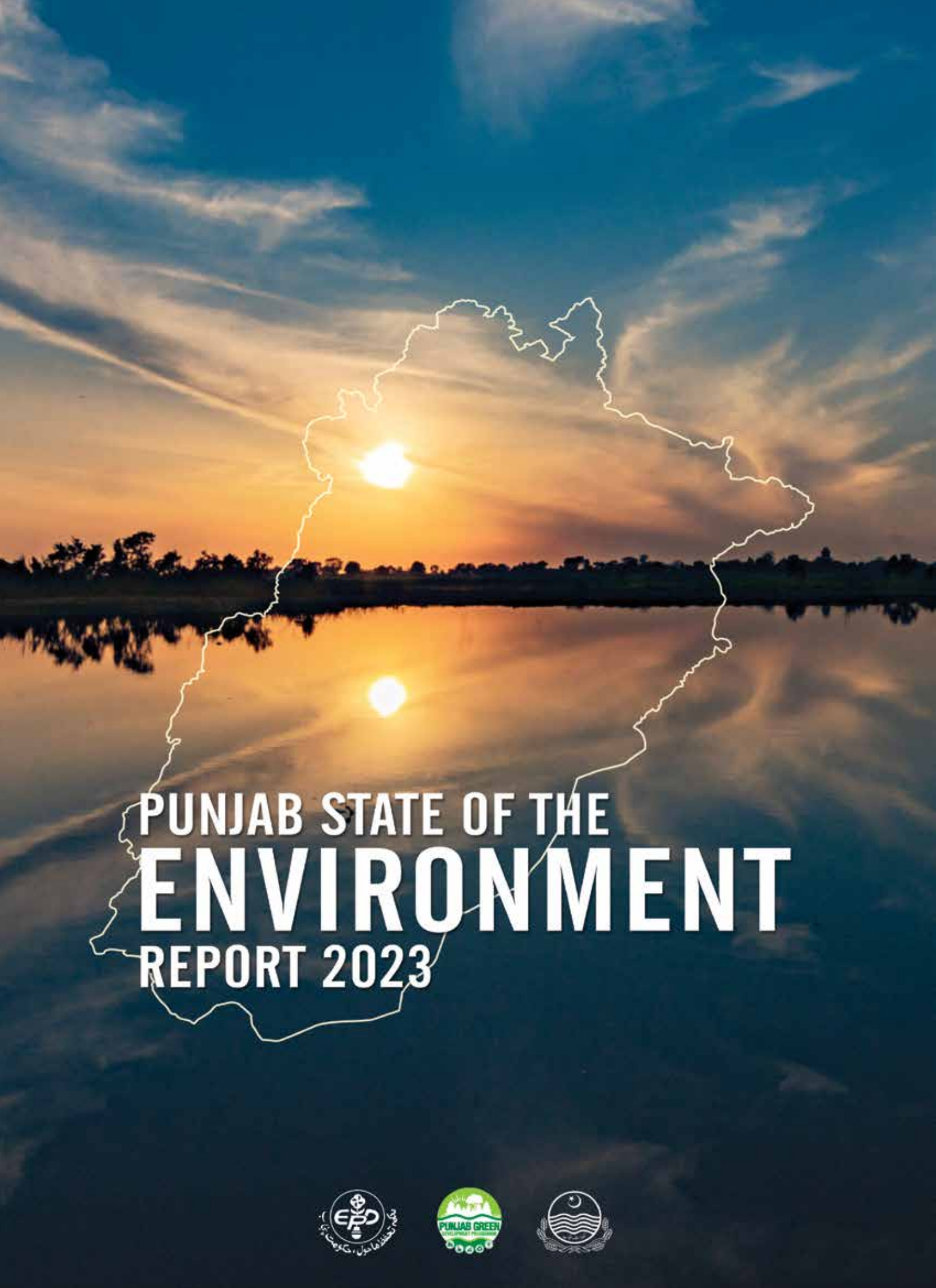

PUNJAB STATE OF THE ENVIRONMENT REPORT 2023

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DISCLAIMER

This "Punjab State of Environment Report, 2023" is based on limited primary data. A significant portion of the information is based on secondary sources. Every effort has been made to ensure accuracy, however, errors and omissions are expected.

MESSAGE
SECRETARY ENVIRONMENT

The Environment Protection and Climate Change Department, Government of the Punjab hereby presents the publication of the second Punjab's State of the Environment Report (SOE 2023), a regulatory requirement under the Punjab Environmental Protection Act, 1997. The report provides a broad evidence-based appraisal of our natural environment and highlights key challenges, efforts and achievements therein. It also advocates concerted management endeavors for environmental conservation and sustainable development in the province.

Punjab faces significant environmental problems, including resource scarcity, pollution and climate change. These challenges pose a complex web of socio-economic and ecological threats, impacting public health, food security, and mobility. SOE 2023 leverages extant environmental data to provide an assessment of key environmental concerns and calls attention to areas requiring further actions. This report is a testament to our commitment towards transparency and accountability in safeguarding the natural environment of the province.

The past few years have witnessed a surge of commendable efforts from our leadership, institutions, businesses, and communities in tackling environmental issues like groundwater depletion, burning of crop residues, contaminated surface water bodies, poor hygiene and sanitation and mushrooming plastic pollution. Our department stands shoulder-to-shoulder in these endeavors: we are actively implementing multi-sectoral policy changes, establishing robust regulations to control air and water pollution, and promoting sustainable resource management practices. These initiatives encompass revising environmental quality standards, implementing real-time air and water quality monitoring, developing sustainable infrastructure projects, and mandating environmental considerations in all planning and development efforts.

I urge everyone to study this report, reflect on its findings, and actively participate in building a cleaner, more resilient, and sustainable future. It's only through collective action and continual improvement that we can overcome these issues and ensure a healthy environment for our present and future generations. I firmly believe that, together, we can weave a flourishing future for Punjab's environment – a legacy of sustainability and prosperity for generations to come.

Raja Jahangir Anwar
Secretary to the Government of the Punjab
Environment Protection and Climate Change Department

MESSAGE
EDITOR-IN-CHIEF

It brings me immense pleasure to introduce the Second Punjab's State of the Environment (SOE) Report, 2023. This report is the culmination of meticulous research, data analysis, and consultations with numerous stakeholders.

SOE 2023 offers a panoramic view of Punjab's environmental landscape, delving deep into critical areas such as air, water and soil quality, climate change and the effectiveness of waste management systems. It also sheds light on governmental and sectoral responses to these pressing environmental challenges.

At the heart of this report lies a commitment to transparency, accountability, and the promotion of environmental stewardship. From the escalating threats of pollution and climate change to the urgent call for sustainable resource management, SOE 2023 serves as a rallying cry for action.

The evaluations within this report provide invaluable insights for decision-makers and policymakers across the major sectors. By closely examining advancements within their specific domains and integrating these into relevant policies, they can play a key role in tackling the environmental hurdles confronting the province. Through these actions, Punjab can progress towards a future that is environmentally sustainable and fosters a higher quality of life for its residents.

Formulation of this report was not an easy task; it entailed strenuous efforts of multiple professionals to produce this evidence-based and insightful piece of work. I would like to extend my deep gratitude to all those who contributed towards the creation of this report – from researchers, data/information collaborators, analysts and reviewers to policymakers and stakeholders. Their dedication and expertise have been instrumental in shaping the narrative of environmental progress in Punjab.

Samia Saleem
Project Director
Strategic Planning and Implementation Unit, Punjab Green Development Program
Environment Protection and Climate Change Department
Government of the Punjab

ACKNOWLEDGEMENTS

Environment Protection and Climate Change Department, Government of The Punjab, is honored to present the Punjab's second State of the Environment Report for CY - 2023. This report stands as a product of the collaborative efforts by so many contributors, whose valued input in data collection, analysis, and compilation in creating a report of such depth and breadth is highly acknowledgeable.

This report stands as a testament to the exemplary leadership of Ms. Samia Saleem, Project Director, Punjab Green Development Program, Strategic Planning and Implementation Unit (SP&IU), EPCCD Punjab. Under her convenorship, a committee comprising Dr. Anber Raheel (Director, Environmental Policy and Planning), Dr. Amir Farooq (Director Planning and Coordination), Dr. Nusrat Naz (Director Monitoring, Labs and Implementation), Dr. Farooq Alam (Deputy Director, Labs), Dr. Asim Rehman (Deputy Director, Environmental Planning Expert), Ms. Azmat Naz (Deputy Director Information and Services), Dr. Shazia Pervaiz (Deputy Director, Technical) and Ms. Ahad Khan (Deputy Program Coordinator-PGDP, Program Coordination Unit, Planning and Development Board), provided invaluable oversight throughout the report formulation process.

We are highly grateful to the Mr. Imran Hamid, Director General, Environmental Protection Agency, Punjab for facilitating the provision of requisite data for the report compilation. We also express our sincere appreciation to EPA field officers and Laboratory staff for their invaluable contributions in the report.

The dedicated support provided by the provincial and federal government entities, including the Pakistan Meteorological Department, Pakistan Space and Upper Atmospheric Commission (SUPARCO) Agriculture Department, Irrigation Department, Local Government and Community Development Department, Forest, Wildlife and Fisheries Department, Transport Department, Livestock and Dairy Development Department, Housing, Urban Development and Public Health Engineering Department, Energy Department, Excise, Taxation and Narcotics Control Department, Primary and Secondary Healthcare Department, Punjab Bureau of Statistics, Provincial Disaster Management Authority (Punjab Water and Sanitation Agency (Lahore, Gujranwala, Faisalabad and Rawalpindi) and others, is highly commendable in providing crucial information and data for the purpose of this report.

We are also thankful to Dr. Sana Bashir, Deputy Secretary (Technical), EPCCD Punjab for her assistance to coordinate with relevant government counterparts.

Special thanks are reserved for Sajid Riaz (Deputy Director, Program Specialist-I) and Dr. Wajid Ijaz, Deputy Director (Monitoring and Evaluation) for providing useful information for the compilation of this report. We are grateful to Ahmad Sajjad (Deputy Director, Administration) and Dr. Hassan Siddique (Deputy Director, Communication Specialist) for arranging logistics and communication activity during public hearings. We appreciate Mr. Shakir Abbas (Assistant Director, GIS) for developing the online portal, streamlining data collection from EPA's field offices. We further acknowledge the invaluable assistance provided by the Hafiz Muhammad Umer (Computer Operator) throughout the process.

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ADP	Annual Development Program
APHA	American Public Health Association
AQI	Air Quality Index
AQMS	Air Quality Monitoring Station
BOD	Biological Oxygen Demand
C&W	Communication and Works Department
CETP	Combined Effluent Treatment Plant
COD	Chemical Oxygen Demand
DLI	Disbursement Linked Indicator
DPSIR	Drivers, Pressures, State, Impacts and Response
EPA	Environmental Protection Agency
EPCCD	Environment Protection and Climate Change Department
FAO	The Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	Green House Gases
GIS	Geographic Information System
GoPb	Government of the Punjab
GRM	Grievance Redressal Mechanism
LG&CD	Local Government and Community Development
MAF	Million Acre Feet
MICS	Multiple Indicator Cluster Survey
OOSC	Out of School Children
OPD	Outpatient (Outdoor) Department
P&D	Planning and Development Department
PCRWR	Pakistan Council of Research in Water Resources
PDMA	Provincial Disaster Management Authority
PEPA	Pakistan Environmental Protection Act (PEPA), 1997
PEQS	Punjab Environmental Quality Standards
PGDP	Punjab Green Development Program
PITB	Punjab Information Technology Board
PLI	Pollution Load Index
PMD	Pakistan Meteorological Department
RSC	Residual Sodium Carbonate
SAR	Sodium Adsorption Ratio

SP&IU	Strategic Planning & Implementation Unit
SUPARCO	Space and Upper Atmosphere Research Commission
USEPA	United States Environmental Protection Agency
VU	Vulnerable
WASA	Water and Sanitation Agency
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WQI	Water Quality Index
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

The Punjab State of the Environment (SOE) Report, 2023 is the second report in the series, with the first one reporting upon the state of the environment for the year 2022. Current report provides an insight on the prevailing environmental conditions, in respect of air, water, soil, climate change, wastewater and solid waste management in Punjab, with updated datasets from primary and secondary sources. The report also covers the remedial measures taken by the EPCCD Punjab and other relevant departments, along with a well thought out action plan for environmental protection and conservation.

What's New in the SOE Report 2023

SOE Report 2023 has been improved in light of comments and feedback from concerned stakeholders as well as the lessons learnt and gaps identified in the previous SOE Report. The sectors untouched or briefly discussed in SOE Report 2022 have also been incorporated and elaborated in the current report, which inter- alia include the energy, industry, mines and minerals, forest cover change, agriculture and livestock, Water, Sanitation & Hygiene (WASH) and social aspects. A new chapter on 'climate change' has been included in this report. In addition to providing a candid picture of state and trends of environment, this report links the state of environment with the health impacts.

Punjab at a Glance

Punjab, the most populous province in Pakistan, has a total population of 127.6 million. Its urban population has grown to 40.70%, up from 31.3% in 1998. The province is Pakistan's economic hub, experiencing employment growth rates higher than the national average and leading in human development indicators and prosperity.

Approximately 56% of Punjab's total geographical area is cultivated due to rich, fertile alluvial soils and an extensive irrigation system. Punjab contributes 39% (17,026 MW) of the country's total energy mix and is progressing rapidly towards solar energy, hosting all major solar power plants.

The manufacturing sector contributes about 20% to the national economic output, with 32,258 manufacturing industries mainly concentrated in large cities like Lahore, Gujranwala, Faisalabad, and others. Significant mineral production includes argillaceous clay, coal, limestone, rock salt, and silica sand.

Livestock plays a crucial role in Punjab's rural economy, contributing 14.36% to the National GDP and 62.68% to the Agricultural GDP. The province boasts a rich diversity of flora and fauna, hosting species of high conservation importance within its 350 protected forests, 5 National Parks, 36 wildlife sanctuaries, and 23 Game Reserves.

98% of Punjab's population has access to improved drinking water sources, and 80.1% use improved sanitation facilities. Urban areas generally have higher access rates (92.8%) compared to rural areas (72.8%). Rapid urbanization and population growth necessitate improved services in water supply, sewerage, drinking water availability, solid waste management, and sanitation.

Air Quality

The Environmental Protection Agency (EPA) of Punjab conducted one-day ambient air quality monitoring in 9 Divisional Headquarters (HQs) during August 17-30, 2023. The report reveals that all divisional HQs had $PM_{2.5}$ concentrations exceeding the PEQS value. Air Quality Monitoring Stations (AQMS) in Lahore recorded the highest AQI-$PM_{2.5}$ value in January, with the lowest value

observed in May and September. Compared to 2022, Lahore experienced more days with good air quality and fewer unhealthy days in 2023. However, urban residents endured 156 days with poor to hazardous air quality. Overall air quality in Lahore was rated as "Poor" and for other divisional HQs it was rated as 'Moderate'. Satellite-based monitoring by SUPARCO identified major air pollution hotspots in and around districts including Lahore, Kasur, Sheikhupura, Nankana Sahib, Faisalabad, Okara, Gujranwala, and Multan. A comparison of CO, NO_2, SO_2 and Absorbing Aerosol Index with regard to annual average (2023) and 5 years averaged (2018-2022) has also been given.

Vehicle inspections conducted in 2023 showed that approximately 68% of vehicles passed safety inspection fitness tests. Punjab's government initiated measures including enhanced air quality monitoring, strict pollution control enforcement, tree planting, electric bus introduction, climate-smart agriculture, water management, and net-zero energy building construction to combat air pollution.

Water Quality

Water insecurity and pollution in Punjab are pressing issues driven by population growth, urbanization, and industrialization. The Indus Basin Irrigation System, the world's largest, supports 18 million hectares of land. However, per capita water availability has drastically decreased from over 5000 m^3 in 1951 to 1100 m^3 in 2005, projected to decline further to 800 m^3 by 2025.

EPA divisional labs monitored surface water quality in Lahore, Sheikhupura, and Faisalabad, rating rivers and canals as 'Moderate' and drains as 'Very Poor'. Groundwater quality for irrigation was suitable in only 58% of samples. WASA distribution systems rated 'Moderate', with biological contamination. Consumer-end drinking water quality varied geographically. For instance, the urban filtered water rated 'Good', except in DG Kahn where arsenic was reported.

Most industrial units were non-compliant with PEQS, with rates of non-compliance at 95.7% for BOD, 94.4% for COD, 91% for sulfide, 84.4% for temperature, and 81.7% for TSS. Main polluters include the leather and tanning industry, textile mills, sugar mills, protein factories, and paper and board mills. Efficient water management, recycling, and conservation are crucial for addressing these challenges.

Soil Quality

Soil quality assessments were conducted in nine divisional HQs of Punjab, sampling the soil from agricultural, Industrial and urban areas as well as the land irrigated will industrial effluents. Results showed predominantly neutral pH levels, except for slightly alkaline soils in DG Khan. Irrigation with industrial effluents led to soil alkalinity in Multan. Electrical conductivity values indicated non-saline conditions. Rawalpindi exhibited strongly sodic agricultural soil, while Lahore and Bahawalpur had sodic soils in areas irrigated with industrial effluents. Punjab's soils generally showed fertility with adequate nitrogen, potassium, and iron levels, though phosphorus levels were marginal. Zinc concentrations were satisfactory.

Pollution Load Index indicated moderately polluted soil types across all divisions, with Rawalpindi and Multan showing the highest values (2.3). Regular soil quality monitoring and sustainable agriculture practices are vital for productivity and soil health. The Punjab Agriculture Department is actively engaged in research, enhanced soil monitoring, and education initiatives, including GIS-Remote Sensing technology utilization and addressing pesticide residue concerns.

Climate Change

Agriculture and energy are the main contributors to the total national greenhouse gas (GHG) emissions, accounting to 45.6% and 44.7% of the share, respectively. Punjab has yet to

develop a comprehensive greenhouse gas (GHG) emission inventory, however, agriculture, energy, transport and industrial sectors are recognized as the known contributing sectors for GHGs. Despite relatively cooler summers during 2023, the overall temperature in Punjab was reported 0.18°C above normal, with the highest recorded as 46.6°C in June. Among other loss and damages associated with the climate change, urban flooding in Punjab affected several districts during August-September 2023, damaging 467 villages/basti/mozas, almost 24,000 homes, and 545,270 acres of farmed land. Government of the Punjab is taking significant steps for climate change mitigation, adaptation, resilience, and finance.

Environmental Performance of Wastewater Treatment Facilities and Solid Waste Management Facilities

In Punjab, there are 434 industrial wastewater treatment plants, categorized into primary, secondary, and tertiary facilities. Their limited number compromises aquatic ecosystems and trade opportunities. Performance assessments revealed textile, sugar, and thermal power industries showing very poor performance.

Municipal Solid Waste (MSW) generation ranges from 115 tons/day in DG Khan to 5000 tons/day in Lahore. MSW generation rates are higher in large metropolises due to high waste production and rapid population growth. Leachate from landfills showed higher BOD, COD, and TSS concentrations than prescribed limits. Ambient air monitoring at landfill sites revealed suspended particulate matter and PM2.5 concentrations exceeding limits.

Analysis of incineration facility ash revealed high unburnt carbon percentages and lead, chromium, and copper detection in some samples. Effective solid waste management requires additional technical and financial resources, integrated management practices, and strengthened policies.

Measures Taken to Control Environmental Pollution

In 2023, EPD Punjab significantly improved pollution control and environmental protection services, integrating business laws related to climate change. The EPCCD Green Building, Punjab's first sustainable office building, exemplifies sustainable site development, water conservation, energy efficiency, green material compliance, and improved indoor environmental quality.

The Punjab Clean Air Policy and Smog Prevention and Control Rules, notified by EPA Punjab in April and June 2023 respectively.

Thirty AQMS are planned to be installed in Punjab. Fifteen Water Quality Monitoring Stations will be installed at principal water bodies, overseen by foreign consulting firms.

In 2023, EPA conducted 125 stack emissions inspections and 1000 industrial effluent examinations, sealing 5970 air-polluting industrial sources and imposing fines totaling PKR 467 million for violations. Dengue inspections resulted in source removals and legal actions, while hospital waste management was enhanced with inspections and confiscations.

EPA Punjab envisions strengthened environmental governance through stakeholder collaborations and institutional, policy, monitoring, and regulatory improvements.

Environmental Complaints

EPCCD Punjab actively addresses environmental complaints through a formalized Grievance Redressal Mechanism (GRM) that operates through an efficient, responsive and accessible complaint handling system. Complaints pertaining to various environmental aspects, such as air pollution, noise pollution and improper waste management, etc., can be filed through a range of channels, including in-person visits to offices such as the Chief Minister's Office, Chief Secretary's Office, and

relevant district authorities, as well as online platforms like the Prime Minister's Delivery Unit and Chief Secretary's complaint cell. Additionally, complaints can be submitted by mail or post directly to the concerned office. Upon receiving a complaint, the process of screening and assessment begins to determine the required action. The nature of action may vary depending on the type of complaint, ranging from filing FIRs to sealing units. In 2023, a total of 908 complaints were received throughout the province, with the highest number of complaints originating from Faisalabad. Most of these complaints were related to air pollution, followed by noise pollution and others. Out of the 908 registered complaints, 552 were successfully resolved, 83 units were sealed, and 42 FIRs were filed due to non-compliance with the Punjab Environmental Protection Act, 1997.

Environmental Action Plan

The Environmental Action Plan is a strategic document detailing specific objectives, actions, and initiatives aimed at tackling environmental challenges and promoting sustainable development. Its goal is to alleviate the adverse environmental effects conserve natural resources, and promote sustainable development. The State of Environment Report (2022) introduced an Environmental Action Plan with 11 interventions and 71 sub-interventions, fixing responsibilities and timelines among provincial government departments. It identified, short-term (CY-23), medium-term (CY-24), and long-term (CY-25) measures required to be taken by government departments In CY-23, significant achievements were made in the legislative, citizen engagement, industry regulation, vehicular emissions control, monitoring enhancements, sustainable green financing, fugitive dust mitigation, and remodelling environmental governance interventions. Environmental Action Plan 2023 is also a three years plan starting from CY-24 and ending at CY-26. Two new interventions (Air and Climate Change) have been added along with some new sub-interventions. A dashboard will be set-up for monitoring of Environmental Action Plan by EPCCD.

In the heart of Punjab, where the rivers flow,
Lies a land where emerald fields grow

Majestic mountains, kissed by dawn's light,
Guard the valleys with towering might

Birds of myriad hues dance in the sky,
Painting a canvas that mesmerizes the eye

Yet, beneath this beauty, a plea is heard,
A call to action, in every whispered word

For the air grows heavy with a modern plight,
And the rivers weep under pollution's blight

O stewards of Punjab, with hearts so true,
Rise with the dawn, with a vision anew

For the land of five rivers deserves our care,
A legacy of beauty, for all to share

Source: Web

The environment is where we all meet;
where we all have a mutual interest;
it is the one thing all of us share.

