronger ties with the World Bank and WHO, give EPA Punjab access to expertise, data and tools that will directly support its work on air quality, environmental monitoring and policy development.

On the domestic side, the MoU with LUMS, the internship programme that brought students into EPA Punjab, and the "COP in My City" simulations held at different universities are all investments in the people who will carry this work forward. Punjab's first youth-focused environmental publication adds to this effort by building awareness among a wider audience. At the national level, the Conference of Directors General of EPAs produced an important outcome all provinces agreed to develop a shared coordination mechanism, which is a necessary step toward consistent environmental governance across Pakistan.

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Taken together, these efforts show that EPA Punjab is building something durable: an agency that learns from international experience, applies it locally and develops the institutional and human capacity to keep improving over time.

The priorities for the period ahead are clear moving MoUs from paper to practice, translating training into policy action and ensuring that the young professionals engaged in 2025 grow into the environmental leaders Punjab will need. The groundwork has been laid; the task now is to build on it.

DRAFT SOE 2025

DRAFT SOE 2025

Part IV Integrated Sustainability, Public Engagement & Future Outlook

Chapter No. 15: Whole of Government Approach for Greener Punjab

15.1 Introduction

Punjab being the most populous province of Pakistan carries a key share of the country's economic, demographic, agricultural, industrial and urban load. This concentration of population has increased pressure on natural and man-made resources. These pressures compound one another: brick kiln emissions worsen respiratory disease, agricultural runoff degrades water bodies relied on for drinking and irrigation, and unchecked urban sprawl fragments the green spaces that buffer communities against heat and flood. At the same time, anthropogenic activities and climate-related pressures have collectively intensified environmental degradation across the province. The environmental challenge in Punjab has therefore expanded beyond the mandate of a single department and has become a shared governance concern which requires coordinated action by all relevant departments, including environment, health, agriculture, transport, industry, energy, local government, urban development, planning and disaster management.

Identifying this need, the Government of Punjab has adopted an integrated, whole-of-government approach to embed environmental considerations into policies, development planning, public investment, monitoring and enforcement. EP&CCD and EPA Punjab serve as key coordinating institutions for aligning sectoral actions with environmental protection and climate resilience objectives. Through digital monitoring systems, regulatory reforms, ADP interventions, climate finance initiatives and interdepartmental coordination, Punjab is strengthening evidence-based environmental governance.

This chapter presents the Government of Punjab's integrated approach towards environmental sustainability and pollution management, and demonstrates how environmental considerations have been mainstreamed into sectoral development planning, regulatory reform and public investment.

15.2 Sectoral Integration of Environmental Governance in Development Projects

To strengthen environmental governance and improve policy coherence, the Government of Punjab organised development initiatives and Annual Development Programme (ADP) projects under key environmental sustainability themes and under concept of green governance. Green governance is based on deliberative and collaborative policy-making by the states to prevent environmental degeneration[1211]. The emerging threats to the environment led the states to develop more transformative and coherent measures to implement new regulations for successfully achieving sustainable development goals. The figure below provides conceptual contributions of

[121] Conceptualizing Green Governance: Prospects and Challenges for Pakistan| Journal of Politics and International Studies

DRAFT SOE 2025

interdisciplinary approaches to sustainability and green governance.[122] This sector-wise approach enabled better coordination among departments, improved resource allocation and ensured integration of environmental considerations into development planning and implementation. The thematic organisation of projects also reflects the Government's commitment to addressing environmental challenges through targeted interventions in climate resilience, clean energy, sustainable transport, urban infrastructure, agriculture and waste management sectors. The following sections highlight major initiatives undertaken by Environment Protection and Climate Change Department (EP&CCD) and by other departments of Punjab Government to promote sustainable development, reduce environmental degradation and strengthen climate resilience.

Figure 15.1: Illustration of integration of green environmental governance model[1].

15.3 Green Public Investment Framework

Government of Punjab, through the Annual Development Programme (ADP), has progressively embedded environmental considerations into public investment planning, reflecting a transition towards a Green Public Investment Framework. Sectoral planning is increasingly aligned with climate mitigation, adaptation and sustainability objectives through climate-tagging of development expenditures and integration of environmental safeguards in project design. Environment Protection & Climate Change Department (EP&CCD) Punjab, has played a central role in mainstreaming environmental priorities into development planning, with a marked increase in development allocations from Rs. 5 billion in FY 2023–24 to Rs. 15 billion in FY 2025–26. In Budget 2025–26, approximately Rs. 795 billion of total ADP expenditure has been formally

[122] Green Governance and Policies for a Sustainable Future| National Education Services| ISBN: 978-81-977776-2-2

climate-tagged (representing 64% of total development allocations), distributed across three categories as follows:

- Rs. 371.7 billion for Climate Mitigation
- Rs. 277.4 billion for Climate Adaptation
- Rs. 146.0 billion for other supporting sectors

This demonstrates increasing alignment with international climate finance frameworks, including SDGs and global climate commitments.

15.4 EP&CCD Development interventions under ADP

Environment Protection & Climate Change Department (EP&CCD) functions as the central coordinating body for environmental governance in Punjab. It ensures integration of environmental safeguards across key sectors such as agriculture, transport, industry, energy and urban development through regulatory frameworks, real-time monitoring systems, enforcement mechanisms and inter-agency coordination with the Planning & Development Board and district administrations. Through a combination of digital governance tools, institutional strengthening and large-scale ADP interventions, EP&CCD is progressively embedding environmental considerations into planning, implementation and monitoring processes across the province, thereby strengthening an evidence-based and technology-driven environmental governance system. The following are the key EP&CCD ADP interventions undertaken to strengthen environmental governance, monitoring, enforcement, climate resilience and sustainable development across Punjab.[123]

i. **Enhanced Air & Water Quality Monitoring Networks (ADP 2025–26; World Bank PCAP)**
   Objective: Strengthen real-time environmental monitoring, improve enforcement and support evidence-based policy.
   Key interventions:

- 42 Air Quality Monitoring Stations (37 fixed, 5 mobile) with centralised dashboard (https://aqi.punjab.gov.pk/)
- Launch of AQI mobile app and ECO Chatbot for public engagement
- Installation of 15 Water Quality Monitoring Stations
- Source apportionment study with SUPARCO to identify pollution sources

[123] Environment Protection & Climate Change Department| Government of Punjab.

DRAFT SOE 2025

- Integrated emissions inventory system (GHGs, air pollutants, Short-Lived Climate Pollutants (SLCPs)) for 5 major districts
- Anti-smog enforcement using drones, GIS systems and multi-gas analysers
- Vehicular emission scanning and fog/smog cannon deployment for hotspot control

ii. Establishment of Environmental Monitoring Centre (PERL Upgradation)
Objective: Enhance laboratory-based environmental diagnostics and analytical capacity.

- Operationalization of Punjab Environmental Reference Laboratory (PERL)
- Installation of ICP-OES for advanced chemical analysis
- Upgradation and accreditation of laboratory systems
- Development of integrated data management system for real-time reporting

iii. CM Punjab Green Credit Program (ADP 2025–26)
Objective: Develop market-based environmental incentives and transition towards Emissions Trading System (ETS).

- 116,586 registered users; 4,059 green credits issued (PKR 40.585 million disbursed)
- Online MRV-based Green Credit dashboard (https://greencredit.punjab.gov.pk/)
- Promotion of EVs, plantation and citizen-led climate actions
- Preparation for carbon market integration under Article 6 mechanisms

iv. CM Punjab Climate Leadership Development Internship Program (Phase-II; Rs. 325.8 million)
Objective: Build a climate-literate youth workforce for environmental governance.

- 5 batches of 250 interns each (2025–27)
- Curriculum developed with SDPI
- Training in environmental governance, field work and policy implementation
- Internship monitoring dashboard for performance tracking

v. Plastic Management & Single-Use Plastics
Objective: Promote circular economy and reduce plastic pollution.

- Plastic Management Information System (PMIS) operational
- 40,000 school environmental clubs established
- EPR guidelines, eco-labelling and procurement frameworks under finalization
- Nationwide awareness campaigns and plastic clean-up drives

vi. Establishment of Environment Protection Force in 10 Zones of Punjab

DRAFT SOE 2025

Objective: Strengthen enforcement and on-ground compliance monitoring.

- Deployment in 10 pollution hotspot zones
- AI-based surveillance system with 8,500 CCTV cameras
- Establishment of Quick Response Centres for stubble burning control
- Digital enforcement through smart monitoring platforms

vii. Climate Policy & Technology Centre (CPTC)

Objective: Integrate climate policy, research and technology transfer under one institutional platform.

- Merged policy and technology institutions into a single centre
- Focus on climate policy formulation, research and capacity building
- Support for clean technology adoption and climate governance alignment

viii. Punjab Climate Observatory (PCO)

Objective: Establish a centralised climate intelligence and data hub.

- Approved PC-I for construction in Lahore IT City
- Integration of multi-sectoral climate and environmental data
- Support for adaptive and evidence-based climate governance

ix. Strategic Communication & Awareness Initiatives (IM4Climate & SCC)

Objective: Promote behavioural change and public climate awareness.

- IM4Climate campaign with 1,800+ registrations
- Green coins reward system and citizen engagement programmes
- Over 800 creative awareness outputs developed
- Climate bulletins, social media campaigns and public events

x. Construction & Operationalization of Divisional Environmental Complexes:

Objective: Decentralize environmental governance and improve service delivery.

- 3 complexes operational (Sahiwal, DG Khan, Rawalpindi)
- Remaining under construction and planning
- IT and laboratory infrastructure integration underway

xi. Establishment of Environmental Endowment Fund Management Unit:

Objective: Mobilize green financing for environmental projects.

- Incorporation of Punjab Environment & Climate Change Endowment Fund Company

DRAFT SOE 2025

- Establishment of governance structure and operational framework

xii. Implementation of Environmental and Social Safeguard Requirements and Pollution Impact Studies:

Objective: Update and strengthen environmental regulatory standards.

- Revision and development of Punjab Environmental Quality Standards (PEQS)
- Capacity building of over 350 stakeholders on safeguards and compliance

xiii. Low-Cost Wastewater Treatment Projects

Objective: Provide sustainable wastewater treatment solutions in rural areas.

- Pilot study completed for 3 villages (Chiniot, Pakpattan, Chakwal)
- Construction of 3 treatment plants under implementation

xiv. Revamping of Biodiversity Park, Murree

The project is being executed by the Directorate General (Wildlife), Punjab and sponsored by EP&CCD. Its objective is to restore biodiversity and promote eco-tourism.

- Infrastructure development including trails, bridges and visitor facilities
- Habitat restoration and sustainable tourism promotion

xv. Piloting the Solutions for Environmentally Sound Management of Crop Residues in Punjab

Objective: Reduce stubble burning and promote sustainable agriculture practices.

- Awareness campaigns and 80 village docudrama screenings
- Promotion of environmentally sound residue management techniques

xvi. Development of Missing Environmental Quality Standards and Revision of Existing Standards (PGDP):

Objective: To update, rationalize and strengthen Punjab Environmental Quality Standards (PEQS) for effective environmental regulation, monitoring and compliance.

- Existing PEQS have been comprehensively reviewed and rationalized to improve regulatory relevance and effectiveness.
- Missing environmental quality standards have been developed to address emerging environmental challenges and pollution sources.
- A multi-stakeholder expert panel (government, industry, academia, laboratories and NGOs) was constituted to review and refine the draft standards.
- The finalized draft PEQS is being submitted to the Punjab Environmental Protection Council for formal approval.

DRAFT SOE 2025

15.5 Institutional Environmental Governance Reforms

Punjab has undertaken extensive institutional reforms to strengthen environmental governance architecture. Environment Protection & Climate Change Department (EP&CCD) and its attached Environmental Protection Agency (EPA) have evolved into a multi-sectoral regulatory body under the Punjab Environmental Protection Act 1997.

Key reforms span four areas: digital monitoring and governance systems, environmental enforcement capacity, regulatory and analytical strengthening, and new climate policy institutions. Each is detailed below.

i. Monitoring and Digital Governance Systems

- Establishment of 42 Air Quality Monitoring Stations (37 fixed, 5 mobile)
- Development of AQI Punjab mobile application and digital dashboard (https://aqi.punjab.gov.pk/)
- Installation of 15 Water Quality Monitoring Stations
- Development of Environmental Assessment Management System (EAMS), Emission Testing System (ETS), Eco Watch and Green Punjab App

ii. Environmental Enforcement Capacity

- Establishment of Environment Protection Force across 10 zones
- Deployment of drones, CCTV-based AI surveillance systems (8,500 cameras)
- Formation of Quick Response Centres for stubble burning control

iii. Regulatory and Analytical Strengthening

- Upgradation of Punjab Environmental Reference Laboratory (PERL)
- Establishment of integrated emissions inventory system under IPCC 2006 Guidelines
- ISO certification and accreditation processes for monitoring systems underway

iv. Climate Policy Institutions

- Establishment of Climate Policy and Technology Centre (CPTC)
- Development of Punjab Climate Observatory (PCO) as a centralised climate intelligence hub

These reforms collectively strengthen institutional capacity for enforcement, monitoring and climate governance.

DRAFT SOE 2025

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. The programme has:

- 116,586 registered users (42% women)
- 9,000+ MRV applications processed
- 4,059 green credits issued
- PKR 40.585 million disbursed

The programme is being developed into a structured Emissions Trading System (ETS), with integration into Article 6 carbon markets and voluntary carbon mechanisms. Additionally, 15 public sector projects have been identified for carbon market registration. These initiatives demonstrate strong alignment with the Paris Agreement and SDG frameworks through measurable emissions reduction and climate finance mobilization.

15.6 Sectoral Environmental Investment Analysis

In order to bring the green governance framework to the province environmental considerations are being embedded across key economic sectors including energy, transport, urban development, solid waste management, agriculture and disaster management. Each sector presents distinct environmental challenges and investment patterns which illustrate the breadth of the whole-of-government approach. This details further shows that environmental outcomes are not confined to the mandate of EP&CCD alone, but are increasingly co-owned by line departments through targeted ADP allocations, regulatory compliance and cross-sectoral coordination.

i. Energy Sector

The energy sector remains a major driver of environmental outcomes in Punjab. Historically dependent on fossil fuels, the province has initiated a transition towards renewable and cleaner energy systems. Energy consumption has increased significantly, with 68–70% of electricity demand met through the grid in 2024–25. However, environmental pressures from fossil fuel dependence remain substantial.

Key interventions include:

- Solarization of public infrastructure
- Distributed renewable energy systems
- Energy efficiency programmes

Renewable energy share has increased from 2% (2017–18) to approximately 13% by 2025, reflecting a gradual structural shift in the province's energy mix. The scale and direction of

DRAFT SOE 2025

ongoing and planned investments in the sector are further reflected in ADP allocations for FY 2025–26, as shown in Figures 14.2 and 14.3.

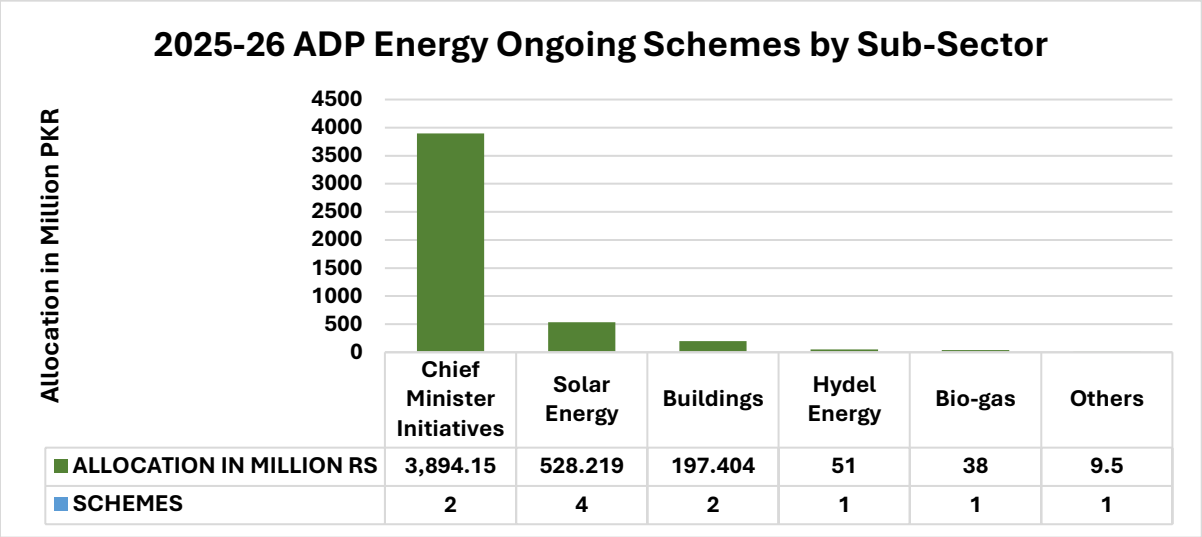

Figure 15.2 ADP Allocation for Ongoing Schemes, FY 2025-26

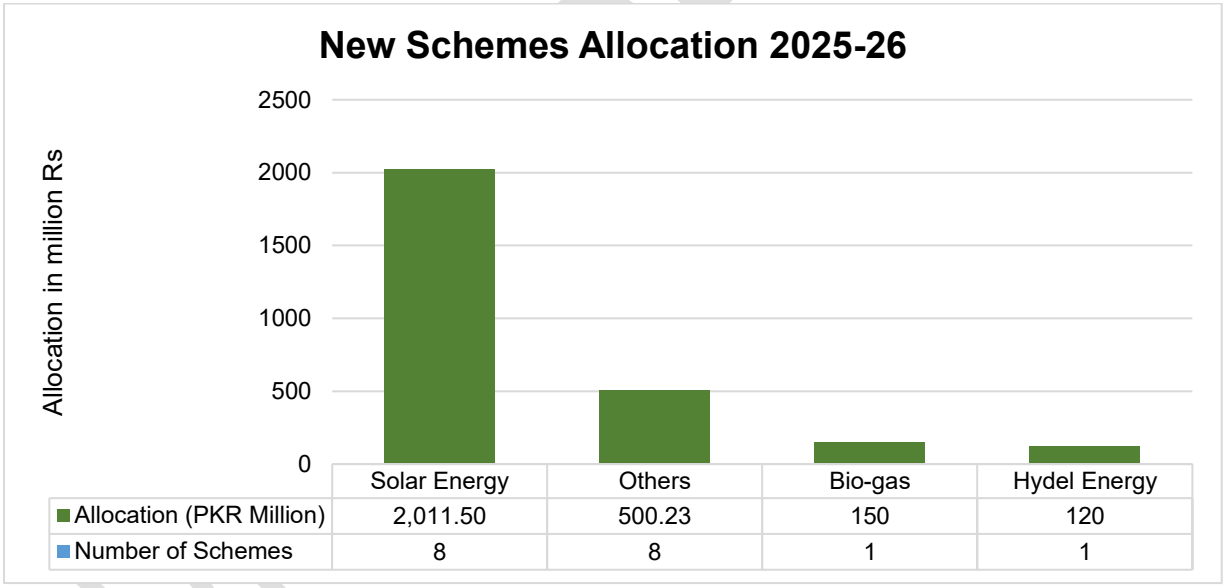

Figure 15.3 Allocation for New Schemes, FY 2025-26

ii. Transport and Mass Transit Sector

The transport sector is a major contributor to urban air pollution, accounting for 40–50% of PM2.5 emissions in major cities (EPA Punjab monitoring data). Rapid vehicle growth (8–10% annually; Punjab Transport Department) has intensified environmental pressures. Table 14.1 shows the summary financial profile of the transport ADP.

The ADP 2025–26 includes:

- 54 transport schemes
- PKR 85,000 million allocation
- 20 ongoing schemes (PKR 4,569.908 million)
- 34 new schemes (PKR 80,430.092 million)
- CMI schemes: PKR 80,014.092 million (94.1%)

Interventions include:

- Eco-friendly bus systems
- Emission inspection and certification systems
- Digital vehicle monitoring frameworks

Table 15.1: 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 On-Going 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**

DRAFT SOE 2025

15.7 Urban Development Sector

Urban development investments totaling PKR 145,000 million across 185 schemes include significant environmental infrastructure. Approximately PKR 97,500 million (67%) is linked to environmental protection, including:

- Wastewater treatment
- Sewerage systems

- Stormwater drainage
- Green urban spaces

a. Wastewater Treatment Infrastructure

Key projects include:

- Babu Sabu Wastewater Treatment Plant, Lahore
- Kattar Bund Wastewater Treatment Plant, Lahore
- Eastern Wastewater Treatment Plant (DANIDA-assisted)
- Faisalabad Water and Wastewater Management Project
- Surface Water Treatment Plant, BRBD Canal

b. Clean Water Supply

- Saaf Pani Program
- AFD-supported Faisalabad Water Project Phase II
- Rawalpindi water supply schemes
- Dadhocha Dam-based feasibility study

These interventions significantly reduce untreated effluent discharge and improve urban environmental health.

15.8 Agriculture Sector

Agriculture remains both a driver and victim of environmental degradation. The ADP 2025–26 includes:

- 37 schemes
- PKR 80,000 million allocation
- 16 ongoing schemes (PKR 32,401.605 million)
- 21 new schemes (PKR 47,598.395 million)

Programmes also include PRIAT and Indus Basin initiatives, focusing on:

- Climate-smart agriculture
- Water efficiency
- Soil health improvement
- Basin-scale resilience planning

DRAFT SOE 2025

Table 15.2: Chief Minister Initiative Schemes in Agriculture Sector

GS	Scheme Name	2025-26 Provision (PKR M)	Environmental Governance Benefit
2544	Solarization 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

These interventions promote climate resilience and resource sustainability.

15.9 Waste Management Sector (Suthra Punjab Program)

Punjab generates approximately 50,000 tons of municipal waste per day, with a per capita generation of 0.3 kg/day. The Suthra Punjab Programme (2024) represents a major institutional reform transitioning from fragmented waste management to a province-wide integrated system covering 41 districts and 141 tehsils.

Key features include:

- Digital governance system
- KPI-based contracts
- PPP-based operations
- Multi-tier audit framework
- Centralised regulatory oversight

The Lakhodair Landfill Gas Project integrates waste management with carbon finance under Article 6 mechanisms.

15.10 Disaster Management Sector

Provincial Disaster Management Authority (PDMA) operates under the provincial disaster management framework to coordinate preparedness, emergency response, mitigation and recovery. The system emphasizes early warning dissemination, real-time monitoring, inter-agency coordination and gender-responsive disaster management.

DRAFT SOE 2025

a. Monsoon Flood 2025

The 2025 monsoon was driven by a northwestward-moving monsoon system supported by westerly troughs and strong moisture inflows from the Bay of Bengal and Arabian Sea. Above-normal rainfall was recorded at 64% of weather observatories across Punjab, with Sialkot Cantt receiving 209 mm and Sialkot Airport recording a 24-hour peak of 101 mm.

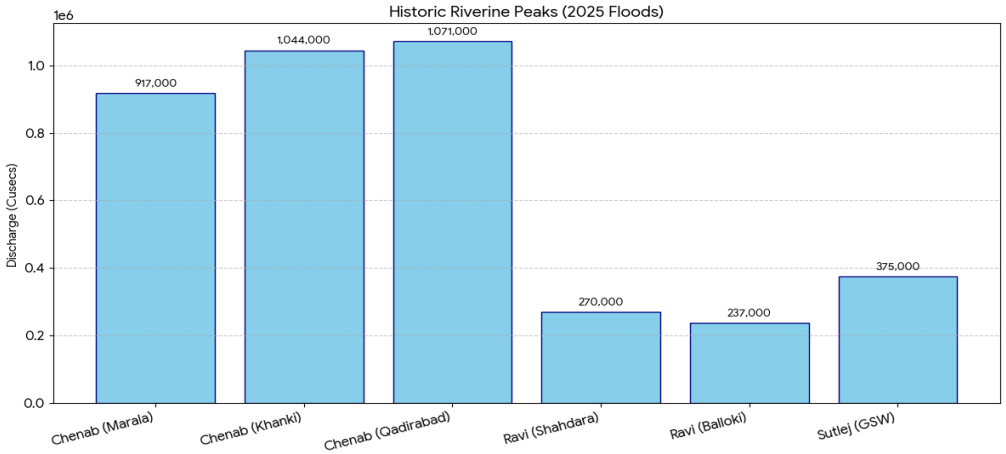

Figure 15.4: Historic Riverine Peaks for Punjab

The floods affected around 4.7 million people and caused 145 deaths. The Chenab River emerged as the most affected system, accounting for 111 fatalities. Agricultural losses were significant, with approximately 2.4 million acres of crops damaged.

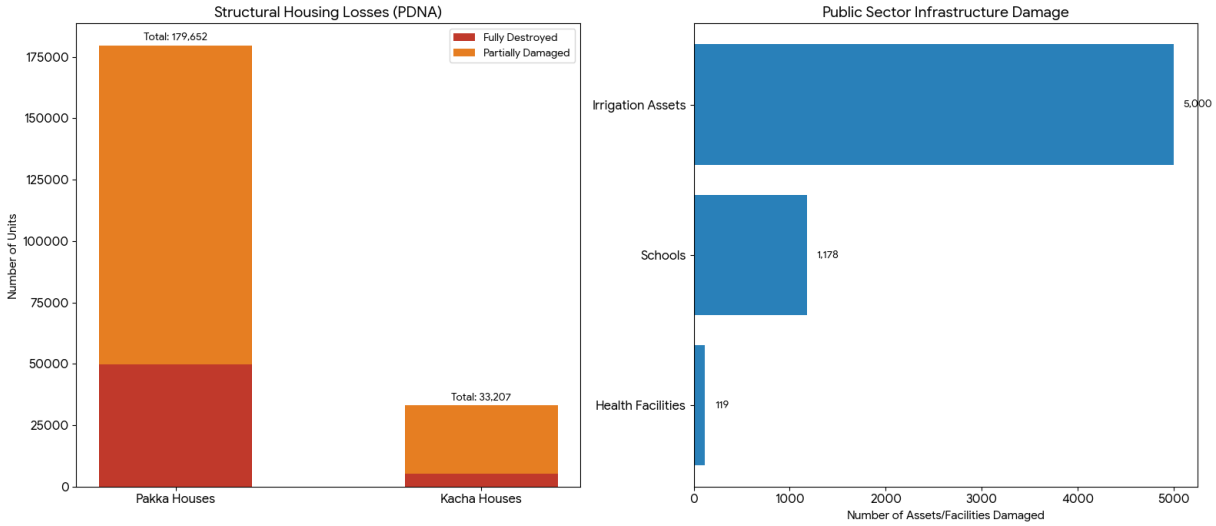

Figure 15.5: Structural and public infrastructure damage summary

To support recovery, the Government launched the Sailab Bahaali Package 2025, providing compensation of up to PKR 1,000,000 per household across 27 districts for more than 4.7 million affected residents.

b. Drought and Heat Conditions 2025

By March 2025, rainfall declined by 40% nationally and 38% in Punjab, while temperatures remained 2–3°C above normal with extended dry spells. In response, district administrations activated emergency operation centres, established heatstroke centres and issued public advisories on heat protection and hydration. Overall, the 2025 events highlight increasing climate variability and underline the need to further strengthen disaster risk management and climate resilience systems in Punjab.