1 INTRODUCTION

1 Introduction

1. Background

1.1 Mainstay

Punjab Environmental Protection Act (PEPA), 1997, mandates the Environmental Protection Agency (EPA) Punjab for the publication of an annual report on state of the Punjab's Environment, henceforth referred as the SOE Report. This is the second report in the series after the first one published for CY 2022[1]. In addition to the Act ibid, the publication of SOE Report is also supported by the Punjab Green Development Program (PGDP).

Annual SOE reports provide environmental quality data and information on actions taken to reduce pollution and strengthen environmental governance. Incorporation of feedback solicited during public consultations indicated both the transparency and citizen engagement for environmental management.

1.2 State of the Environment Report 2022

SOE Report 2022 provided a comprehensive assessment of the environment, including ambient air, industrial emissions, surface and ground water, soil, wastewater treatment plants and solid waste management facilities. It aimed at informing policymakers, stakeholders, and general public about the environmental conditions prevailing in the province, their implications for human health and deciding way forward through an environmental action plan. In addition to discoursing the environmental profile of the Punjab, the SOE Report also highlighted a number of environmental challenges faced by the province during 2022. The main findings of the SOE Report 2022 are presented in Figure 1-1.

2. Purpose of the Report

SOE Report, 2023 aims to provide an insight on the updated environmental quality data, measures taken by EPCCD and other departments to reduce environmental pollution and improve environmental quality, as well as the way forward for environmental protection and conservation. The report is meant to be an environmental diagnostic report to be used by policy-makers, researchers and the people of Punjab for taking informed decisions.

3. Approach and Methodology

The formulation of SOE Report is an intricate process, comprising multiple steps. The section below provides the approach and methodology adopted for the compilation of the report.

3.1 Approach

The SOE Report 2023 is a product of state and trends of environmental quality indicators, assessed from primary and secondary environmental quality data analysis and a series of thorough consultations and collaborations among multiple stakeholders. The report focuses on:

i. Providing comprehensive assessment of the state of environment in Punjab.
ii. Depicting the impacts of prevailing state of environment on human health and well-being.
iii. Engaging stakeholders, public and experts in environmental reporting to ensure informed environmental decision- and policy-making.

SOE Report 2023 has been framed by following the DPSIR approach, keeping it in line with the SOE Report 2022. The Drivers-Pressures-State-Impact-Response (DPSIR) approach:

a. Identifies main drivers directly or indirectly influencing environmental quality and sustainability.
b. Describes the 'pressures' in form of spatio-temporal change in environment, using the qualitative and quantitative data.
c. Analyses the 'state' of environment subsequent to such changes derived from the environmental pressures.
d. Evaluates the environmental and health impacts of the state of environment.
e. Highlights the policy measures and actions taken in response to the changing environment.

[1] Available at https://epd.punjab.gov.pk/system/files/Report%202022-hi-res%20%284%29.pdf

Air Quality

- Good or satisfactory Air Quality Index (AQI) ($PM_{2.5}$) was observed only for 17 out of the total 309 monitored days in District Lahore.
- Satellite images indicate the major metropolises of Punjab including Lahore, Gujranwala and Faisalabad are the hotspots for CO, SO_2 and NO_2 emissions.

Water Quality

- Population growth, rapid urbanization, industrialization, over-extraction and climatic variability are the key pressures on water resources.
- Bacterial contamination is found in drinking water of most districts of the Punjab, including Multan, Rawalpindi, Sargodha, Sheikhupura and Lahore.
- Organic loads are resulting in high Biological Oxygen Demand (BOD) in the rivers.
- Major contributors of industrial effluents include textile factories, sugar mills and leather tanneries.
- The overall quality of water in rivers was rated as 'moderate' (for irrigation purposes) and 'very poor' for drains due to high pollution loads.

Soil Quality

- In Punjab 56% of total geographical area is cultivated, which is mainly attributed to its rich, fertile alluvial soils.
- The overall quality of various types of soils in Punjab in terms of salinity is rated as 'Good', 'Moderate', and 'Poor' for agriculture, urban and industrial soils, respectively.
- Fertility (Zn, Fe, Mn) and heavy metal (Ni, Cr, Cu, Pb) content of all soil types are rated as 'Good'.

Performance of Industrial Wastewater Treatment and Solid Waste Management Facilities

- EPA identified, 392 industrial wastewater treatment plants (primary, secondary, and tertiary).
- In terms of performance efficiency, the wastewater treatment facilities installed at sugar and paper mills were rated as 'very poor'.
- There is only one environmentally approved landfill site in Punjab located at Lakhodair area Lahore.
- The overall solid waste management system of Punjab was rated as 'poor'.

Measures Taken to Control Pollution

- EPA launched the anti-smog campaign as a preemptive measure to minimize air pollution.
- 705,650 trees were planted under the supervision of EPA field offices across Punjab in collaboration with multiple stakeholders.
- EPD established a Health Advisory System for Critical Air Pollution Events targeting vulnerable population groups.
- EPA inspected 2169 public and private hospitals to check the implementation of Punjab Hospital Waste Management Rules (PHWMR), 2014 and action was taken against the non-compliant hospitals.
- Major regulatory and institutional reforms in Punjab for strengthening environmental governance in the province (accomplished/in pipeline) are establishment of missing environmental quality standards, revision of existing standards and development of industry-specific environmental quality standards, Punjab Review of IEE and EIA Regulations (2022), Plastic Management Strategy, Regulations' on the production and consumption of single-use plastics and Punjab Climate Change Policy.

Environmental Complaint Redressal

- EPA received a total of 1091 complaints from 36 districts across Punjab.
- Faisalabad remained at top (116) while Lahore remained second with 99 in receiving highest number of registered complaints, out of which 63% complaints were resolved.
- Almost 47% of the complaints were related to air pollution showing public concerns towards clean air.

Environmental Action Plan

- The report provided an Environmental Action Plan, with distinct roles, responsibilities and timeline.

Figure 1-1: Overview of SOE Report 2022

3.2 Methodology

The methodology adopted for the formulation of the report (Figure 1-2), is described below:

i. Developing the content

The contents of SOE Report 2023 has been developed by the Strategic Planning and Implementation Unit. The primary data was collected from various government departments. The authors developed the content in line with the structure and sequence of information defined in the program appraisal document of (PGDP). External experts were engaged for environmental monitoring, laboratory analyses and data interpretations for soil, drinking (tap) water quality and environmental performance of solid waste management facilities. Literature and secondary data sources were also reviewed to align the primary data therewith.

ii. Review and recommendations

A committee, comprising technical experts in the subject matter, was notified by the EPCCD Punjab for periodic review of the draft report and to provide recommendations for improvement to the authors.

iii. Inter-departmental coordination

Concerned provincial departments were approached to link all relevant sectors with the state and trends of the environment. Sectoral data pertaining to 'environment' was graciously provided by the stakeholder departments for incorporation in the report.

4. What's New in the Report?

SOE Report 2023 has been improved in light of comments and feedback from concerned stakeholders as well as the lessons learnt and gaps identified in the previous report. Some of key features that distinguish the current report from earlier one are given in Figure 1-3

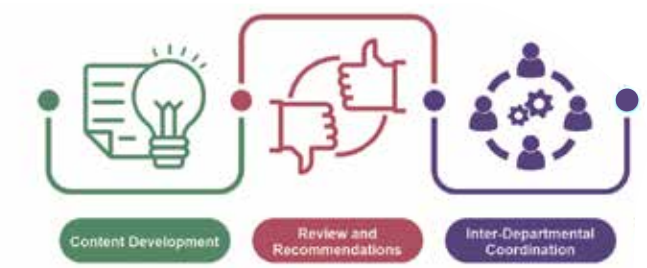


Figure 1-2: Methodology adopted for SOE 2023

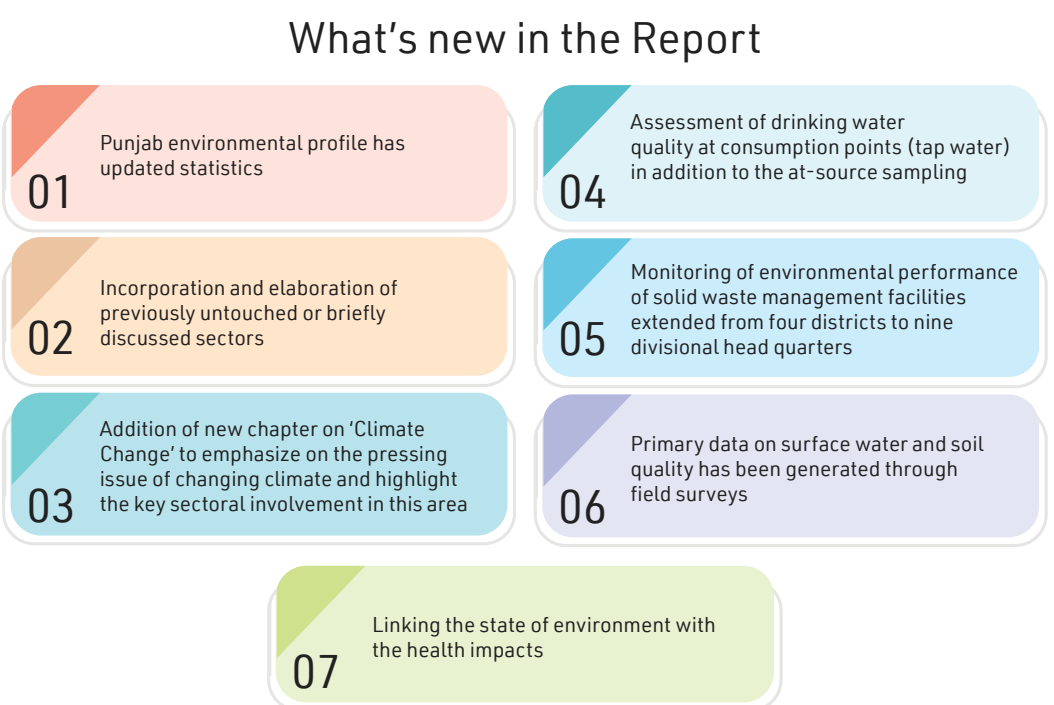


Figure 1-3: Key features of SOE Report 2023

5. Stakeholder Consultations

To engage all the relevant stakeholders and public in environmental reporting, three public hearings were conducted in different districts during formulation of SOE Report 2023; with the first hearing on table of contents in Lahore, second on draft report in Sahiwal and third in Multan (Figure 1-4). The hearings had a representation from provincial and federal government departments/attached departments, non-governmental organizations, academia, civil society organizations, chambers of commerce and industry, youth and general public. The key findings of the public hearings and the response thereon is given in detail at **Annexure A**

Figure 1-4: Stakeholder consultations

6. Reader's Guide

6.1 Components and Indicators

The SOE Report 2023 retains the basic structure as was used last year. It is based on seven (07) broad components enlisted below:

i. Assessment of air, surface water, groundwater and soil quality based on available monitoring data.
ii. Assessment of pollution sources along with a list of pollutants and their intensity that add to air, water and soil pollution[2].
iii. Assessment of environmental performance of solid waste management and waste water treatment facilities.
iv. Suitable course of action adopted to inhibit pollution and revamp the quality of environment.
v. Summarizing the details of environmental complaints received, categorized by nature of the issue and appropriate actions taken accordingly.
vi. Public opinion and EPD's responses on the report.
vii. Annual environmental action plan.

Component-wise detail of data streams is given in **Annexure-B**.

6.2 Drivers, Pressures, State, Impacts and Response (DPSIR)

The environmental indicators identified for the SOE Report 2023 have been assessed by using DPSIR framework (Figure 1-5). The indicators identified for reporting, are mainly the physical (abiotic) components of the environment. The drivers, pressures, state, impacts and responses related to particular environmental issues are described in the relevant sections.

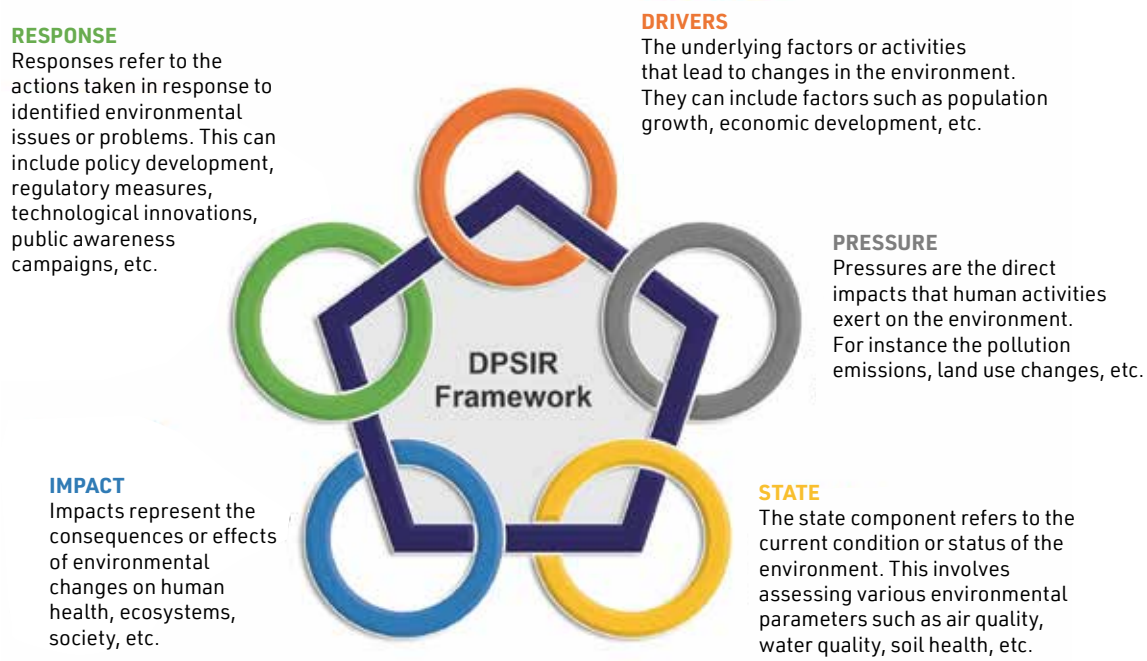


Figure 1-5: DPSIR Framework

6.3 Indicator ranking

Figure 1-6 presents an environmental quality assessment rating scale which has been used in this report to rate air, water, soil quality and performance of wastewater treatment and solid waste management in Punjab following the pattern of SOE Report 2022.

2 This very component will be covered in detail in upcoming SOE reports, as EPCCD is in process of building its capacity to generate a pollutant release inventory of Punjab (in-phases).

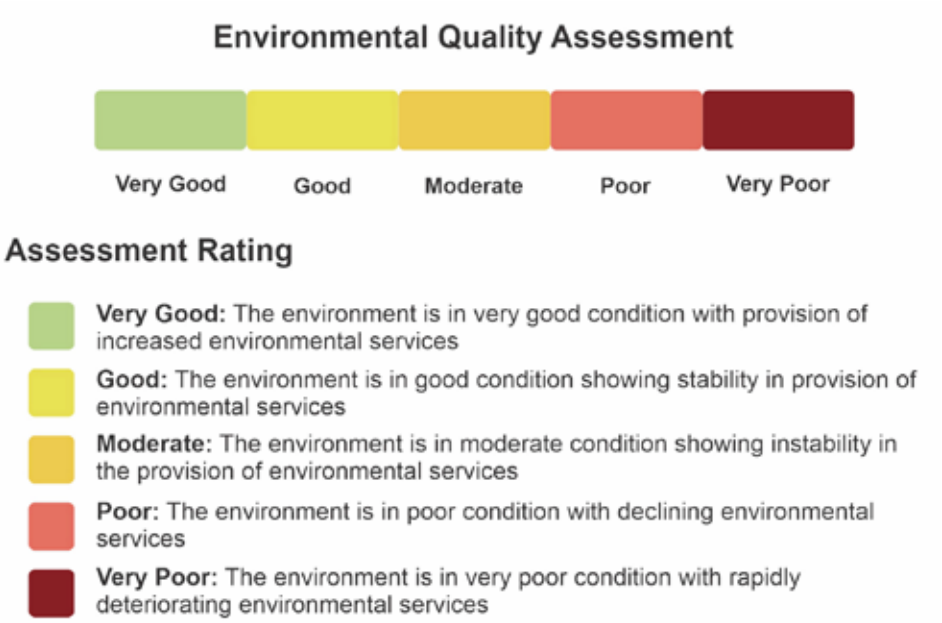


Figure 1-6: Environmental Quality Assessment Scale

7. Limitations in reporting

In light of the lessons learnt from the publication of SOE Report 2022, data acquisition has been facilitated by enhanced and timely coordination with stakeholder departments and developing online portals for regular uploading of environmental data by EPA Punjab. However, it is good to make the process of reporting more transparent by explicitly narrating the limitations experienced while reporting. These are as follows:

Heterogeneity of data: The limitation pertaining to heterogeneity of data still prevailed for the SOE Report 2023 as for pervious report. The data is scattered and heterogeneous both spatially and temporally, challenging the all-inclusive, quantified representation of linkages between the state of environment and its health and economic impacts.

Limited scope of monitoring: District – wise monitoring of data, covering whole province is still a major gap in reporting, pertaining to limited available resources.

Punjab, Pakistan, is a region where the vibrant hues of its fields create a stunning tapestry of beauty, and the welcoming nature of its people illuminates every corner.

2 PUNJAB AT A GLANCE

2. Punjab at a Glance

1. Punjab at a Glance

This Section covers the key features of environmental profile of Punjab with updated facts, figures and statistics with additional sectors. e.g. energy and social sector. The sectors were identified on the basis of comments and feedback on the previous report.

1.1 Demography

In a lapse of five years (2017-2023), Punjab has maintained its status of being most populous province of the country with its total population approaching 127.6 million people in 2023 (Figure 2-1). The urban population is also gradually increasing in Punjab with 40.70% population living in urban areas in 2023 as compared to 31.3% reported in 1998. Lahore division stands as the most populous division of Punjab with a population of 22.8 million), followed by Gujranwala division with 18.8 million inhabitants[1] (Figure 2-2).

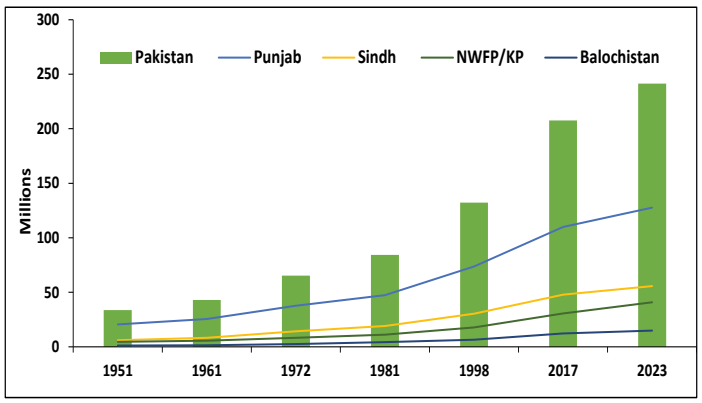


Figure 2-1: Population Growth Rates in the provinces of Pakistan

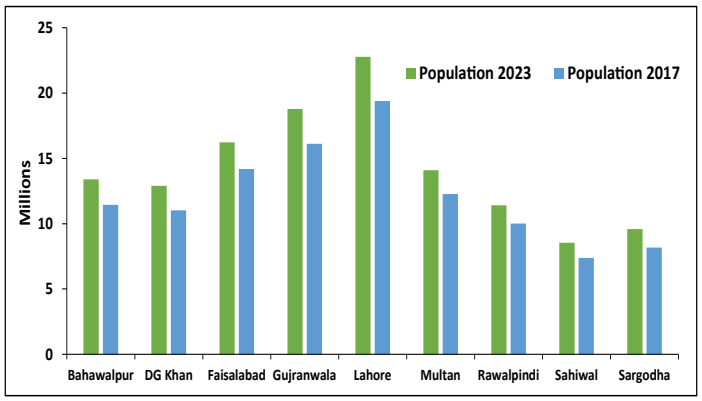


Figure 2-2: Division-wise population of Punjab (2017 and 2023)

KEY FINDINGS

- Total population of Punjab has approached 127.6 million people in 2023
- Employment growth rate is higher in Punjab at national level.
- Land use in Punjab comprises around 0.476 Mha of forest area, 3.016 Mha area not available for cultivation, 1.458 Mha cultivable waste land, 12.585 Mha cultivated area and 17.140 Mha cropped area of the country.
- More than 350 protected forests are in Punjab. There are total 5 National Parks, 36 wildlife sanctuaries, and 23 Game Reserves in the Province.
- Pakistan's total energy mix (by fuel) is 43,775 MW, out of which 17,026 is Punjab's share.
- 30 million metric tons/year production of limestone in Punjab, followed by argillaceous clay, which is above 6.5 million metric tons.
- The share of Punjab in Pakistan's livestock population is 60%.
- Total 32,258 manufacturing industries are located in Punjab, mainly including the textile, construction material, glass, furniture and grain mill production units.
- Women are almost half of the population in Punjab but their representation in public sector is not adequate.
- About 98% of the population has access to improved source of drinking water. Tap water is available to 18.8%, motorized pumps to 37.5% and 25.3% population uses hand pumps.
- Total 80.1% of the population is living in households using improved sanitation facilities, which is higher in urban (92.8%) as compared to rural areas (72. 8%).
- Punjab province has been remained at top in comparison to other provinces in Pakistan pertaining to higher human development indicators and prosperity.

1.2 Land Use

According to the latest available statistics, Punjab comprises around 0.476 Mha of forest area, 17.14 Mha of cropped area, 3.016 Mha area not available for cultivation, 1.458 Mha cultivable waste land and 12.58 Mha cultivated area[2]. The comparison of land use statistics from 2016 to 2020 indicates a relatively uniform pattern (Figure 2-3).

1 Pakistan Population Census 2023, Pakistan Bureau of Statistics
2 Page No. 51, Statistical Pocket book of Punjab (2023), Punjab Bureau of Statistics

The rangelands provide several direct and indirect ecosystem services, including the dairy products, medicinal products and conservation of soil and water. Rangelands in Punjab roughly cover 8.28 million hectares[3]. These rangelands generally fall in Pothohar, Thal, DG Khan and Cholistan areas. About 412,800 farmers residing on boundaries of these rangelands are directly benefited by grazing their animals[4].