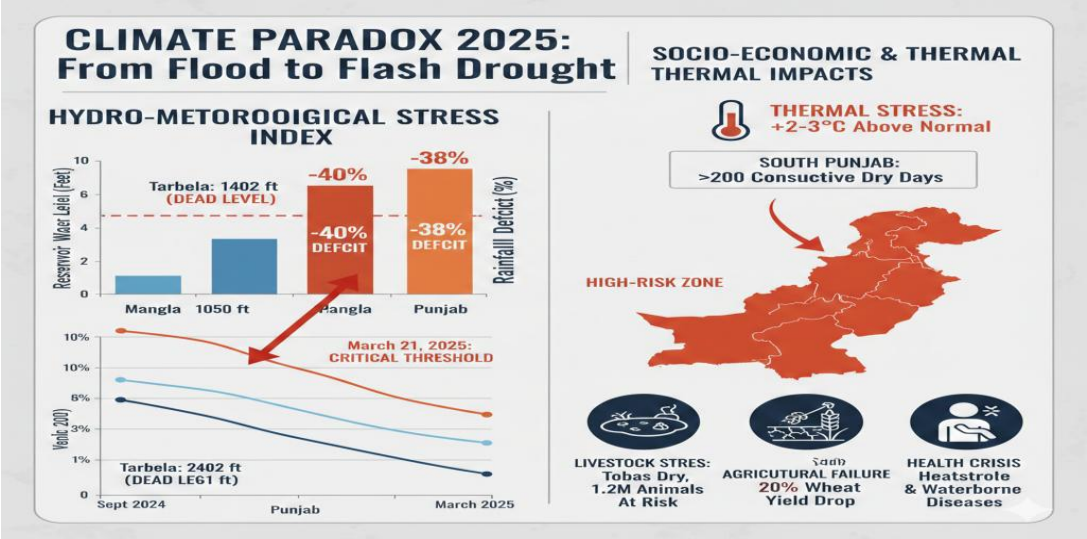

Figure 15.6: Socio-economic & thermal impacts

15.11 Environmental Co-benefits of ADP Investments

Environmental investments under ADP 2025–26 have generated significant co-benefits across multiple sectors. These include:

- Reduction in urban air pollution through transport and energy reforms
- Improved water quality through wastewater treatment infrastructure
- Enhanced public health outcomes through reduced exposure to pollutants
- Climate resilience in agriculture through water and soil management programmes
- Economic stabilization through reduced smog-related productivity losses

Wastewater treatment plants in Lahore and Faisalabad are reducing untreated effluent discharge into the Ravi River system, thereby improving ecosystem health and reducing public health risks.

These co-benefits demonstrate that environmental governance now functions as a development-enabling framework.

15.12 Governance Performance & Monitoring

A major shift in governance has been the development of performance-based environmental monitoring systems. The establishment of real-time dashboards, compliance tracking systems and KPI-based enforcement mechanisms reflects a transition towards evidence-based governance. Under various EP&CCD initiatives, digital platforms have been deployed to enhance transparency and citizen engagement, including AQI dashboards, emissions monitoring systems, Green Credit platforms and public complaint systems such as the 24/7 helpline 1373. The integration of AI-based surveillance, GIS systems and digital enforcement tools is strengthening compliance monitoring and enabling data-driven decision-making across sectors.

Benefits of Green Investment and Development Projects

The structural implementation of Punjab's green development frameworks across different sector has yielded concrete, data-verified improvements that underscore the high return on the province's environmental capital. These targeted interventions have forced an unprecedented 56% drop in daily $PM_{2.5}$ peaks in major urban hubs like Lahore during critical winter months plunging from 539 microgram/m3 down to 237 microgram /m3 This air quality breakthrough is systematically paired with a massive 65% reduction in crop residue burning incidents, a milestone achieved through agricultural mechanization program that deployed thousands of subsidized "Super Seeders" directly to farmers. Beyond mitigating the winter smog crisis, this shift has directly bolstered climate resilience and food security by eliminating open-field burning, preserving vital topsoil organic carbon and nutrients and triggering up to a 15% increase in subsequent wheat crop productivity. Simultaneously, the province has fundamentally institutionalized fiscal accountability and long-term sustainability by introducing a pioneer Climate Budget Tagging System, officially aligning 64% of its entire Annual Development Program (ADP) amounting to an envelope of over Rs. 479 billion toward verifiable climate mitigation and adaptation strategies. Supported by green mobility rollouts like the deployment of 50,000 electric bikes and localized plastic recycling drives like the Waste and Wise initiative across 5,112 schools, these interventions establish a legally and scientifically robust record of economic, energy and environmental restoration across Punjab.

15.13 Challenges & Implementation Constraints

Punjab's environmental governance system continues to face structural constraints, including fragmented institutional capacity, uneven enforcement across districts, limited technical expertise in emerging environmental technologies and financial sustainability challenges in long-term operation and maintenance of infrastructure systems.

Historically, environmental service delivery particularly in waste management and pollution control was limited to urban centres, with weak rural coverage and inconsistent monitoring

DRAFT SOE 2025

systems. Despite recent reforms, ensuring uniform compliance across all sectors remains a key challenge.

15.14 Conclusion

Punjab's environmental governance system is gradually shifting from a limited regulatory approach to a more integrated and modern system. The ADP 2025–26 shows that environmental protection is now being considered across major sectors including disaster management, energy, transport, urban development, agriculture and waste management. The Government has introduced climate-related investments, digital monitoring systems and stronger enforcement mechanisms to improve environmental management and support sustainable development in the province.

Environment Protection & Climate Change Department (EP&CCD) and EPA Punjab are playing a central role in this transition through coordination, monitoring and implementation of environmental initiatives. Programmes such as AQMS, WQMS, PERL, Green Credit initiatives, digital dashboards and the Environment Protection Force have strengthened environmental monitoring and public engagement. However, challenges such as climate change, air pollution, institutional capacity and enforcement gaps still remain. Future initiatives including the Punjab Climate Observatory, Lahore Air Improvement Framework and expanded digital governance systems are expected to further strengthen environmental governance and climate resilience in Punjab.

DRAFT SOE 2025

Chapter No. 16: Behavioural Change through Community Engagement

16.1 Introduction

Principle 10 of the Rio Declaration on Environment and Development, 1992 provides that:

"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."

Following the spirit of Principle 10, environmental governance cannot be restricted to conventional regulatory measures alone. Laws, inspections, notices, penalties and enforcement actions remain essential tools for environmental protection; however, EPA Punjab recognised that these measures cannot produce sustainable results unless the behaviour of citizens, communities and different sectors of society is also addressed. Environmental issues such as smog, waste burning, stubble burning, vehicular emissions, plastic pollution, poor waste disposal and weak civic ownership are not only technical or legal challenges; they are also deeply connected with daily public habits, social practices and behavioural patterns.

While continuing its conventional and regulatory framework, EPA Punjab examined the underlying causes of recurring environmental problems and observed that behavioural change was one of the most critical missing links. In many cases, environmental degradation was not merely the result of absence of law, but of repeated practices, lack of awareness, weak community ownership and limited public participation. Therefore, the Agency realised that enforcement alone could control violations temporarily, but long-term improvement required a wider social shift in the way people understand, respond to and participate in environmental protection.

Accordingly, EPA Punjab adopted a strategy to link behavioural change with community engagement. The objective was to transform environmental protection from a department-led regulatory function into a shared public responsibility. Under this approach, the Agency focused on identifying different behavioural patterns among various groups of society and engaging them through targeted awareness, education, communication and participation. Children, students, youth, academia, farmers, communities, transporters, industries and the general public were treated as important stakeholders in environmental governance.

Through this combined approach, EPA Punjab worked on two parallel tracks: continuing conventional enforcement and regulatory action on one side, and promoting behavioural transformation through community engagement on the other. This strategy helped connect public awareness with practical action, encouraged citizens to adopt environmentally responsible

DRAFT SOE 2025

practices and strengthened the role of communities in supporting environmental protection across Punjab**.**

16.2 Understanding Behavioural Patterns in Environmental Governance

Behavioural pattern refers to the repeated habits, choices and practices through which individuals, communities and sectors interact with the environment. In environmental governance, these patterns are very important because pollution and environmental degradation are not created only by machines, industries or vehicles; they are also created by the way people live, consume, dispose, travel, cultivate, report and respond to environmental issues. Therefore, environmental governance is shaped not only by laws and enforcement, but also by the collective behaviour of society.

A behavioural pattern can either support environmental protection or weaken it. For example, when a citizen avoids open burning, reports pollution, plants and protects trees, reduces plastic use or maintains a vehicle properly, such behaviour contributes positively to environmental governance. On the other hand, when waste is burnt in open spaces, crop residue is set on fire, smoke-emitting vehicles continue to operate, plastic is used irresponsibly, industrial emissions are ignored or communities remain silent against violations, these patterns create negative environmental outcomes. In this way, public behaviour directly influences the success or failure of environmental regulation.

Environmental behavioural patterns may broadly be divided into two categories: positive behavioural patterns and negative behavioural patterns.

16.2.1 Positive Behavioural Patterns

Positive behavioural patterns are those habits and practices that support environmental protection and reduce pressure on natural resources. These include plantation and care of trees, proper waste disposal, reduction in plastic use, avoidance of open burning, regular vehicle maintenance, reporting of environmental violations, adoption of cleaner technologies, participation in awareness activities and community ownership of public spaces. Such behaviour helps convert environmental protection from a government-only responsibility into a shared civic duty.

16.2.2 Negative Behavioural Patterns

Negative behavioural patterns are those repeated practices that contribute to pollution, environmental degradation and weak compliance. These include burning of waste, stubble burning, littering, excessive use of single-use plastic, operation of smoke-emitting vehicles, non-compliance by industrial and commercial units, poor handling of waste, weak civic ownership and lack of public reporting. These practices increase air pollution, worsen smog, damage public health and reduce the effectiveness of regulatory interventions.

EPA Punjab observed that many environmental problems in Punjab were linked with these negative behavioural patterns. Therefore, while continuing its conventional legal and regulatory framework, the Agency realised that enforcement alone would not be sufficient unless the

DRAFT SOP 2025

behaviour of citizens, farmers, students, industries, transporters and communities was also changed. This understanding became the basis for EPA Punjab's community engagement and behavioural transformation approach.

16.3 EPA Punjab's Integrated Behavioural Transformation Model

EPA Punjab's community-based environmental initiatives may be understood as an integrated behavioural transformation framework that linked awareness, participation and environmental responsibility across different social groups. However, behavioural transformation should not be assumed only on the basis of campaign activities. It must be assessed through measurable outcomes, community response and independent evaluation. Therefore, this section presents EPA Punjab's model not as automatic proof of behavioural change, but as a structured approach through which behavioural change could be promoted, monitored and evaluated.

16.3.1 The Green Behaviour Transformation Model

Under this model, EPA Punjab connected children, rural communities and urban citizens through a common environmental objective: to encourage environmental ownership across Punjab. The model was distinctive because it did not rely only on general awareness campaigns. Instead, it divided society into specific target groups according to their role, behaviour and environmental impact.

Children were engaged through school-based activities such as plantation drives, cleanliness campaigns and climate awareness sessions. Rural communities and farmers were approached through focused awareness activities related to crop residue burning, stubble burning control and sustainable agricultural practices. Urban citizens were engaged through media campaigns, digital platforms, AQI advisories, complaint systems and public outreach regarding waste disposal, vehicular emissions, plastic use and civic responsibility.

The practical strength of this model was its recognition that different groups contribute to environmental problems in different ways. A farmer, school student, shopkeeper, vehicle owner, industrial operator and urban household do not have the same environmental responsibilities. Therefore, EPA Punjab's approach required different communication methods for each group while keeping the larger objective of environmental protection consistent.

However, to demonstrate actual behavioural transformation, the model should be supported by measurable indicators. For example, school-level change may be assessed through the number of participating schools, student involvement in plantation activities, cleanliness practices adopted and follow-up monitoring of environmental clubs. In rural areas, behavioural change may be measured through reduction in reported stubble burning incidents, farmer participation in awareness sessions and adoption of alternative residue management practices. In urban areas, progress may be assessed through complaint registration data, public response to AQI advisories, reduction in plastic use, waste reporting, vehicle emission compliance and citizen participation in environmental campaigns.

DRAFT SOE 2025

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 important to verify whether awareness activities resulted in real behavioral change. Such assessment may include third-party surveys, school audits, farmer interviews, field monitoring, and satellite-based observation of crop burning, air quality data comparison and analysis of public complaint trends. These methods would help determine whether EPA Punjab's initiatives produced only short-term awareness or contributed to long-term behavioral improvement.

Therefore, EPA Punjab's Green Behaviours Transformation Model should be viewed as a participatory environmental governance framework with the potential to influence behaviours across schools, rural communities and urban areas. Its effectiveness depends on whether awareness activities can be linked with measurable behavioral outcomes. When supported by reliable data and independent assessment, this model can demonstrate how environmental governance may move beyond regulation towards active public participation and shared responsibility.

16.4 Building Environmental Behaviour from Childhood

Following the Green Behaviour Transformation Model, EPA Punjab introduced school-based interventions aimed at developing environmental awareness among children as a foundation for long-term behavioural change. The approach is based on the assumption that early exposure to environmental practices can influence lifelong attitudes; however, this requires empirical validation rather than being assumed.

The Agency focused on under-matric students to encourage environmental habits at an early stage of development. Within this framework, EPA Punjab launched the "Mera Poda Mera Class

DRAFT SOE 2025

Fellow" initiative to engage students in plantation and basic environmental activities within schools.

While such initiatives demonstrate active participation, they primarily reflect programme activity rather than confirmed behavioural transformation. There is limited evidence provided on whether these interventions lead to sustained environmental literacy, continued pro-environmental behaviour, or influence beyond the school setting.

To strengthen evaluation, impact assessment would require indicators such as pre- and post-intervention knowledge tests, follow-up tracking of student behaviour at home, continued participation in environmental activities, and teacher-reported behavioural changes. Long-term effectiveness would also depend on whether environmental habits persist beyond the duration of the programme.

Therefore, although school-based interventions represent an important step toward environmental awareness, their long-term behavioural impact remains unclear without systematic and longitudinal assessment.

16.4.1 Mera Pouda Mera Class fellow

The "Mera Pouda Mera Class Fellow" initiative launched by Environmental Protection Agency Punjab is a unique and creative environmental awareness campaign designed to develop a lifelong connection between students and nature. Under this initiative, an entire class of 8th Standard collectively plants a sapling and adopts it as their "class fellow." The plant remains associated with that class throughout their educational journey till 10th class, symbolizing friendship, responsibility, care and environmental stewardship. Students regularly look after the plant by watering, protecting and monitoring its growth which creates a sense of ownership and emotional attachment towards environmental conservation from an early age. An important and distinctive feature of this initiative is the continuity and legacy it establishes within educational institutions. As students are promoted to higher classes and eventually pass out after 10th class, the same plant continues to remain within the school premises as a "senior class fellow" for the upcoming classes. Every new batch of students plants its own sapling and similarly adopts it as a class fellow, while the previously planted trees stand as senior companions and living memories of former students. In this way, schools gradually develop a complete green lineage where every plant represents a specific class and batch of students. This continuous cycle not only increases plantation and greenery in educational institutions but also strengthens the emotional bond between students, schools and the environment.

The initiative aims to promote tree plantation, environmental awareness and climate responsibility among students while contributing towards a cleaner and greener Punjab. It also helps students understand the importance of trees in controlling pollution, improving air quality, reducing the impacts of climate change and maintaining ecological balance. Through this campaign, educational institutions become active partners in environmental protection, while students learn

DRAFT SOE 2025

values of teamwork, responsibility, continuity and sustainability. The "Mera Pouda Mera Class Fellow" initiative reflects the vision of Environmental Protection Agency Punjab to engage future generations in practical environmental action and to establish long-term green culture within schools across Punjab.

16.4.2 Green School Certification Program

As part of the Green Schools Stream under the Green Behaviour Transformation Model, EP&CCD Punjab introduced the Punjab Green School Certification Program to institutionalise environmental responsibility within educational institutions. The programme was designed as a structured certification framework encouraging schools to integrate sustainability into daily operations, student engagement, and campus management rather than limiting it to classroom awareness.

Schools are assessed 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 earn certification points based on documented activities such as plantation drives, waste segregation systems, recycling practices, AQI awareness sessions, energy conservation measures, and water-saving initiatives.

The certification process is based on a star-rating system, where schools are awarded levels according to accumulated points across the six domains. However, programme transparency depends on clearly defined verification procedures, including how activities are validated, who conducts inspections, and whether independent monitoring is included. Without clearly documented verification and audit mechanisms, the reliability of reported compliance may be limited.

Monitoring arrangements typically involve periodic school reporting and departmental review; however, details regarding external evaluation or third-party validation remain limited in available documentation. This creates a gap between reported participation and independently verified environmental outcomes.

In terms of outcomes, the programme aims to promote long-term behavioural change by embedding environmental practices within school systems and encouraging student participation in sustainability activities. However, measurable environmental impact indicators such as reductions in waste generation, energy consumption, or improvements in environmental literacy are not consistently reported.

Therefore, while the certification framework provides a structured incentive system for environmental engagement in schools, its effectiveness depends on stronger transparency in verification methods, consistent monitoring mechanisms, and the inclusion of measurable environmental outcome indicators.

DRAFT SOE 2025

16.4.3 Environmental Council

The Environmental Council Initiative launched by Environmental Protection Agency Punjab is an organized platform established in educational institutions to promote environmental awareness, leadership and active participation of students in environmental protection activities. The primary objective of this initiative is to engage students, teachers and school administration in collaborative efforts aimed at creating environmentally responsible educational institutions and communities. Under this initiative, Environmental Councils are formed in schools and colleges comprising students, teachers and focal persons who work together to plan, organize and monitor various environmental activities throughout the academic year.

The Environmental Councils serve as student-led bodies responsible for spreading awareness regarding major environmental issues such as air pollution, climate change, water conservation, waste management, plastic pollution and plantation. These councils encourage students to become environmental ambassadors within their institutions by conducting awareness campaigns, seminars, speech competitions, cleanliness drives, plantation activities and eco-friendly projects.

An important feature of the initiative is the development of environmental leadership and responsibility among students. Members of the Environmental Council are assigned specific duties related to monitoring cleanliness, promoting waste segregation, ensuring proper plantation care, reducing plastic use and encouraging environmentally friendly behaviour among fellow students. Through regular meetings and environmental activities, students gain practical knowledge and develop a sense of ownership towards environmental conservation. The initiative also strengthens coordination between educational institutions and Environmental Protection Agency Punjab in implementing sustainable environmental practices at the grassroots level.

The Environmental Council Initiative further aimed to create long-term behavioural change by integrating environmental responsibility into the educational culture of institutions across Punjab. By directly involving students in environmental governance, awareness campaigns and practical environmental activities, the initiative contributed towards building a cleaner, greener and healthier society. It reflected the commitment of EPA Punjab to equip future generations with environmental knowledge, practical skills and leadership qualities required to address emerging environmental and climate challenges.

Building upon school-level interventions and student engagement, EPA Punjab subsequently expanded its focus towards youth engagement at a broader societal level. Recognizing the growing influence of digital platforms, social media and youth-led communication, department initiated a new phase of environmental awareness targeting young citizens, influencers, digital creators and online communities through its programme Im4Cliamte.

DRAFT SOE 2025

16.4.4 Im4Climate Campaign

Im4Climate Campaign was launched under the Punjab Clean Air Program (PCAP) by the Environment Protection & Climate Change Department (EP&CCD), Government of Punjab. The campaign was designed as a citizen-centric behavioural change initiative aimed at utilising the outreach power of social media to promote environmental awareness, clean air advocacy and climate-sensitive behaviour among the public, particularly the youth. Through influencers, online campaigns, public participation and digital engagement activities, Im4Climate attempted to transform environmental protection into a social movement driven by awareness, participation and collective responsibility.

Im4Climate is a citizen-centric behavioural change initiative launched under the Punjab Clean Air Program (PCAP) by the Environment Protection & Climate Change Department (EP&CCD), Government of Punjab. It was designed with a clear mission: to harness the reach and influence of social media to mobilize citizens particularly youth towards meaningful action on clean air and broader environmental challenges.

The campaign targets a wide audience including individual social media users, emerging content creators and registered digital media entities. Participants are encouraged to create and share content across major platforms including Instagram, Facebook, TikTok, YouTube, Snapchat, X (formerly Twitter) and LinkedIn. The content is expected to be creative, solution-oriented and grounded in real environmental issues with a particular focus on reducing air pollution and promoting sustainable lifestyles across Punjab.

What sets Im4Climate apart from conventional awareness drives is its structured support for creators. The campaign runs dedicated boot camps, storytelling workshops and university-based outreach activities designed to equip participants with the skills needed to produce high quality responsible environmental narratives. These sessions help creators understand how to communicate climate issues effectively turning complex environmental data into relatable viral stories that resonate with everyday audiences.

DRAFT - 2025

The campaign operates under a clear set of content guidelines established by EP&CCD. While creativity is strongly encouraged participants are strictly required to avoid hate speech, political messaging and misinformation of any kind. The focus is kept firmly on positive behavioural change inspiring communities to adopt eco-friendly habits rather than fueling division or spreading panic.

Beyond individual content creation Im4Climate aims to build a broader community of climate-conscious digital advocates. By encouraging informed dialogue on air quality challenges and promoting collective action through evidence-based storytelling the campaign seeks to create a ripple effect where one person's post inspires another to change a habit and that habit change multiplies across neighborhoods, cities and eventually across Punjab as a whole.

Ultimately the initiative represents a shift in how environmental policy is communicated. Rather than relying solely on traditional public awareness methods EP&CCD is betting on the creativity and connectivity of Punjab's youth to drive the kind of cultural change that government notices alone cannot achieve. Im4Climate is not just a campaign. It is an effort to build a lasting culture of sustainability, shared responsibility and civic pride around the issue of clean air.

However, despite these awareness campaigns and youth-centeredinitiatives, EPA Punjab observed that certain environmental issues particularly stubble burning and unsustainable agricultural practices continued to persist in rural areas due to repeated behavioural patterns, limited outreach mechanisms and lack of direct access to environmental awareness resources. The Department realised that conventional communication methods and digital campaigns alone could not effectively reach many farming communities and remote rural populations.

Keeping this challenge in view, EP&CCD adopted a more direct community outreach approach and initiated the **Docudrama Initiative** to take environmental awareness physically into villages, farming communities and local public spaces. Instead of expecting citizens to access awareness platforms themselves, the Department moved directly towards communities through dramatized field presentations, mobile awareness activities and visual storytelling campaigns conducted at the grassroots level.

16.4.5 Docudrama

The Docudrama Initiative is an innovative environmental awareness campaign designed to educate the public through visual storytelling, dramatized presentations and community engagement activities. The initiative aims to raise awareness regarding critical environmental challenges such as smog, air pollution, stubble burning, climate change, improper waste disposal, deforestation and public health impacts associated with environmental degradation. By combining documentary-style information with dramatic performances and real-life scenarios, the initiative effectively communicates environmental issues in a manner that is both informative and emotionally impactful for students, farmers and the general public.

DRAFT SOE 2025

A major component and centrepiece of this outreach campaign was a purpose-built docudrama focusing on the environmental and health consequences of stubble burning. The docudrama highlighted how crop residue burning contributes significantly to smog formation, deteriorates air quality, damages soil fertility and causes severe respiratory and cardiovascular diseases among the public. The production visually demonstrated the harmful effects of smoke emissions, particularly pollutants such as PM2.5 and PM10, which pose serious risks to human health and the environment. To maximise outreach and awareness, the docudrama was screened in more than 100 high-cultivation villages across Punjab where crop burning incidents are more prevalent. These screenings were conducted as part of community awareness sessions aimed at encouraging environmentally responsible agricultural practices.

The initiative further incorporated interactive dialogue sessions following each screening, where agricultural experts, environmental specialists and local stakeholders engaged directly with farmers and community members. These discussions provided farmers with an opportunity to share their experiences, discuss field-level challenges and understand practical alternatives to crop residue burning including sustainable residue management techniques and environmentally friendly farming methods. Through these engagements, farmers were encouraged to adopt non-burning practices that support cleaner air, improved soil health and long-term agricultural

Figure 16.1: (a) Community members attending docudrama screening session

DRAFT 2025

Prior to the launch of the Docudrama Initiative, EPA Punjab had already initiated environmental awareness efforts through cultural and theatrical engagement under the production titled "Dharti Maa." The initiative was organised as an environmental theater performance aimed at creating emotional connection between the public and environmental protection through dramatized storytelling. The show portrayed nature as a nurturing mother figure suffering due to pollution, deforestation, smog, waste and irresponsible human activities, while also highlighting the responsibility of citizens towards environmental preservation.