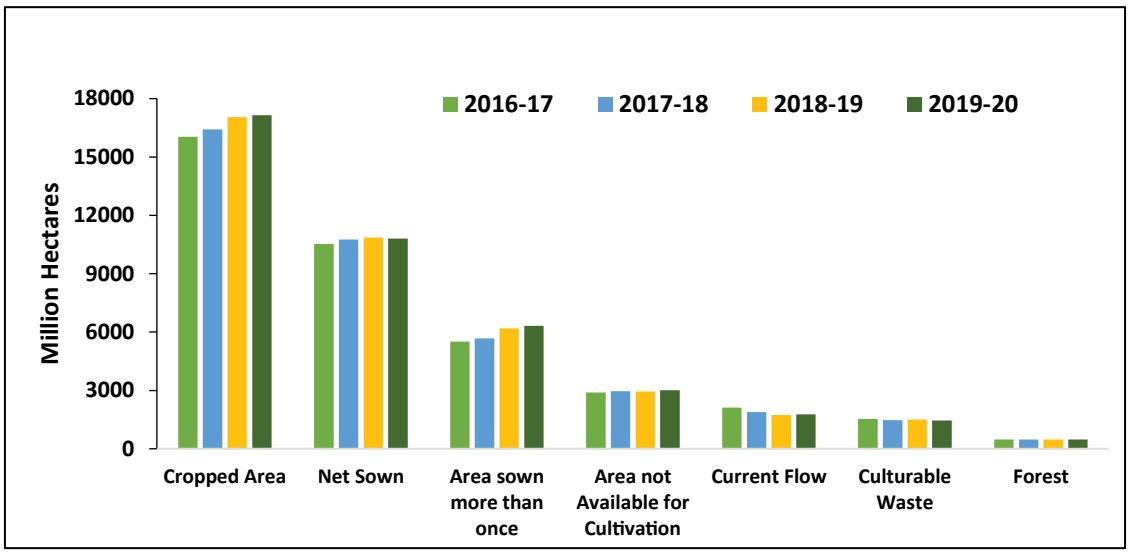


Figure 2-3: Land-use in Punjab (2016-2020)

1.3 Energy

Punjab's energy mix encompasses a diverse array of sources including thermal, nuclear, hydropower, solar, and bagasse-based electricity generation, with thermal power predominating at 74% share[5]. Total energy mix (by fuel) of Pakistan is reported to be 43,775 MW, out of which Punjab contributes 17,026 MW (Figure 2-4).

3 UN Food and Agriculture Organization (FAO), Rangelands of Pakistan Current status, threats and potential, 2016
4 Forestry, Wildlife and Fisheries Department (2022)
5 Energy Department, Government of the Punjab

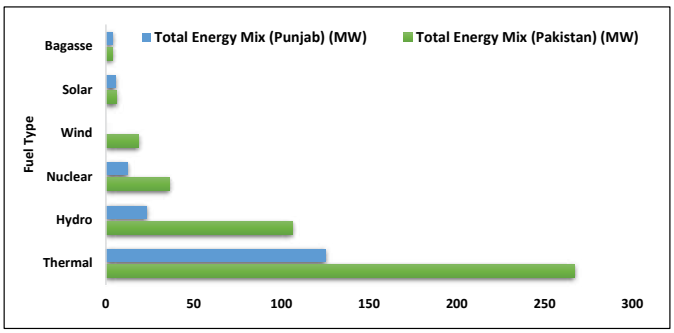


Figure 2-4: Punjab's Energy Mix (by fuel) and its contribution in National Energy Mix (MW)

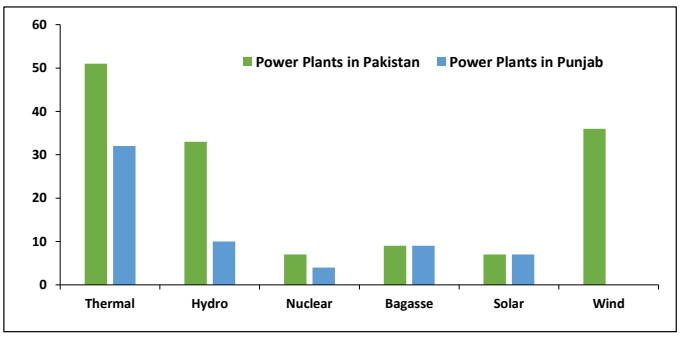


Figure 2-5: Power Plants in Punjab (by fuel)

About 62% of total power plants in Pakistan are located in Punjab province, with major proportion comprising of thermal power plants, followed by hydropower plants (Figure 2-5).

The province is making advancements towards solarization at a rapid pace. So far, all the major solar power plants of the country are located in Punjab with total dependable capacity of 530 MW (Table 2-1)[6]. However, there is need to further enhance the dependency on renewable fuels and explore further options for renewable energy production such as wind power in the province[7]. As reported by the Energy Department, Government of the Punjab, Punjab Energy Efficiency and Conservation Agency is executing solarization of public sector institutes, with a total solar potential of 19 MW, with an estimated GHG reduction of 9390 MT CO_2eq. Furthermore, around 82,000 lights and 38,000 fans have been retrofitted in public sector institutes. Solarization and retrofitting is also underway in public hospitals.

Table 2-1: Power Plants located in Punjab along with dependable capacity (2022)

Fuel	Total No. of Plants	Dependable capacity (MW) (June 2022)
Hydel	52.25	1802
Thermal	42.66	12447
Nuclear	32.27	1246
Solar	30.36	530
Biomass Power Projects	32.62	279

1.4 Forests and Biodiversity

Punjab has a diverse network of subtropical dry scrub forests, tropical dry thorn forests, tropical dry broadleaved forest and subtropical pine forests situated in the subtropical sub-Himalayan and temperate regions to the south of tropical Indus plains. Punjab Forest Department reports the state of forest in terms of the total area planted, plantable blank, un-plantable blank, total blank and the area needing revenue verification. On the basis of this categorization, the latest available data is given in Figure 2-6.

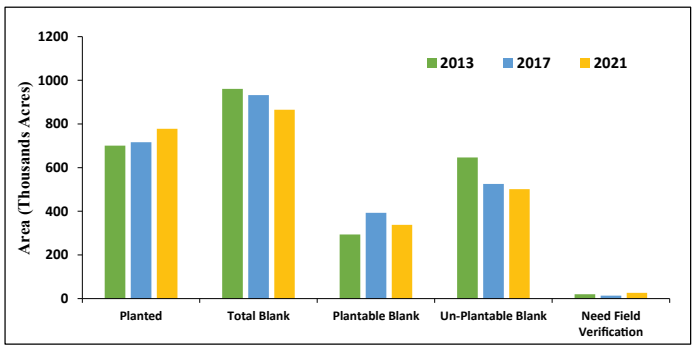


Figure 2-6: Forest Cover Change in Punjab

The figure depicts a gradual increase in total planted area in the province, however the total unplanted/blank area is quite higher than the planted area **(Annexure C)**[8]. Punjab has more than 350 protected forests, covering an area of around 560,000 acres of land[9].

The flora and fauna in Punjab is diversely distributed on the basis of topography and geography of the province. In sub-tropical Chir Pine forests of the northern region Pinus roxburghii (Chir) forms practically the entire forest canopy. The other coniferous species are Pinus wallichiana, Cedrus deodara, Picea smithiana and Abies pindrow, including broad leaf species of Quercus. The riverine flora ('Belas') include Acacia nilotica, Dalbergia sissoo and other species of deciduous

6 State of Industry Report (2022), NEPRA
7 Energy Department, Government of the Punjab
8 Forests, Wildlife and Fisheries Department, Government of the Punjab
9 Forests, Wildlife and Fisheries Department, Government of the Punjab

plants. Scrub forests are dominated by Acacia modesta and Olea ferruginea. The desert area of Cholistan supports thorn forest species including Prosopis cineraria, Capparis decidua, Salvadora oleoides, Tamarix aphylla and Zizyphus jujube, etc.

The relative abundance of wildlife species is declining globally. It has been reported that there has been a 69% decline in average relative abundance of wildlife globally, with 55% decline reported in Asia and Pacific[10], the region wherein the province of Punjab falls. Deforestation, overgrazing by livestock and land use change are the major drivers of biodiversity loss. Some of the key wildlife species in Pakistan including the Punjab have been listed as vulnerable (VU) or endangered (EN) globally by International Union for Conservation of Nature (Table 2-2)[11]. Whereas species like Chinkara, Blackbuck, Barking Deer, Indian Monitor Lizard, Cheetal, Neel Gaye, Indian Hog Deer are high priority conservation species due to alarming decline in their population at local levels.

Table 2-2: List of Endangered Species in Punjab

Name	IUCN Status	Date Assessed
Asiatic Black Bear	VU	17 March 2016
Black Partridge	VU	11 August 2021
Common Leopard	VU	23 October 2022
Fishing Cat	VU	21 June 2016
Goral	NT	14 January 2020
Great Indian Bustard	CR	17 August 2018
Hog Deer	EN	03 December 2014
Honey Badger	NT	28 February 2015
Houbara Bustard*	VU	05 April 2023
Indian Pangolin	EN	10 May 2019
Indus River Dolphin	EN	01 August 2021
Panther	VU	11 July 2015
Punjab Urial	VU	16 March 2020
Sambar Deer	VU	November 2014
See-see Partridge	VU	October 2016
Smooth Coated Otter	VU	21 January 2020
Striped Hyaena	VU	02 October 2014
White Rumped Vulture	CR	07 July 2021
* Migratory, IUNC (International Union for Conservation of Nature)		

The total area of high conservation priority in Punjab is estimated to be around 63,695 km^2, accounting for 29.72% of its landmass. Additionally, there are 120,788 km^2 (56.35%) designated with a moderate conservation value, and 28,870 km^2 (13.93%) with a low conservation priority. The protected area within Punjab comprises merely 1.03% of its total area[12]. There are total 5 National Parks, 36 wildlife sanctuaries, and 23 Game Reserves in the Province[13]. Moreover, Chashma Barrage, Taunsa Barrage and Uchhali Complex are recognized Ramsar Sites in Punjab. Under the Punjab Wild Life Protection (Preservation, Conservation and Management) Act, 1974 special permission is mandated for any developmental activities within wildlife sanctuaries and national parks.

In the context of wildlife conservation, a network of in-situ and ex-situ conservation sites have been established throughout the Province (Figure 2-7).

10 WWF (2022) Living Planet Report 2022 – Building a nature positive society. Almond, R.E.A., Grooten, M., Juffe Bignoli, D. & Petersen, T. (Eds). WWF, Gland, Switzerland.
11 Wildlife and Parks Department, Government of the Punjab
12 Punjab Spatial Strategy, 2047
13 Wildlife and Parks Department, Government of the Punjab

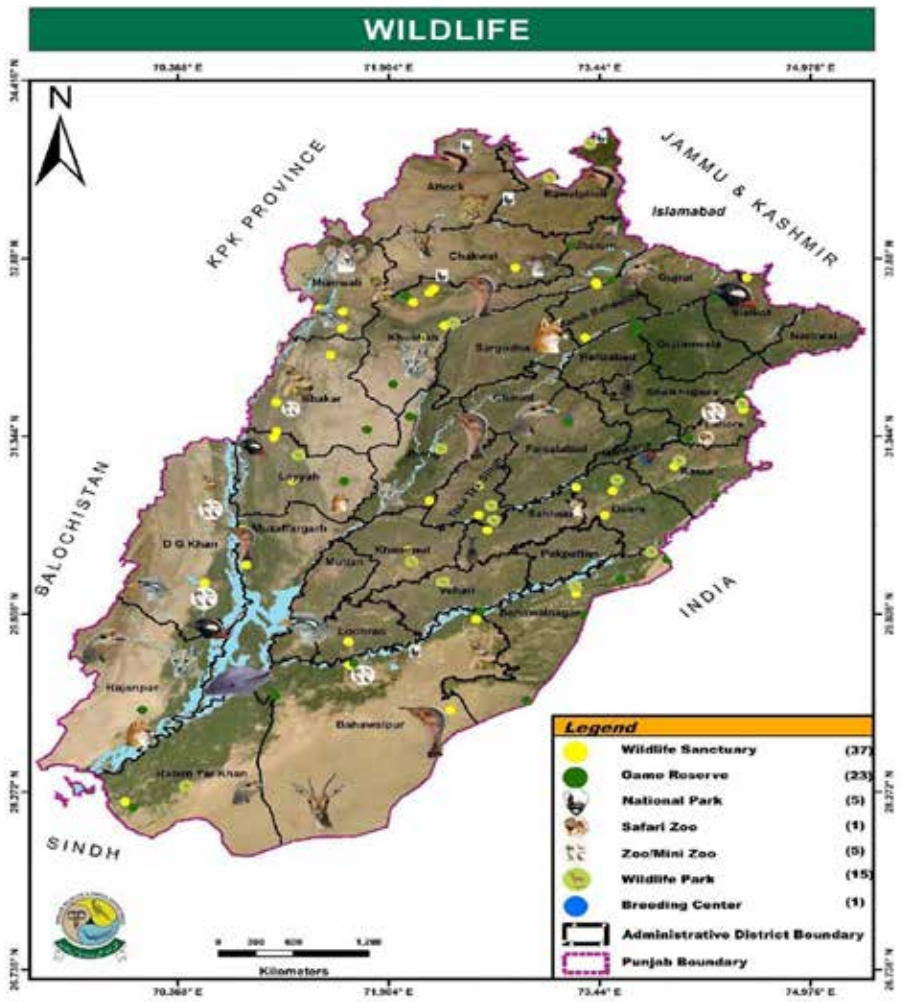


Figure 2-7: Wildlife Conservation Facilities in Punjab Pakistan

1.5 Transport

In Punjab, the common modes of transport range from heavy transport vehicles (trucks, buses, trolleys, etc.) to low transport vehicles (rickshaw, taxi, vans, cars) and two-wheelers (motorbikes, bicycles, etc.). Roads and Railways are common modes of inter-city transportation. The major metropolises including Lahore, Multan and Rawalpindi have mass transit systems in place. Transport and communication sector contributes 58.2% in national sectoral value[14].

1.6 Mines and Minerals

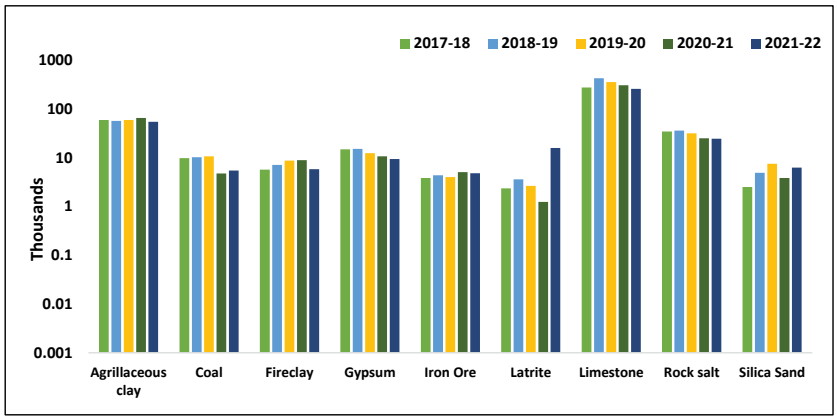


Figure 2-8: Mineral Production in Punjab from 2017 - 2022 (Logarithmic Scale)

In Punjab, the major mineral production is of argillaceous clay, coal, limestone, rock salt, silica sand. The year-wise (2017-2022) data on the mineral production indicates more than 30 million Metric tons/year production of limestone in Punjab, followed by argillaceous clay, which is above 6.5 million Metric tons. On a logarithmic scale, the extraction of limestone has remained maximum among other minerals as reported during 2017-2022[15] (Figure 2-8).

Although mining and mineral production is a key economic sector, it has remarkable impacts on environmental and ecological resources. A recent study conducted in District Chakwal confirmed that, the soil and water were found contaminated with high levels of Total dissolved solids (TDS), salts and heavy metals, attributed by both the saline and

14 Punjab Growth Strategy 2018-2023 (2018)
15 Statistical Pocket Book of Punjab (2023), Punjab Bureau of Statistics

acidic mine drainage, in and around the coal mines[16].

1.7 Agriculture and Livestock

Most of the total cropped area in Punjab is covered by wheat crop (46%), followed by rice (16%), fodder (10%) and others[17].The statistics further reveal that agriculture is a major water-dependent sector, as 89% of sown area is irrigated through various sources of surface and groundwater. Canals and tube-wells are the main source of irrigation in Punjab[18].

Livestock plays an important role in the uplift of the rural economy with a 14.36% share in the National GDP and 62.68% contribution in Agricultural GDP. Livestock is also a major economic sector of Punjab. The share of Punjab in Pakistan's livestock population is 60%[19].

1.8 Industry

Punjab is known for its rapid industrialization. Punjab is an economic center of Pakistan, with main industrial hubs clustered in its large metropolises such as Lahore, Gujranwala, Faisalabad, Sialkot, Sargodha, Mianwali, Jhang, Khushab and Chakwal. Faisalabad is the main point of industrial activity in the province, followed by Lahore[20].

The manufacturing sector contributes around 20% in total economic output of the country[21]. As of 2023, a total of 32,258 manufacturing industries are located in Punjab, mainly including the textiles, construction material, glass, furniture and grain mill production units[22]. According to the Punjab Bureau of Statistics, highest number of industries (6082) are located in District Faisalabad, followed by District Lahore (3940) and Gujranwala (3286).

1.9 Water, Sanitation and Hygiene (WASH)

Access to safe drinking water, sanitation and hygiene (WASH) is a fundamental right for good health, welfare and productivity and is widely recognized as a human right[23] as implicit under Article 9 of the Constitution of Pakistan, "No person shall be deprived of life or liberty, save in accordance with the law." United Nations General Assembly, on 28 July 2010, through Resolution 64/292, explicitly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realization of all human rights.

Data source: Punjab Multiple Indicator Cluster Survey (MICS) 2018

1.10 Social Sector

1.10.1 Gender

Women are almost half of the population in Punjab but their representation in national assembly is only 20%[24]. Out of 27 resolutions passed in Punjab, only 4 were led by female MPAs. Similarly, women are 40% on gazette seats. Their under representation is not only restricted to these sectors but gender gap also persists in economic participation and

16 Muneeb, A., 2021, Status of Soil And Water Pollution At The Largest Coal Mining Area Of Punjab, Pakistan, Fresenius Environmental Bulletin 30(01):441-447 (https://www.researchgate.net/publication/358285867_STATUS_OF_SOIL_AND_WATER_POLLUTION_AT_THE_LARGEST_COAL_MINING_AREA_OF_PUNJAB_PAKISTAN)
17 Punjab Bureau of Statistics
18 Statistical Book of Punjab 2023 (Pg. 72)
19 Livestock Department, Government of the Punjab
20 Census for Manufacturing Industry (CMI) (2015-2016)
21 Punjab Board of Investment and Trade (PBIT) (http://www.pbit.gop.pk/manufacturing)
22 Bureau of Statistics, Government of the Punjab
23 The human rights to water and sanitation were explicitly recognized by the UN General Assembly and Human Rights Council in 2010 and in 2015. Punjab Multiple Indicator Cluster Survey 2017-18
24 Gender Parity Report (2022), Women Development Department, Punjab

opportunities as well that is responsible for widening socio-economic disparities as female Labor Force Participation (LFP) in Punjab is 27.8% as compared to 74.2% male LFP[25].

1.10.2 Employment

Employment growth rate is higher in Punjab than the national level (Table 2-3)[26]. Whereas, employment rate has shown more increase in urban areas as compared to rural areas. With respect to male and female participation in the employment, men far exceed in numbers as compared to women both at national and provincial levels.

Table 2-3: Employment- Pakistan and Punjab

Area		Employed (Millions)					
		2018-19			2020-21		
		Total	Male	Female	Total	Male	Female
Pakistan	Total	64.03	49.33	14.70	67.25	51.91	15.34
	Rural	42.93	30.59	12.34	45.70	32.79	12.90
	Urban	21.10	18.74	2.36	21.55	19.12	2.44
Punjab	Total	38.21	27.71	10.50	39.07	28.41	10.66
	Rural	26.09	17.29	8.80	40.0	17.91	8.93
	Urban	12.12	10.42	1.70	37.6	10.50	1.74

1.10.3 Inequality and Poverty

Punjab province has remained at the top in comparison to other provinces in Pakistan pertaining to higher human development indicators and prosperity. However, there are very sharp regional disparities found within the province. Employing a multidimensional measure of poverty[27], which considers different factors as income levels, education attainment, health and standards of living, it becomes evident that the rural areas of the province are more deprived as compared to the urban areas i.e., 6.3% of the population in urban areas can be considered poor under this multidimensional index while the incidence soars to 43.7% in rural areas.[28] Information on growth and poverty patterns of Punjab shows that by decrease of 1% in the inequality ratio will reduce multidimensional poverty by almost 0.4%[29].

Starting from 1998-99 to 2018-19, there is continuous decline in poverty rate across Punjab from 61.8 to 16.3 due to two possible reasons, (i) periods of high economic growth translated into poverty reduction, (ii) successful implementation of traditional and modern programs for alleviating poverty[30].

However, it is worth mentioning that Southern Punjab has remained the most deprived zone relative to Central and Northern Punjab (Table 2-4)[31].

Table 2-4: Division/region wise incidence of poverty, 2017-18 (%)

Division	Incidence of poverty	Region	Incidence of poverty
DG Khan Division	52.25	Southern Punjab	42.03
Bahawalpur Division	42.66		
Multan Division	32.27		
Sargodha Division	30.36	Northern Punjab	18.98
Sahiwal Division	32.62		
Faisalabad Division	23.96		
Gujranwala Division	11.55	Central Punjab	26.12
Lahore Division	16.21		
Rawalpindi Division	9.91		

25 Gender parity report 2022
26 Punjab Growth Strategy, 2023
27 Multidimensional poverty index is a common tool to assess severity and patterns of poverty in a region.
28 Punjab Education Sector Plan 2019/20 – 2023/2024
29 Punjab Growth Strategy, 2023
30 Poverty Trend in Pakistan -A Glimpse from Last Two Decades, Pakistan Institute of Development Economic (PIDE), Poverty Trend in Pakistan, published by 2021.
31 Punjab Growth strategy 2023

1.10.4 Child Labour

Definition of child labour is described in two categories; one is involvement in economic activities and other is household chores based on different age groups.[32] However, they are classified as child laborers if they are either too young to work or are involved in any activity which may compromise their physical, social, mental, or educational development.[33] In Punjab, 15% of children aged 5 to 17, 8% of those in 5 to 11 years and 28% between 15 to 17 years are involved in child labor. A major share of child labour is of boys than girls and more children are from rural areas as compared to urban areas. A disproportionate share of children who married at age of 15 and 18 years either did not attend school or are uneducated.[34]

1.10.5 Education

Education is one of the fundamental factors for increasing the productivity and enhancing the employment creation. Punjab has a young population; more than one-fourth of the total provincial population is of school going age. There are two demographic characteristics that make education planning in Punjab complex. The first: most of the 110 million people living in this province (63.3%) reside in rural areas. The second: internal migration is very significant.[35]

During the last five years, Punjab has shown substantial progress in school participation, but disparities by gender, location and socioeconomic status persist, and children are less likely to continue beyond primary school. About 25% of the population of Punjab is of school-going age and 10.5 million children of school age (5-16 years) are out of school children (OOSC) in Punjab despite in the expansion of public and private schools. It is important to mention that 54% of the total OOSC aged 5-9 years majorly reside in the eight districts: Rahim Yar Khan, Dera Ghazi Khan, Rajanpur, Muzaffargarh, Multan, Bahawalnagar, Faisalabad and Lahore. Many of the OOSC are in hard-to-reach areas and special efforts will be required to facilitate them with learning opportunities.[36]

The total and gender wise rural and urban literacy rates in Pakistan and Punjab. Data shows that there is a slight increase in total literacy rate in Pakistan (62.4 to 62.8%) and Punjab (66.1-66.3) from years 2018-19 to 2020-21. Literacy rates in both males and females of rural areas in Punjab have increased marginally but for females in the urban areas they remained constant over specified timeframe (74.3%).