The success of "Dharti Maa" demonstrated that environmental communication through cultural expression and live performances could create stronger public engagement and emotional impact compared to conventional awareness methods alone. Building upon this experience, EPA Punjab later expanded the concept into broader field-level outreach through the Docudrama Initiative, where environmental awareness activities were taken directly into communities, rural areas and public spaces to address repeated harmful behavioural patterns at the grassroots level.

16.4.6 Public Awareness Play "Dharti Maa" at Alhamra Art Council

The Punjab Environment Protection Department (EPA) has involved theatres in its environmental awareness campaigns by staging *Dharti Maa* at the Alhamra Arts Council. The Punjab Environment Protection Department (EPA) has taken a refreshingly creative leap by moving away from traditional, dry seminars and into the spotlight of the **Alhamra Arts Council**. By commissioning the theatrical play *Dharti Maa* (Mother Earth), the department has recognised that while data and statistics inform the mind, it is art and storytelling that actually move the heart. Using a 100-minute performance to highlight the devastating effects of smog and environmental degradation allows the audience to witness the "personality" of the planet, making the abstract concept of climate change feel deeply personal and urgent.

Traditional awareness sessions often suffer from "information overload," where complex scientific jargon can alienate the general public. By choosing a theatrical format, the EPA utilises sensory learning. The combination of specially composed music, folk traditions and live performances creates an immersive environment where the audience isn't just told about the environment, they feel its distress. This "edutainment" approach bridges the gap between official policy and public emotion, ensuring that

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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.

DRAFT SOP 2025

the message of conservation lingers long after the curtain falls.

The casting of renowned actors like Samia Mumtaz to personify "Mother Earth" is a masterstroke in psychological communication. In the play, the environment is no longer a distant ecosystem or a set of legal regulations; it is a maternal living, breathing entity that the audience can relate to through the universal lens of love and protection. This personification makes the "unknowing harm" we cause our planet feel like a familial betrayal, triggering a stronger sense of individual responsibility than a pamphlet or a lecture ever could.

By dedicating specific days for students, office workers and families, the EPA is effectively tailoring a social experience that encourages collective dialogue. A play at Alhamra acts as a cultural town square, where different segments of society witness the same struggle simultaneously. The planned provincial tour further amplifies this impact, ensuring that the message isn't confined to the urban elite of Lahore but reaches the divisional levels across Punjab. This strategic use of the stage transforms environmentalism from a niche administrative concern into a vibrant, shared cultural movement

INTERNATIONAL THE NEWS

Lahore

'Dharti Maa' play from 10th to highlight climate issues

By Our Correspondent January 06, 2025

An image from the theater play "Dharti Maa".— Facebook@punjabepa/File

LAHORE : A theatrical play titled 'Dharti Maa' will be enacted at Alhamra Arts Council.

Punjab environment dept presents *Dharti Maa* at Alhamra

By Our Staff Reporter

LAHORE: The Punjab Environment Department and Climate Change Department is presenting a play titled Dharti Maa (Mother Earth). The play will run from Jan 10 to Jan 16 at Alhamra Hall, Lahore.

A press briefing regarding the play was held on Sunday at the Adbi Baithak of Alhamra Arts Council by the entire team of *Dharti Maa*.

Renowned actors Samia Mumtaz and Wahab Shah will play the lead roles. Ms Mumtaz will portray the role of a mother in the play. Mr Shah highlighted that the title *Dharti Maa* reflects the importance of love and connection with Mother Earth.

The play emphasizes that this small world is made better and cleaner through the collective effort of many things. It aims to raise awareness about how unknowingly we harm our planet and inspires ways to protect it.

Especially composed music has been created for this play to enhance the story and its emotional impact. The play is 1 hour and 40 minutes long. A total of 130 artists will showcase their talents in the production.

It is a blend of reality, spirituality, literature, art, and folk traditions, creating a culturally rich experience. Folk art and music play a central role, as highlighted by Ms Mumtaz.

The play is supported by the Punjab government and aims to highlight the severe effects of smog on Punjab. Following its debut in Lahore, the play will embark on a provincial tour, reaching audiences across Punjab at the divisional level.

The audience is invited to attend, not only to understand environmental issues but also to take away valuable ideas for improving the environment.

School students, office workers, women, and people from all walks of life will enjoy this play. Dedicated days have been allocated for students, stakeholders, departments, media representatives, and families, as shared by senior producer-director Shakeel.

The play aims to entertain while delivering a meaningful message, ensuring that everyone leaves with a sense of responsibility toward preserving the earth.

A SCENE from the play *Dharti Maa*.

Keeping this changing behavioural landscape in view, EPA Punjab expanded its outreach strategy towards digital environmental engagement. The objective was not only to spread awareness but

also to create continuous public interaction, citizen participation and real-time environmental communication through social media, digital campaigns, influencers and online engagement platforms.

16.5 Digital Media Engagement

In the contemporary digital era, social media and real-time communication platforms have become important tools for environmental awareness and public engagement. Recognising this shift, EPA Punjab integrated digital media into its environmental governance strategy by using social media platforms, digital dashboards, mobile applications and real-time information systems to disseminate AQI updates, anti-smog advisories, enforcement actions and environmental awareness content.

This approach transformed environmental communication from traditional one-way messaging into a more interactive system where citizens could access information and, in some cases, report environmental concerns. While these activities demonstrate strong digital presence and outreach capacity, they do not in themselves confirm behavioural change or communication effectiveness.

To assess effectiveness, digital engagement should be evaluated using objective indicators such as audience reach, engagement rates (likes, shares, comments), frequency of citizen interaction with AQI dashboards, response time to public complaints, and the extent of user participation in reporting systems. Without such metrics, it is difficult to determine whether digital communication translated into increased environmental awareness or sustained behavioural change.

Furthermore, behavioural impact could be assessed through changes in public compliance behaviour, such as reduced waste burning reports, increased use of air quality alerts for decision-making, or improved participation in environmental campaigns. Currently, such outcome-based evidence is not consistently presented alongside digital outreach activities.

Therefore, while EPA Punjab's digital media strategy enhances visibility and accessibility of environmental information, its overall effectiveness should be measured through structured engagement analytics and behavioural outcome indicators rather than communication activity alone.

16.5.1 Social Media Platforms & Digital Outreach

The EPA Punjab's social media presence, spearheaded by the Strategic Communication Cell (SCC), evolved into a high-impact digital platform for environmental governance, public awareness and citizen engagement during 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 during peak pollution periods. Simultaneously, social media was extensively used to disseminate real-time AQI updates/Forecasts, environmental alerts and awareness messages regarding pollution prevention and environmentally responsible practices. To strengthen transparency and institutional visibility,

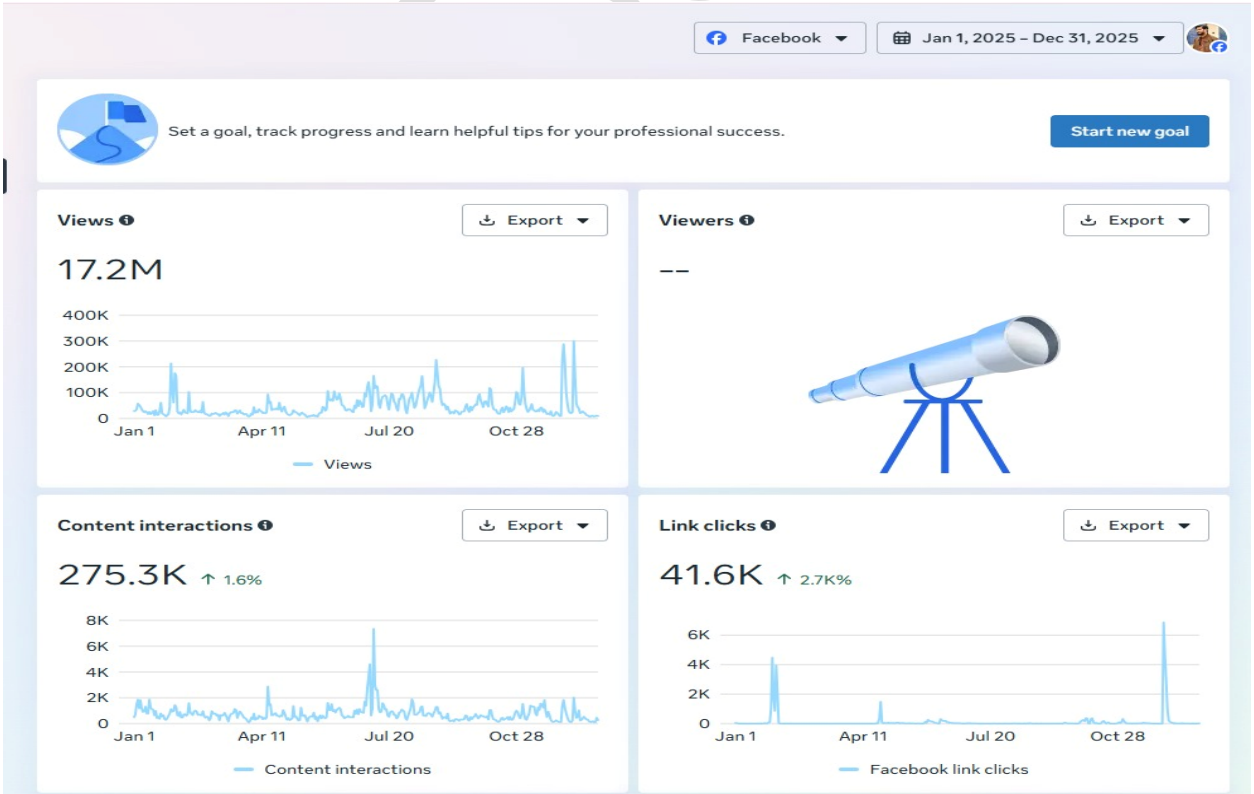
DRAFT SOE 2025

EPA Punjab also showcased enforcement actions such as demolishing, sealing, confiscation, vehicle emission drives and field surveillance operations, while regularly highlighting progress on initiatives including Punjab Climate Watch, the CM Punjab Green Credit Program and adoption of Zig-Zag technology. The integration of citizen-engagement tools such as the Green Punjab App further transformed these platforms into interactive public participation mechanisms, enabling crowdsourced reporting and direct public interaction. Through this structured digital communication strategy, EPA Punjab successfully positioned itself as a proactive, transparent and digitally connected environmental institution.

16.5.1.1 Engagements through Facebook

EPA Punjab's Facebook platform emerged as one of the Agency's most impactful digital communication channels during 2025, significantly strengthening public outreach, environmental awareness and citizen engagement across Punjab. The platform recorded approximately 17.2 – million total views during the year, reflecting the extensive reach and visibility of EPA Punjab's environmental campaigns, enforcement activities and public advisories. Public engagement remained consistently strong throughout the year, with major spikes observed during October and November corresponding with peak smog season, anti-smog enforcement operations and intensified public concern regarding air quality and public health.

The platform generated approximately 275.3K content interactions, demonstrating active public participation through likes, comments, shares and discussions on environmental issues. Simultaneously, page follows increased to approximately 34.6K, reflecting a substantial growth of



nearly 58%, which indicates increasing public reliance on EPA Punjab's digital platforms as a trusted source of environmental information and updates. In addition, the page recorded nearly 624.2K visits, highlighting strong direct audience engagement and sustained public interest in environmental governance and regulatory developments.

16.5.1.2. 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 recorded approximately 2.6 million total views during the year, while overall reach exceeded 1.1 million, reflecting a significant expansion in audience visibility and public interaction. Engagement levels remained particularly high during the latter half of the year, especially throughout the smog season, when environmental issues gained increased public attention across Punjab.

The platform generated approximately 68.2K content interactions through likes, comments and shares, indicating strong audience responsiveness towards EPA Punjab's environmental messaging and awareness campaigns. Additionally, link clicks increased significantly, demonstrating growing public interest in accessing detailed environmental information, advisories and official updates beyond social media posts. Through visually driven communication, short awareness videos, enforcement highlights, environmental campaigns and real-time public advisories, Instagram enabled EPA Punjab to effectively connect with younger and digitally active audiences.

DRAFT SOE 2025

Beyond audience growth, the platform played an important role in strengthening environmental communication by making complex environmental issues more accessible, engaging and publicly understandable.

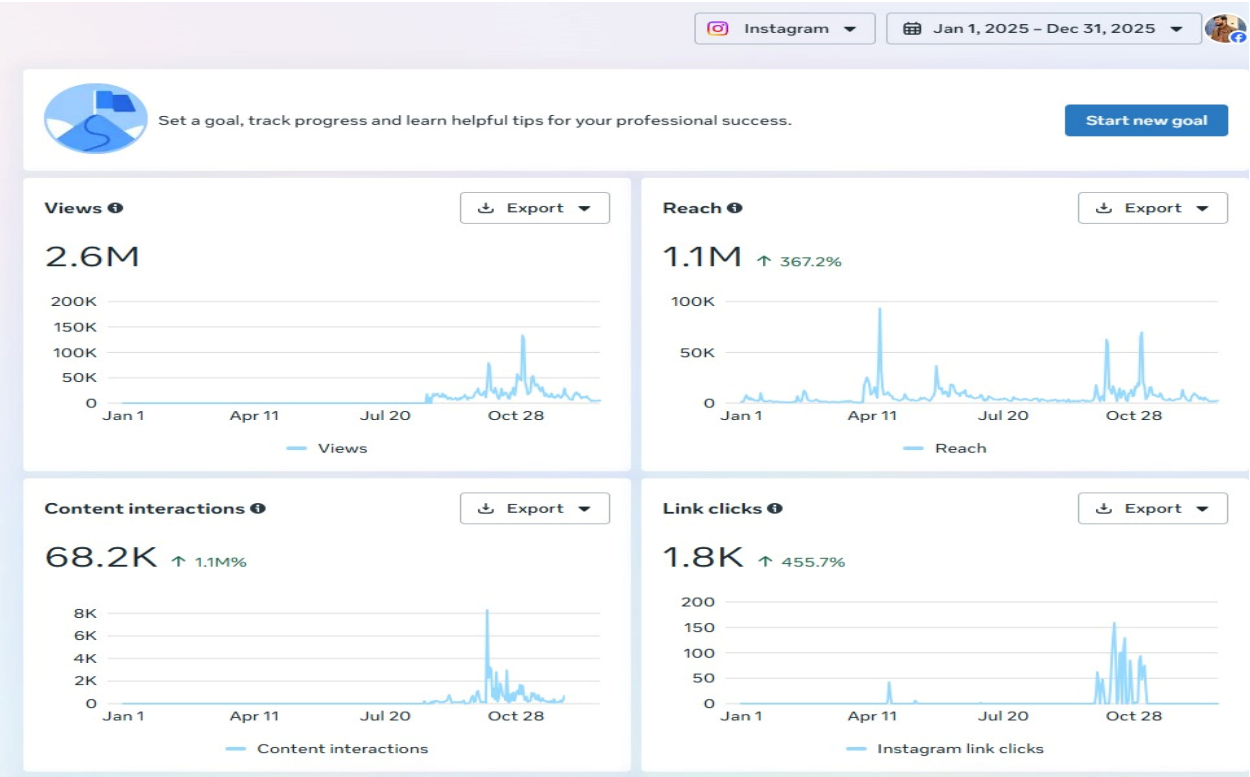


Figure 16.3: Insights for Instagram Platform for year 2025

16.5.1.3 Engagement through YouTube

EPA Punjab also strengthened its digital outreach through its official YouTube platform, "Climate Corner," which served as an important medium for environmental communication, public awareness and institutional visibility during 2025. Unlike short-format social media engagement, the platform enabled the Agency to deliver detailed visual content regarding environmental challenges, government interventions and public awareness initiatives in a more informative and accessible manner. The channel featured a wide range of content including AQI forecasts, anti-smog campaigns, environmental awareness videos, Air Quality Monitoring Stations (AQMS), Green Credit Program activities, departmental trainings, enforcement operations and public messages from senior officials regarding environmental protection and climate-related risks.

The platform played a significant role in simplifying complex environmental issues through visual storytelling and explanatory content, enabling citizens to better understand air pollution trends, smog risks, environmental technologies and government response mechanisms. Through continuous uploads of awareness material, operational activities and real-time environmental updates, Climate Corner strengthened public access to verified environmental information while

enhancing institutional transparency and public confidence in EPA Punjab's environmental governance initiatives.

16.5.2 AI-enabled Citizen Engagement

16.5.2.1 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 enables citizens to interact with the department in a simple and conversational language, making it easier for them to access environmental information. To access EcoBot, users can simply scan a QR code available on the department's website and social media pages and start chatting with the bot.

EcoBot is integrated with live environmental monitoring feeds from the department's air quality monitoring stations, ensuring accurate and up-to-date information. The bot provides hour-by-hour pollution levels, educational tips and guidance on how to protect oneself from smog and air pollution. The chatbot is designed to support both English and Urdu inputs, making it accessible to a wide demographic. The department plans to expand EcoBot's capabilities in the future including features such as noise pollution data, waste management information and reporting mechanisms for environmental violations.

initiative is expected to enhance public engagement and contribute to a cleaner and healthier environment in Punjab.

Figure 16.4: EPA Introduces First WhatsApp AI ECO Bot

Figure 16.4: EPA Introduces First WhatsApp AI ECO Bot

Beyond providing real-time environmental information and citizen facilitation through tools such as the ECO Bot, EPA Punjab gradually expanded its digital communication strategy towards broader public participation and behavioural transformation. Recognizing that environmental protection requires active societal involvement

rather than passive information consumption alone, the Agency increasingly focused on engaging youth, digital communities and ordinary citizens through participatory digital campaigns and citizen-driven environmental advocacy initiatives.

Figure 16.5: Environmental Protection Force

16.6 Technology-Driven Environmental Communication & Enforcement Visibility

While initiatives such as "Im4Climate" focused on transforming citizens into active participants of environmental awareness and behavioural change, EPA Punjab simultaneously strengthened the digital visibility of its on-ground enforcement and environmental interventions. Recognizing that public trust and behavioural transformation depend not only on awareness campaigns but also on visible institutional action, the Agency increasingly utilised technology-driven communication and digital storytelling to bring environmental governance directly into the public domain. 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.

16.6.1 Environmental Protection Force & Enforcement Visibility

The Environmental Protection Force (EPF) emerged as a visible and proactive enforcement mechanism aimed at strengthening field operations and improving regulatory compliance across Punjab.

Enforcement activities including inspections, anti-smog operations, industrial monitoring and field crackdowns were actively disseminated through digital platforms and media coverage to enhance public visibility and institutional transparency. By bringing enforcement actions into the public domain, EPA Punjab strengthened deterrence against environmental, violations while simultaneously promoting public awareness regarding environmental laws**,** compliance requirements and government interventions.

16.6.2 Drone Surveillance & Smart Environmental Monitoring

EPA Punjab further modernized environmental monitoring through the introduction of drone surveillance and technology-enabled field monitoring systems during 2025. The use of aerial

DRAFT

surveillance significantly enhanced the Agency's operational capacity by enabling monitoring of industrial zones, illegal dumping sites, smoke emissions and hard-to-access areas with improved efficiency and accuracy. In addition to strengthening enforcement capability, drone-based monitoring enhanced digital visibility of environmental governance by providing real-time visual documentation of field operations and environmental violations.

This technology-driven approach improved institutional responsiveness, strengthened evidence-based enforcement and projected EPA Punjab as a modern and technologically adaptive environmental regulator.

Figure 16.6: EPA Drone Surveillance & Vigilant Aerial Enforcement

16.6.3 Liquid Tree & Innovative Environmental Communication

The "Liquid Tree" initiative reflected EPA Punjab's emphasis on innovative and technology-oriented environmental solutions aimed at improving urban environmental sustainability and public awareness.

Through structured digital campaigns and visual public communication, the initiative introduced alternative environmental technologies to the public in an accessible and understandable manner.

Beyond its environmental significance, the project strengthened public discourse regarding innovation-driven sustainability solutions and reinforced EPA Punjab's image as a forward-looking institution actively promoting modern approaches towards environmental protection and climate resilience.

DRAFT 2025

16.6.4 AQI Forecasting & Public Environmental Advisory System

The AQI Forecasting initiative represented a major shift in EPA Punjab's environmental communication strategy by transforming complex air quality data into a real-time public advisory and decision-support system for citizens. Rather than limiting environmental monitoring to technical reporting, EPA Punjab utilised digital platforms and social media to disseminate simplified, colour-coded and publicly understandable AQI forecasts, enabling citizens to make informed decisions regarding outdoor exposure, health precautions and daily activities during periods of elevated pollution. Through continuous dissemination of real-time forecasts, smog alerts and public health advisories,

Figure 16.7: Liquid Tree

environmental information became integrated into daily public discourse similar to weather reporting and traffic updates. This consistent visibility not only strengthened public awareness regarding air pollution risks but also promoted precautionary behaviour, increased responsiveness to environmental advisories and established air quality forecasting as an essential public information service across Punjab.

The AQI Forecast Campaign of 2025 transformed environmental data from an abstract scientific metric into a daily utility for the citizens of Punjab. By distilling complex parameters like $PM_{2.5}$ concentrations into colour-coded, user friendly bulletins and digital dashboards, EPA Punjab effectively democratized air quality information. This shift moved the needle from mere observation to actionable intelligence, allowing families and schools to make informed decisions about outdoor activities and health precautions in real-time.

The campaign's success was rooted in its multi-channel dissemination strategy. By leveraging social media and real time digital displays, the EPA ensured that "smog levels" were as accessible as the daily weather report. This consistent stream of data fostered a gradual but significant behavioural shift across the province, reducing peak hour exposure and increasing the use of protective measures. For the media, this provided a reliable, daily anchor for environmental reporting, moving the conversation away from seasonal panic towards a year-round, data driven dialogue on public health and individual responsibility.

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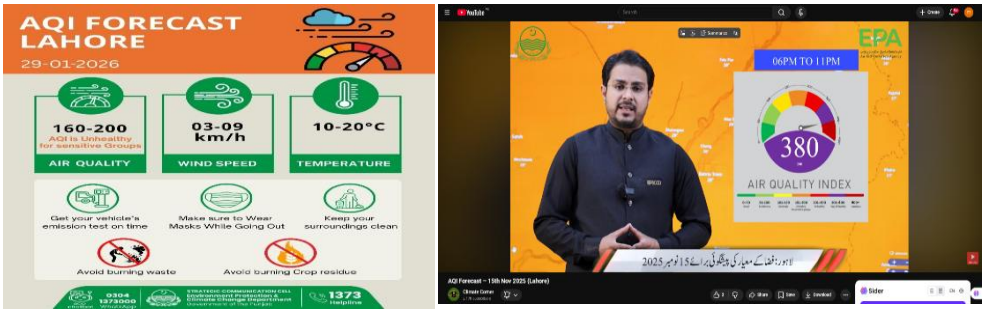

Figure 13.8: AQI Forecast through social media

While digital media significantly expanded EPA Punjab's real-time outreach and citizen engagement capabilities, the Agency simultaneously utilised conventional electronic media platforms to amplify environmental messaging to wider and more diverse audiences across Punjab. Recognizing the continued influence of television broadcasting and mainstream news networks in shaping public discourse and public opinion, EPA Punjab strategically integrated electronic media engagement into its broader communication framework to strengthen environmental awareness, institutional visibility and public confidence in government-led environmental interventions.

16.7 Electronic Media Engagement

Recognizing the extensive reach and influence of electronic media across diverse segments of society, EPA Punjab strategically utilised television networks, broadcast media and mainstream news platforms as a core component of its environmental communication framework during 2025. Considering the broad audience base and strong public influence of electronic media particularly among households, urban populations, transport sectors, commercial stakeholders and rural communities the Agency adopted a targeted communication approach to ensure that environmental messaging remained accessible, visible and socially impactful. In this regard, electronic media engagement was broadly utilised across five major areas including leadership-led 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 purely administrative function into a publicly visible and continuously communicated societal issue, thereby strengthening public awareness, institutional transparency and citizen participation across Punjab.

16.7.1 Strategic Media Communication & Leadership Outreach

EPA Punjab adopted a leadership-driven communication strategy in which senior departmental leadership directly engaged with the public through television interviews, morning shows, live discussions and current affairs programmes on mainstream media channels. In this regard, the Secretary EP&CCD and Director General EPA Punjab regularly appeared on electronic media platforms to explain environmental challenges, communicate anti-smog measures, disseminate public health advisories and highlight ongoing environmental initiatives across Punjab. This direct engagement enabled the Agency to shape environmental discourse at the national level while ensuring that environmental governance remained publicly visible and institutionally accountable from the highest levels of leadership. By utilising mainstream television platforms, EPA Punjab

DRAFT SOE 2025

successfully projected environmental protection as a shared public responsibility rather than merely a regulatory obligation of the government.

16.7.2 Public Awareness Campaigns & Environmental Narrative Building

Electronic media was extensively utilised to strengthen public awareness regarding 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 concerns remained part of mainstream public discourse throughout the year. Particular emphasis was placed on anti-smog awareness, AQI communication and precautionary public health messaging during peak pollution periods. This sustained media engagement significantly improved environmental literacy among citizens while encouraging precautionary behaviour, public responsiveness and broader societal participation in environmental protection efforts.

16.7.3 Media Visibility of Environmental Enforcement & Field Operations

EPA Punjab also strategically utilised electronic media to amplify the visibility of environmental enforcement operations and field interventions conducted across Punjab. Major enforcement activities including Anti-Smog Gun operations, vehicle emission testing drives, anti-stubble burning operations, fuel quality inspections and enforcement against smoke-emitting vehicles received extensive electronic and digital media coverage. By bringing field operations directly into the public domain, the Agency transformed environmental enforcement into a publicly observable governance process, thereby strengthening institutional transparency, improving public confidence and reinforcing deterrence against environmental violations. Continuous visual coverage of enforcement activities also helped citizens better understand the scale, seriousness and operational intensity of government interventions against pollution and smog.