1.10.6 Health and Nutrition

The health system across Punjab has improved significantly in the last decade because of the focused approach, allocation of resources and effective monitoring by the government. Despite improvements in health system, the health and nutrition indicators in the southern region of Punjab are still alarming due to issues such as low literacy rate, poverty and poor infrastructure.[37] However, Punjab demonstrates better nutrition outcomes as compared to other provinces.

While Punjab's stunting and underweight rates showed some improvement over the past two decades, wasting rates have been on the rise since 2021, indicating a long-term nutritional problem. As per Multiple Indicator Cluster Surveys (MICS) Survey comparison from 2011 and 2018, acute malnutrition, known as 'wasting' (15.1% in MICS 2011 and 7.5% in MICS-2018) is partly caused by arid conditions and occasional droughts in some areas. Stunting is associated with increased risk of illness and death, poor cognitive development, lower educational attainment and diminished life-long income generation potential.[38] Underweight, a type of chronic malnutrition (32.6% reported in MICS 2011 and 21.2% in MICS 2018) is mainly caused by low intake of food/nutrients over long periods, repeated illness/infections, eating disorders, digestive problems like inflammatory bowel disease and thyroid disease etc. High burden of underweight children is common in some southern districts of Punjab.[39]

32 Pakistan (Punjab) Education Fact Sheets | 2022
33 Multiple Indicator Cluster Surveys MICS-2018
34 Pakistan (Punjab) Education Fact Sheets I 2022
35 Punjab Education Sector Plan 2019/20 – 2023/2024
36 Punjab Education Sector Plan 2019/20 – 2023/2024
37 Provincial Nutrition Response Plan for COVID-19,
38 Policy Brief: Highlights of Malnutrition in Punjab Province by world bank
39 Scaling Up Nutrition (SUN) Provincial Unit Planning and Development Board Government of Punjab

Clean air is the breath of life, essential for our health today and the legacy we leave for tomorrow

3 AIR QUALITY

3. Air Quality

1. Overview

Air is the first component of environment as defined in the PEPA[1]. The quality of air determines the quality of human life. Pakistan is experiencing an increase in air pollution due to population growth, urbanization, industrial expansion, burgeoning economic development, inadequate regulatory policies, road dust and vehicles with weak emission control measures. Moreover, elevated concentration of pollutants during the winter season may be attributed to meteorological conditions such as low wind speed, limited air dispersion and temperature inversion.

PEQS for Ambient Air, 2016 provide permissible/acceptable concentration levels in ambient air and their methods of measurement. Currently, EPCCD has a limited setup of fixed AQMS in Punjab. However, the availability of a mobile AQMS facilitates in measuring concentration of pollutants in areas lacking fixed station. EPCCD is under the process of enhancing air quality monitoring systems in Punjab.

KEY FINDINGS

- The AQI ($PM_{2.5}$ based) in Lahore is rated as "Poor" and for other Divisional HQs of Punjab it is rated as 'moderate' for 2023.
- Number of days of good/satisfactory air quality with respect to AQI ($PM_{2.5}$ based) in Lahore have increased from 17 in 2022 to 74 in 2023.
- The highest concentration of $PM_{2.5}$ in Lahore was reported in January (373 µg/m³) while the lowest value was recorded in September 10.5 µg/m³.
- All 9 Divisional HQs had $PM_{2.5}$ concentrations higher than the PEQS value with Rawalpindi having the least and Multan having approximately 1.5 times higher concentration than PEQS on the particular monitoring day.
- About 67% Public Service Vehicles tested during January 1, 2023 to December 18, 2023 were declared fit (road worthy).
- Lahore district alone accounts for 27.18% of the total registered vehicles in the province and remained at the top.
- Thermal power plants, cement factories, and textile mills are primary NOx emitters, while SO_2 surpass limits in power plants; multiple industries emit excessive CO, whereas all the industries inspected except sugar mills had the smoke emissions exceeding the prescribed PEQs limits.
- Government of the Punjab is striving hard for providing clean air to the inhabitants of Punjab. Various government departments are actively taking measures to control increasing air pollution at their various tiers.

2. Environment

2.1 Ambient Air Quality and AQI

Ambient air refers to the atmospheric air in its natural state comprising what surrounds us and what we breathe. Elevated levels of air pollutants such as, particulate matter, exhaust gases, smoke, dust particles, odour, light, electromagnetic radiation, heat, fumes, hazardous substances and radioactive materials lead to a decline in the overall quality of ambient air.

The Air Quality Index (AQI) is a numerical scale used to determine the level of air pollution in a specific location and it is calculated based on criteria air pollutants such as Particulate matter ($PM_{2.5}$ and PM_{10}), Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Carbon monoxide (CO) and Ozone (O_3). The daily value of Air Quality Index (AQI) is disseminated through official website of EPCCD[2]. AQI calculated by EPCCD, as presented in this report, is based on $PM_{2.5}$ concentration only. Table 3-1 provides colour illustration of AQI values and required public response in case of higher air pollution levels[3].

Table 3-1: AQI categories, colour illustration and required response level

AQI	AQI Category	Colour Code & AQI Response Level
0-50	Good	Prevention
51-100	Satisfactory	
101-150	Moderate	Preparedness
151-200	Unhealthy for sensitive group	Alert
201-300	Unhealthy	Warning
301-400	Very Unhealthy	Emergency
401-500+	Hazardous	Severe

1 Under section 2 (x) of the Act
2 https://epd.punjab.gov.pk/aqi
3 https://epd.punjab.gov.pk/system/files/Health%20Advisory%20Notification_0.pdf

2.2 Overview of Air Quality in the Nine Divisional Headquarters of Punjab (Excluding Lahore)

Ambient air quality monitoring was carried out in 09 Divisional HQs by EPA Lahore laboratory on a single day at each city during August 17-30, 2023 through mobile air quality monitoring station. Figure 3-1 shows that all Divisional HQs had $PM_{2.5}$ concentrations higher than the PEQS value (35 µg/m³) with Rawalpindi having the least and Multan with the highest concentration (approximately 1.5 times higher than the standard value) on the particular monitoring day.

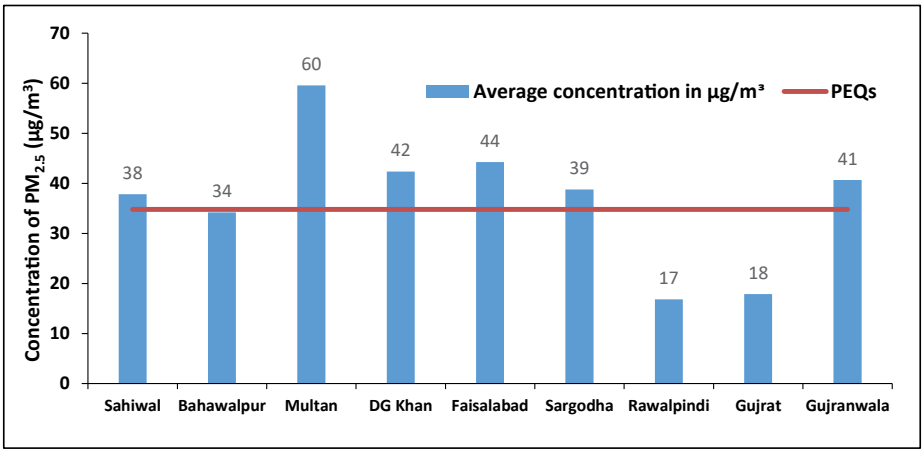


Figure 3-1: Monitoring of ambient air quality at 09 Divisional HQs

Figure 3-2 shows the geographic distribution of the monitoring sites across the 09 Divisional HQs along with AQI values (based on $PM_{2.5}$) that were satisfactory for Rawalpindi (55), Gujrat (58) and Bahawalpur (97) only while all other Divisional HQs showed moderate values with highest in Multan (135).

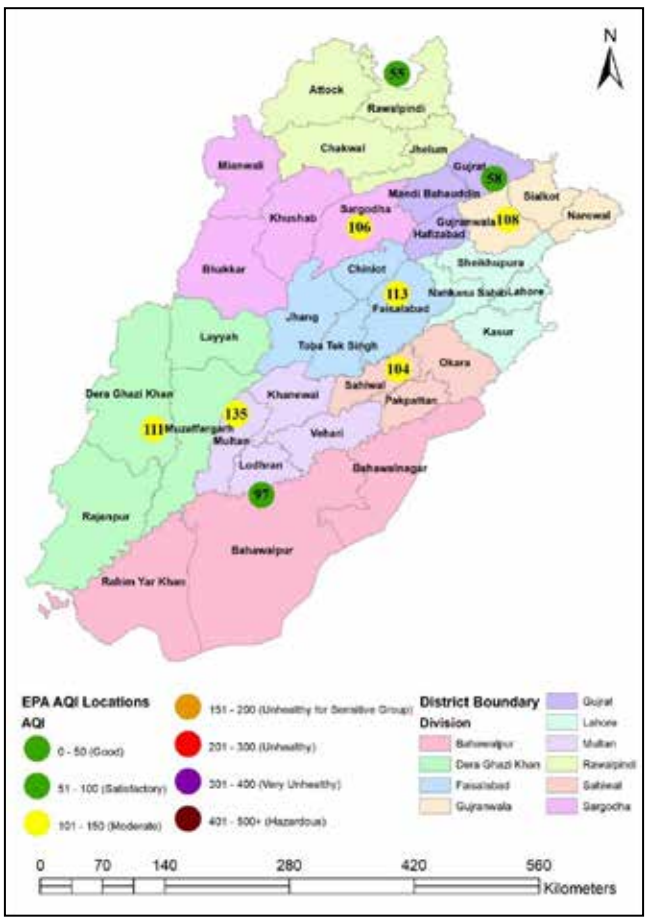


Figure 3-2: Ambient air quality monitoring of 09 Divisional HQs (AQI-$PM_{2.5}$)

2.3 Air Quality of Lahore

In 2023, the concentration of $PM_{2.5}$ was monitored at multiple locations in Lahore, by EPA Lahore laboratory, using a mobile AQMS (Figure 3-3). Highest concentration of $PM_{2.5}$ (373 µg/m³) was noted in January with corresponding AQI value of 427, while the minimum concentration of $PM_{2.5}$ (11 µg/m³) with corresponding AQI (37) was measured in May

and September. On an average, concentration of $PM_{2.5}$ (96 µg/m^3) has been over six times higher than the standard value of PEQS with corresponding AQI (169) classified as "Unhealthy for sensitive group".

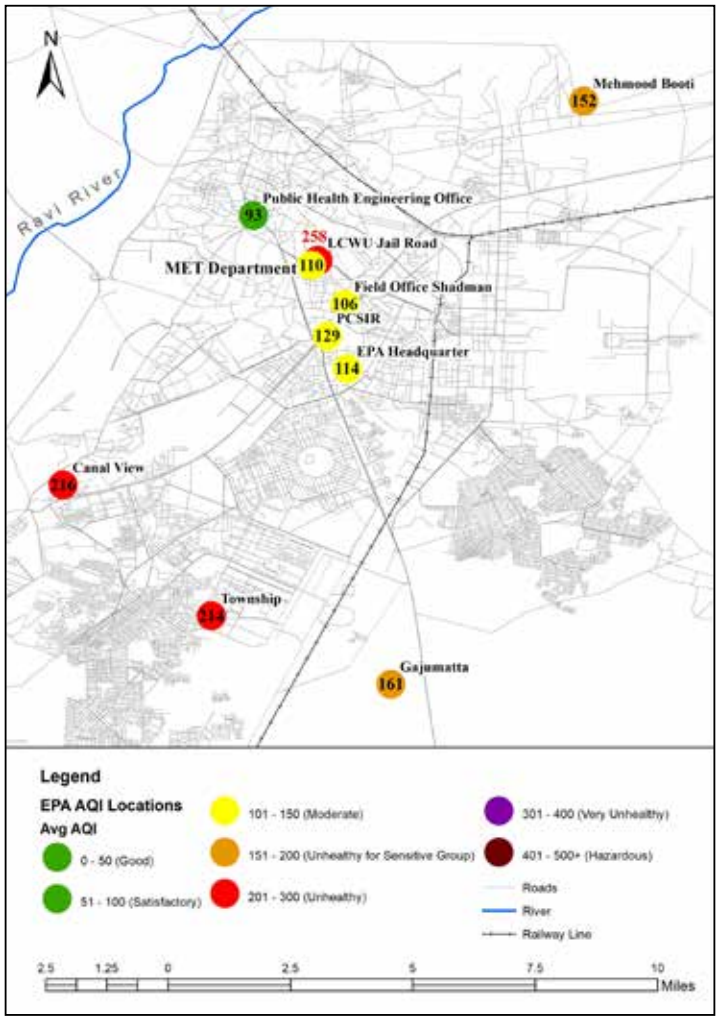


Figure 3-3: Monitoring of AQI-$PM_{2.5}$ at various locations in Lahore

For the years 2022 and 2023, the values of AQI on the same dates are presented in Figure 3-4. There might be a change of location of mobile AQMS.

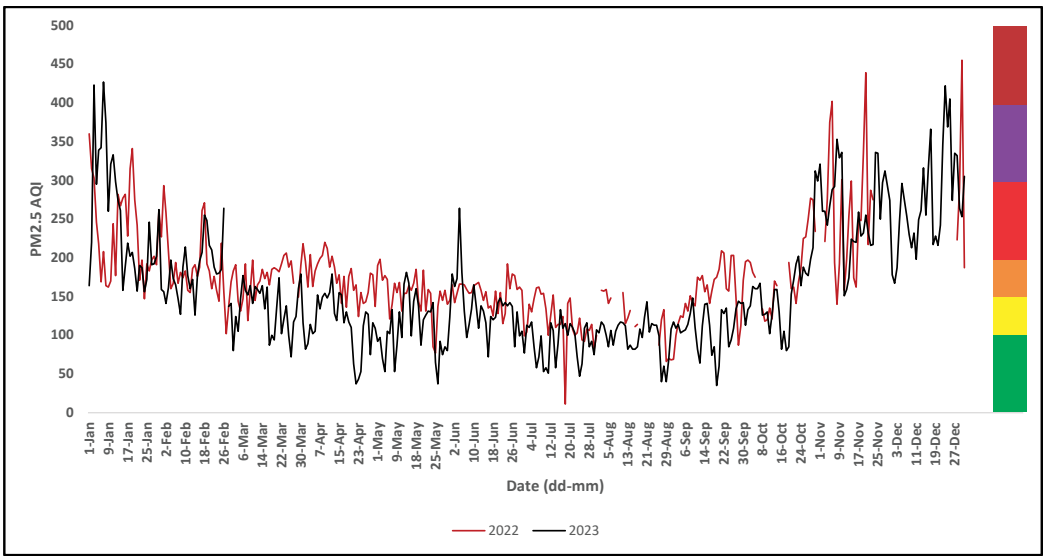


Figure 3-4: Comparison between AQI-$PM_{2.5}$ values of Lahore in 2022 and 2023

The trend analysis of the annual average $PM_{2.5}$ concentration during 2019 and 2023, as monitored by the AQMS installed at the US Consulate in Lahore, indicates that the values consistently exceeded the standard PEQs threshold (Figure 3-5).

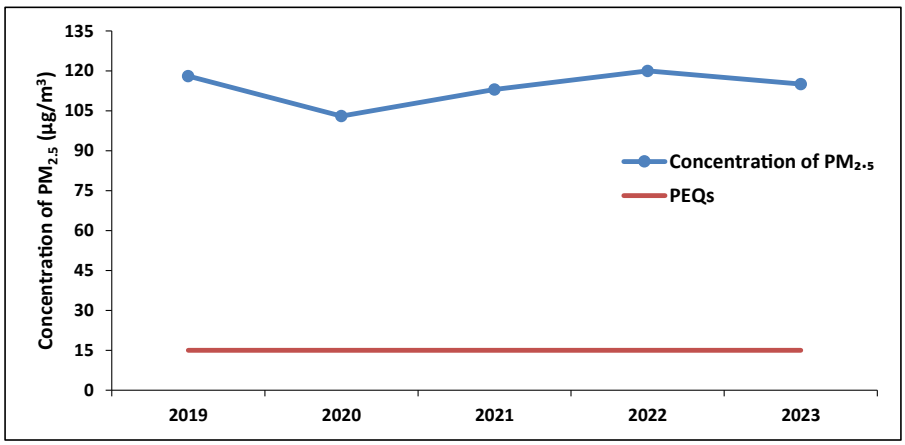


Figure 3-5: Measurement of Concentration of $PM_{2.5}$ from 2019 to 2023 at US Consulate Lahore.

Figure 3-6 shows that the numbers of days of good air quality with respect to AQI $PM_{2.5}$ value in Lahore have been increased from 17 in 2022 to 74 in 2023, while numbers of days of "unhealthy air for sensitive groups" have been reduced from 154 in 2022 to 75 in 2023. But still the urbanites experienced 156 days of unhealthy-hazardous air quality.

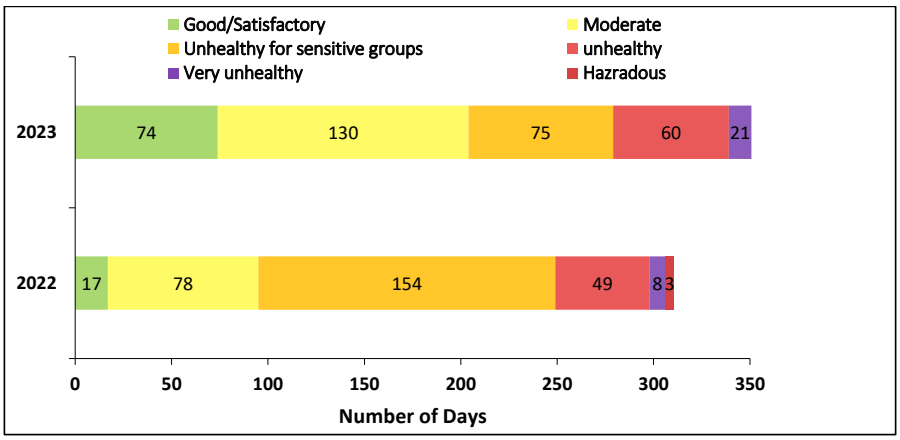


Figure 3-6: Number of days with respect to AQI ($PM_{2.5}$) air quality in Lahore in 2022 and 2023

Similarly, the AQI monitoring at US Consulate, Lahore over the time span of 5 years from 2019 to 2023 has shown that number of good/moderate AQI days have decreased from 2019 to 2023 in the Lahore. Similarly, number of hazardous air quality days has increased. The improved AQI in year 2020, is attributed to limited industrial and transportation activities during COVID-19 pandemic (Figure 3-7). It is noteworthy that data of US Consulate uses US AQI categories while that of EPCCD is based on EPA Punjab AQI, differing in their class boundaries.

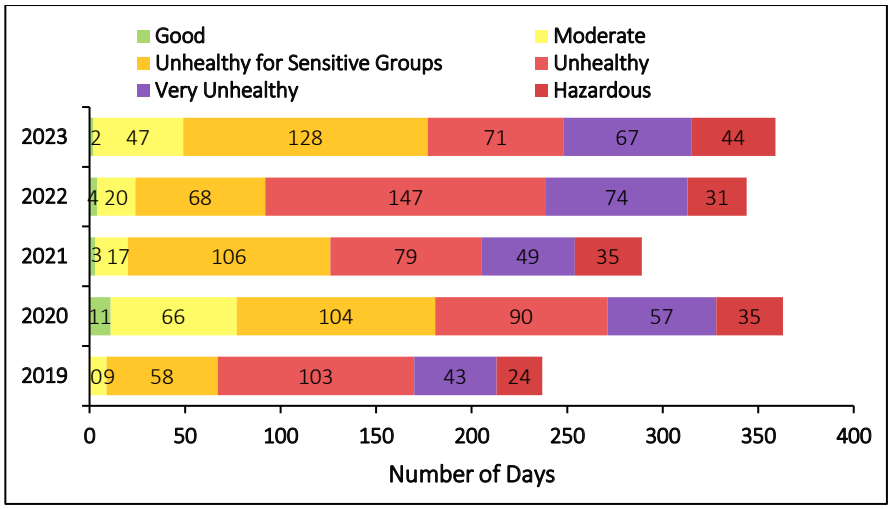


Figure 3-7: Number of days with respect to AQI (PM2.5) monitoring at US Consulate, Lahore from 2019 to 2023

2.4 Satellite Based Monitoring of Absorbing Aerosol Index (AAI) and Atmospheric Trace Gases[4]

The annual averaged (for year 2023) and 5-year's averaged (for years 2018-2022) AAI and concentrations of three major atmospheric trace gases viz. CO, NO_2 and SO_2 measured by TROPOMI sensor on-board Sentinel-5P satellite over the Punjab, Pakistan are presented in this section. Table 3 contains comparison of Annual average concentration of trace gases & AAI measured by satellite-based sensors.

Table 3: Comparison of Annual average concentration of trace gases & AAI measured by satellite-based sensors

Parameters	Average Concentration		Hotspots	
	2018-22	2023	2018-22	2023
Carbon Monoxide	27. 59 to 43. 49 mmol/m2	27 to 43 mmol/m2	Lahore, Faisalabad, Gujranwala, and Multan	Lahore, Kasur, Sheikhupura, Nankana Sahib, Faisalabad, Okara, Gujranwala, and Multan
Nitrogen Dioxide	15.60 to 143. 93 µmol/m2	13 to 133 µmol/m2	Lahore, Faisalabad, Gujranwala, Multan, Mianwali and Rawalpindi	Lahore, Kasur, Sheikhupura, Faisalabad, Gujranwala, Mianwali, Multan and Rawalpindi
Sulfur Dioxide	48.30 to 280.94 µmol/m2	-1.36 to 473.3 µmol/ m2	Lahore, Faisalabad	Lahore, Faisalabad, Attock
AAI	-0.94 to 0.64	-0.40 to 1.06	Deserted areas of the Punjab province	Deserted areas of the Punjab province

Figure 3-8 shows that major AAI hotspots are observed in the desert areas of the Punjab viz. Bhakkar, Dera Ghazi Khan, Rajanpur, Rahim Yar Khan, and Bahawalpur. AAI was found to be predominantly high in 2023 as compared to the last 5-year baseline for the province. The positive (> 0) values of AAI reflect absorbing component of aerosol (UV absorbing aerosol such as dust, smoke, black carbon/ elemental carbon) in atmosphere, whereas, the negative (< 0) values of AAI show non-absorbing (scattering such as sulfates, nitrates etc.) component of aerosol and/ or cloud.