16.7.4 Technology-Driven Environmental Monitoring & Smart Enforcement

EPA Punjab further strengthened its electronic media strategy by highlighting technology-driven environmental governance and smart monitoring initiatives undertaken during 2025. The use of drone surveillance systems, smart monitoring mechanisms and collaboration with the Punjab Safe Cities Authority (PSCA) introduced a modern and technology-oriented dimension to environmental regulation and enforcement. Similarly, environmental infrastructure projects such as Smog Towers received significant electronic media visibility, projecting EPA Punjab as a forward-looking and technologically adaptive environmental institution. Through strategic media dissemination of these initiatives, the Agency strengthened public confidence in modern environmental governance tools while improving awareness regarding technology-based pollution monitoring and environmental management systems.

DRAFT OF 2025

16.7.5 Sectoral Environmental Compliance & Regulatory Reporting

Electronic media platforms were additionally utilised to strengthen visibility of sector-specific environmental compliance initiatives and regulatory enforcement actions across industrial and commercial sectors. Enforcement against illegal pyrolysis plants, mandatory suction hood compliance for restaurants and other sectoral interventions were actively highlighted through media reporting and televised coverage. This public visibility enhanced regulatory accountability while simultaneously informing businesses, industries and commercial operators regarding environmental compliance obligations and pollution control requirements. Through structured media engagement, EPA Punjab successfully expanded environmental accountability into sectors traditionally considered outside mainstream public environmental discourse, thereby promoting broader acceptance of environmental regulation and sustainable operational practices across Punjab.

Figure 16.8: Anti-Stubble Burning Quick Response Unit

Figure 16.9: EPA Anti-Smog Tower Installation in Lahore

Figure 16.10: EPA Anti-Smog Gun Initiative

Figure 16.11: EPA Vehicle Emission Testing Drive

Figure 16.12: EPA Action Against Non-compliant Vehicles

Figure 16.13: EPA Zero Tolerance Stance Against Pyrolysis Plants

Figure 16.14: EPA Action Against Non-compliant Vehicles in Collaboration with Punjab Safe City

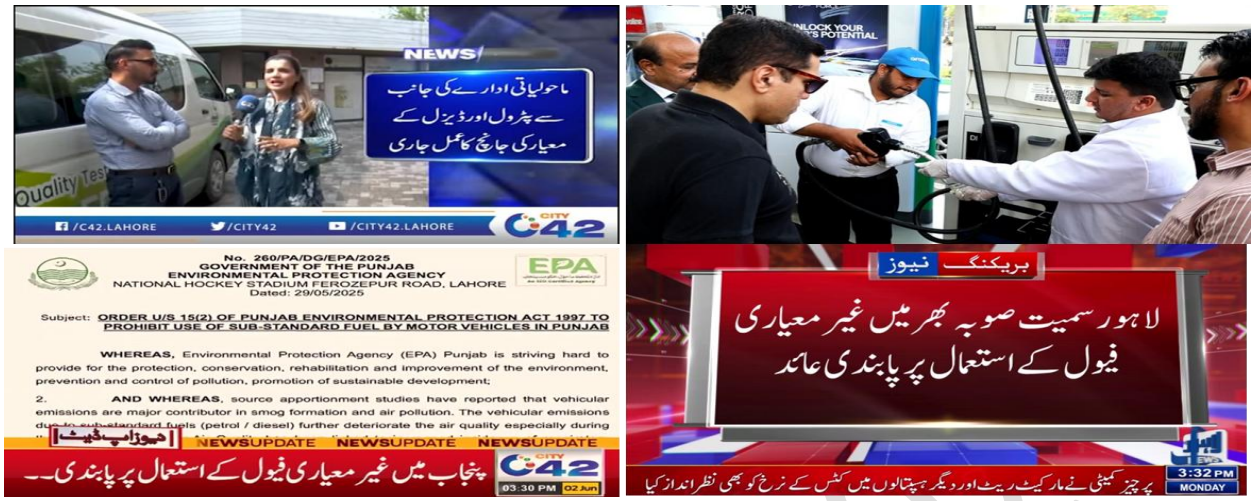

Figure 16.15: EPA Fuel Quality Testing Drive around Lahore Fuel Station

Figure 16.16: EPA Mandatory Suction Hood for restaurants & Live Barbeque

Figure 16.17: EPA Action for Water Conservation

Collectively, EPA Punjab's electronic media engagement strategy played a critical role in transforming environmental governance into a publicly visible, continuously communicated and socially relevant subject across Punjab. By strategically utilising leadership outreach, public awareness campaigns, enforcement visibility and technology-driven communication, the Agency successfully expanded environmental discourse beyond administrative and technical circles into mainstream public conversation. This integrated media approaches not only strengthened institutional transparency and public trust but also contributed towards greater environmental awareness, behavioural responsiveness and citizen participation in environmental protection efforts. While electronic media enabled real-time public communication and large-scale audience outreach, print media further complemented these efforts by providing in-depth reporting, analytical coverage and detailed documentation of environmental policies, interventions and governance challenges across the province.

16.8 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 strengthening the visibility of Punjab's environmental governance efforts at domestic as well as global levels. International media outlets including Reuters, Associated Press, The Washington Post, Gulf News, BBC Urdu and Voice of America highlighted Punjab's environmental challenges, anti-smog operations and government response mechanisms, bringing international attention towards regional environmental and air quality issues. 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 regarding environmental enforcement actions, policy interventions, smog mitigation measures and public health concerns throughout the year. This sustained print media engagement significantly enhanced public visibility of environmental governance while strengthening transparency, public awareness and institutional credibility at both national and international levels.

16.8.1 EPA Post-Smog Appraisal & Institutional Learning

Following the conclusion of the smog season, EPA Punjab conducted a comprehensive post-smog appraisal aimed at evaluating the effectiveness, operational impact and implementation challenges of various anti-smog interventions undertaken during 2025. The review process included environmental data analysis, assessment of enforcement operations, inter-departmental consultations and identification of policy and operational gaps requiring future improvement. Rather than limiting its role to enforcement alone, the appraisal reflected EPA Punjab's transition towards evidence-based and adaptive environmental governance focused on continuous institutional learning and policy refinement. The exercise also contributed towards the preparation of improved mitigation strategies, operational recommendations and future response mechanisms for subsequent smog seasons. Through analytical reporting and policy-focused media coverage, the appraisal further reinforced institutional transparency and demonstrated the Agency's

DRAFT SOE 2025

commitment towards evaluating, improving and strengthening long-term environmental management and anti-smog governance frameworks across Punjab.

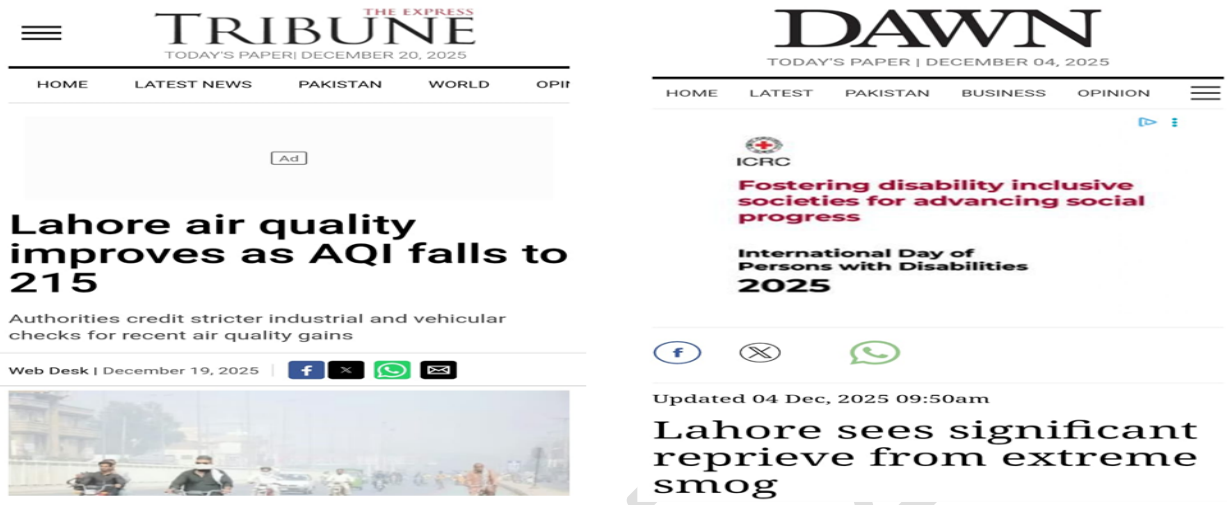

Figure 16.18: EPA Post Smog Appraisal

16.9 Outcomes and Societal Impact of Media & Community Engagement

EPA Punjab's media and community engagement initiatives are reported to have contributed to increased public awareness of environmental issues, improved citizen participation, and stronger visibility of environmental governance across Punjab. These outcomes are primarily associated with awareness campaigns, school and community programmes, and digital media outreach activities.

However, many of the stated impacts are largely descriptive and lack systematic empirical validation. In the absence of structured surveys, perception studies, or longitudinal behavioural assessments, it is difficult to confirm whether increased awareness has translated into sustained behavioural change at the societal level.

To rigorously assess societal impact, evidence-based evaluation mechanisms would be required, including public perception surveys, before-and-after awareness studies, citizen feedback analysis, and independent monitoring of behavioural indicators such as waste disposal practices, compliance with environmental advisories, and participation in reporting systems. Additionally, third-party evaluations or academic studies could strengthen the credibility of reported outcomes by reducing reliance on institutional reporting alone.

Without such empirical verification, conclusions regarding societal transformation remain indicative rather than conclusive. Therefore, while EPA Punjab's media and community engagement initiatives demonstrate strong outreach capacity and public visibility, their broader

DRAFT SOE

societal impact should be interpreted cautiously until supported by robust, independently verified evidence.

16.9.1 Environment as Mainstream Public Discourse

One of the most transformative outcomes of EPA Punjab's communication strategy during 2025 was the elevation of environmental issues into mainstream public discourse across Punjab. Environmental concerns such as smog, pollution, climate change and public health risks increasingly became part of everyday discussion within households, educational institutions, workplaces, media platforms and digital communities. What was once considered a technical and regulatory subject gradually evolved into a socially recognised public issue receiving sustained public attention and engagement.

16.9.2 Transformation of Environmental Governance into Publicly Visible Governance

EPA Punjab's integrated communication approach significantly reduced the traditional gap between government operations and public visibility. Through continuous dissemination of environmental information, leadership outreach and visibility of institutional actions, environmental governance became more transparent, publicly observable and socially connected. Citizens were no longer disconnected from environmental decision-making and government interventions; instead, environmental governance became increasingly accessible, understandable and visible within public space and media narratives.

16.9.3 Strengthening Public Trust, Responsiveness & Environmental Awareness

The continuous flow of environmental communication through electronic, digital and print media strengthened public confidence in institutional responsiveness and improved environmental literacy among citizens. Real-time advisories, public awareness messaging and accessible environmental information enabled citizens to better understand pollution risks, precautionary measures and the broader societal impact of environmental degradation. This sustained engagement contributed towards greater public responsiveness and stronger awareness regarding environmental protection responsibilities.

16.9.4 Emergence of Participatory Environmental Culture

The communication and outreach initiatives undertaken during 2025 also contributed towards the emergence of a more participatory environmental culture across Punjab. Citizens, youth, educational institutions, digital communities and businesses increasingly became active stakeholders within environmental protection efforts rather than passive observers of government policy. This gradual societal shift strengthened the idea that environmental sustainability is a shared social responsibility requiring collective participation, behavioural change and community-level engagement.

DRAFT SOE 2025

16.9.5 Enhancing Institutional Credibility & Global Visibility

The scale and consistency of EPA Punjab's communication efforts significantly enhanced institutional credibility at both national and international levels. Continuous media visibility, structured public engagement and technology-driven communication initiatives projected EPA Punjab as a modern, proactive and publicly engaged environmental institution. The extensive coverage received through national and international media platforms further elevated the visibility of Punjab's environmental governance framework, positioning it as an emerging 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 large-scale digital, electronic and print media campaigns, EPA Punjab gradually achieved institutional recognition and post-appraisal maturity in environmental communication and public engagement. However, the Department also realised that long-term environmental governance could not rely solely on awareness campaigns and enforcement mechanisms. There was a growing need for an institutional platform capable of preserving environmental knowledge, strengthening policy dialogue, developing technical expertise and promoting focused stakeholder interaction on environmental issues.

16.10 Centre for Knowledge Exchange and Policy Dialogue (CKE&PD)

Keeping this requirement in view, EPA Punjab established the Centre for Knowledge Exchange and Policy Dialogue (CKE&PD) as the Agency's first organised training, research and policy dialogue centre. The establishment of the Centre reflected EPA Punjab's transition from conventional environmental regulation towards a more knowledge-driven and collaborative governance model focused on institutional learning, research support and evidence-based policymaking.

The primary objective of the Centre is to conduct structured capacity-building programmes for all ranks of EPA Punjab, including promotion-linked trainings for officials from BS-01 to BS-15. In addition, the Centre serves as a platform for organising national and international workshops, seminars and policy dialogues to strengthen stakeholder engagement and environmental knowledge-sharing at multiple levels.

The Centre further aims to establish collaborations with universities, academic institutions, training academies and research organisations for research, innovation and environmental policy development. It also functions as a centralised repository for environmental data, research studies, case studies and best practices to support policymakers, researchers and public awareness in accordance with applicable legal frameworks.

Beyond institutional training functions, the Centre has also been envisioned as a policy support and research facilitation platform where researchers and technical experts can share findings and transform research outcomes into actionable policy recommendations for decision-makers. Through this initiative, EPA Punjab attempted to institutionalize environmental learning, policy

DRAFT SOE 2025

innovation and stakeholder collaboration while simultaneously developing an internal think tank capable of supporting future environmental governance challenges in Punjab.

16.11 Conclusion

The media and community engagement framework adopted during 2025 demonstrated that environmental governance in the modern era is no longer confined to regulatory actions and administrative interventions alone; it increasingly depends upon the ability to shape public perception, sustain public attention and build collective social responsibility around environmental issues. The growing integration of environmental concerns within mainstream media discourse reflected an important societal transition in which pollution, smog, climate risks and environmental sustainability emerged not merely as technical subjects but as matters of public interest, public health and everyday social relevance.

The extensive utilisation of digital, electronic and print media highlighted the transformative role of communication in influencing behavioural patterns, strengthening public responsiveness and encouraging participatory environmental culture. Environmental information became more accessible, visible and understandable for ordinary citizens, while media platforms evolved into powerful instruments for awareness generation, public mobilization and institutional transparency. This shift reinforced the understanding that effective environmental governance is closely linked with informed communities, active citizen participation and sustained public engagement.

The overall communication landscape during 2025 further demonstrated that environmental media engagement is no longer limited to information dissemination alone; rather, it has evolved into a strategic governance mechanism capable of shaping societal attitudes, influencing policy discourse and strengthening long-term environmental consciousness at both national and community levels.

DRAFT SOE 2025

Chapter 17 Future Direction

17.1 Environmental Governance Maturity

The Environmental Protection Agency Punjab is gradually transforming from a conventional regulatory institution into a modern, technology enabled and data driven environmental governance authority. This transformation reflects a broader shift towards proactive environmental management based on scientific evidence, digital monitoring systems, institutional coordination and informed decision making.

The evolving governance model emphasizes prevention rather than reactive enforcement, enabling the Agency to identify environmental risks at an earlier stage, improve regulatory efficiency and strengthen public trust. Through the integration of advanced technologies, environmental intelligence systems and transparent governance mechanisms, EPA Punjab aims to improve environmental protection while supporting sustainable economic development across the province.

The transition also reflects Punjab's growing recognition that environmental governance is no longer limited to regulatory compliance alone. Instead, it now requires integrated planning, predictive analysis, digital governance, public participation and interdepartmental coordination to effectively address increasingly complex environmental and climate related challenges.

17.1.1 Progress Achieved in 2025

The year 2025 marked a significant phase in strengthening environmental governance and institutional modernization in Punjab. During the year, EPA Punjab undertook multiple reforms and initiatives aimed at improving environmental monitoring, regulatory enforcement, pollution management and public engagement.

These efforts were initiated in response to growing environmental pressures including air pollution, industrial emissions, water stress, plastic waste, climate vulnerability and rapid urban expansion. The Agency adopted a more technology oriented and evidence based approach to environmental management by integrating digital systems, strengthening monitoring infrastructure and improving institutional coordination.

Several governance improvements were introduced during the year, including expansion of environmental monitoring systems, development of digital complaint management mechanisms, strengthening of environmental enforcement, promotion of sustainable development practices and enhancement of public accessibility to environmental information.

The cumulative impact of these initiatives reflects an important institutional shift in environmental governance across Punjab. Key characteristics of this transformation include:

- Transition from reactive to proactive environmental governance

DRAFT SOE 2025

- Increased reliance on data driven decision making
- Greater use of digital monitoring and analytical systems
- Improved environmental transparency and public participation
- Strengthened enforcement and compliance culture
- Integration of science and technology into policymaking
- Enhanced institutional coordination and operational capacity
- Promotion of sustainable development and ease of doing business

Collectively, these developments positioned EPA Punjab among the leading environmental regulatory institutions in Pakistan with a growing focus on modern, adaptive and technology enabled governance.

17.1.2 Focus Areas for 2026

Building upon the institutional progress achieved during 2025, EPA Punjab will further strengthen environmental governance through a series of strategic interventions and targeted reforms during 2026.

The Agency's future direction will focus on strengthening environmental monitoring systems, improving climate resilience, enhancing digital governance infrastructure, expanding predictive environmental management capabilities and promoting sustainable resource management across the province.

17.1.2.1 Targeted Enforcement in Pollution Hotspot Districts

EPA Punjab will establish dedicated environmental enforcement infrastructure in identified pollution hotspot districts across Punjab. These districts will receive focused monitoring, rapid response interventions and strengthened field enforcement in order to control industrial emissions, open burning, waste related pollution and other major environmental violations.

The initiative aims to improve on ground regulatory presence while enabling quicker environmental response and improved compliance monitoring in high risk areas.

17.1.2.2 Strengthening AQI Forecasting and Monitoring Systems

EPA Punjab will further expand and strengthen the provincial Air Quality Index (AQI) monitoring and forecasting network. The Agency plans to increase the number of monitoring stations across Punjab while integrating real time environmental data, meteorological information, satellite observations and AI based predictive models.

DRAFT SOE 2025

The upgraded forecasting system will improve early warning capabilities, strengthen pollution response planning and support informed policy interventions during smog and high pollution episodes.

17.1.2.3 Climate Resilient Water Management Initiatives

Recognizing the growing risks associated with water scarcity and climate change, EPA Punjab will prioritize climate resilient environmental planning with a particular focus on sustainable water management practices.

The Agency will promote rainwater harvesting systems, groundwater recharge measures, wastewater reuse practices and integrated stormwater management systems across residential, commercial and industrial sectors. These initiatives aim to improve long term water security while enhancing climate resilience in urban and semi urban areas.

17.1.2.4 Capacity Building and Institutional Development

EPA Punjab will continue strengthening institutional capacity through specialized training programs, technical collaborations and professional development initiatives. National and international partnerships will be explored to improve technical expertise in environmental monitoring, climate governance, data analytics and digital environmental management.

The Agency also plans to establish a dedicated Environmental Training Center to support continuous professional learning, operational efficiency and adoption of international best practices.

17.1.2.5 Strengthening Digital and IT Infrastructure

EPA Punjab will continue modernizing its digital governance infrastructure through the integration of smart monitoring technologies, IoT based systems, environmental data analytics and centralized digital platforms.

The objective is to improve environmental data collection, regulatory coordination, monitoring efficiency and public accessibility to environmental information. Enhanced digital infrastructure will also support faster reporting, transparent governance and evidence based policymaking.

17.2 Strategic Outlook for 2026

The progress achieved during 2025 provides a strong institutional foundation for EPA Punjab's strategic direction in 2026. Moving forward, the Agency aims to further strengthen environmental governance through technological modernization, sustainable development initiatives and climate responsive policymaking.

EPA Punjab envisions a governance framework that combines environmental regulation with digital innovation, scientific planning and community participation in order to effectively address emerging environmental and climate related challenges.

DRAFT SOE 2025

17.2.1 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 position EPA Punjab as a modern, adaptive and globally aligned environmental governance institution capable of addressing future environmental challenges through proactive and technology driven solutions.

To ensure the effective achievement of these strategic priorities EPA Punjab will establish a comprehensive implementation framework supported by measurable performance targets, clearly assigned institutional responsibilities, defined implementation timelines and sustainable financing mechanisms. Regular monitoring and evaluation through key performance indicators (KPIs) will enable systematic progress tracking, evidence based decision making and timely corrective actions where required. The framework will also support adaptive management by incorporating periodic reviews, stakeholder feedback and emerging environmental challenges thereby ensuring that strategic interventions remain responsive, accountable and aligned with long term environmental governance objectives.

17.2.1.1 Sustainable Development and Circular Economy

EPA Punjab will promote sustainable development principles through the gradual transition from a traditional linear economic model towards a circular economy framework based on reducing waste, improving resource efficiency and promoting recycling and recovery practices.

Industries will be encouraged to adopt cleaner production technologies, optimize energy and water consumption and implement environmentally sustainable operational practices. Integrated waste management systems will also be strengthened through improved waste segregation, recycling infrastructure and responsible disposal mechanisms.

DRAFT SOE 2025

Special emphasis will be placed on reducing plastic pollution through phased restrictions on single use plastics, promotion of environmentally friendly alternatives and implementation of Extended Producer Responsibility (EPR) mechanisms.

17.2.1.2 Pollution Reduction and Environmental Protection

EPA Punjab will further strengthen pollution control measures through expansion of environmental monitoring infrastructure, improved regulatory enforcement and enhanced industrial compliance systems.

Air quality monitoring networks, water quality surveillance systems and environmental inspection mechanisms will continue to expand across urban and industrial areas. The Agency will increasingly rely on real time environmental data, predictive analytics and targeted interventions to identify pollution hotspots and address environmental risks proactively.

Industrial emissions monitoring through Continuous Emission Monitoring Systems (CEMS), stricter enforcement of Punjab Environmental Quality Standards (PEQS) and stronger field enforcement mechanisms will further strengthen regulatory compliance and accountability.

17.2.1.3 Climate Resilience and Clean Energy Integration

Climate resilience will remain a central component of EPA Punjab's future environmental strategy. The Agency will promote renewable energy adoption, energy efficiency measures and sustainable infrastructure development across Punjab.

Solar energy systems, waste to energy initiatives, biogas generation projects and environmentally sustainable industrial technologies will be encouraged to reduce environmental pollution while supporting low carbon economic development.

In parallel, climate adaptation measures including climate smart agriculture, flood resilience planning, heat mitigation strategies and sustainable urban infrastructure will be promoted to strengthen environmental resilience across vulnerable sectors.

17.2.1.4 Technology Driven Environmental Governance

EPA Punjab will continue advancing towards a technology enabled environmental governance framework based on digital monitoring systems, AI assisted environmental analysis and GIS based decision support mechanisms.

The integration of environmental intelligence systems will improve institutional responsiveness, strengthen forecasting capability and enable proactive environmental management. Public accessibility to environmental information will also be enhanced to improve transparency, citizen participation and institutional accountability.

DRAFT SOE 2025

17.2.1.5 Partnerships and Community Participation

Environmental protection requires collective responsibility and institutional collaboration. EPA Punjab will continue working closely with government departments, international organizations, research institutions, NGOs and private sector stakeholders to strengthen environmental sustainability initiatives across Punjab.

Community participation will also remain an important component of environmental governance through awareness campaigns, participatory monitoring initiatives and public engagement mechanisms aimed at promoting environmentally responsible behavior.

17.2.1.6 Predictive Environmental Governance through Artificial Intelligence

EPA Punjab aims to gradually transition towards predictive environmental governance through the integration of artificial intelligence and advanced environmental analytics into monitoring and regulatory systems.

AI based models trained on historical environmental data, industrial emissions, meteorological patterns and satellite observations will support pollution forecasting, environmental risk identification and dynamic regulatory planning.

These systems will strengthen early warning capabilities, improve environmental response mechanisms and support evidence based inspection scheduling and enforcement prioritization.

17.2.1.7 Provincial Environmental Data Exchange Platform

EPA Punjab plans to develop a centralized Environmental Data Exchange Platform (EDEP) to improve interdepartmental environmental coordination and data interoperability.

The platform will facilitate integration of environmental datasets from sectors including health, transport, agriculture, urban development and industry. This integrated approach will improve environmental planning, strengthen policy coordination and support more comprehensive environmental analysis across Punjab.

17.2.1.8 Expansion of IoT Based Environmental Monitoring

EPA Punjab will continue expanding IoT based environmental monitoring systems across urban centers, industrial clusters and environmentally sensitive areas.

The use of low cost sensor networks will improve real time environmental surveillance, strengthen spatial monitoring coverage and support rapid regulatory response mechanisms. Integration of IoT systems with centralized dashboards and analytical tools will further enhance environmental governance efficiency.

DRAFT SOE 2025

17.2.1.9 Climate Intelligence and Decision Support Systems

The Agency aims to strengthen climate intelligence systems capable of integrating environmental monitoring, climate modeling and risk assessment into environmental planning and policymaking processes.

These systems will support climate risk mapping, prediction of extreme weather events and development of adaptive environmental management strategies aimed at improving resilience against floods, droughts and heatwaves.

Implementation of advanced environmental intelligence systems will require strong data governance arrangements, interoperable information systems, institutional ownership mechanisms, cybersecurity safeguards, technical infrastructure and specialized human resources. Integration of these systems into planning, regulatory decision making, environmental monitoring and disaster preparedness processes will be essential for realizing their intended benefits.

17.2.1.10 Institutional Transformation and Digital Capacity Building

EPA Punjab recognizes that successful digital governance depends not only on technology but also on institutional capacity and technical expertise.

Continuous training programs in environmental data analysis, GIS, AI assisted monitoring and digital governance systems will therefore remain a priority. Specialized technical units focusing on environmental intelligence, digital systems and advanced analytics may also be established to strengthen institutional innovation and operational effectiveness.