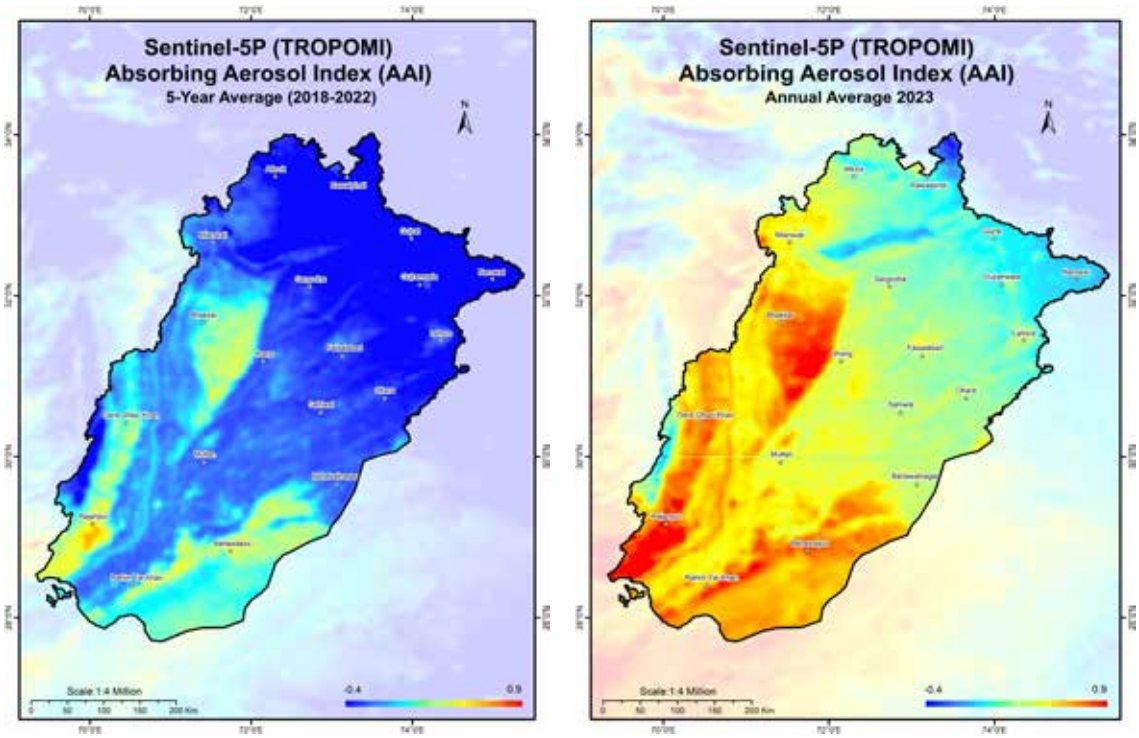


Figure 3-8: Comparison b/w 5-Year baseline (2018-2022) and annual averaged (2023) Absorbing Aerosol Index (AAI)

Figure 3-9 shows that major hotspots for CO in 2023 are observed in districts Lahore, Kasur, Sheikhupura, Nankana Sahib, Faisalabad, Okara, Gujranwala, and Multan.

4 Satellite based data, statistics and maps contributed by SUPARCO

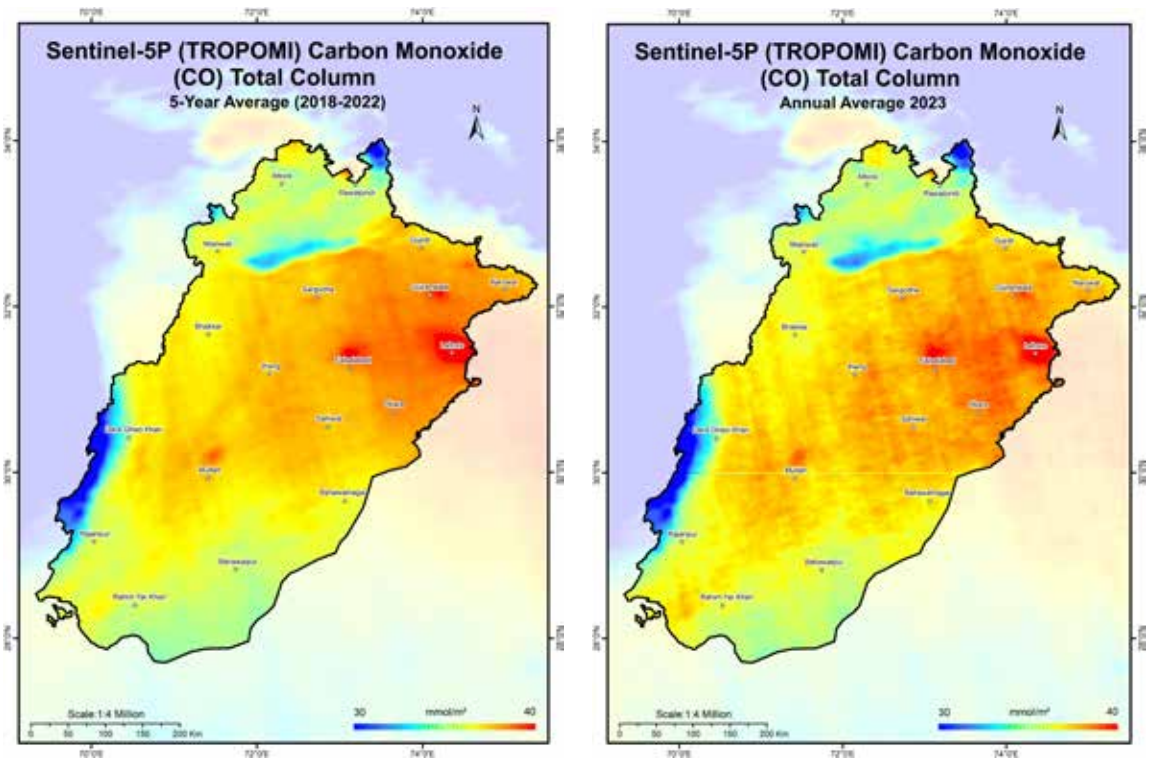


Figure 3-9: Comparison b/w 5-Year baseline (2018-2022) and annual averaged (2023) total column concentration of CO (mmol/m²)

Figure 3-10 shows that major hotspots for NO_2 in 2023 are observed in districts Lahore, Kasur, Sheikhupura, Faisalabad, Gujranwala, Mianwali, Multan and Rawalpindi. The major source of this atmospheric trace gas is the vehicular activities as evident from city and urban hotspots. In comparison to the baseline concentration, the annual averaged concentration in 2023 was found to be relatively low in all above mentioned hotspots.

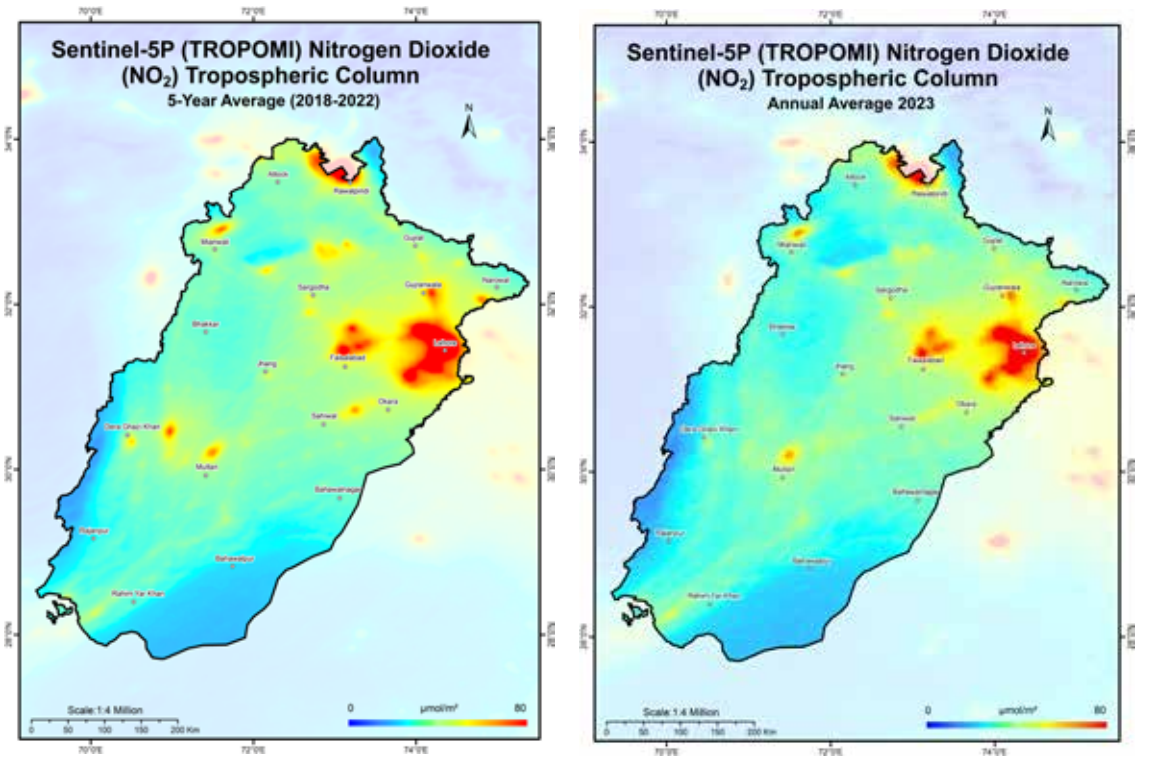


Figure 3-10: Annual averaged concentration of NO_2 (µmol/m²) during years 2022 and 2023

Figure 3-11 shows that major hotspots for SO_2 are observed in districts Lahore, Faisalabad, and Attock. The major source of this atmospheric trace gas is the burning of fossil fuel that contains sulfur, such as coal or oil used in power plants and other industrial facilities.

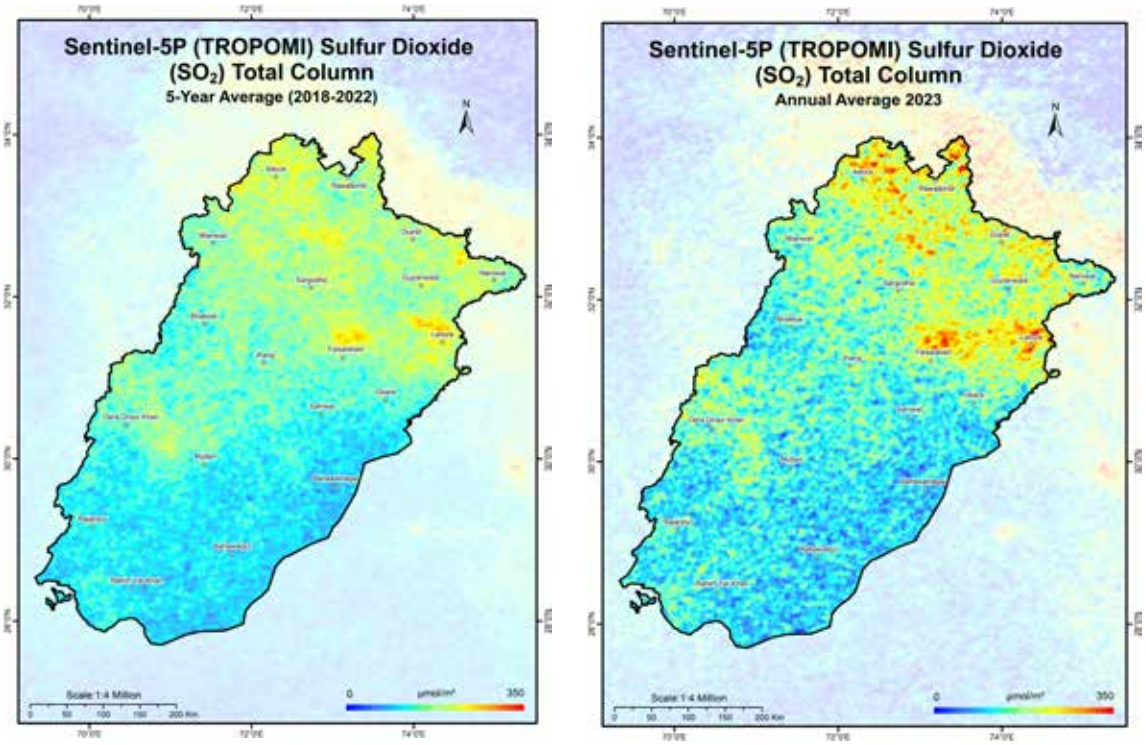


Figure 3-11: Comparison b/w basline (5-Year averaged) and annual averaged concentration of SO2 (µmol/m2)

2.5 Industrial Monitoring and Vehicle Inspection

Industrial and vehicular emissions are among the main sources of air pollution in the Punjab. Other sources may include agricultural practices, burning of biofuels and waste, fugitive dust and trans boundary pollution sources. Industrial emission monitoring is being carried out by the EPA Punjab, whereas vehicular monitoring is being carried out by the Transport Department through a public-private partnership. Details are given below:

2.5.1 Industrial Stack Emission Monitoring

In 2023, environmental laboratories of EPA conducted a total of 232 industrial inspections[5] to monitor the compliance of the PEQS for industrial gaseous emissions, 2016[6]. These standards include the parameters such as smoke, particulate matter, hydrogen chloride, chlorine, hydrogen fluoride, hydrogen sulphide, sulphur oxides, carbon monoxide, oxides of nitrogen and heavy metals. The standard values are provided in mg/Nm^3, except for Smoke, which is measured on the Ringelmann Scale or equivalent number. The monitoring of gaseous emissions was conducted mainly in industries such as brick kilns, textiles furnaces, paper and paperboard, cement plants, paints and dyes, foods, oil and fats and vegetable ghee, chemical projects and sugar mills. Industrial emissions are assessed through stack testing, using various methods for different pollutants. Japanese International Standard No. Z8808 is employed to measure Particulate Matter, while USEPA methods 03 (for Dry molecular weight O_2, N_2, CO_2, CO), 07 (for Nitrogen oxide), and 10 (for Carbon Monoxide) for gaseous emissions. Industry wise results of Oxides of nitrogen, SO_2, Particulate matter, CO and Smoke are given in Figures 3-12 to 3-16.

Following is the industry-wise overview of pollutant concentration:

- The Smoke emissions for the brick kiln had an average value of 58.3% on the Ringelmann Scale which is 45% higher than the prescribed values of PEQS.
- In the textile sector the gaseous emissions had average values (mg/Nm^3) of NO_x (1019) and SO_2 (937) within the permissible limits of PEQS. Whereas, CO (6887 mg/Nm^3) and smoke (48.2%) exceeded 761% and 20.61% of the PEQS value, respectively.
- In steel furnaces gaseous emissions had an average value of particulate matter (342 mg/Nm^3) within the prescribed limits of PEQs. Whereas, the Smoke (52.6%) exceeded the PEQs value.
- In paper and paper board mills, the gaseous emissions had average values (mg/Nm^3) of NO_x (246) and SO_2 (4.26) within the permissible limits of PEQs. Whereas CO (5714 mg/Nm^3) and Smoke (61.7%) exceeded the PEQs limits.

5 This data has been entered by EPA laboratories on the module of "Chemical Analysis Report (CAR)" at dashboard https://idm.pgdp.pk/ till 08th January, 2024.

6 https://epd.punjab.gov.pk/system/files/NOTIFICATION_REGARDING_THE_PUNJAB_ENVIRONMENTAL_QUALITY_STANDARDS_FOR_INDUSTRIAL_GASEOUS_EMISSIONS%20%281%29.pdf

- In cement plants gaseous emissions had average values (mg/Nm^3) of PM (178), NO_x (1092), SO_2 (7.09) and CO (491) within the permissible limits of PEQs.
- In Paints and dyes factories gaseous emissions had average values (mg/Nm^3) of NO_x (371) and SO_2 (253) within the prescribed limits of PEQs. Whereas CO (3506 mg/Nm^3) and Smoke (53.2%) exceeded the PEQS limits.
- In the Food sector, the gaseous emissions had average values (mg/Nm^3) of PM (436), NO_x (954) and SO_2 (1331) within the prescribed limits of PEQs. Whereas concentration of CO (3042 mg/Nm^3) exceeded 280% of the PEQs value.
- In Chemical Projects gaseous emissions had average values (mg/Nm^3) of NO_x (402), SO_2 (1328) and CO (25.32) within the permissible limits of PEQs. Whereas Smoke (50%) exceeded 25% of the PEQs value.
- In Sugar mills gaseous emissions had average values (mg/Nm^3) of NO_x (97.55), Sulphur dioxide (2.83 mg/Nm^3) and Smoke (34%) within the prescribed limits of PEQs. Whereas concentration of CO (1952 mg/Nm^3) exceeds 34% of the PEQs value.
- In Thermal power generation power plants gaseous emissions had an average value of CO (371 mg/Nm^3) within the prescribed limits of PEQs. Whereas NO_x (3580 mg/Nm^3) and SO_2 (2670 mg/Nm^3) exceeded the PEQS limits.

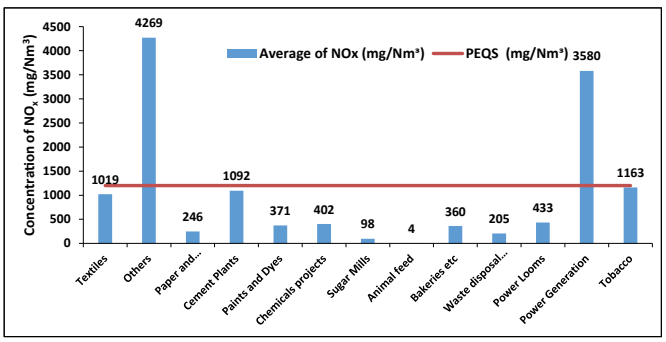


Figure 3-12: Average NO_X in stack emissions of various industries

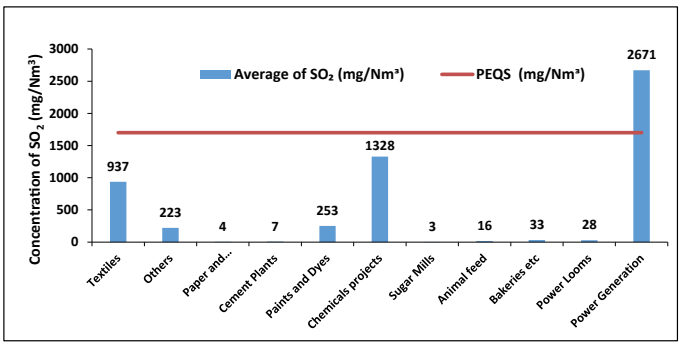


Figure 3-13: Average SO_2 in stack emissions of various industries

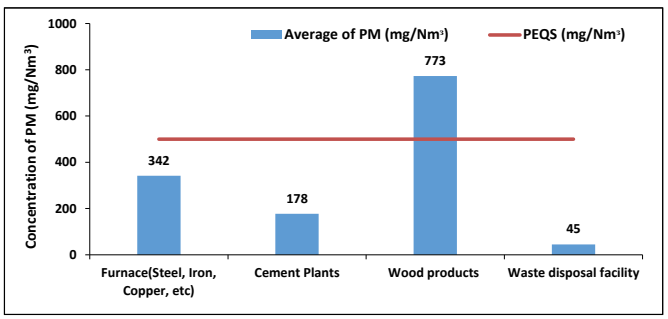


Figure 3-14: Average PM concentration in stack emissions of various industries

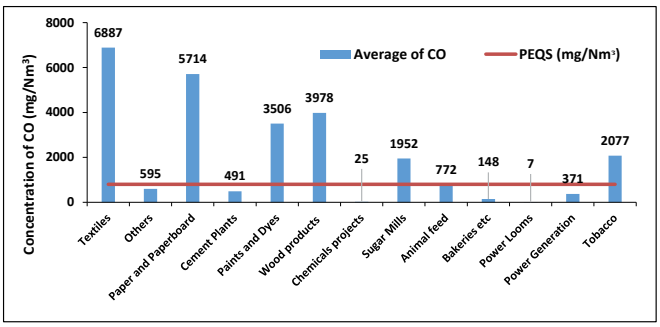


Figure 3-15: Average CO concentration in stack emissions of various industries

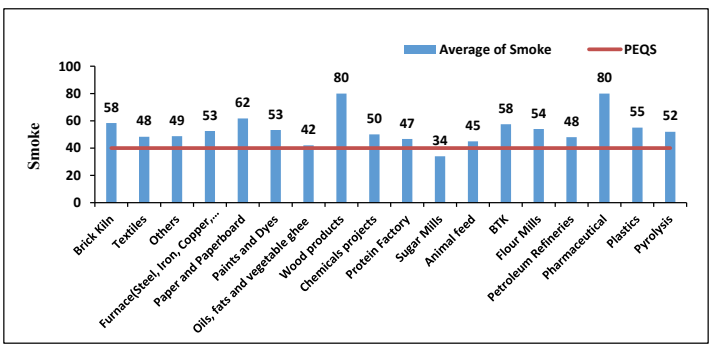


Figure 3-16: Average smoke produced by various industries

2.5.2 Vehicular Inspection

Approximately 17 million vehicles were registered between 2012 and 2023, comprising of motorcars, motorcycles, rickshaws, and commercial vehicles[7]. Notably, motorcycles alone accounted for 89% of this total (Figure 3-17).

7 Data from Transport Department.

Percentage of registered motorcars steadily increased from 6.4% in 2012 to 9.9% in 2023, while percentage of Rickshaws declined from 1.5% to 1.2%. In terms of Compound Annual Growth Rate (CAGR), motorcycles, cars, rickshaws, and commercial vehicles exhibited values of 0.36%, 4.5%, -2.5% and 0.8%, respectively. These values indicate consistent increase for motorcycles and cars, a gradual decline for rickshaws, and a relatively stable presence for commercial vehicles. Lahore district accounted for 27.18% of the total registered vehicles, maintaining its position at the top.

The Transport Department, Government of Punjab has taken a revolutionary step in collaboration with Opus Inspection (Pvt.) Ltd. This step was taken in the field of Road Safety and Environmental Protection by introducing a modern and computerized Vehicle Inspection and Certification System (VICS) network. Under the system, all Public Service Vehicles (PSVs)[8] operating in Punjab are being regularly inspected for fitness. The vehicle inspection procedure under VICS includes emissions testing for pollutants like CO, HC, CO_2, smoke density, and noise. This assessment commences with the initial categorization of vehicles based on their fuel type and age. PSVs are granted a Fitness Certificate upon confirmation that they meet safety standards for operation on public roads and highways, while adhering to environmentally friendly noise and emission limits. Criteria for Inspection of Vehicles in VICS is given at **Annexure-C**

If a vehicle fails the inspection test, the vehicle has to be maintained and brought to the concerned VICS station for re-test within two weeks. A preliminary test within two weeks is free of cost and if a vehicle even fails the first re-test, the it must be maintained and brought back again within two weeks. The fee for the second re-test is 25% of the initial test fee and if the vehicle fails in the second re-test another two weeks period is granted for its maintenance and re-inspection. If the vehicle fails in the third re-test, the route permit is suspended and the vehicle is declared 'off-road', that is intimated to the concerned Regional Transport Authority. A vehicle once declared off-road can use roads and highways to access inspection centres and repair shops but is not allowed to be used for transposition purposes.