17.2.1.11 Water Conservation and Sustainable Resource Management

EPA Punjab will continue implementing water conservation initiatives including restrictions on excessive water use, promotion of wastewater recycling and expansion of rainwater harvesting systems.

The Agency also plans to encourage sustainable water management practices across residential, commercial and industrial sectors in response to increasing groundwater depletion and climate related water stress.

17.2.1.12 Floating Wetlands and Nature Based Solutions

EPA Punjab plans to expand the use of floating wetland technology as a sustainable and nature based solution for wastewater treatment and ecological restoration.

The initiative will support improvement of water quality in drains, canals, ponds and polluted water bodies while contributing to biodiversity enhancement and environmental restoration.

DRAFT SOE 2025

17.2.1.13 Advanced Air Quality Management and Source Apportionment

EPA Punjab will undertake detailed source apportionment studies to scientifically identify and quantify major contributors to $PM_{2.5}$ and urban air pollution across Punjab.

Advanced analytical tools including receptor modeling, satellite analysis, trajectory modeling and Positive Matrix Factorization (PMF) will support evidence based policymaking and targeted pollution control interventions.

17.2.1.14 Automated Air Quality Forecasting and GIS Based AQI Zoning

EPA Punjab aims to operationalize an integrated air quality forecasting system capable of predicting pollution trends 24 to 72 hours in advance through the integration of AQMS data, meteorological information and AI assisted forecasting models.

Simultaneously, GIS based AQI mapping and zoning systems will be developed to identify district wise pollution hotspots, strengthen environmental planning and support localized pollution mitigation strategies.

17.3 Conclusion

The future direction of EPA Punjab reflects a broader transformation in environmental governance across the province. The Agency is gradually moving beyond traditional regulatory functions towards a more integrated, technology driven and predictive governance framework capable of addressing increasingly complex environmental and climate related challenges.

Through the expansion of environmental monitoring systems, digital governance infrastructure, climate resilience initiatives and scientific decision support mechanisms, EPA Punjab aims to strengthen environmental protection while supporting sustainable economic growth and public well being.

The strategic direction outlined for 2026 demonstrates EPA Punjab's commitment to building a transparent, responsive and adaptive environmental governance system aligned with emerging national priorities and global environmental sustainability goals.

DRAFT SOE 2025

Acknowledgements

DRAFT SOE 2025

Conferring of Sitara e Imtiaz

The Government of Pakistan recognised the outstanding work of Dr. Imran Hamid Sheikh, Director General of the Environmental Protection Agency Punjab, the functional arm of the Environmental Protection & Climate Change Department. In recognition of his visionary leadership, he was subsequently selected for the prestigious Sitara-e-Imtiaz. The Cabinet Division formally announced his nomination on 14 August 2025. Since taking office in March 2024, Dr. Sheikh has led major improvements in environmental governance and public service delivery across Punjab.

Dr. Imran Hamid Sheikh set up Pakistan's first Environmental Protection Force (EPF), a milestone in the country's environmental history. He conducted unprecedented anti-smog operations which led to the sealing of more than 3,000 polluting units and fines of more than Rs. 300 million. These efforts resulted in 22 less unhealthy air days in 2024 than in 2023. Under his guidance, more than 720 emission control systems were installed, resulting in a 41.25% reduction in PM2.5 levels, which helped to reduce industrial pollution. His Anti-Plastic Campaign led to the seizure of more than 200 tons of illegal plastic and filing of 252 cases before the magistrates.

He led the digitalization of EPA with Smog War Room, Green Punjab App and Environment Management System (EMS). Under his leadership, for the first time in Pakistan's history a vehicular emission testing regime was introduced in Punjab. He was involved in public engagement and environmental restoration activities, such as planting 400,000+ trees around brick kilns and planting a Miyawaki forest at Hiran Minar.

DRAFT SOE 2025

The Lahore High Court, the National Assembly Committee, ICIMOD, the World Economic Forum 2025 and the US Congressional Pakistan Caucus have all recognised his achievements, while EPA's efforts in smog mitigation have garnered a 63% satisfaction rate from the public. His commitment and efforts to make Punjab a serious environmental leader at the national and international level is plausible.

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 honour, among the most distinguished civil awards of the country, stands as a testament to his firm commitment and the lasting impact of his work on Punjab's environment and its people.

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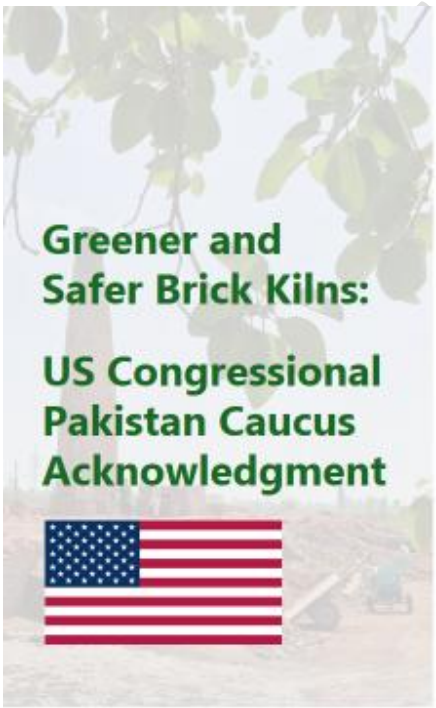
US Congressional Pakistan Caucus Acknowledges Punjab's Brick Kiln Reforms

The United States Congressional Pakistan Caucus has acknowledged the work being done by the Punjab government to encourage cleaner brick kiln technologies. This is an important endorsement by a foreign legislature and a testament to the world-class attention that the Punjab environmental reform agenda is gaining.

Air pollution is an important issue in Punjab and brick kilns contribute heavily to it. They are significant sources of particulate matter (PM) pollution that reduces air quality and causes health impacts. To help with this, EP&CCD embarked on a long term campaign to switch the firing process of kilns from the traditional firing method which is very polluting to the zig-zag firing method.

The zig-zag technology helps to reduce fuel consumption and significantly lower PM2.5 emissions. Punjab's strategy included a mix of regulatory pressure, technical support and enforcement action to achieve this transition on a scale.

The recognition by US Congressional Pakistan Caucus is a testimony to the gravity and success of this endeavour. It also conveys to other provinces and nations: viable emission reductions from the brick kiln sector are possible, if the policy mix is appropriate.



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

SOE 2025

ICIMOD Nepal Commends Punjab's Zig-Zag Technology Campaign

The International Centre for Integrated Mountain Development (ICIMOD), Nepal, has formally endorsed the efforts of the Environmental Protection Agency of the Punjab on the issue of emissions from brick kilns. ICIMOD is a credible intergovernmental regional organisation that has 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 is a statement of two important outcomes. First, it validates the efforts of the campaign in Punjab, stating that there has been measurable effect in reducing the concentration of one of the most harmful air pollutants affecting human health PM2.5. Secondly, it points out that the Punjab model is one that can be replicated across other provinces.

ICIMOD's recognition further solidifies Punjab's status as a leader in industrial pollution control in South Asia. It also illustrates the power of firm regulation combined with technology assistance, which is proven to affect 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

Swiss-based air quality technology firm, that is a leading air quality platform, has recognised Punjab's tremendous success in improving air quality in 2025. Multiple districts across the Punjab including Lahore, Multan, Gujranwala and Rawalpindi have recorded measurable improvements in PM2.5 concentration levels. These province-wide gains reflect the cumulative impact of coordinated anti-smog campaigns, vehicular emission controls, brick kiln regulations and large-scale industrial crackdowns that have progressively strengthened Punjab's air quality governance framework.

Among all districts, Lahore the most populous city of Punjab and historically one of the most severely affected urban centres by smog-related challenges has recorded the most significant improvement, emerging as a symbol of the province's environmental recovery. In 2025, Lahore had an annual average PM2.5 concentration of 89 µg/m³, which is a 13% decrease from the previous year of 2024, when the concentration was recorded at 102 µg/m³, according to IQAir-Insight data. This is the cleanest year for Lahore since the COVID-19 lockdown in 2020 when PM2.5 levels fell temporarily to 79 µg/m³.

This recognition reflects the continuous anti-smog and environmental enforcement efforts by the Environmental Protection Agency (EPA) Punjab. This is not just a testament to the progress achieved, but also a reaffirmation to continue and further strengthen the initiatives aimed at ensuring cleaner air for the people of Punjab.

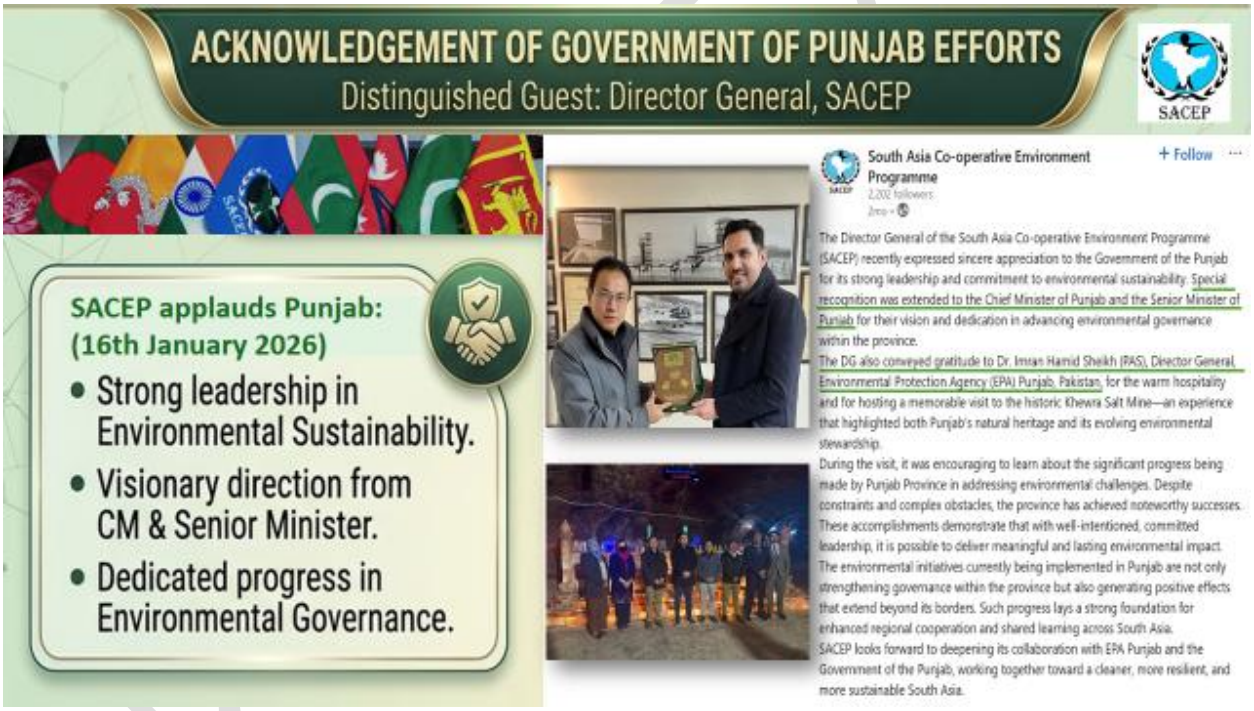
SACEP Applauds Punjab's Environmental Leadership

On 16 January 2026, South Asia Co-operative Environment Programme (SACEP) officially acknowledged Punjab for its role in environmental governance efforts in South Asia.

An intergovernmental organisation, SACEP was formed to support and encourage the protection of the natural environment in South Asia. It'll carry weight of its own for the recognition of Punjab. It is an indication that the work of Punjab is not only being seen in Pakistan but it is being mentioned in the multi-lateral level.

This recognition puts Punjab among the top performing environmental government of South Asia at sub-national level. It also underscores the importance of sustainable, evidence-based environmental management to which EP&CCD has been contributing with its monitoring systems, enforcement campaigns and adaptation for the climate.

SACEP's applause is a tribute to past efforts; it is also a "call to action" to continue to build on the progress that has been made.



DRAFT SOE 2025

EPA Punjab's Success Stories

Punjab Recognised at the World Economic Forum 2025, Davos

The environmental leadership of Punjab was brought to the attention during the World Economic Forum (WEF) 2025, held in Davos, Switzerland. The World Economic Forum is among the most powerful conferences of political leaders, business people and civic society members in the world. The recognition on this platform puts Punjab in a small club of sub-national governments that have made a statement on climate actions.

Davos is a forum where world priorities are set. Recognition here is a testament to the significance of Punjab's environmental efforts and their relevance to global climate and sustainable development conversations.

This recognition is a testament to the efforts of the Punjab government on environmental causes ranging from brick kiln reform to smog management, international cooperation to knowledge sharing. It confirms the EP&CCD's long-term vision of developing strong institutions for the environment, producing credible data and developing policies that lead to measurable environmental outcomes.

The World Economic Forum recognition highlights the province is not merely taking action on its environment, but also demonstrating how sub-national governments can be part of the climate action.

EPA's Success Story Presented at International Air Quality Conference, Colombia

Punjab's Environmental Protection Agency (EPA) was invited to share its success story during an International Air Quality Conference in Colombia in March 2025. This acknowledgment put Punjab's EPA on a front row seat in a worldwide platform that focuses on the problem of air pollution, one of the most important public health issues in the world today.

It's a privilege to be chosen to speak at such a conference. It validates the EPA's practices, tools and policies as best practices that can be shared with the global community.

This presentation may have concentrated on the way EPA manages air pollution in the form of smog and particulate matter in Punjab, a problem which impacts millions of people annually. The EPA methods shared with other countries around the world added to the global knowledge base on urban and regional air quality management.

This recognition also puts emphasis on data-driven governance. The investments made by the Government of Punjab in air quality monitoring and real-time environmental intelligence, with the establishment of facilities like Climate Watch, have furnished the evidence to make credible contribution in international discussions on air pollution.

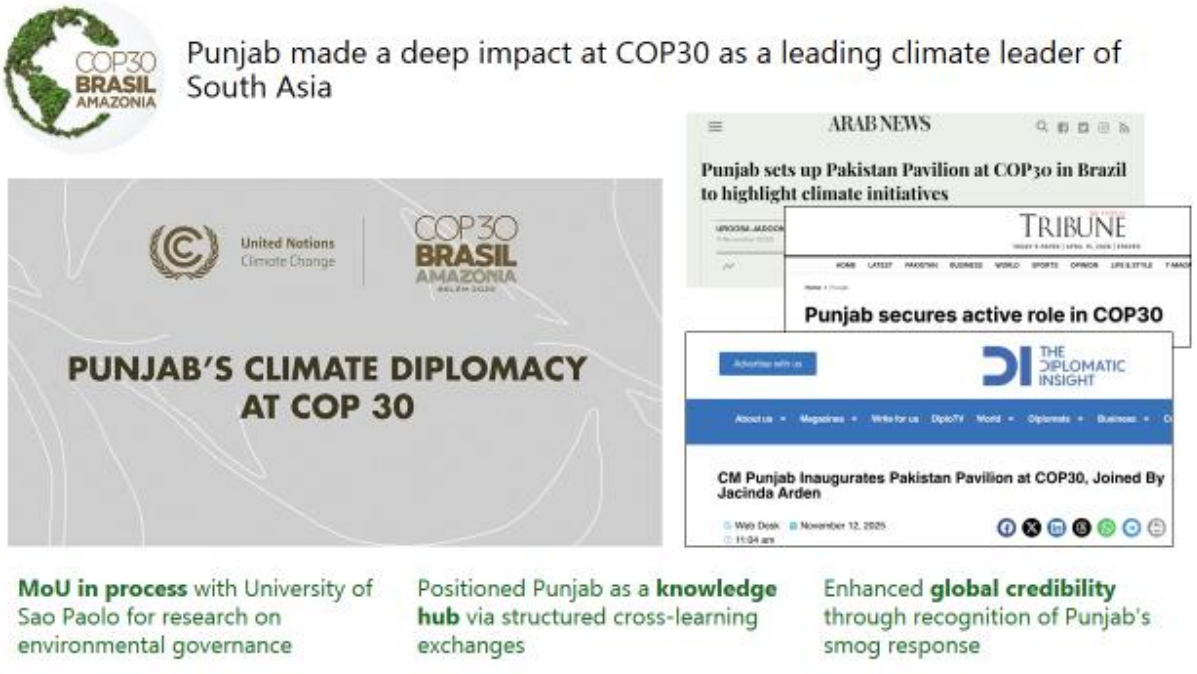
Punjab Emerges as a Leading Climate Voice at COP30

The 30th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP30) was a major event for the Punjab. The province was not only an observer but also a key climate player in South Asia.

At COP30, Punjab achieved some tangible results:

- A Memorandum of Understanding (MoU) is in the process of completion with the University of São Paulo. In this collaboration, the research areas will be environmental governance and establishing an institutional relationship between the Government of Punjab and one of the best academic institutions of Latin America.
- Punjab has been placed as a hub of knowledge. The province helped others by enabling a system of cross-learning and sharing good practise in environmental management and climate response.
- The international recognition of the way Punjab is responding to smog added to its global credibility. The province's way of tackling this persistent and complicated problem, smog, was cited as a good practise example of sub-national climate governance.

COP30 was an opportunity for the Punjab province to showcase its potential to take action at the provincial level. Being at this global forum and performing well has enhanced the province's credibility and its role as a proactive climate leader.



Achievements

DRAFT SOE 2025

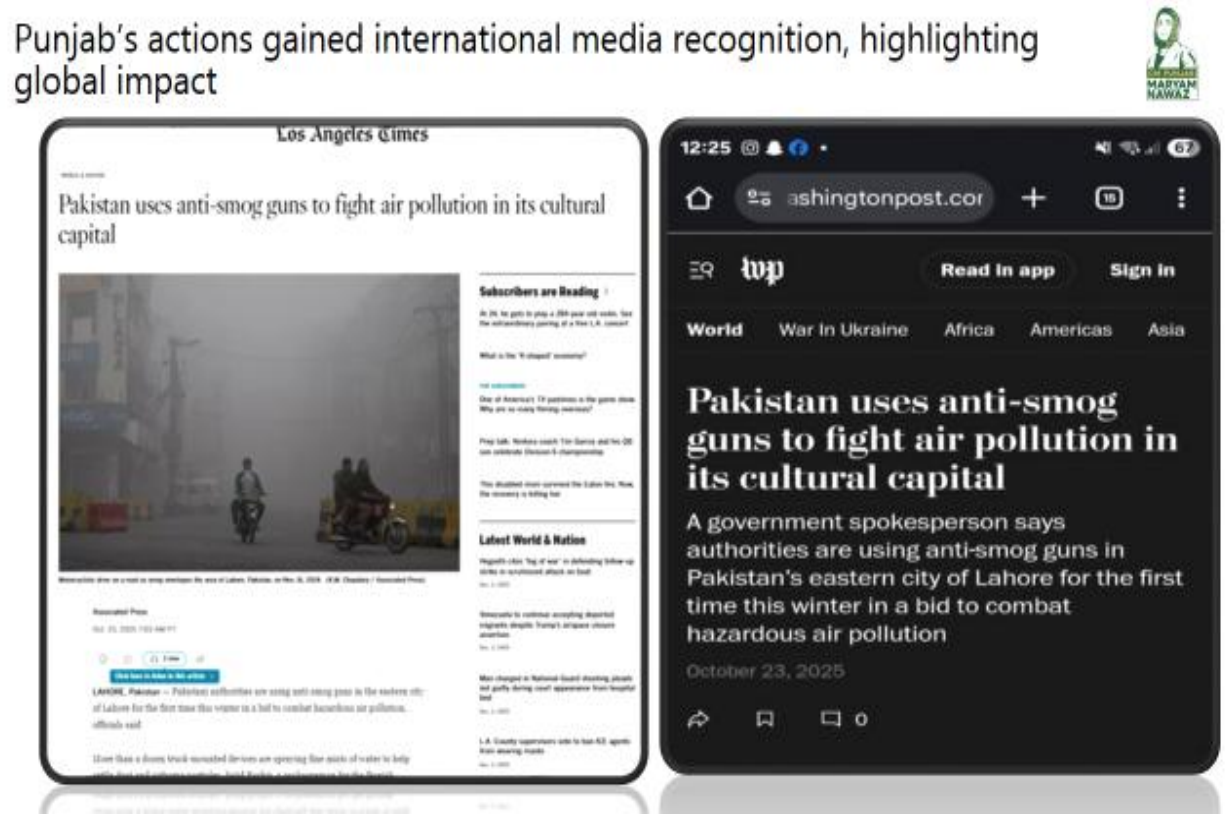
Punjab's Climate Actions Gain International Media Recognition

The environmental activities of Punjab have been covered by international media. This represents a broader recognition one that goes beyond institutional or diplomatic channels of the province's work on climate and pollution.

There are a number of reasons why it is important to be recognised in the media on an international level. It is an indication of the fact that the environmental story of Punjab is credible and compelling enough to be reported to the world. It also raises the profile of the province's efforts by showcasing them to research, policy and civil society groups from around the world.

The coverage brings to the fore the impact of Punjab's climate actions worldwide. This is important as it demonstrates that the steps taken to solve a local problem smog, air pollution and environmental degradation have a multi-national impact.

International media also accounts for them, which can be a source of accountability. It prompts Punjab to keep striving for ambitious environmental goals and makes sure that the standards set are maintained.



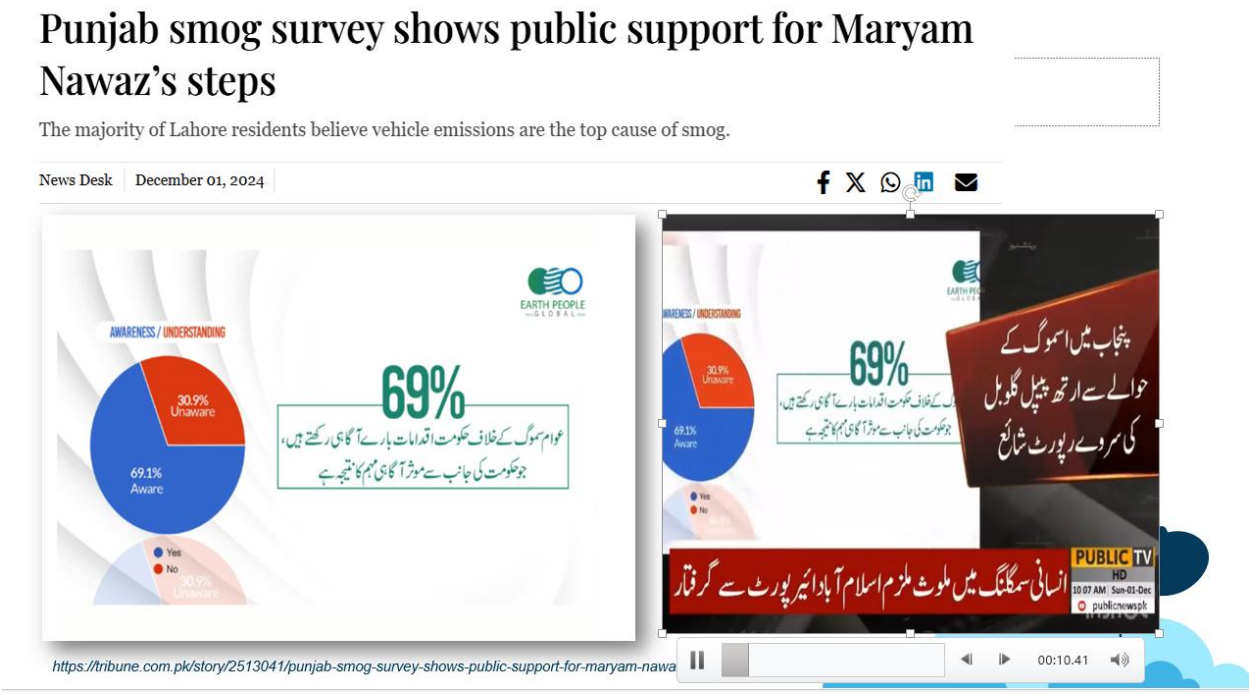
Public Endorsement: Survey Shows Support for Punjab's Smog Initiatives

A public survey conducted in smog hit Punjab, which was covered by Express Tribune, also showed that the public support the measures being taken by the Chief Minister Maryam Nawaz for the negative effect of smog. The domestic recognition is in addition to the international recognition that has been received by the province.

Public support is an important measure of any environmental programme's success. When citizens acknowledge and approve of the action of their government, it gives the government an authorisation to continue and strengthen its efforts. It also shows that environmental policies are making an impact on the people who live them, by being felt and appreciated in their everyday lives.

The findings from the survey remind us of another message: Environmental governance is not a technical or diplomatic process. It needs to gain the faith and backing of the communities it serves. The strategy of the Punjab government seems to have hit the mark, as it has a mix of enforcement, awareness building and visible improvements in air quality.

These are domestic recognitions, in addition to all international recognitions reported across this section, which give a round up picture: Punjab's environmental journey is getting recognition both internally and externally. The province has earned the trust of its citizens and the respect of the global community a dual achievement that provides a strong foundation for the environmental challenges that lie ahead.



Punjab as a Global Model for Climate Action: International Delegations Seek Lessons from EP&CCD

In order to acknowledge EPA's leading role for environmental protection and monitoring oversight the global leaders are frequently visiting Punjab Climate Watch to learn about Punjab's strategy to climate action. This is an increasing international appreciation for Punjab's environmental policies and monitoring systems.

In 2025, multiple high-level delegations including a US Delegation, the British High Commission, a Turkish Delegation, a UNFPA Delegation and a World Bank Delegation visited Punjab Climate Watch or received detailed briefings on EP&CCD's environmental strategy, real-time monitoring systems and institutional framework.

These visits represent a sustained and growing pattern of international interest rather than isolated diplomatic engagements. Each interaction has contributed to refining Punjab Climate Watch as an institution, enabling EPA Punjab to benchmark its systems against global best practices while simultaneously offering its model as a replicable framework for regions facing similar environmental challenges.