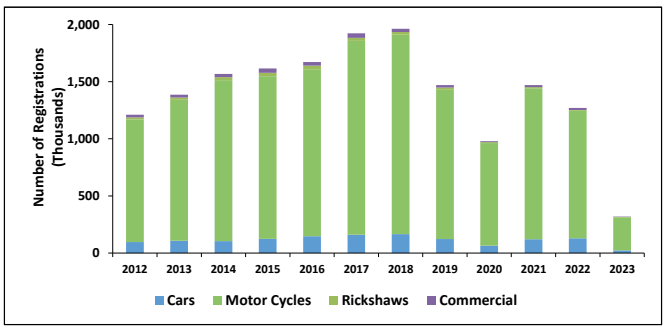


Figure 3-17: Year-wise registration of vehicles (2012 to 2023)

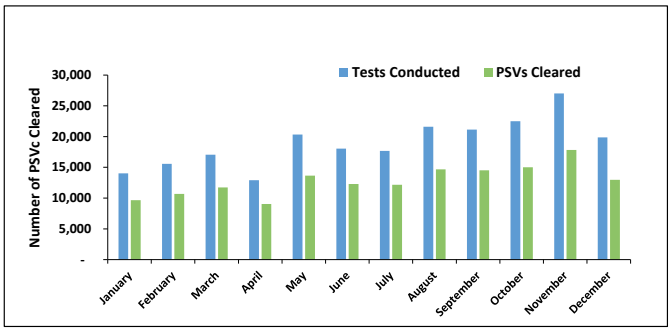


Figure 3-18: Number of tests conducted vs PSVs cleared during 2023

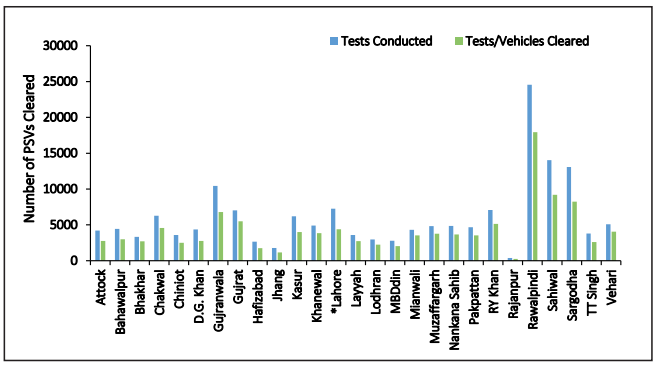


Figure 3-19: District-wise number of tests conducted vs PSVs cleared during 2023 (*The number of PSV tests conducted and cleared for Lahore is divided by 10.)

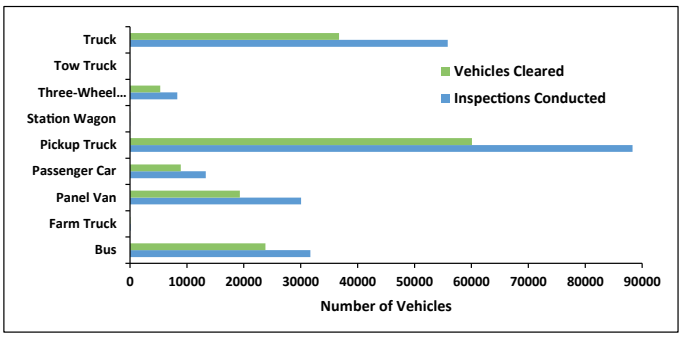


Figure 3-20: Types of PSVs and inspection/vehicles cleared during 2023

From January 1, 2023 to December 18, 2023, a total of 0.2 million tests were conducted[9]. The average clearance rate was 67.7%, indicating that roughly two-thirds of vehicles are roadworthy (Figure 3-18). Passenger cars consistently maintained the highest monthly clearance rates throughout the year. Whereas, farm trucks and three-wheel vehicles consistently had the lowest monthly clearance rates. District-wise number of tests conducted versus PSVs cleared during 2023 is given in Figure 3-19. The type of PSVs-wise number of tests conducted versus vehicle is given in Figure 3-20.

8 It includes "***Bus, Farm Truck, Panel Van, Passenger Car, Pickup Truck, Station Wagon, Three-Wheel Vehicle, Tow Truck, Truck***"
9 Data as obtained from VICS through Transport Department.

2.6 Overall Assessment

The overall air quality in Lahore city is rated as 'Poor'. A positive trend was observed in 2023 with an increase in the number of days with 'good/satisfactory' AQI $PM_{2.5}$ values and a decrease in the number of unhealthy days. The concentrations of most pollutants, including smoke, carbon monoxide, and NO_x exceed permissible limits in stack emissions of many industries. Industry-wise findings for the stack emissions for the monitored parameters shows that brick kilns, oil, fat, and vegetable ghee processing units, flour mills, petroleum refineries, pharmaceutical facilities, plastics manufacturing plants, pyrolysis operations, protein factories, and wood product manufacturing industries have non compliance of PEQS.

Ambient Air Quality Assessment

Assessment: Lahore (AQI $PM_{2.5}$)

3. Management

3.1 DPSIR Framework

Drivers

Punjab has almost 54.2% economic contribution to the national GDP and employs approximately 37.6 million people[10]. The drivers of poor air quality in Punjab are identified as follows:

a. **Population Growth:** Punjab is the most populous province of Pakistan. Around 128 million dwellers of Punjab constitute an overall 53% population count of the country. With an annual percentage average growth rate (2017-2023) of 2.53%, Punjab has a population density of 621.8 persons per Square Kilometre[11].

b. **Urbanization:** Urbanization is increasing at an unprecedented rate in Punjab. The urban proportion in Punjab is 40.70%[12].

c. **Industrialization**: The industries in Punjab significantly contribute to the GDP of the country. The industries are forced to run on 24/7 basis due to heavy demands which in turn result in emitting high volumes of air pollution.

d. **Poor Agricultural practices:** Punjab is a major producer of crops. In order to meet the increasing market demands (for wheat, rice, etc.), the farmers use conventional ways like stubble burning to sow the next crop in an expeditious manner without considering the environmental impacts of their activities.

e. **Increase in Vehicles:** Due to rapid urbanization, number of vehicles on roads in Punjab is increasing. Most of the vehicles run on fossil fuels, which release pollutants such as carbon monoxide, nitrogen oxides, and particulate matter into the air. Poor fuel quality and outdated engine technologies do not allow the clean burning of fossil fuels and cause vehicular pollution.

f. **Transboundary Pollution:** Stubble burning has been reported to be amongst the major contributors of air pollution especially for countries in Indo-Gangetic Plains. Therefore, the ambient air quality of Punjab has a direct linkage with the practices in the neighbouring countries.

Pressures

The above identified drivers pose a number of pressures on the air quality of the Punjab, which are explained as follows:

a. **Higher Greenhouse Gas Emissions (GHG):** Every driver exerts multiple pressures on the air quality. But, every driver, invariably results in a higher concentration of criteria pollutants especially particulate matter and the release of other GHG emissions.

b. **Industrial Emissions:** Industrial emissions exert multiple pressures on the ambient air quality including the release of criteria pollutants as well as greenhouse gas emissions. Criteria air pollutants have negative impacts on public health and the environment.

c. **Vehicular Emissions:** Air quality is exacerbated by adulterated fuel, lack of emission control devices such as catalytic converters/diesel particulate filters, low-efficiency engines, and poorly maintained vehicle fleets etc.

d. **Agriculture Related Emissions:** The activities like stubble burning, fertilization, cattle farming, rice paddies and the use of farm machinery and tube wells release a significant amount of particulate matter and other GHG emissions into the air contributing to poor air quality. Poor agricultural practices in Punjab are putting tremendous pressure on the ambient air quality.

10 https://punjab.gov.pk/system/files/PGS_2023.pdf
11 https://www.pbs.gov.pk/sites/default/files/population/2023/Press%20Release.pdf
12 https://www.pbs.gov.pk/sites/default/files/population/2023/Press%20Release.pdf

State

The state of the ambient air quality of the Punjab is as follows:

a. Air Quality: From 2019 to 2023, the air quality as measured at the US consulate at Lahore (near Shimla Hill) shows that annual $PM_{2.5}$ concentration is consistently more than seven times higher than its PEQS value (15 µg/m^3). The average value of monitoring at various points in Lahore is 96 µg/m^3, which is over six times higher than the PEQS. At this concentration the corresponding AQI $PM_{2.5}$ value is 169 "Unhealthy for sensitive group". Amongst other Divisional Headquarters, the highest concentration was recorded in Multan (approximately four times higher than the PEQS standards value) and lowest concentration was found for Rawalpindi (closest to the PEQS standard value).

b. Higher values of industrial emissions: Most of the industries monitored for stack emissions in 2023, showed higher emission levels and non-compliance with the PEQS thus polluting the environment.

c. Vehicular Inspection: During 2023, out of a total 227,684 PSVs tests conducted the average clearance rate was 67.75%, indicating that roughly only two-thirds of the vehicles passed the safety inspections and were road worthy.

Impacts

High concentration of criteria pollutants has serious health implications. For example, Carbon monoxide is a deadly gas that, even at low levels, can permanently damage the heart and brain, posing greater risks for those with heart or lung disease[13]. Ozone exposure can lead to respiratory issues, worsen lung diseases like asthma, and increase the frequency of asthma attacks[14]. Toxicity of lead is well-known, affecting various bodily systems[15], while nitrogen oxides can cause respiratory irritation and fluid build-up in the lungs, with high levels leading to severe throat and respiratory tissue damage[16]. Similarly, exposure to sulphur dioxide also results in respiratory difficulties, especially dangerous for children and can be immediately life-threatening at high concentrations[17]. Particulate matter poses diverse health risks including respiratory effects, heart diseases, diabetes, and neurological disorders in both children and adults[18].

Children, in general are exposed to elevated levels of air pollutants owing to their higher respiratory rates compared to adults[19]. Studies suggest that air pollution may trigger systemic inflammation and oxidative stress, potentially impacting fetal growth through several mechanisms. These include modifying placental volume and blood flow, prompting epigenetic alterations in placental and fetal tissues, and influencing mitochondrial content[20]. Exposure to air pollutants during critical developmental windows, especially prenatal phases, may significantly impair brain and cognitive development in children[21,22]. The exposure to elevated level of air pollution also causes mental health disorders among the citizens including seasonal depression, anxiety and mood sickness.

District Health Information System (DHIS) is a mechanism of data collection, transmission, processing, analysis and information feedback to the first-level and secondary-level health care facilities in Punjab[23]. The overall number of ARI patients were highest in Lahore, followed by Faisalabad and Rawalpindi. Whereas, highest were in the 1–4-year age group, followed by the 5–14-year age group and 15–49-year age group. In the 50+ year age group the number of ARI patients were lowest. The results revealed that:

- Males are more likely to be exposed to risk factors for ARI, such as air pollution and second-hand smoke than females.
- Young children are more susceptible to ARI than adults because their immune systems are not fully developed.
- The number of ARI patients increased steadily from January to May 2023, before decreasing in June and July. It then increased again in August and September, before decreasing again in October-December. Figure 3-21 presents the district-wise number of OPD patients reported during 2023. Whereas, Figure 3-22 shows the month-wise distribution of number of patients reported during 2023.

It is important to note that this data is only for OPD-ARI patients, which means that it does not include patients who were

13 https://www.atsdr.cdc.gov/toxprofiles/tp201.pdf
14 https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution
15 https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf
16 https://www.atsdr.cdc.gov/toxfaqs/tfacts175.pdf
17 https://www.atsdr.cdc.gov/toxprofiles/tp116.pdf
18 https://www.atsdr.cdc.gov/pha-guidance/resources/ATSDR-Particulate-Matter-Guidance-508.pdf
19 Fleming, S., Thompson, M., Stevens, R., Heneghan, C., Plüddemann, A., Maconochie, I., & Mant, D. (2011). Normal ranges of heart rate and respiratory rate in children from birth to 18 years of age: a systematic review of observational studies. The Lancet, 377(9770), 1011-1018.
20 Nobles, C. J., Grantz, K. L., Liu, D., Williams, A., Ouidir, M., Seeni, I., ... & Mendola, P. (2019). Ambient air pollution and fetal growth restriction: Physician diagnosis of fetal growth restriction versus population-based small-for-gestational age. Science of the total environment, 650, 2641-2647.
21 Calderón-Garcidueñas, L., Leray, E., Heydarpour, P., Torres-Jardón, R., & Reis, J. (2016). Air pollution, a rising environmental risk factor for cognition, neuroinflammation and neurodegeneration: The clinical impact on children and beyond. Revue neurologique, 172(1), 69-80.
22 Rivas, I., Basagaña, X., Cirach, M., López-Vicente, M., Suades-González, E., Garcia-Esteban, R., ... & Sunyer, J. (2019). Association between early life exposure to air pollution and working memory and attention. Environmental health perspectives, 127(5), 057002.
23 https://dghs.punjab.gov.pk/district_health

hospitalized for ARI. Additionally, the data does not include any information about the severity of the ARI cases.

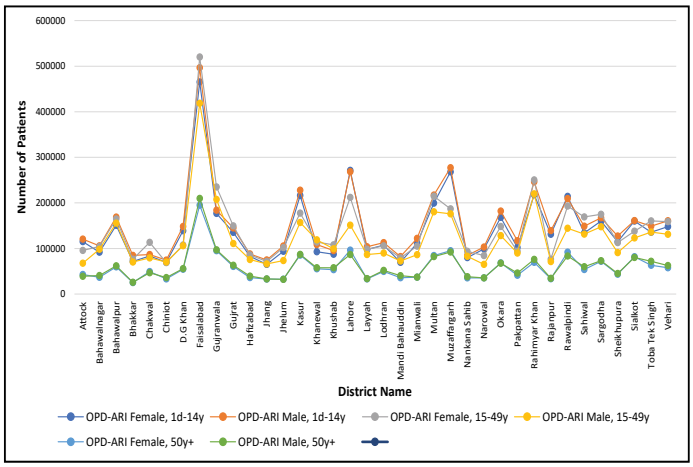


Figure 3-21: District-wise number of ARI patients during 2023

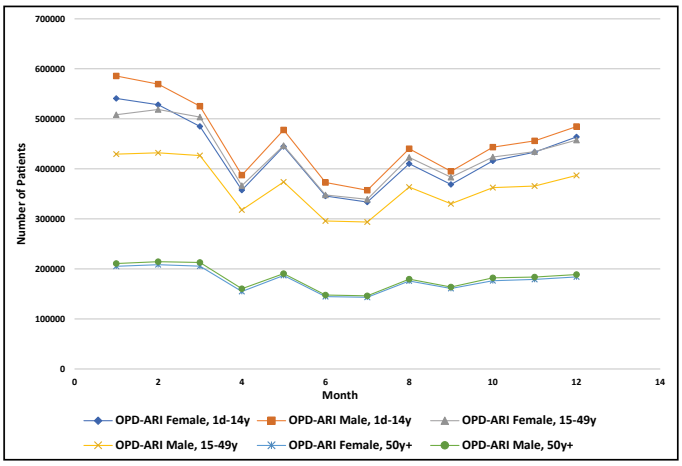


Figure 3-22: Month-wise ARI patients during 2023

Meeting the WHO guidelines for $PM_{2.5}$ would increase the life expectancy of an average citizen in Pakistan by 3.9 years, while in Lahore this gain would be of 7.5 years[24]. The World Bank (2014) estimated that transitioning to cleaner transportation systems not only results in substantial fuel savings but also reduces the incidence of air-quality-related health complications, such as respiratory illnesses and associated deaths. These transitions were estimated to yield savings of approximately $170 per ton of CO2 emissions avoided in 2014. Reducing emissions, particularly of black carbon and methane, can prevent hundreds of millions of metric tons of crop losses annually, offering substantial developmental benefits such as improved health and augmented agricultural yields (UNEP/WMO, 2011)[25]. Yields for four major crops–maize, wheat, rice, and soybeans have been estimated to increase around 1.3 million metric tons globally by mitigating Ozone emissions[26].

Response

Government of the Punjab is striving hard to provide clean air to the inhabitants of Punjab. Various government departments are taking action for controlling air pollution at their various tiers. Details of initiatives of some government departments as mentioned in the Annual Development Program[27] are as follows:

- Industries Commerce and Investment Department is undertaking Establishment of Excellence Hub(s) in the field of Renewable Energy – (KFW Development Bank, Germany Assisted Project in TEVTA Punjab); Demonstration Projects on Industries for Urban Centres, Relocation of Tannery Units to Sialkot Tannery Zone and its Operationalization (PGDP, DLI-7); Pilot/Demonstration Resource Efficiency and Cleaner Production Investments in key Industrial Sectors (PGDP, DLI-7); Infrastructure Development Work of Allama Iqbal Industrial City, Faisalabad-FIEDMC; Infrastructure Development (civil works) of Quaid-e-Azam Business Park (QABP) Sheikhupura; and Development of Bahawalpur Industrial Estate – PIEDMC
- Transport Department is undertaking the Lahore Orange Line Metro Train Project; Punjab Digital Transport Governance; Induction of Eco-Friendly Buses in Cities of Punjab (DLI-6 PGDP); Consultancy Studies for Induction of Eco-Friendly Buses in Cities of Punjab; and Expansion of Inspection and Certification System for Motor Vehicles (DLI-6 PGDP)
- Forest Wildlife & Fisheries Department is undertaking the development of the National Park at Pabbi; Tree planting along ROW Ghazi Barotha Hydro Project; Establishment of Dargai Gill Forest Park; Solar Pumps in Depalpur Plantation; Afforestation along Vehari Burewala Road; Livelihood Improvement and Green Job Creation Through Ecosystem Restoration in Punjab; Ten Billion Tree Tsunami Programme (Phase-I) Up-Scaling of Green Pakistan Programme (Revised) in Attock, Bahawalnagar, Bahawalpur, Bhakkar, Chakwal, Chiniot, Dera Ghazi Khan, Faisalabad, Gujranwala, Jhang, Jhelum, Kasur, Khanewal, Khushab, Lahore, Layyah, Lodhran, Mianwali, Multan, Muzaffargarh, Nan kana Sahib, Narowal, Okara, Pakpattan, Rahim Yar Khan, Rajanpur, Rawalpindi, Sahiwal, Sargodha, Sheikhupura, Sialkot, Toba Tek Singh, Vehari. Apart from this various rehabilitation,

24 Greenstone, M., Hasenkopf, C., & Lee, K. (2023). Annual Update. Air Quality Life Index. https://aqli.epic.uchicago.edu/wp-content/uploads/2023/08/AQLI_2023_Report-Global.pdf

25 UNEP/WMO (2011). Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers. UNON/ Publishing Services Section/Nairobi, ISO 14001:2004.

26 World Bank 2014 Climate-smart Development: Adding up the benefits of actions that help build prosperity, end poverty and combat climate change

27 https://pnd.punjab.gov.pk/system/files/Dev%20Prgm%202023-24.pdf#overlay-context=D7fR0aHpE_n5Yix1C/3

digitization and strengthening activities are being carried out by the department.

- Agriculture Department is undertaking development of hybrid and OPVs in Vegetables Resilient to Climate Change; Promotion of Mechanized Agriculture for Increasing Crop Productivity; National Program for Improvement of Watercourses in Pakistan Phase-II; Punjab Resilient and Inclusive Agriculture Transformation (PRIAT; Transforming the Indus Basin with Climate Resilient Agriculture and Climate-Smart Water Management. Apart from these initiatives there are programs for productivity enhancement of wheat, sugarcane and rice.
- Energy Department is undertaking setting up Solar Tube wells in water logged areas of Punjab; Design and construction of net zero energy building (ACEIP , DLI-8); Energy Efficiency & Conservation Programme (PGDP, DLI-5) in Attock, Bahawalnagar ,Bahawalpur, Bhakkar, Chakwal, Chiniot, Dera Ghazi Khan, Faisalabad, Gujranwala, Gujrat, Hafizabad, Jhang, Jhelum, Kasur, Khanewal, Khushab, Lahore, Layyah, Lodhran, Mandi Bahauddin, Mianwali, Multan, Muzaffargarh, Nankana Sahib, Narowal, Okara, Pakpattan, Rahim Yar Khan, Rajanpur, Rawalpindi, Sahiwal, Sargodha, Sheikhupura, Sialkot, Toba Tek Singh, Vehari; Punjab Ujala Program (Central Punjab) (ACEIP, DLI-1,2,3,4); Distribution of 1-Kw solar systems to poor population of Punjab based on BISP data; Development of renewable energy initiatives; Installation of biogas plant for Gujjar Colony; Installation of solar panels at the residences of Hon'ble Judges situated in GOR-I Lahore; establishment of waste to energy fund to meet financial viability gap for waste to energy projects in Punjab; Renewable energy development sector investment programme (REDSIP); Converting three cities of Punjab into solar smart cities in Gujranwala, Mianwali, Multan; Improvement of energy efficiency in WASA systems in Attock, Bahawalnagar, Bahawalpur, Bhakkar, Chakwal, Chiniot, Dera Ghazi Khan, Faisalabad, Gujranwala, Gujrat, Hafizabad, Jhang, Jhelum, Kasur, Khanewal, Khushab, Lahore, Layyah, Lodhran, Mandi Bahauddin, Mianwali, Multan, Muzaffargarh, Nankana Sahib, Narowal, Okara, Pakpattan, Rahim Yar Khan, Rajanpur, Rawalpindi, Sahiwal, Sargodha, Sheikhupura, Sialkot, Toba Tek Singh, Vehari; and solarization of Lahore High Court, Other residences in GOR-I Lahore, Basic Heath Units (Phase-II) (ACEIP, DLI-2,3), 100 Higher secondary schools in Punjab (ACEIP), 35 Tehsil Headquarter Hospitals and 100 Rural Health Care Centres and Installation of B.E.S.S, Schools for differently abled children, commissioners complexes, Public institutes (Phase-II), public sector building, Basic Health Units (Phase-I) (ACEIP, DLI-2,3), and Institutes of Cardiology in Faisalabad and Multan. Measures taken to control air pollution in Punjab by EPCCD are given in detail in chapter 8. The DPSIR framework is depicted in Figure 3-23.

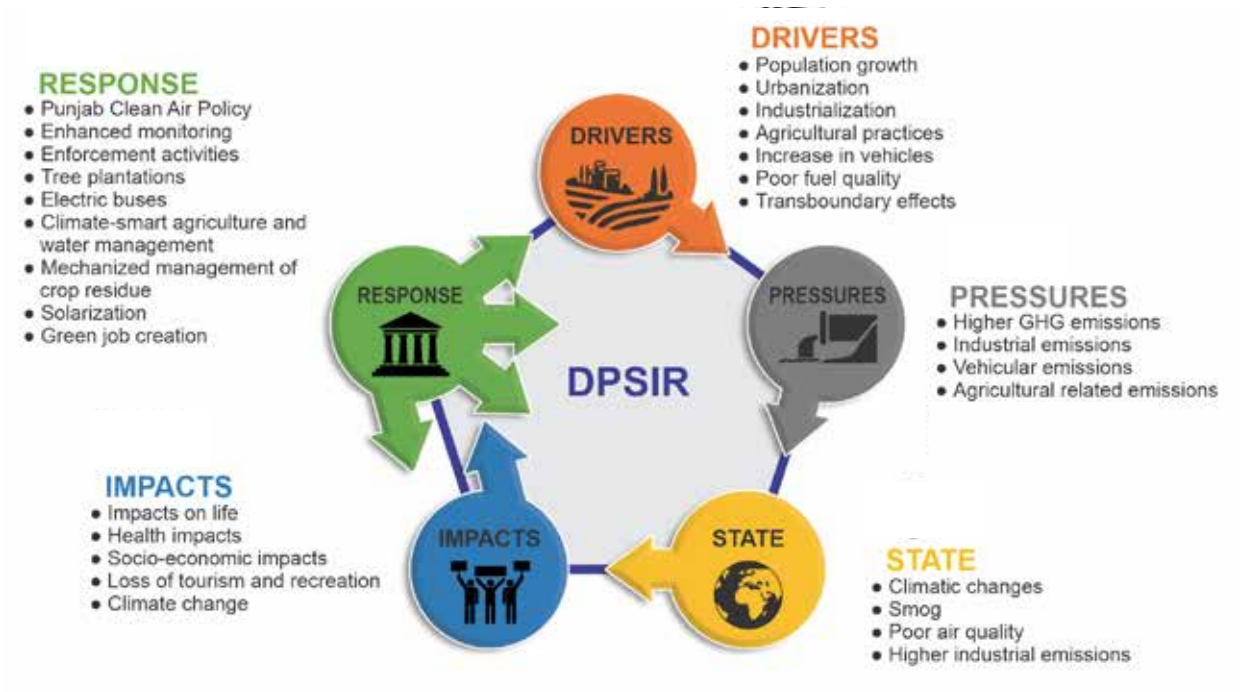


Figure 3-23: DPSIR framework for air quality in Punjab

4. Way Forward

The recommendations given below are in addition to the earlier provided in the SOE Report, 2022. This will help in the building of the following:

1. AQM Policy and Governance

Citizen engagement: Establishment of web-based air portal and engage public, private and civil sectors in the

development of joint policy framework to address air quality related environmental challenges. Effective participation of stakeholders and public-private sector cooperation in decision making-processes shall be carried out.

Strengthening of regulatory framework: EPCCD has notified the Punjab Clean Air Policy with phased action plan, now there is a need for implementation of the same to harness its fruits. It also requires the stern implementation of the Punjab Environmental Protection (Smog Prevention and Control) Rules, 2023. Further the clean air act is also a need of the hour.

Implementation of key achievement: EPCCD has been able to get notified the Punjab Clean Air Policy (with phase Action Plan) and Health Advisory on the wake of critical air pollution. The implementation of these key documents will pave the way towards reduction in air pollution as well as improvement in quality of life.

Enhanced Air Quality monitoring with apportionment studies: To strengthen the capacity for measurement of air quality in 10 districts of Punjab, Environment Protection and Climate Change Department has signed contracts for 30 air quality monitoring stations on engineering procurement and construction mode. However, the apportionment studies have not been carried out due to certain limitations. EPCCD is committed to carry out the apportionment studies during 2024.

Engagement with the development partners: There is need to strengthen the relation with the development partners for increasing planning capacity, strengthening air quality monitoring capacity, financing clean technology adoption and for ancillary matters.

2. Sector Abatement Actions

One City one solution: Every district in Punjab has some intrinsic characteristics and distinct practices in terms of agriculture, industries and vehicular pollution. Therefore, there is need to develop one district one solution. One solution cannot be fit for all. Area specific environmental action plans including pollution and dust control/urban dust management plan are required to be developed.

Industrial establishments: Comprehensive control of industrial establishments and reduced emission of multi

pollutants, end of pipe particular matter remover, installation of continuous emission monitoring systems etc. are required. Development, implementation, and encouragement of techniques and technologies that prevent pollution at the source are the need of the time.

Vehicular emissions: The recommendations for reducing vehicular emissions include, green transportation, standards, action plans and solutions, road engineering for removing traffic congestion in the major roads of the urban centres, increase in the counters of issuance/renewal of fitness certificates/route permits and deployment of the teams for checking vehicles plying on road without fitness certificates and route permits.

Other actions: There is a need to carryout study to move towards alternative solutions for residential cooking (such as improved cook stoves). Moreover, it is also required to address crop residue burning and excess fertilizer use and livestock (manure), and waste burning issues.

3. Trans-Boundary Cooperation

The air quality of Indo-Gangetic Plain air shed is largely dependent on the regional practices. These regional practices significantly affect the quality of life of its residents. Therefore, it is highly important to promote Punjab's participation in regional level knowledge exchange and initiatives on air pollution.

Clean water is the liquid thread that weaves together health, prosperity, and the promise of a sustainable future

4 WATER QUALITY

4. Water Quality

1. Overview

Water is considered as the second most essential element for life, after oxygen. Water is a resource that affects all facets of development and is connected to almost all Sustainable Development Goals. It is vital and basic to life itself, promotes ecological health, and propels economic progress. Indus River System is primary source of water in Pakistan. The burgeoning human population along with escalating industrial activities, agricultural needs and improved living standards have intensified consumption of water resources.

It has been estimated that per capita water availability in Pakistan has reduced from 5000 m^3 in 1951 to 1100 m^3 in 2005 and is expected to further decline by 800 m^3 till 2025[1]. The current storage capacity is inadequate as the three major water reservoirs in Pakistan, i.e. Mangla (1967), Tarbela (1978) and Chashma (1971), have a total designed capacity of 15.75 MAF, which has been reduced to 13.1 MAF due to sedimentation. These reservoirs can only save water requirement for up to 30 days as compared to the internationally lowest water storage requirement of 120 days[2].

It is estimated that water shortfall of Pakistan will increase from 11% in 2004 to 31% by 2025, leading to an annual food shortage of almost 70 million tonnes[3].

KEY FINDINGS

- In 2023, average flows across all rivers (Indus, Chenab, Kabul, and Jhelum) increased notably by 10.47% as compared to CY 2022.
- Surface water quality assessment rating was "moderate" for monitored Rivers and Canals and 'Very Poor' for drains respectively.
- Groundwater monitoring by Irrigation Department revealed that about 58% of tested groundwater sources were suitable for direct irrigation.
- Based on Water Quality Index, the overall quality of unfiltered drinking water (tap water) in both urban and rural areas was rated as 'Poor'.
- The majority of filtered drinking water sources in rural areas (except for Lahore and Rawalpindi), were found to be unsuitable for drinking purposes, mainly due to elevated arsenic levels.
- The assessment conducted by EPA laboratories indicated that only 0.8% of industrial units from the sampled group met the PEQS for all monitored parameters.

2. Environment

2.1 Surface Water Resources

Surface water is a vital resource, serving not only for irrigation needs but also as a crucial source for industrial and potable water supplies. Beyond its immediate usage, surface water plays a multifaceted role in sustaining ecosystems and facilitating the replenishment of underground aquifers.

The Indus Basin Irrigation System is one of the largest contiguous irrigation systems in the world with fiver major rivers – the Indus, Jhelum, Chenab, Ravi and Sutlej – and their tributaries flow in the province (Figure 4-2).

2.1.1 Rivers

The Irrigation Department, Government of the Punjab, monitors the flows of rivers flowing in the province. Figure 4-3 shows average monthly flows of – Indus, Chenab, Kabul and Jhelum – as monitored at rim stations for the past two years (CY 2022 and CY 2023).

Indus river had the highest average annual flow (4.9 MAF), nearly equivalent to the combined flows of the other three rivers, followed by the River Chenab (1.98 MAF). The highest flow for a particular month was observed for River Indus in July (13.98 MAF), whereas the lowest flow was observed for River Jhelum in December (0.32 MAF). The flow trajectories in CY 2023 generally remained same as CY 2022 for all rivers, with minor deviations.

Notably, River Indus experienced deviations during May-September, River Chenab during June-July, River Jhelum during May-July, and River Kabul during April-September. Overall, there was a 10.47% increase in average flows across all four rivers in CY 2023 as compared to CY 2022, with River Jhelum recording the highest percentage increase (24.34%), followed by Chenab (11.37%), Indus (4.3%), and Kabul (1.87%).

1 Qureshi, R., and Ashraf, M. (2019). Water security issues of agriculture in Pakistan. PAS Islamabad Pak, 1, 41.
2 Ishaque, W., Mukhtar, M., & Tanvir, R. (2023). Pakistan's water resource management: Ensuring water security for sustainable development. 11, 1096747.
3 Ashraf, M. Water Scarcity in Pakistan: Issues and Options. Pakistan Council of Research in Water Resources (PCRWR). 2018.

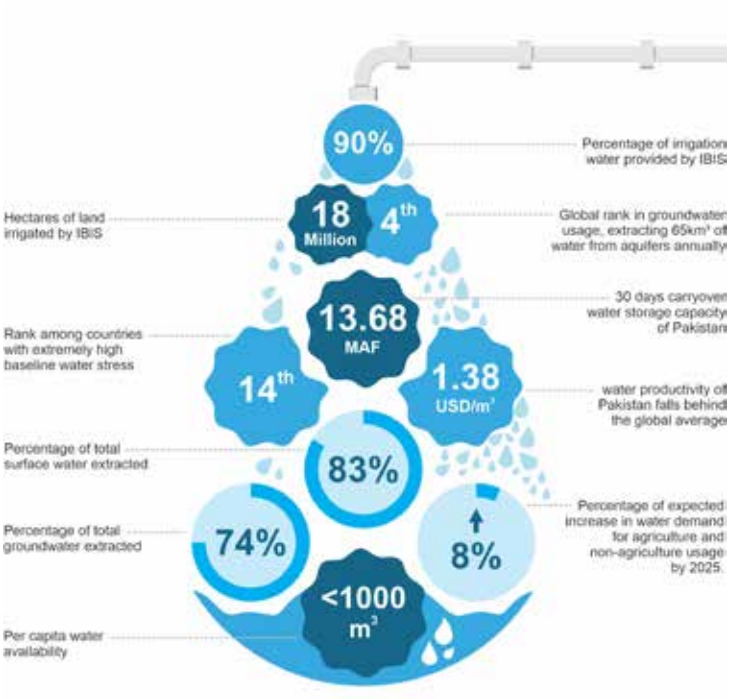


Figure 4-1: A snapshot of surface and groundwater supplies in Pakistan

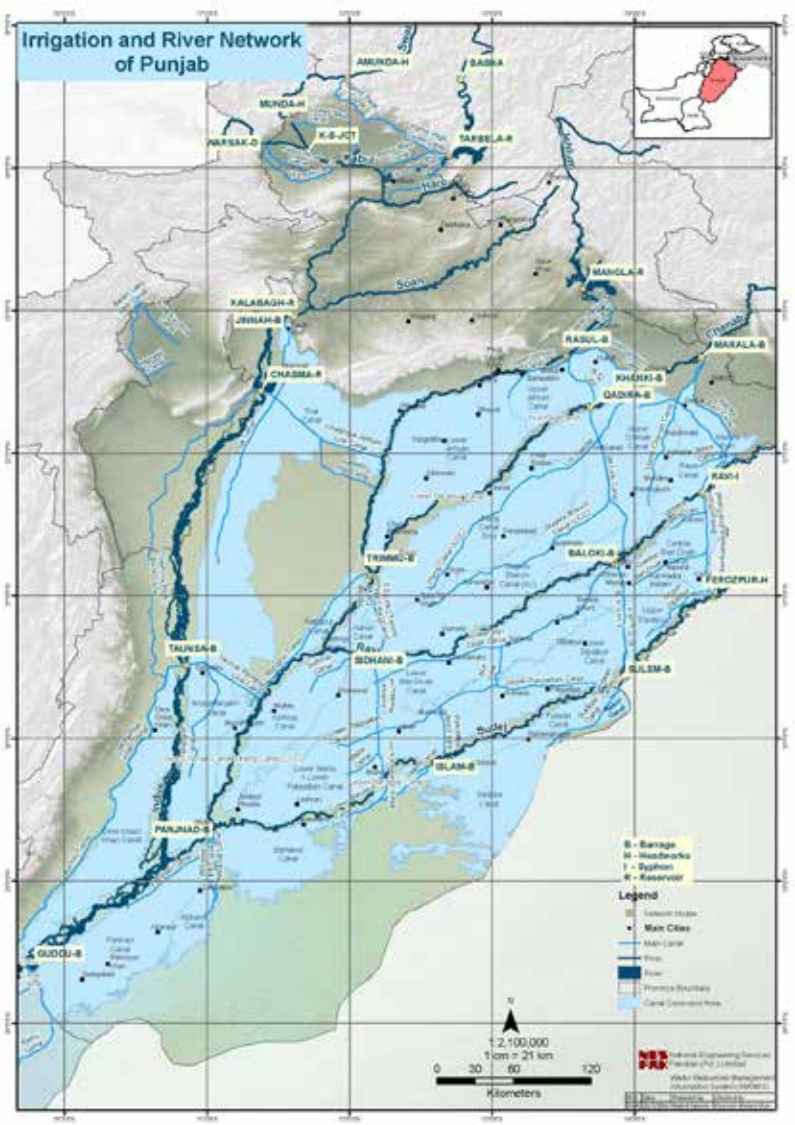


Figure 4-2: Irrigation and River Network of Punjab

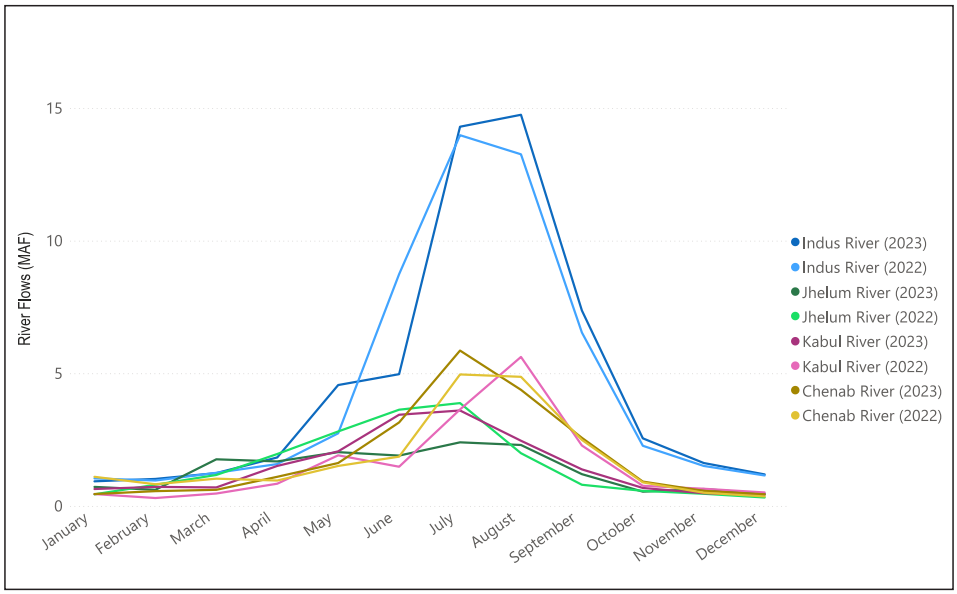


Figure 4-3: Average Monthly Flows of Major Rivers in Punjab – CY 2023 and CY 2022

2.1.2 Canals

Pakistan possesses one of the largest man-made contiguous canal systems in the world. Most of the canal network is situated in the province of Punjab. The Irrigation Department, GoPb has divided the provincial irrigation system into 8 operational canal zones for administration and management of the system. According to a working paper by Pakistan Institute of Development Economics (PIDE), the provincial canal system delivers irrigation supplies to farmers through 51,990 outlets in its system of 24 main canals and distribution canals spanning an area of over 22,700 km[4].

Major canal withdrawals occur at the two prime command zones in the north of Punjab, namely the Indus Zone and the Jehlum-Chenab (JC) Zone (Figure 4-4). Here, water is discharged into canals through two command centres (dams); Tarbela Command and Mangla Command. Figure 4.4 shows actual canal withdrawals for both Rabi 2022-23 (October 2022 through to March 2023) and Kharif 2023 (April to September 2023) crop seasons. It is observed that despite monthly variability amongst both zones, the overall canal withdrawal was similar: Indus Zone contributed 20.35 MAF (49%) while JC Zone contributed 21.18 MAF (51%) over the entire period.

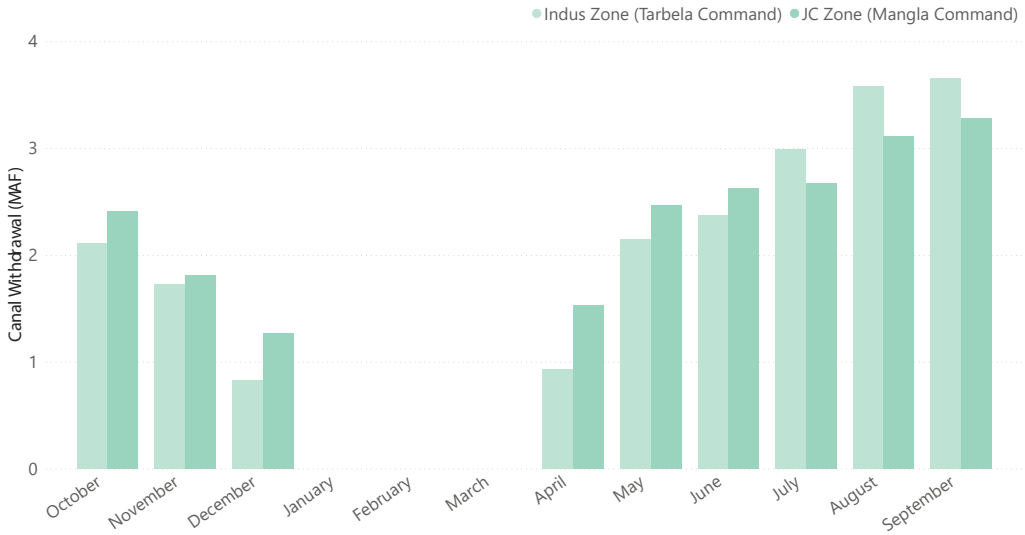


Figure 4-4: Actual canal withdrawals in Punjab [October 2022 – September 2023]

2.2 Surface Water Quality

Maintaining the quality of surface water is of the utmost importance due to its significant impact on both aquatic ecosystems and human well-being. Rivers and other freshwater sources are highly vulnerable to pollution given their role of carrying industrial and municipal wastewater along with runoff from the agriculture fields. As the surface water quality deteriorates, its use for domestic, drinking, agriculture, industrial, recreation and other purposes is impaired.

4 https://www.pide.org.pk/pdf/Rural/water_and_irrigation(Khalid_Riaz).pdf

To assess the water quality of surface water bodies, EPA Divisional Labs monitored the surface water quality by measuring key physico-chemical parameters such as pH, BOD, COD, TDS, TSS, Chloride, Sulphate and Sulphide. Suitability of surface water for sustaining aquatic life and irrigation was assessed by using USEPA and FAO Standards respectively. Samples from rivers, canals and drain were collected during the months of August and September. River water samples were collected from Ravi (Ravi Siphon, Shahdara Bridge, and at Saggian Bridge) and Chenab (near Chiniot). Canal water samples were collected at three points along the Lahore Canal (originating point at Jallo, Ferozepur Road Bridge and Thokar Niaz Baig), at two different locations along the Upper Chenab Canal in Sheikhupura and four samples from Jhang branch Chiniot and Faisalabad. Drain samples were collected from Jhang at two locations i.e., upstream and downstream of Rani Wah Drain (Figure 4-5).

Figure 4-5: Monitoring points of surface water bodies in Lahore and Faisalabad

Results of the analyses are shown in Figures 4-6 and are described below in the relevant section.

2.2.1 Rivers

Mean pH and TDS (mg/l) of both Ravi and Chenab rivers were in FAO acceptable limits for irrigation water quality[5], while Cl^- concentration exceeded in both rivers. Mean COD (mg/l) of Ravi (35) was higher than Chenab (22). TSS value of River Ravi (932) was much higher than Chenab (126). Results of other parameters (mg/l) i.e. for BOD (7.1), sulfate (30) and sulfide (0.26) were only reported for River Ravi.

2.2.2 Canals

All the samples were found to be within safe limits of pH. Jhang Branch canal was found to have highest values of COD, TDS and Chloride followed by Upper Chenab, Sheikhupura. Similarly, BOD, sulfate and sulfide was also found higher in Upper Chenab than Lahore Canal. However, TSS value was found highest in Lahore Canal.

2.2.3 Drains

pH (9.4) and Cl^- (1083 mg/l) values were found exceeding the FAO limits. Other monitored parameters (mg/l) were also found in high concentrations (COD 161 and TSS 2575).

2.3 Ground/Drinking Water Resources

Access to safe and clean drinking water is a basic human right, and a fundamental tenet of public service provisioning. Groundwater plays a vital role in sustainable development as it provides around 25% to 40% of the world's drinking water. Only about 3% of water on earth is fresh water; of that, only about 1.2 % can be used as drinking water[6]. It is estimated that the quantity of groundwater in the province is being depleted at the rate of 2% per annum, whereas water output for irrigation, drinking and industrial use far exceeds the input recharge through surface water and precipitation. With increasing population, the pressures of water availability and quality have increased manifolds in recent times[7].

5 https://www.fao.org/3/t0234e/T0234E01.htm
6 https://education.nationalgeographic.org/resource/earths-fresh-water/
7 Ishaque, W., Mukhtar, M., & Tanvir, R. (2023). Pakistan's water resource management: Ensuring water security for sustainable development. Frontiers in Environmental Science, 11, 1096747.