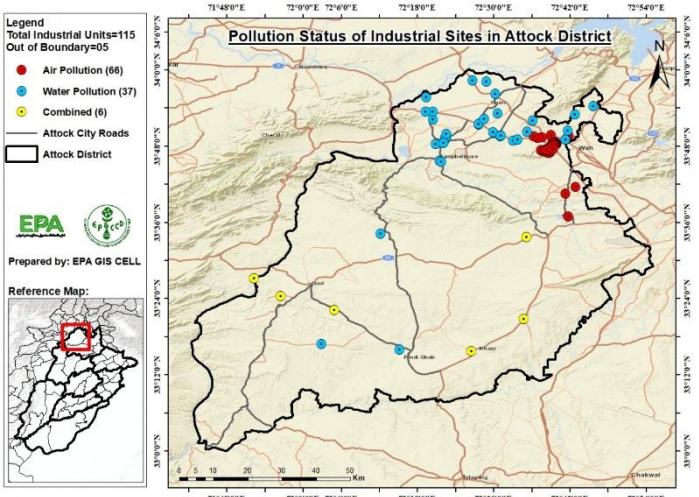
Most significantly, Punjab has transitioned from being a recipient of international advice to becoming a global reference point a province that has demonstrated the capacity to respond effectively to the climate crisis through institutional innovation, data-driven governance and coordinated enforcement. As global engagement with Punjab Climate Watch continues to grow, this cycle of learning and improvement positions the facility as an evolving hub of climate knowledge exchange on the world stage.

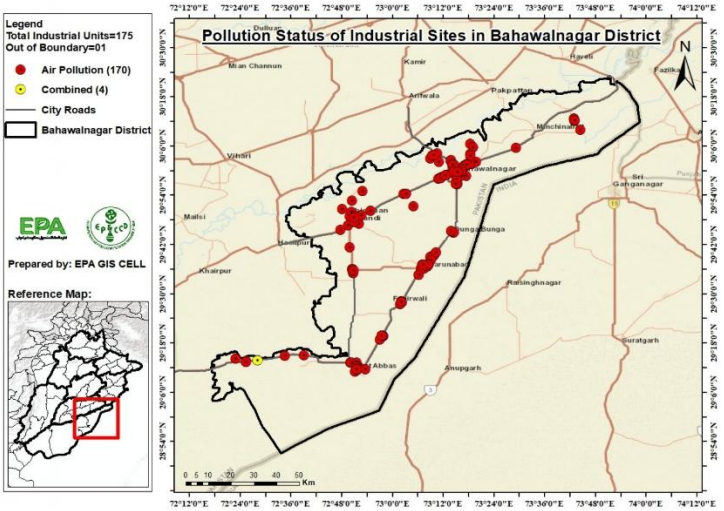
DRAFT SOE 2025

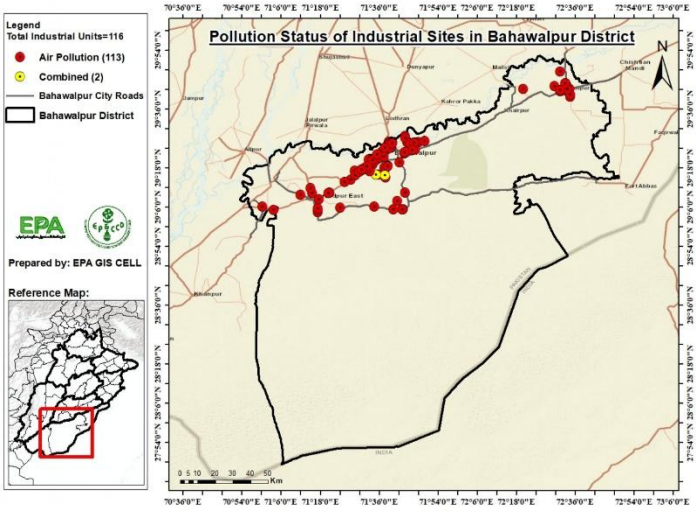
Annexures

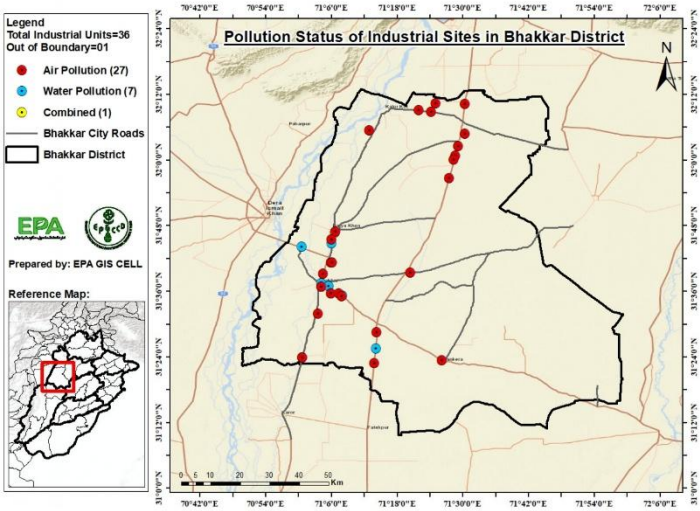
Annex-I

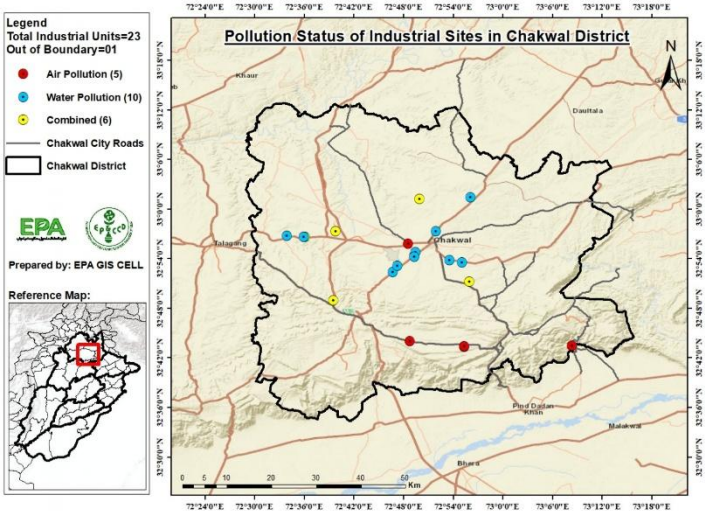
Pollution status maps of Punjab

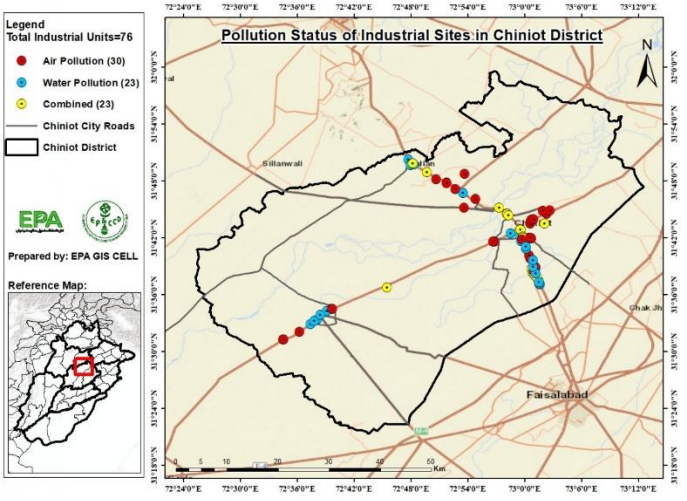


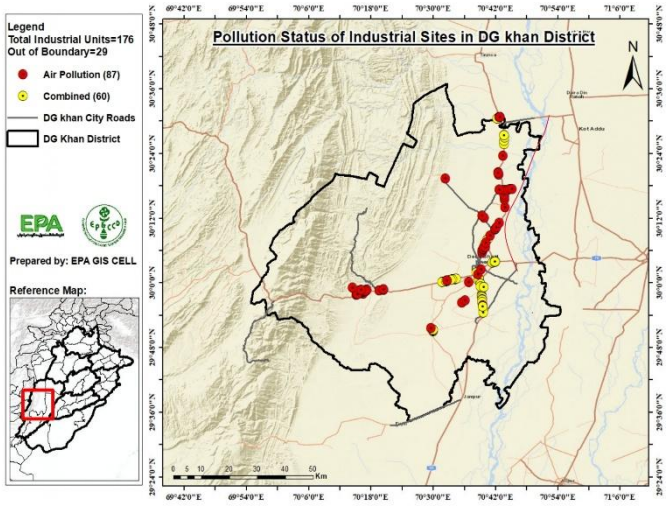


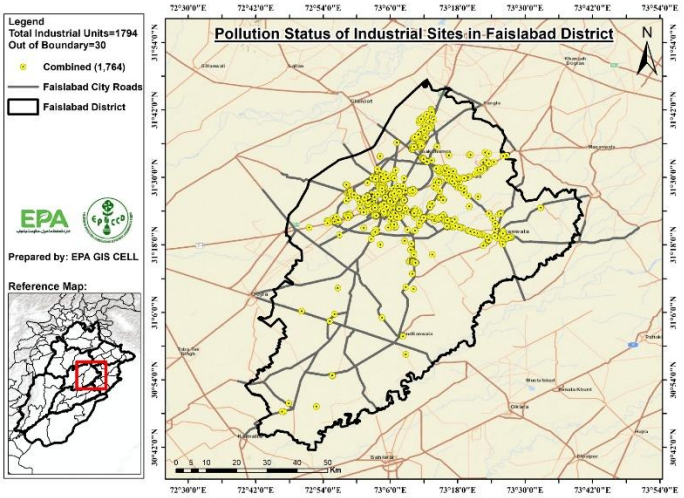









Pollution Status of Industrial Sites in DG khan District
Legend
Total Industrial Units=176
Out of Boundary=29
Air Pollution (87)
Combined (60)
DG khan City Roads
DG Khan District
Prepared by: EPA GIS CELL
Reference Map:
N


Pollution Status of Industrial Sites in Faislabad District
Legend
Total Industrial Units=1794
Out of Boundary=30
Combined (1,764)
Faislabad City Roads
Faislabad District
Prepared by: EPA GIS CELL
Reference Map:
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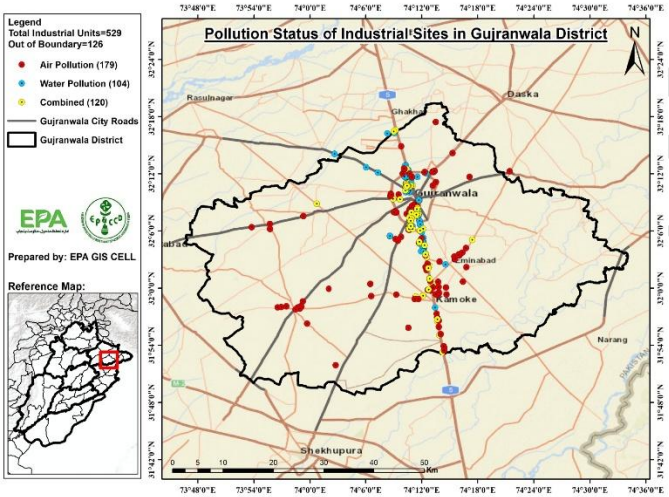
Pollution Status of Industrial Sites in Gujranwala District
Legend
Total Industrial Units=529
Out of Boundary=126
Air Pollution (179)
Water Pollution (104)
Combined (120)
Gujranwala City Roads
Gujranwala District
Prepared by: EPA GIS CELL
Reference Map:
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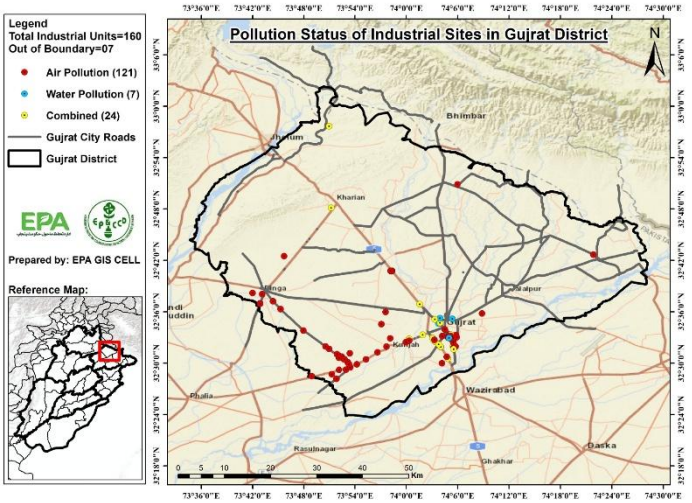
Pollution Status of Industrial Sites in Gujrat District
Legend
Total Industrial Units=160
Out of Boundary=07
Air Pollution (121)
Water Pollution (7)
Combined (24)
Gujrat City Roads
Gujrat District
Prepared by: EPA GIS CELL
Reference Map:
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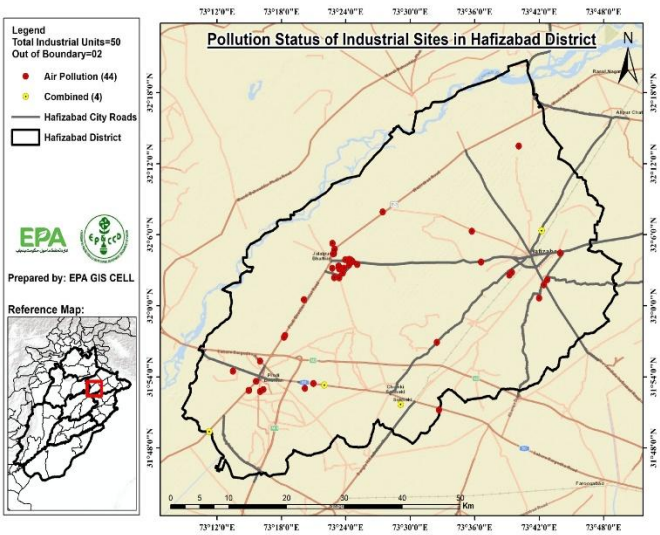
Pollution Status of Industrial Sites in Hafizabad District
Legend
Total Industrial Units=50
Out of Boundary=02
Air Pollution (44)
Combined (4)
Hafizabad City Roads
Hafizabad District
Prepared by: EPA GIS CELL
Reference Map:
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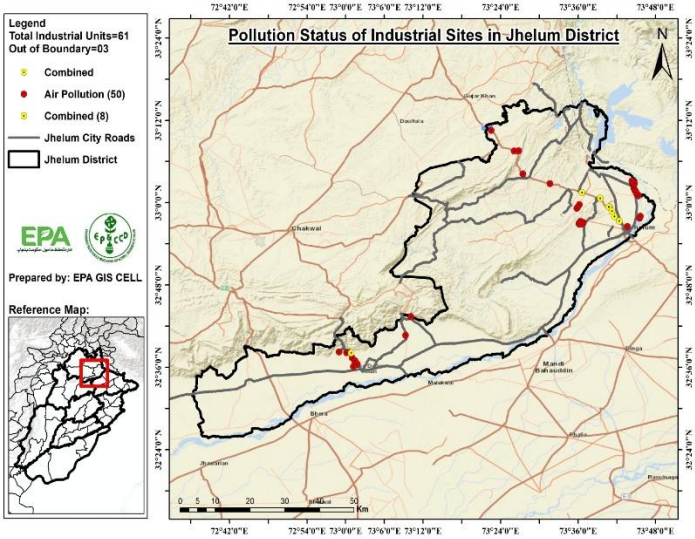
Pollution Status of Industrial Sites in Jhelum District
Legend
Total Industrial Units=61
Out of Boundary=03
Combined
Air Pollution (50)
Combined (8)
Jhelum City Roads
Jhelum District
Prepared by: EPA GIS CELL
Reference Map:
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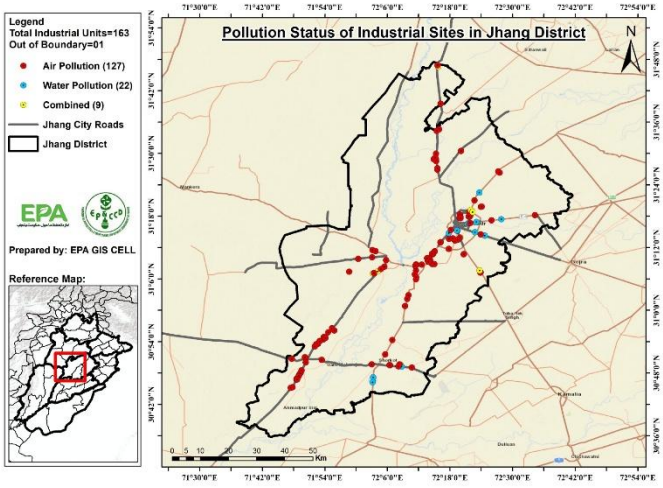
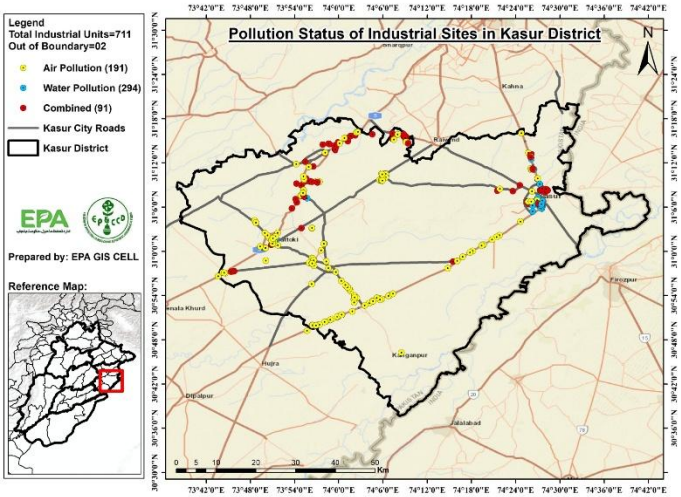

Pollution Status of Industrial Sites in Jhang District
Legend
Total Industrial Units=163
Out of Boundary=01
Air Pollution (127)
Water Pollution (22)
Combined (9)
Jhang City Roads
Jhang District
Prepared by: EPA GIS CELL
Reference Map:
N
Km


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:
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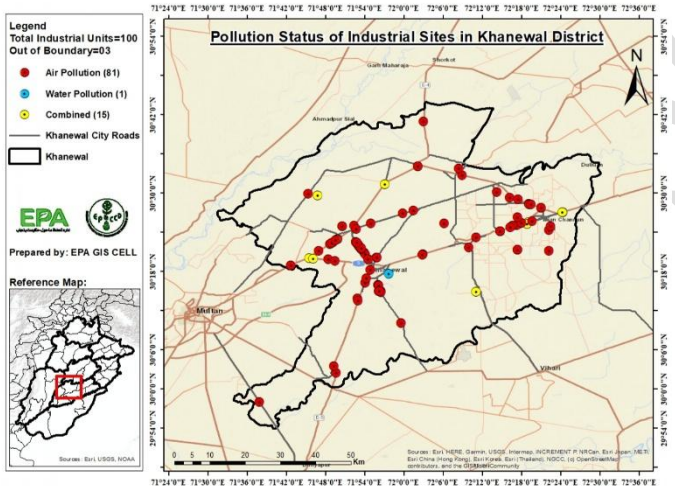
Km


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:
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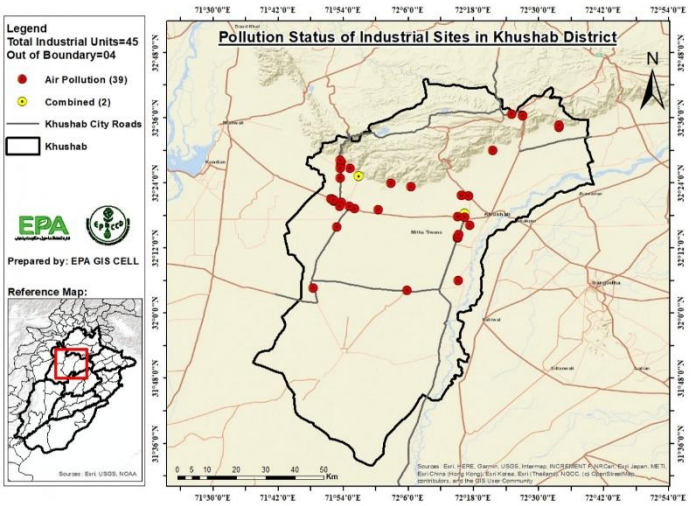
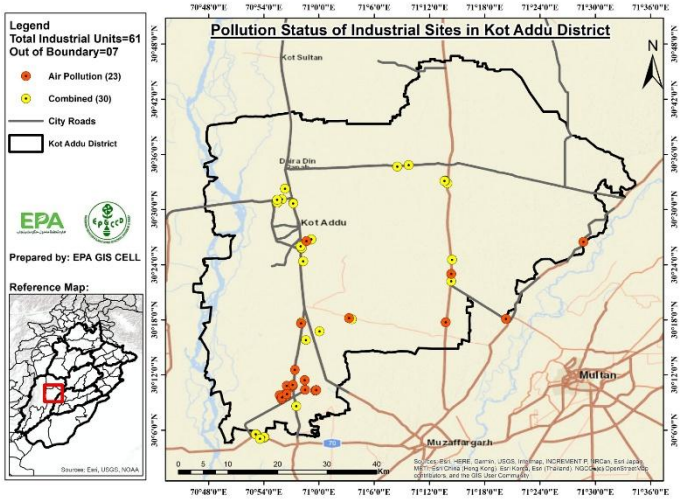
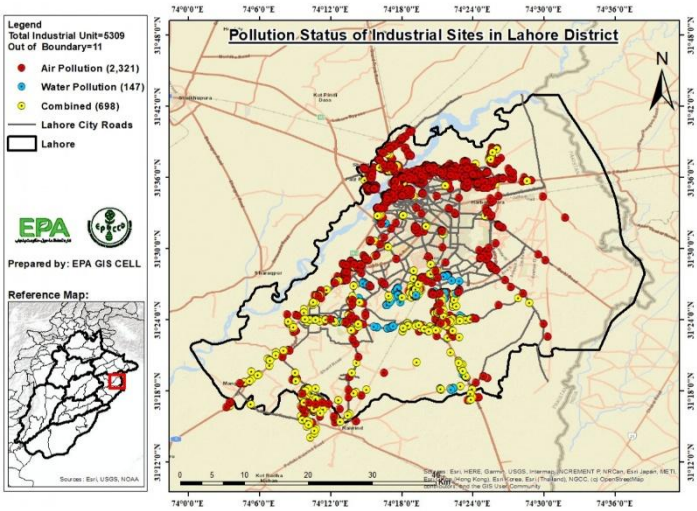
Km


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
Km


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:
N
Km


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:
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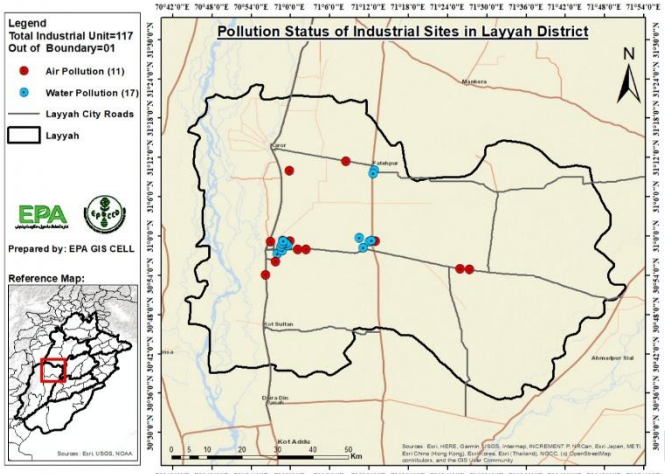
Km


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:
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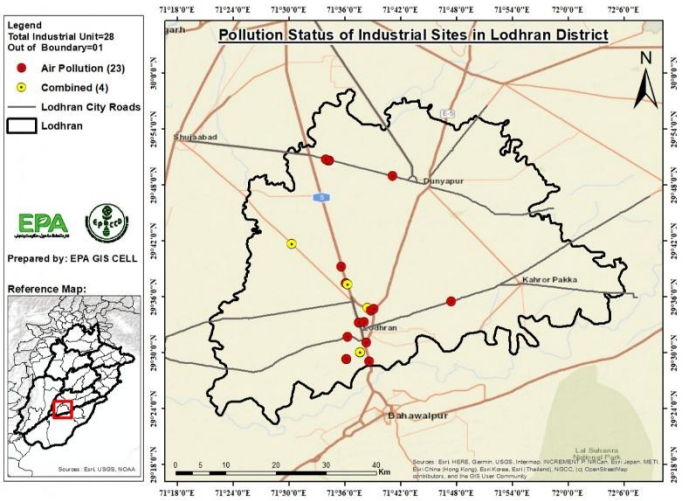
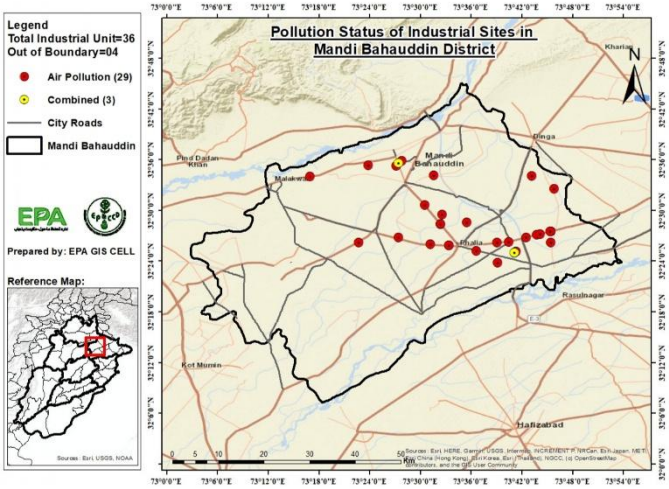
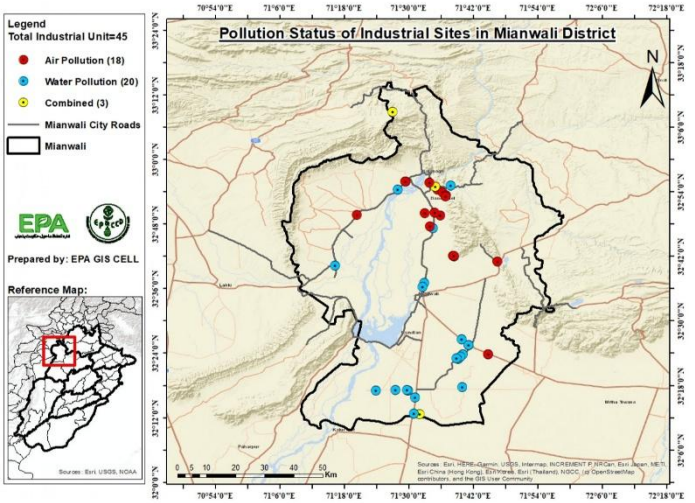
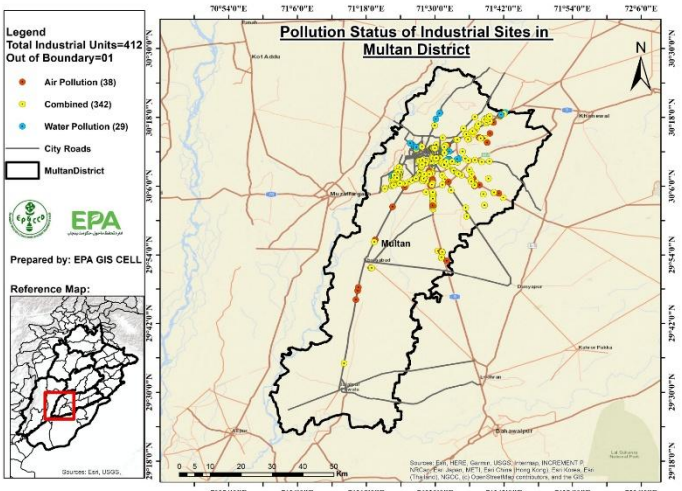
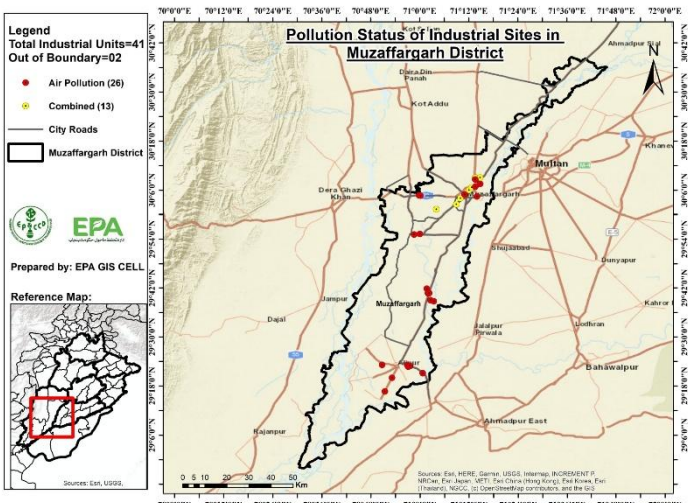
Kot Addu
Dera Din Panah
Ahmadpur Sial
Sources: Esri, USGS, NOAA

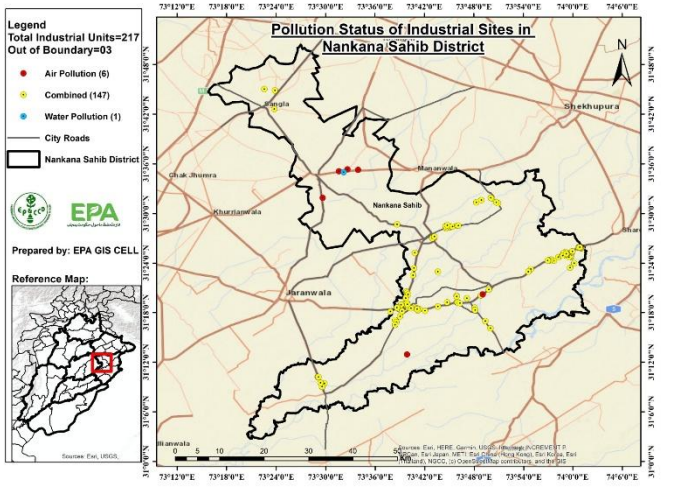

Pollution Status of Industrial Sites in Lodhran District
Legend
Total Industrial Unit=28
Out of Boundary=01
Air Pollution (23)
Combined (4)
Lodhran City Roads
Lodhran
Prepared by: EPA GIS CELL
Reference Map:
N
Shujaabad
Dunyapur
Kahror Pakka
Lodhran
Bahawalpur
Sources: Esri, USGS, NOAA

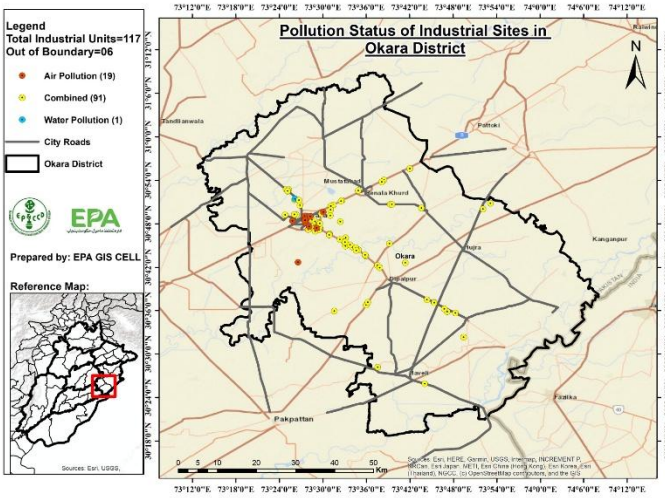

Pollution Status of Industrial Sites in Mandi Bahauddin District
Legend
Total Industrial Unit=36
Out of Boundary=04
Air Pollution (29)
Combined (3)
City Roads
Mandi Bahauddin
Prepared by: EPA GIS CELL
Reference Map:
N
Kharian
Dinga
Pind Dadan Khan
Malakwal
Mandi Bahauddin
Phalia
Rasulnagar
Kot Momin
Hafizabad
Sources: Esri, USGS, NOAA

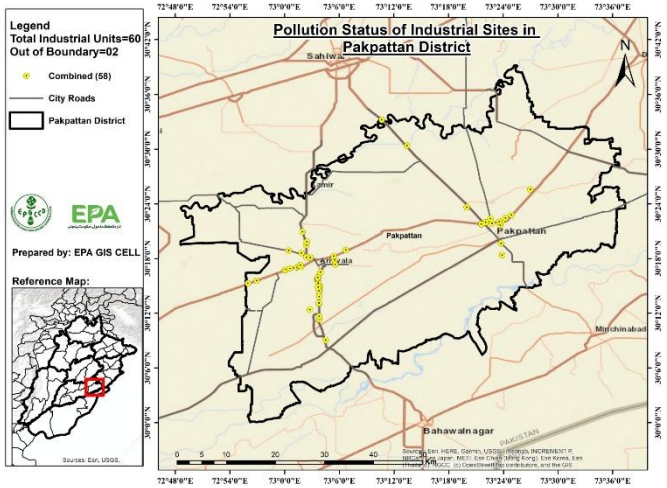

Pollution Status of Industrial Sites in Mianwali District
Legend
Total Industrial Unit=45
Air Pollution (18)
Water Pollution (20)
Combined (3)
Mianwali City Roads
Mianwali
Prepared by: EPA GIS CELL
Reference Map:
N
Sources: Esri, USGS, NOAA

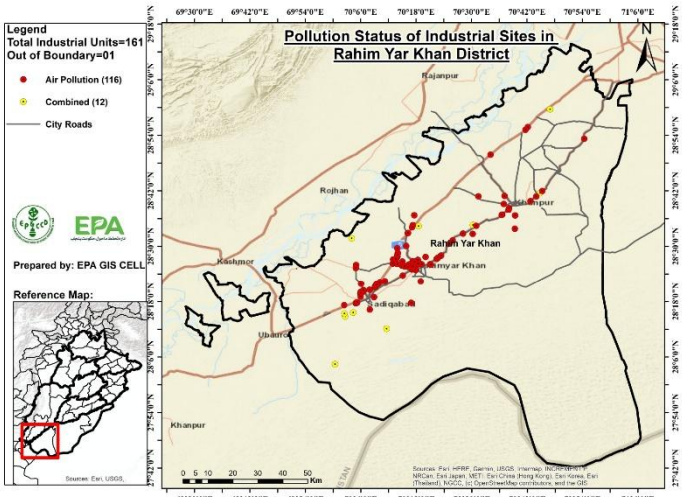

Pollution Status of Industrial Sites in Multan District
Legend
Total Industrial Units=412
Out of Boundary=01
Air Pollution (38)
Combined (342)
Water Pollution (29)
City Roads
MultanDistrict
Prepared by: EPA GIS CELL
Reference Map:
N
Kot Addu
Khanewal
Multan
Shujaabad
Dunyapur
Kahror Pakka
Lodhran
Bahawalpur
Sources: Esri, USGS,

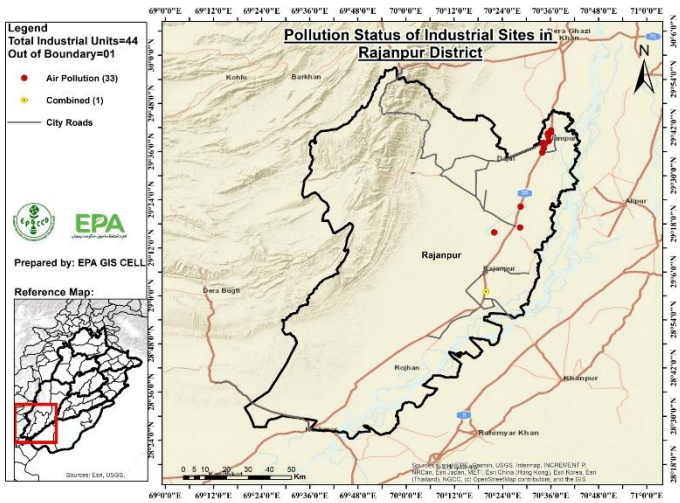

Pollution Status of Industrial Sites in Muzaffargarh District
Legend
Total Industrial Units=41
Out of Boundary=02
Air Pollution (26)
Combined (13)
City Roads
Muzaffargarh District
Prepared by: EPA GIS CELL
Reference Map:
N
Ahmadpur Sial
Dera Din Panah
Kot Addu
Khanewal
Multan
Dera Ghazi Khan
Muzaffargarh
Shujaabad
Dunyapur
Jampur
Dajal
Kahror
Lodhran
Bahawalpur
Rajanpur
Ahmadpur East
Sources: Esri, USGS,

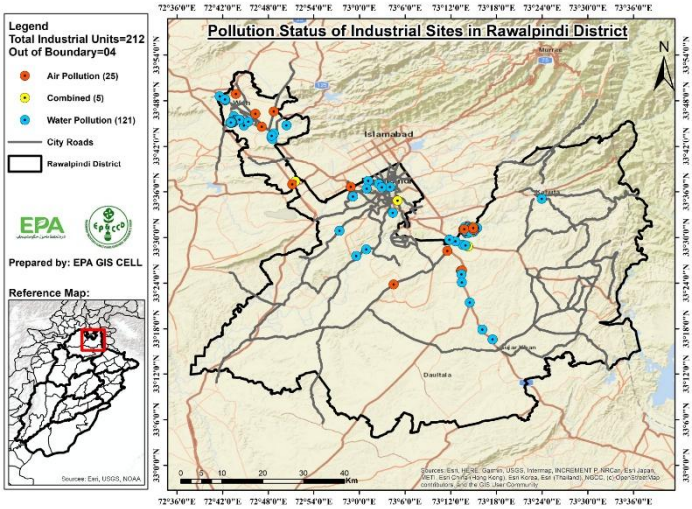

Pollution Status of Industrial Sites in Nankana Sahib District
Legend
Total Industrial Units=217
Out of Boundary=03
Air Pollution (6)
Combined (147)
Water Pollution (1)
City Roads
Nankana Sahib District
Prepared by: EPA GIS CELL
Reference Map:
Shekhupura
Sangla
Ghak Jhumra
Nankana Sahib
Khurianwala
Jaranwala
Sharaqpur
Hanjarwala
Ittanwala

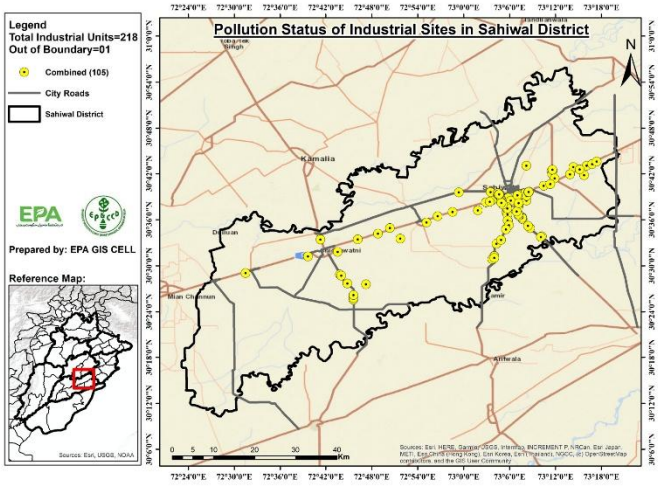

Pollution Status of Industrial Sites in Okara District
Legend
Total Industrial Units=117
Out of Boundary=06
Air Pollution (19)
Combined (91)
Water Pollution (1)
City Roads
Okara District
Prepared by: EPA GIS CELL
Reference Map:
Renala Khurd
Okara
Depalpur
Kangunpur
Pakpattan
Patika
Haveli
Pattoki

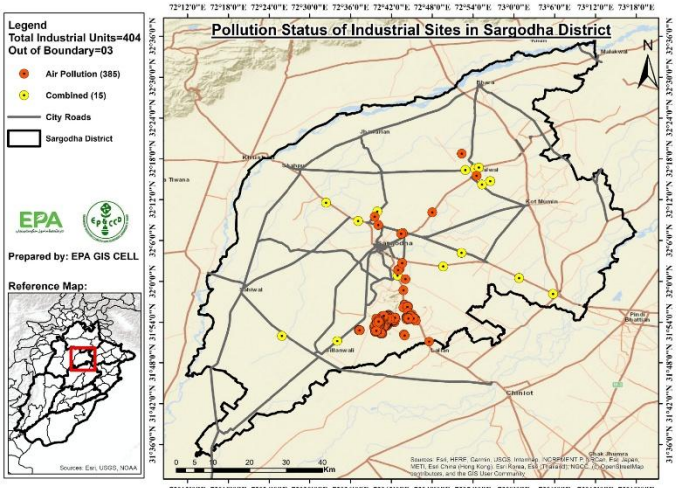

Pollution Status of Industrial Sites in Pakpattan District
Legend
Total Industrial Units=60
Out of Boundary=02
Combined (58)
City Roads
Pakpattan District
Prepared by: EPA GIS CELL
Reference Map:
Sahiwal
Pakpattan
Arifwala
Mirchinabad
Bahawalnagar

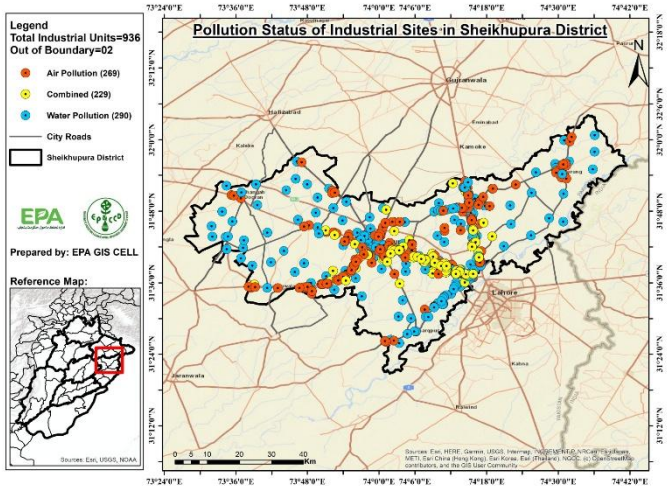

Pollution Status of Industrial Sites in Rahim Yar Khan District
Legend
Total Industrial Units=16
Out of Boundary=01
Air Pollution (116)
Combined (12)
City Roads
Prepared by: EPA GIS CELL
Reference Map:
Rajanpur
Rojhan
Kashmor
Ubauro
Khanpur
Rahim Yar Khan
Sadiqabad

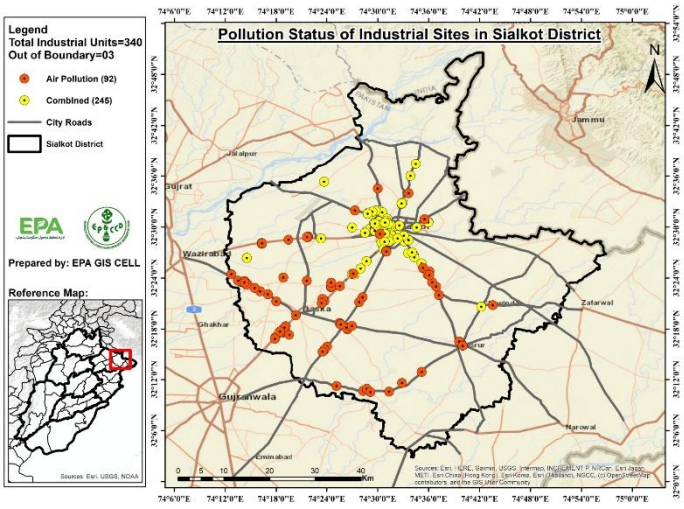

Pollution Status of Industrial Sites in Rajanpur District
Legend
Total Industrial Units=44
Out of Boundary=01
Air Pollution (33)
Combined (1)
City Roads
Prepared by: EPA GIS CELL
Reference Map:
Kohlu
Barkhan
Dera Ghazi Khan
Dera Bugti
Rajanpur
Jampur
Jatoi
Rojhan
Khanpur
Rahimyar Khan

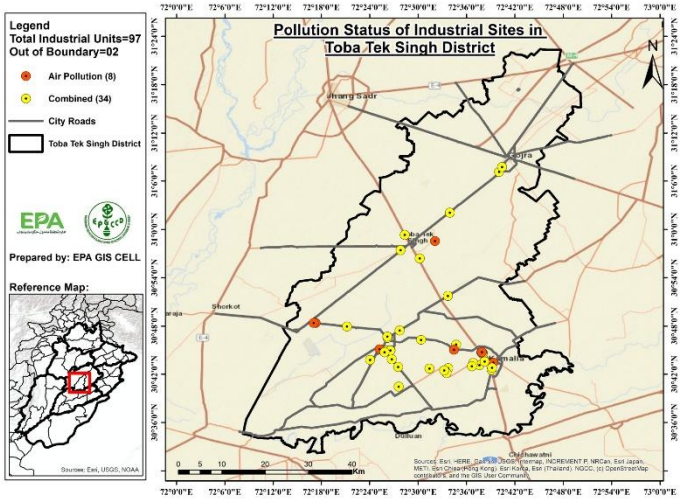

Pollution Status of Industrial Sites in Rawalpindi District
Legend
Total Industrial Units=212
Out of Boundary=04
Air Pollution (25)
Combined (5)
Water Pollution (121)
City Roads
Rawalpindi District
Prepared by: EPA GIS CELL
Reference Map:
Islamabad
Murree
Taxila
Attock
Daultala

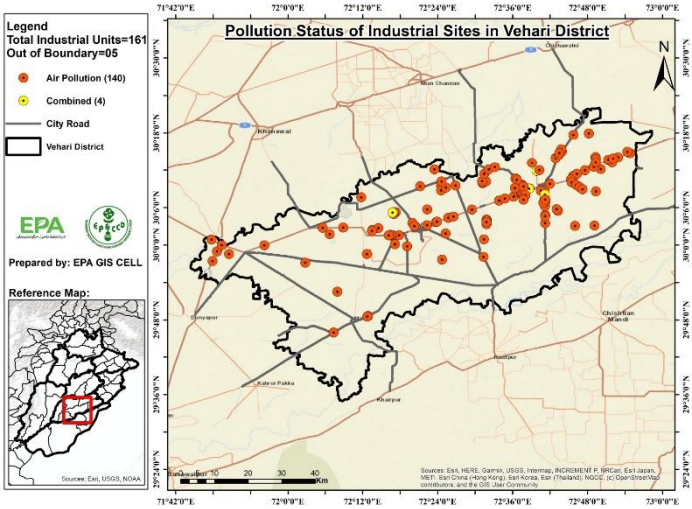

Pollution Status of Industrial Sites in Sahiwal District
Legend
Total Industrial Units=218
Out of Boundary=01
Combined (105)
City Roads
Sahiwal District
Prepared by: EPA GIS CELL
Reference Map:
Kamalia
Dunyan
Chichawatni
Mian Channun
Arifwala
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Sources: Esri, USGS, NOAA


Pollution Status of Industrial Sites in Sargodha District
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:
Bhera
Malwal
Kot Momin
Sillanwali
Shahpur
Sources: Esri, USGS, NOAA


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:
Gujranwala
Kamoke
Ferozwala
Sharaqpur
Kala Shah Kaku
Sources: Esri, USGS, NOAA


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
Zafarwal
Ghakhar
Gujranwala
Narowal
Sources: Esri, USGS, NOAA


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:
Jhang Sadr
Gojra
Toba Tek Singh
Shorkot
Kamalia
Chichawatni
Sources: Esri, USGS, NOAA


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:
Mian Channun
Mailsi
Burewala
Vehari
Chichawatni
Sources: Esri, USGS, NOAA

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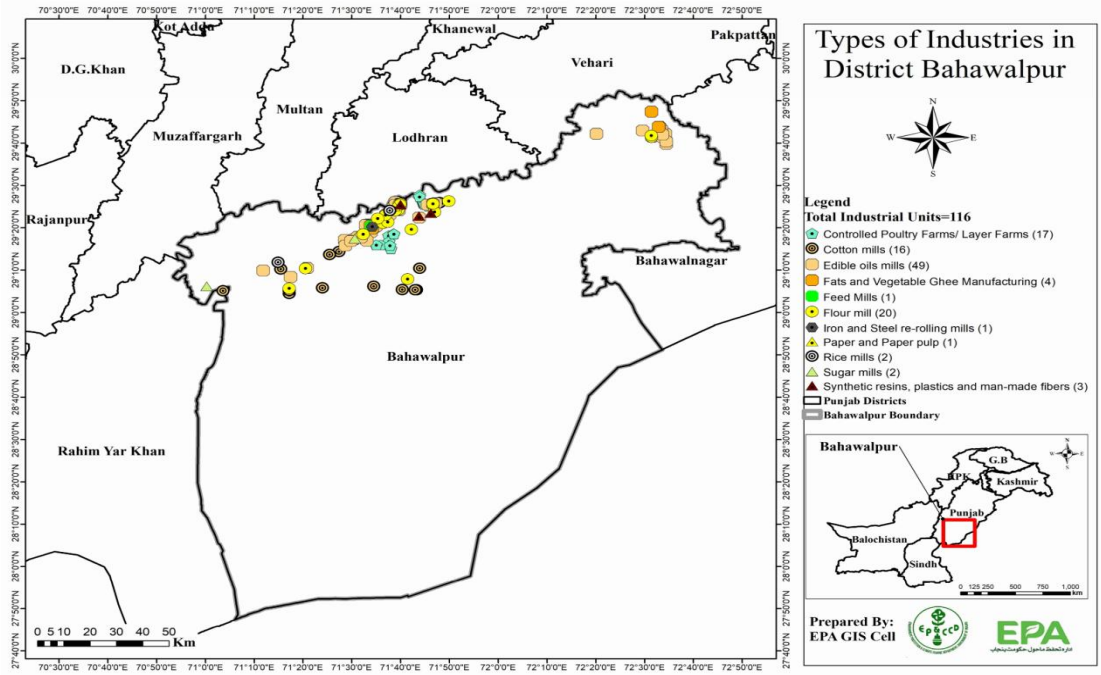
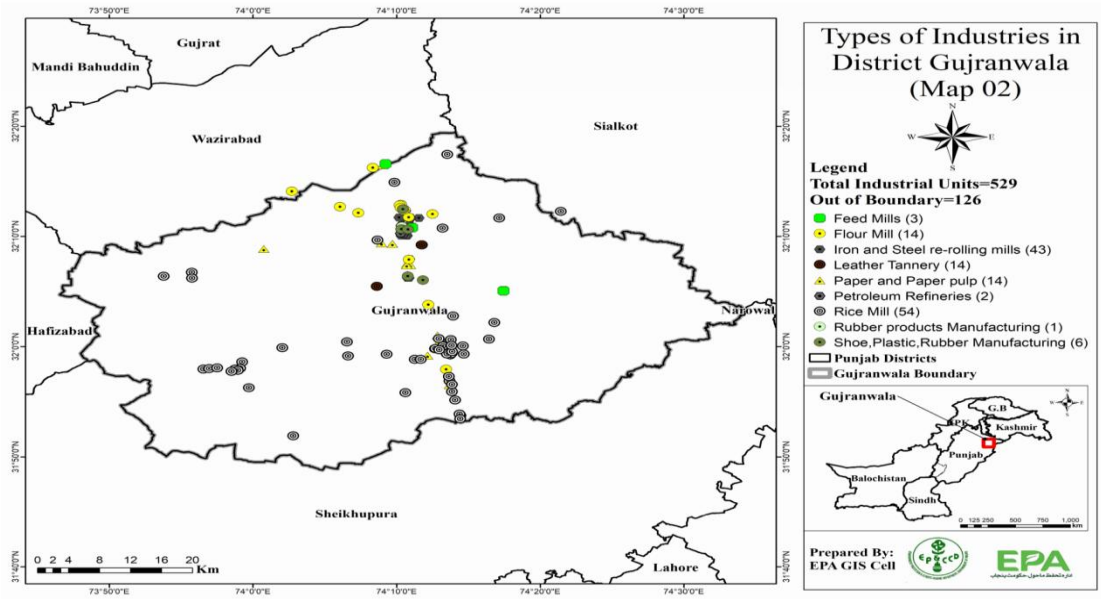
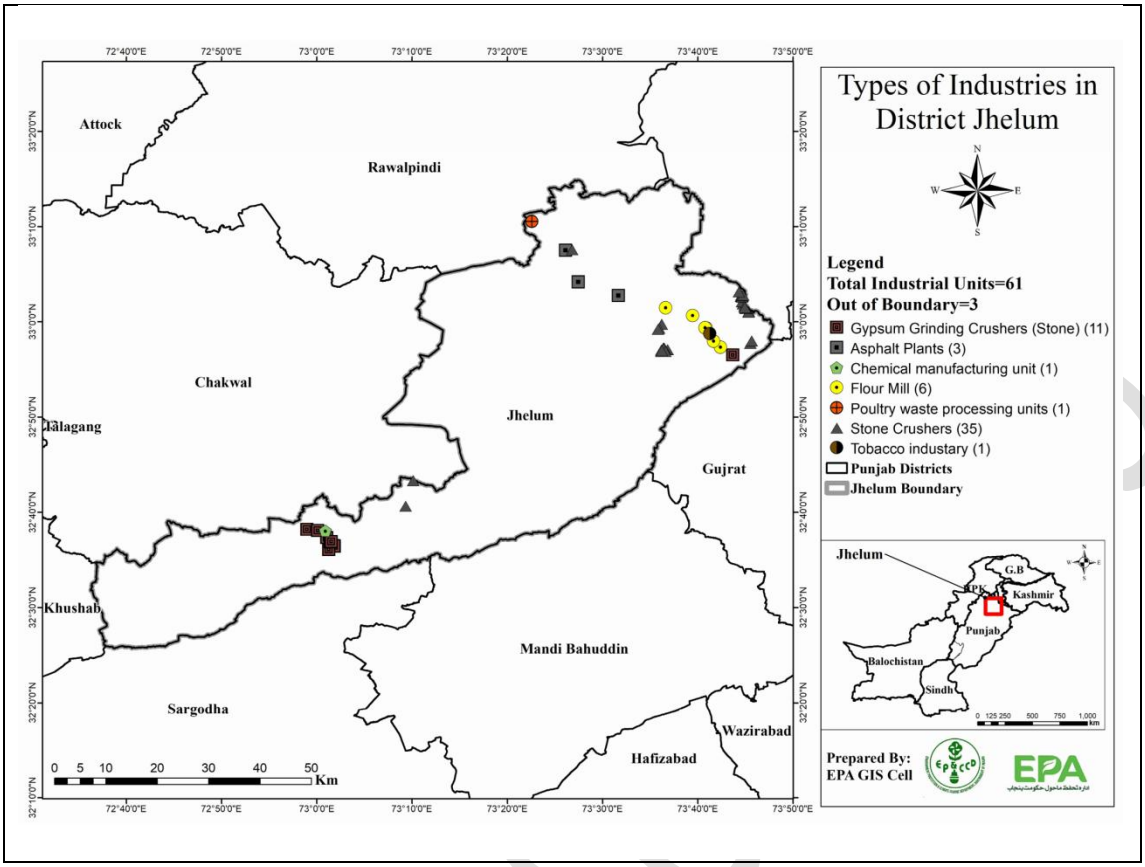
Annexure-II
Industry types map of Punjab






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

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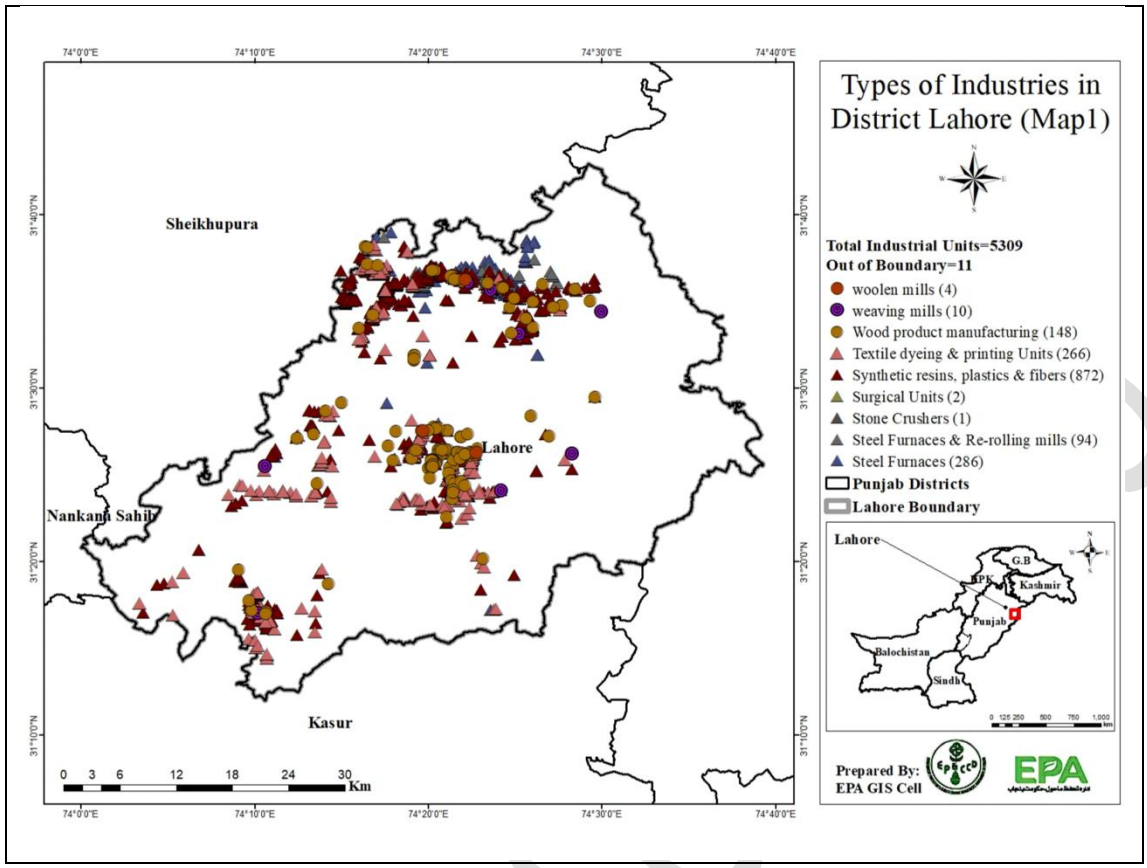
Types of Industries in District Lahore (Map1)
Total Industrial Units=5309
Out of Boundary=11
woolen mills (4)
weaving mills (10)
Wood product manufacturing (148)
Textile dyeing & printing Units (266)
Synthetic resins, plastics & fibers (872)
Surgical Units (2)
Stone Crushers (1)
Steel Furnaces & Re-rolling mills (94)
Steel Furnaces (286)
Punjab Districts
Lahore Boundary
Sheikhupura
Lahore
Nankana Sahib
Kasur
0 3 6 12 18 24 30 Km
Lahore
G.B
KPK
Kashmir
Punjab
Balochistan
Sindh
Prepared By:
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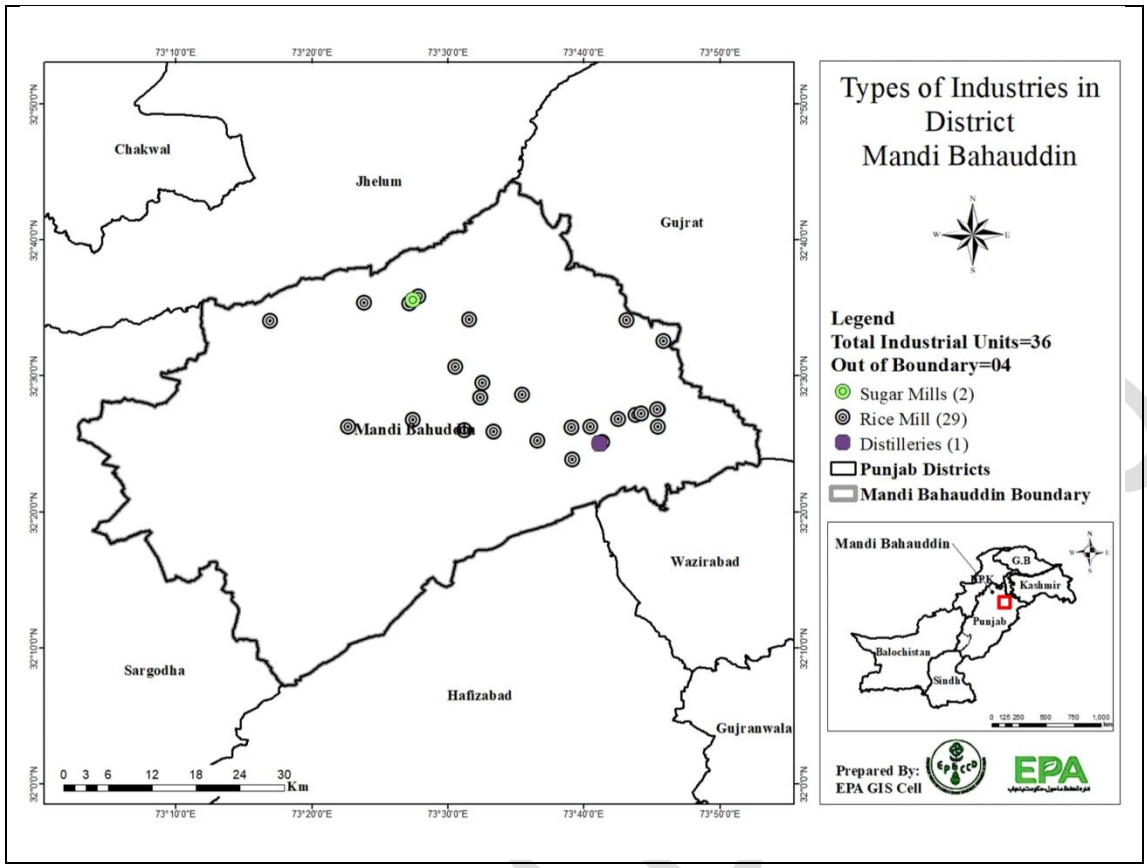
Types of Industries in District Mandi Bahauddin
Legend
Total Industrial Units=36
Out of Boundary=04
Sugar Mills (2)
Rice Mill (29)
Distilleries (1)
Punjab Districts
Mandi Bahauddin Boundary
Chakwal
Jhelum
Gujrat
Mandi Bahuddin
Wazirabad
Sargodha
Hafizabad
Gujranwala
Km
Mandi Bahauddin
G.B
AJK
Kashmir
Punjab
Balochistan
Sindh
Prepared By:
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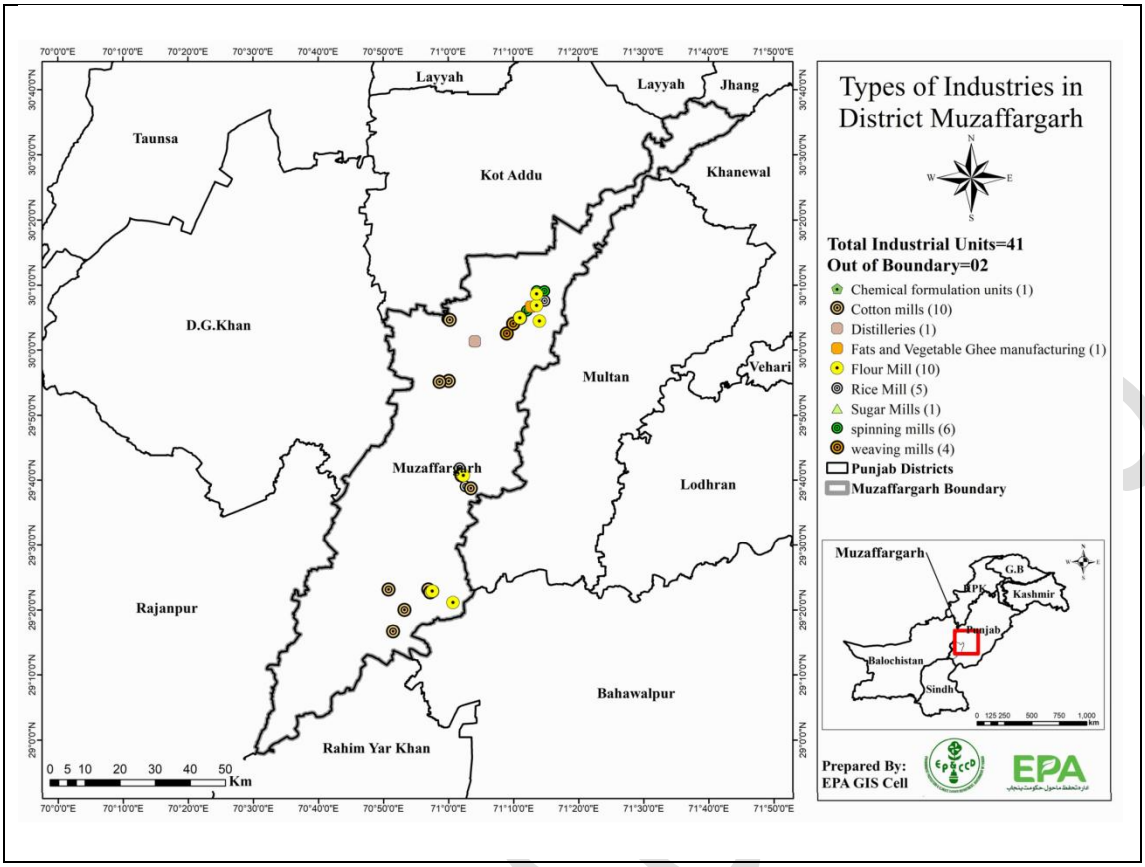
Types of Industries in District Muzaffargarh
Total Industrial Units=41
Out of Boundary=02
Chemical formulation units (1)
Cotton mills (10)
Distilleries (1)
Fats and Vegetable Ghee manufacturing (1)
Flour Mill (10)
Rice Mill (5)
Sugar Mills (1)
spinning mills (6)
weaving mills (4)
Punjab Districts
Muzaffargarh 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
AJK
Kashmir
Punjab
Balochistan
Sindh
Prepared By:
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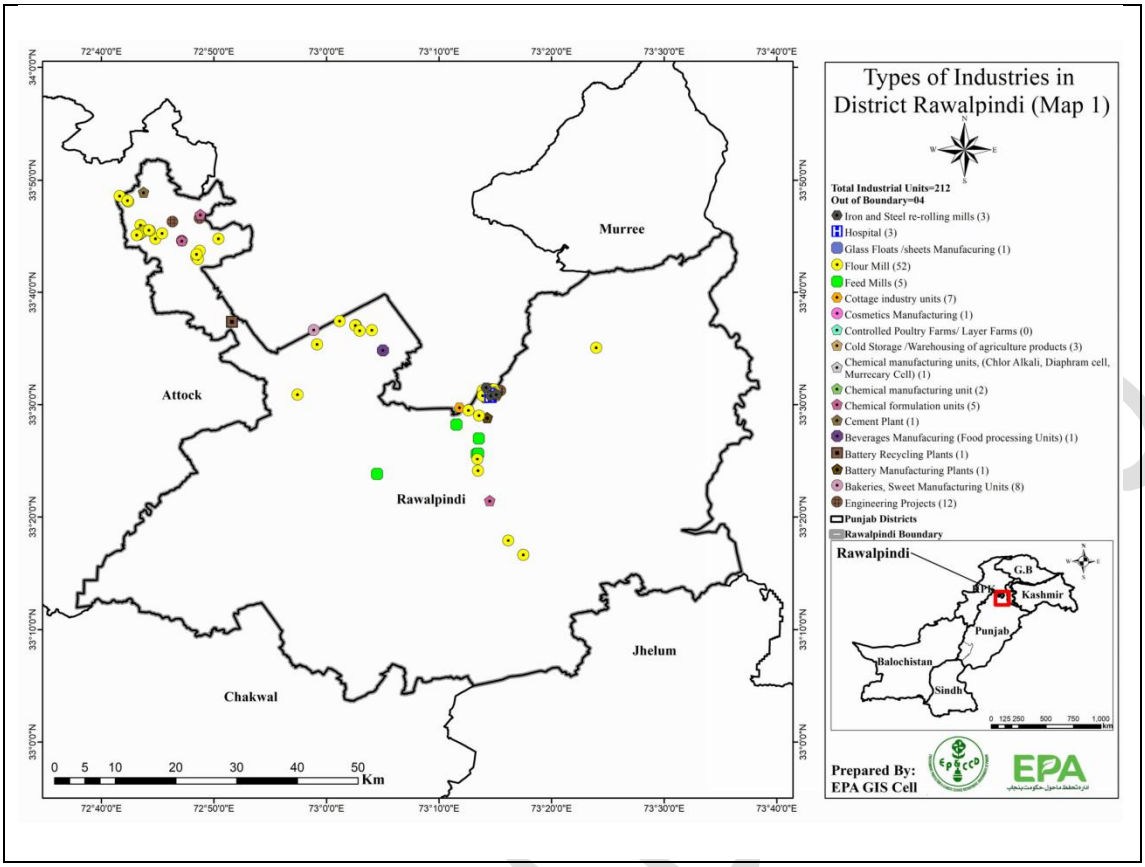
Types of Industries in District Rawalpindi (Map 1)
Total Industrial Units=212
Out of Boundary=04
Iron and Steel re-rolling mills (3)
Hospital (3)
Glass Floats /sheets Manufacuring (1)
Flour Mill (52)
Feed Mills (5)
Cottage industry units (7)
Cosmetics Manufacturing (1)
Controlled Poultry Farms/ Layer 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
Murree
Attock
Rawalpindi
Jhelum
Chakwal
0 5 10 20 30 40 50 Km
Prepared By:
EPA GIS Cell
EPA

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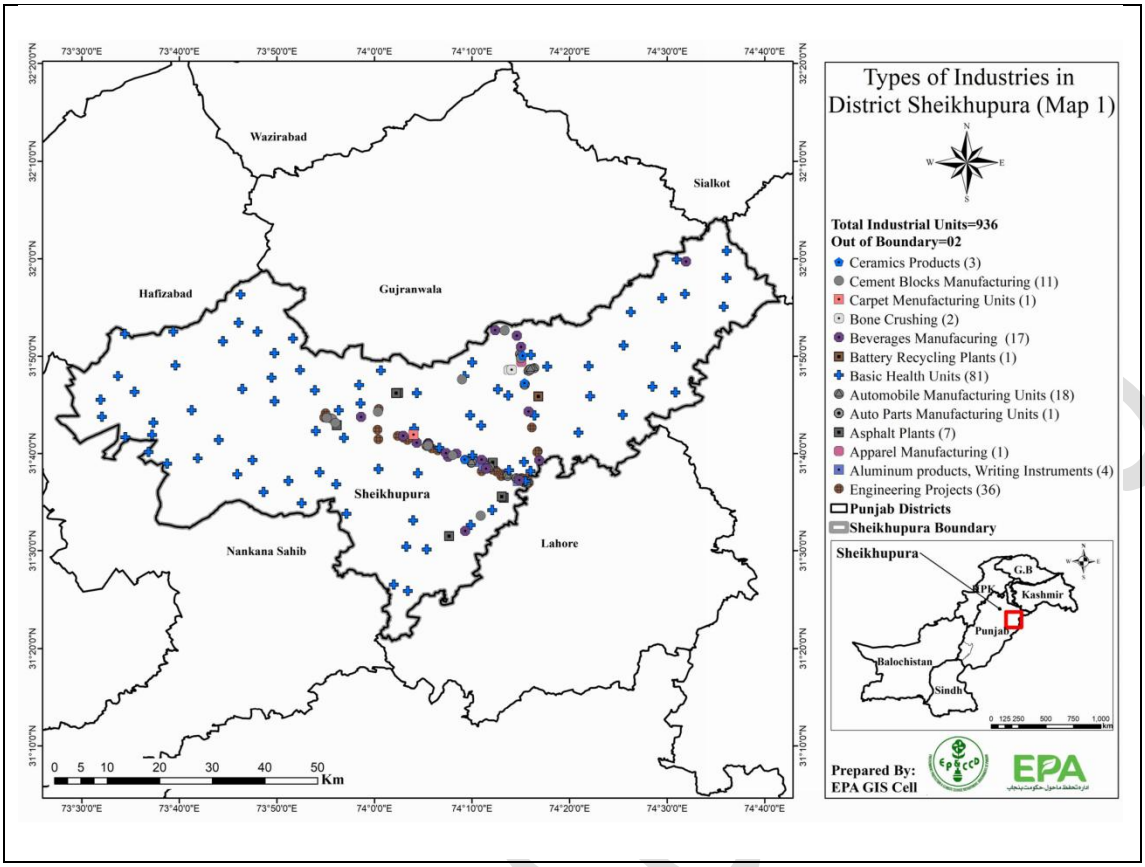

Annexure –III

Design and SOPs of Suction Hood

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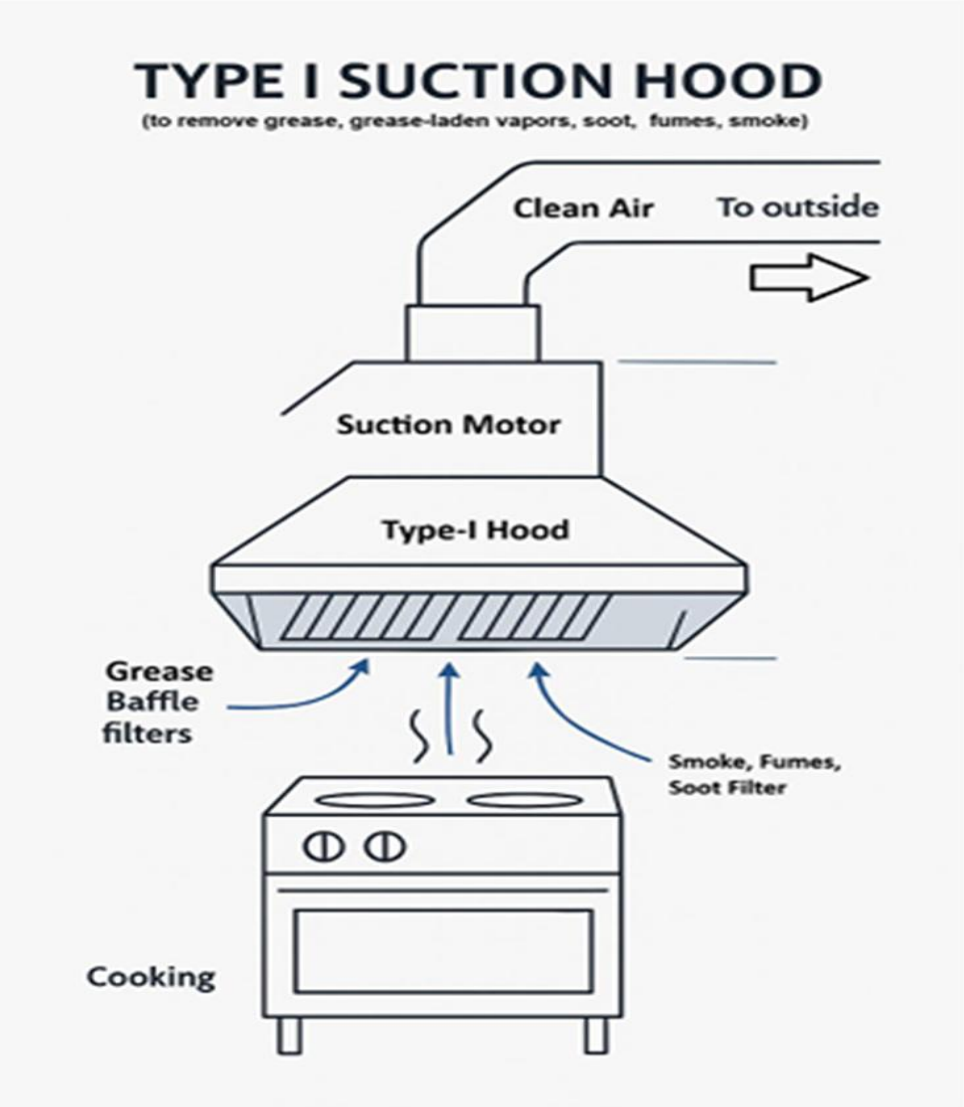
(Reference schematic of Suction Hood for Commercial Kitchens)



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	Utilization 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.

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1687	Solarization 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	Solarization 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	Solarization of Public Sector Buildings in Punjab	Solar Energy Expansion	Ongoing	Utilization 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.

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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	Solarization of Punjab Governor House	Solar Energy	New	Demonstrates renewable energy adoption in government buildings and reduces carbon emissions
1702	Solarization of Government Higher Secondary Schools	Solar Energy in Education Sector	New	Reduces electricity costs and emissions while promoting environmental awareness among students
1703	Solarization 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	New	Supports development of large-scale renewable energy systems and promotes low-carbon energy infrastructure

DRAFT SOE 2025

		Energy Program		
1705	Solarization 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	Solarization 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	Solarization 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.

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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
3	**2955**	Construction of Environment Complex in Gujranwala (DLI-1 PGDP)	321.897	271.897
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

DRAFT SOE 2025

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

DRAFT JUNE 2025

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**

DRAFT SOE 2025

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	30.16544152223379, 71.49690014417796	Operational

DRAFT SOER-25

				Engineering & Technology Multan		
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

DRAFT SOE 2025

24			1	UET	31.57763400 , 74.35739500	Operational
25			1	FMDRC	31.53573300 , 74.43563300	Operational
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

DRAFT SOE 2025

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

DRAFT SOE 2025

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

DRAFT SOE 2025

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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