2.4 Ground Water Quality

Deterioration of drinking water quality is directly linked with adverse impacts on environmental, economic and social welfare of a nation. Extraction of deep ground water for drinking purpose is generally considered safe and free from

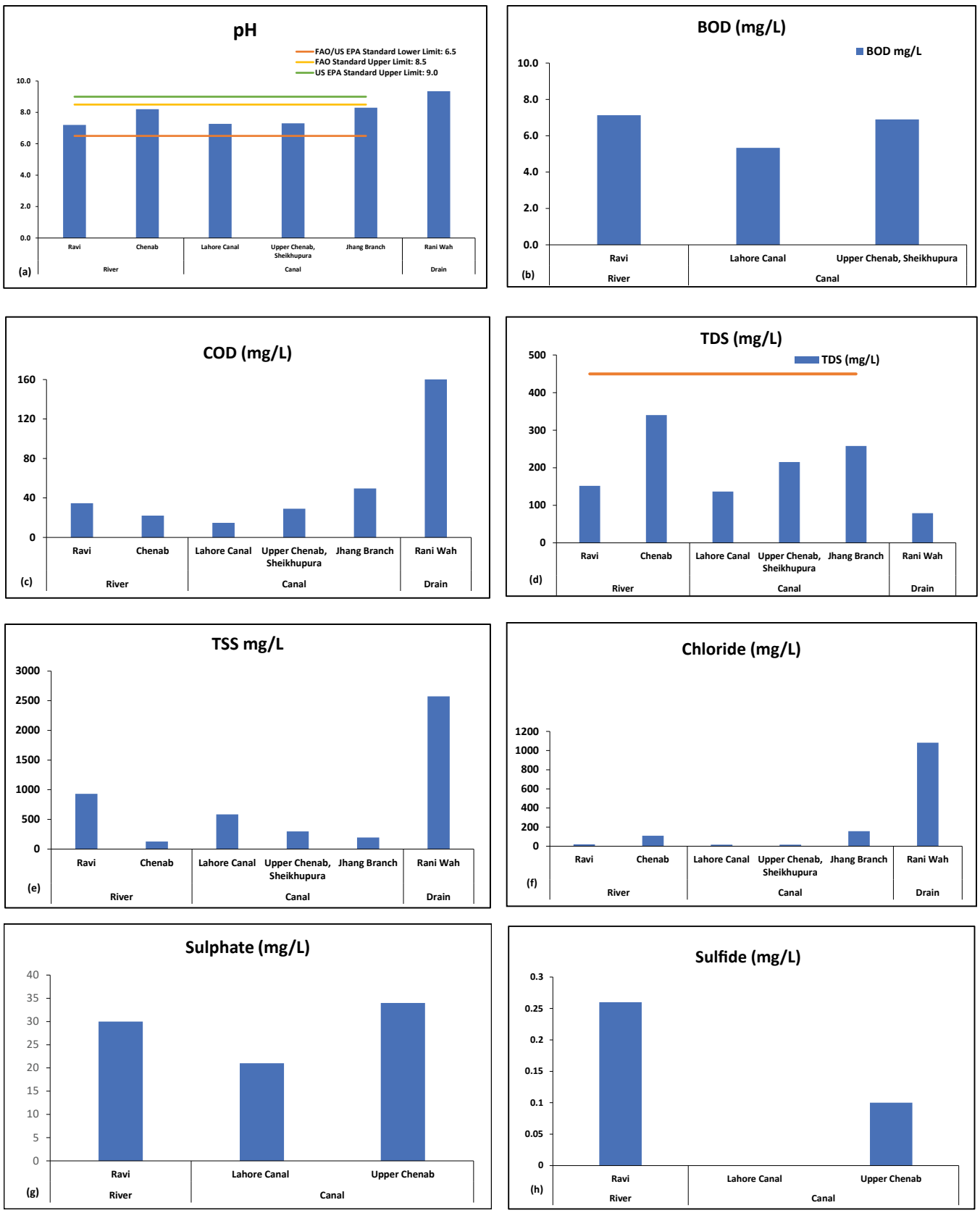


Figure 4-6: Water quality assessments in surface water bodies

contamination, but requires more economic cost and is a challenge for poor societies, and leads to lowering of water table. In Punjab, public drinking water is mainly provided by Water and Sanitation Agencies (WASAs) in large cities and

by TMAs in smaller towns. Individual or community-based systems exist in other non-serviced locations. Water filtration plants have also been installed by WASAs/TMAs/NGOs, in some parts of major cities and in several rural villages, to provide clean drinking water to people.

For the purpose of this report, water quality assessments were conducted at three key points i.e., receiving sources, distribution systems and consumer endpoints. Groundwater quality assessment by the Irrigation Department, focused on suitability for irrigation, especially near canal sources. The WASAs monitored the quality of groundwater within their distribution systems to gauge its suitability for drinking purposes. Whereas, the SP&IU organized assessments of drinking water for checking fitness/quality compliance at the consumer end by testing water from taps and filtered sources throughout the province.

2.4.1 Ground Water Quality (for Irrigation Purposes)

Irrigation Network Sources (Irrigation Department, GoPb)

The Irrigation Department, GoPb surveyed the quality of groundwater for irrigation purposes throughout Punjab. The department has divided the province into 8 canal divisions, encompassing around 30 districts, on the basis of the provincial irrigation network. Various locations along the irrigation network were bored to collect samples for ground water quality assessment during pre-monsoon (June) and post-monsoon (October) months. The average boring depth of samples across all canal divisions was around 145 feet, and average screen length was reported to be around 93 feet. The average Natural Surface Elevation (NSL) was reported to be around 189 metres. The average discharge was stated as 1.93 Cs. Although this is normally an annual exercise undertaken by the department, data currently was only available for CY 2022. The results of the assessment are expressed in terms of three chemical parameters, namely EC, Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC). The Irrigation Water Quality Standards and classification notified by WAPDA were used as standard[8].

In terms of EC, both pre- and post-monsoon monitoring revealed small differences in values. Only 4 canal divisions complied with the EC standard limit, while the overall average level (1.57 dS/m) was slightly above the stipulated limit (1.5 dS/m). The overall average SAR (5.72) alongwith the average pre-monsoon (5.79) and post-monsoon levels (5.65) were all significantly below the specified limit (10). Results of RSC revealed overall average (2.05 meq/L), pre-monsoon (2.15 meq/L) and post-monsoon (1.95 meq/L) levels were within the given threshold.

Overall fitness level Groundwater monitoring revealed that only 58% of groundwater sources contained usable water which could be used directly for irrigation without dilution; the remaining groundwater sources either needed dilution with canal water or were deemed hazardous to be used for crop irrigation. Thal canal division had the highest fitness efficacy (≈80%), followed by Sahiwal (≈77%) and Lahore (76%) canal divisions (Figure 4-7). Both Faisalabad canal divisions were found to have the lowest fitness efficiency (collectively averaging around 30%), followed by Bahawalpur canal division (40%).

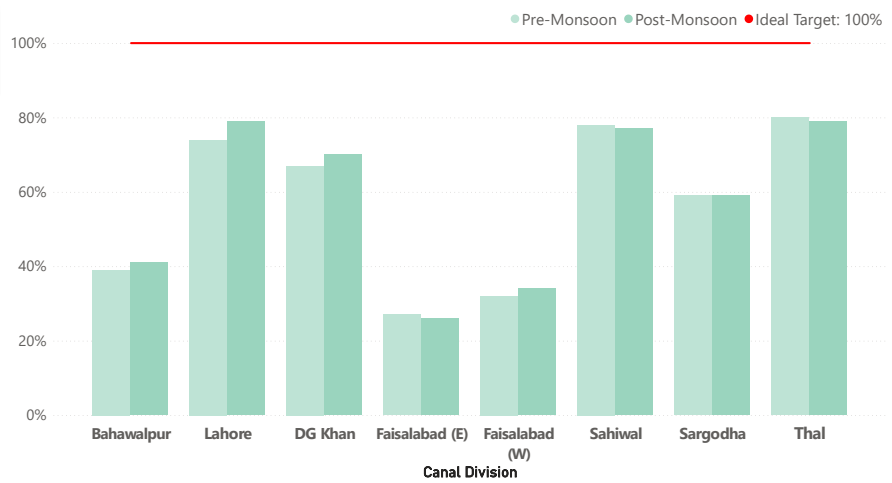


Figure 4-7: Average fitness level of groundwater in the provincial irrigation network

2.4.2 Ground Water Quality (for Drinking Purposes)

Drinking Water Distribution System (Provincial WASAs)

Data from four WASAs (Lahore, Gujranwala, Faisalabad and Rawalpindi) was received and analysed. All the four WASAs, monitored and tested water within their distribution systems to ensure compliance with the stipulated physical, chemical and biological standards/guidelines.

Physical Characteristics: All of the four WASAs reported that more than 90% of the samples were in acceptable PEQS limits for physical characteristics including physical appearance (% clear), odour, taste, colour, EC, Turbidity, TDS and overall fitness level (Figure 4-8). In terms of pH, all the WASAs reported that more than 98% of the assessed samples were in compliance to PEQs (Figure 4-9).

8 Water and Power Development Authority, 1981.

Chemical Contamination: In terms of residual chlorine level, assessed samples were in the compliance range set by all WASAs except in Lahore, where only 51% of the samples met the standard criteria during the year. In a number of cases ,assessed by WASA Lahore, it was reported that there was no residual chlorine detected in the sample. This is somewhat alarming as chlorine is used as a disinfectant and absence of it within the distribution system can lead to introduction of biological contamination within the mass water supply network, with potentially adverse health impacts.

Various other chemical parameters were reported varyingly by different WASAs. WASA Rawalpindi, for example, reported average alkalinity value (186 mg/L) within applicable standard limits[9]. Both WASA Rawalpindi and WASA

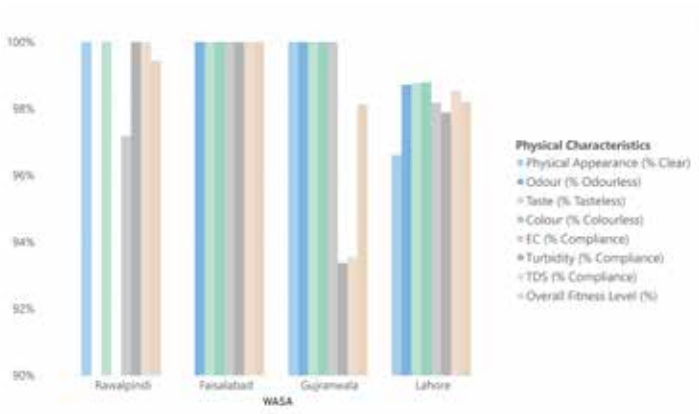


Figure 4-8: Compliance levels of physical characteristics across different WASAs

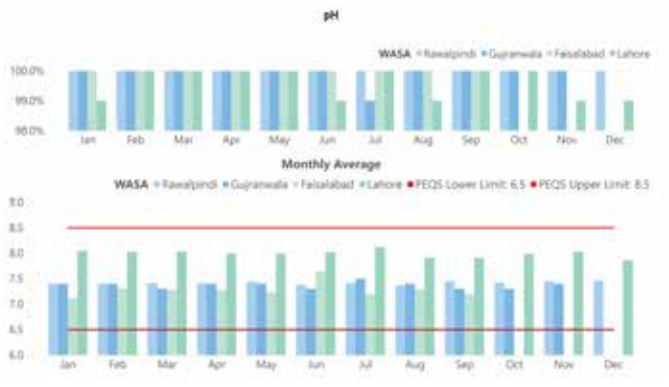


Figure 4-9: Monthly pH average and compliance levels

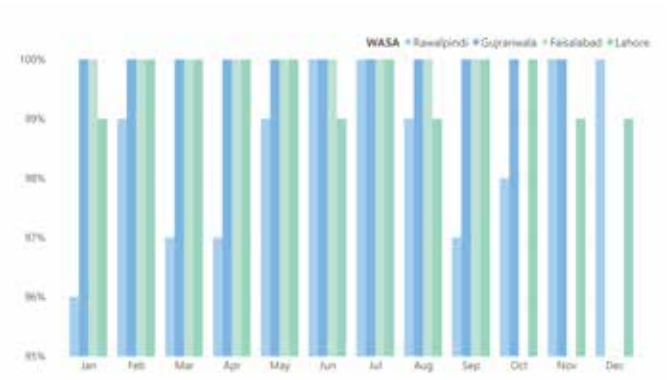


Figure 4-10: Chemical fitness of drinking water in distribution systems

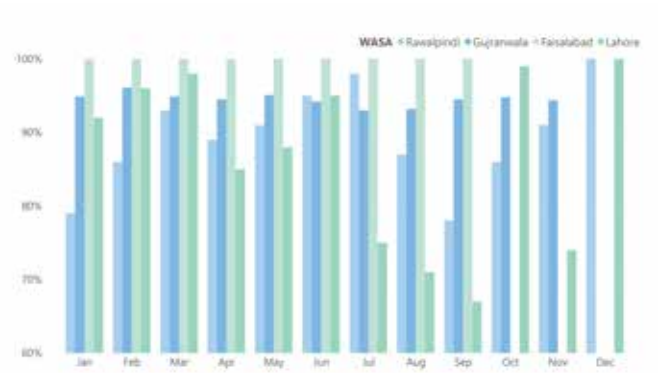


Figure 4-11: Biological fitness of drinking water in distribution systems

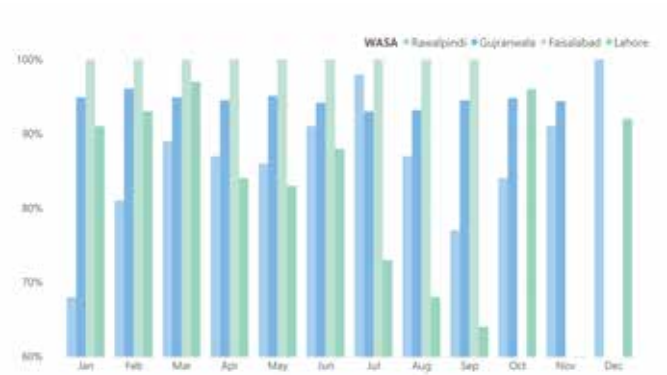


Figure 4-12: Overall fitness of drinking water in distribution systems

Faisalabad reported annual average of total hardness (as Calcium Carbonate) within the PEQS limits. All WASAs also reported on the overall chemical fitness of water for each calendar month, based on the chemical parameters used for assessing the drinking water quality within their jurisdictions. All the agencies reported average chemical fitness score of more than 98%, thereby implying that the drinking water supplied by them was largely free from chemical contaminations and suitable for human consumption (Figure 4-10).

9 The Indian Standard "IS 10500 (2012): Drinking water [FAD 25: Drinking Water]" gives the maximum requirement (acceptable limit) for total alkalinity (as Calcium Carbonate) as 200 mg/L. The standard also provides for a permissible limit for alkalinity in water sample as 600 mg/L, which is to be employed in the absence of an alternate source.

Biological Fitness: WASAs monitored the biological contamination of water by the presence or absence of Escherichia coli, within their distribution networks. E. coli is a type of faecal coliform bacteria usually present in the lower intestinal tracts of humans and some animals that is excreted and may be washed into water bodies along with sewage, thereby contaminating them. It is important to monitor presence of E. coli as while most strains of the bacteria are harmless, some may cause severe illnesses like diarrhoea, urinary tract infections, respiratory illnesses and bloodstream infections.

All WASAs reported high levels of biological fitness (>85%) in terms of average annual microbial (pathogenic) non-contamination, as depicted in Figure 4-11. Monthly variabilities in biological fitness were observed in several cases , especially evident in case of Lahore during late summer months, which were mostly rectified upon conducting a follow-up. The general trend for microbial fitness appeared to be increasing at the start of the year, dipping somewhat during summers and rising again in winters; perhaps this could be attributed to excess water washing into water bodies (along with contaminants) during and post the monsoon season.

Overall Fitness: The overall fitness was taken as a function of physical, chemical and biological fitness as reported by each WASA. According to the WASAs, they report the water samples to be fit only if they conform to all three fitness dimensions i.e., physical, chemical and biological. As narrated above, water in distribution systems was generally found to be physically and chemically fit in all four cases. Overall fitness levels reported by respective WASAs were generally higher and uniform over the months for Faisalabad and Gujranwala as compared to Rawalpindi and Lahore showing lower fitness and greater temporal variability, as shown in Figure 4-12.

WASA Lahore monitored the quality of water within its distribution system using its water testing laboratory to assess its suitability for drinking purposes. Initially, only 71.4% of the water samples met the criteria for drinking water quality based on tested parameters. Subsequently, WASA Lahore implemented follow-up remedial treatment measures at the sites where the water was deemed unfit. Upon re-evaluation, it was found that the fitness for drinking purposes had increased to around 98.5%.

2.4.3 Drinking Water Quality Assessment at Consumer End

Assessments of water quality for drinking purpose at the consumer end in all divisional HQs of the province were carried out. The quality of water was assessed from public consumer facilities in both urban and rural areas in each divisional HQ, evaluating water from both public filtered and unfiltered (tap) water supply systems.

Total 108 water samples were collected and assessed for their compliance with physical, chemical and biological parameters. The physical parameters included colour, taste, odour, electrical conductivity, TDS and turbidity. The chemical parameters comprised of alkalinity, Arsenic, Bicarbonate, hardness, Calcium, Carbonate, Bicarbonate, Chloride, Magnesium, Nitrate-Nitrogen, pH, Potassium, Sodium and Sulphates. The biological parameters entailed checking for coliform presence in terms of Total Coliform, Faecal Coliform and E.coli. These parameters were assessed for fitness in terms of their compliance with the PEQS (for drinking water - 2016) limits; wherein PEQS limits were not present for a particular parameter, corresponding thresholds from WHO guidelines or USEPA standards for drinking water were used instead.

Laboratory analyses of urban filtered and unfiltered drinking water revealed that nearly all samples complied with the stipulated requirements of PEQS/WHO guidelines for all physical, chemical, and biological parameters assessed. The only exception was arsenic monitoring in DG Khan, with a concentration of 5.9 mg/L, far exceeding the standard limits. The WQI rating indicated that Gujranwala had the best rating score (26.8, Good), whilst Sargodha scored the worst rating (76.5, Very Poor).

In case of unfiltered drinking water at the consumer end almost all the physical parameters were found well within PEQS limits. However, EC values for Faisalabad, Sargodha, Bahawalpur and DG Khan, whereas TDS levels for Faisalabad, Sargodha and DG Khan exceeded the permissible limits.

In terms of chemical fitness, lab testing for most parameters including hardness, bicarbonates, carbonates, chlorides, fluorides, nitrate-nitrogen, pH, potassium, sodium and sulphates were found in compliance with recommended threshold limits except few parameters exceeding limits in Faisalabad, Sahiwal and Sargodha divisions. However, the situation was particularly concerning for other chemical parameters. For example, arsenic levels exceeded the WHO guidelines (≤ 0.01 µg/L) in all collected samples, although samples from the Rawalpindi division (0.03 µg/L) complied with the more lenient PEQS standard limit (≤ 0.05 µg/L). DG Khan (2.86 µg/L) had the highest arsenic level. Alkalinity limits for Faisalabad, Sargodha, Bahawalpur, and DG Khan exceeded WHO guidelines. In the context of biological contamination, no coliforms were detected in any of the samples.

The assessment results for rural filtered drinking water indicated that all samples conformed with the stipulated standard requirements for all tested physical quality parameters including colour, odour, taste, and turbidity; however, it was also noted that EC in DG Khan (1,393 µS/cm) and TDS in both Bahawalpur (990 mg/l) and DG Khan (920 mg/l) were quite close to the standard limits. In terms of chemical fitness, all samples conformed to the stated standard requirements for hardness, Carbonates, Bicarbonates, Chlorides, Fluorides, Nitrate-Nitrogen, pH, Potassium, Sodium and Sulphates parameters. Only two water samples, from Lahore and Rawalpindi, were found to comply with arsenic standard limit. Samples from Bahawalpur and DG Khan (testing at 6.43 µg/l and 2.59 µg/l respectively) had the highest

reported Arsenic concentration. No coliforms were detected during biological fitness testing.

In Bahawalpur, the monitoring of rural unfiltered drinking (tap) water revealed that 13 out of 21 tested parameters were non-compliant to the prescribed standard limits. In terms of physical quality fitness, all samples conformed to standard requirements for colour, taste and turbidity. EC and TDS compliance was found lacking in all divisions except for Rawalpindi, Gujranwala and Lahore. Bahawalpur was reported with the worst EC and TDS recordings.

Regarding chemical quality testing, all samples conformed to the limits specified by standards for Carbonates, Fluorides, Nitrate-Nitrogen and pH. However, standard limits for alkalinity were found in compliance in only two divisions (Gujranwala and Rawalpindi), whereas Bahawalpur and DG Khan reported the highest readings. Alarmingly, Arsenic was detected in all divisions, with Sargodha reporting the highest measurements. Bahawalpur failed to meet the standard limits for hardness, Bicarbonates, Potassium, Sodium and Sulphates. Monitoring in DG Khan also failed to comply with the standard requirements for Bicarbonates and Chlorides (whilst it was quite close to the prescribed limit for Sodium monitoring. Moreover, Bahawalpur and DG Khan were the only regions where biological quality standards were not met.

Water Quality Index:

Water Quality Index (WQI) of drinking water samples collected from urban and rural areas in all nine divisions was computed. The WQI score obtained from the aforementioned fitness analyses categorized the drinking water into five classes as shown in Table 4-1.

Table 4-1: Drinking Water Quality Index (WQI) Thresholds

WQI	STATUS
0 to 25	Excellent
26 to 50	Good
51 to 75	Poor
76 to 100	Very Poor
>100	Unfit

The Water Quality Index (WQI) scores computed based on the aforementioned analyses revealed that the quality of tap water collected from urban sites in most of the divisions was categorized as poor. In particular, Faisalabad, Sargodha, and Bahawalpur were classified as unfit.

However, based on WQI of rural filtered water samples, most of the divisions categorized as good, while a few were classified as poor. However, in overall analysis, most of the filtered drinking water sources in rural areas (within the selected areas), except for Lahore and Rawalpindi, were deemed unfit for drinking purposes, primarily due to excess arsenic levels.

The WQI rating of rural unfiltered (tap) water highlighted that water sources from Faisalabad, Sargodha, Bahawalpur and DG Khan were categorized as unfit, while those from Lahore, Gujranwala, Multan, and Rawalpindi were designated to be very poor.

Looking at the physical parameters in particular EC and TDS, it is evident from the Figure 4-13 that: (1) the filtered water sources are much better than the unfiltered ones (by an average factor of ≈2.8), and (2) the urban sources are much better than their rural counterparts (by an average factor of ≈1.4). Taken individually, for both of these factors, the values increase in the order. For both these parameters, it can also be seen that – on average – only the rural unfiltered water sources exceed the stipulated standard limits; all the other three sources fall within the prescribed limits.

Figure 4-14 depicts the assessment results for alkalinity and hardness. Whilst, on average, only the filtered drinking water sources conform to prescribed (WHO) guidelines for alkalinity, all filtered and unfiltered water sources comply with the threshold value (PEQS) on average. Both these chemical parameters increase in manner: urban filter<rural filter<urban unfiltered<rural unfiltered.

The WQI[10] computation analysis provided clear delineations regarding both absolute and relative fitness quality ratings of water sources amongst the selected sites in the province. In terms of urban filtered water, it was found that sources in Lahore, Gujranwala, Sahiwal, Multan, Rawalpindi, and DG Khan were ranked as good while those in Faisalabad, Sargodha, and Bahawalpur were categorized as poor. At the same time, WQI analysis for urban unfiltered (tap) water sources depicted that fitness of such sources in most of the divisions was rated as poor whilst the quality of corresponding sources in Faisalabad, Sargodha and Bahawalpur divisions ranked them in the unfit criteria. according to WQI analysis, whereas the same in Faisalabad, Sargodha, DG Khan and Bahawalpur divisions was graded in poor criteria. In the case

10 The Water Quality Index (WQI) of drinking water samples was calculated as: WQI=∑_(i=1)^(i=n) w_i q_i , where q_i is the quality rating scale for each assessed parameter in terms of its concentration versus standard limit (as a percentage) and w_i is the unit standard limit weight for that parameter.

of rural unfiltered (tap) water, the sources in Bahawalpur, Sargodha, Faisalabad, and DG Khan were ranked in unfit category on the basis of WQI, while sources in Lahore, Gujranwala, Multan and Rawalpindi were characterized in poor category (Figure 4-15). Composite WQI has also being mapped as depicted in Figure 4-16.

Findings of a study conducted on the drinking and irrigation quality of groundwater in Sheikhupura reflected that level of arsenic surpassed the WHO standards in the collected water samples[11]. A safety assurance study of some of the water purification plants in the three zones of Lahore (urban, suburban and old areas) revealed that arsenic and fluoride were

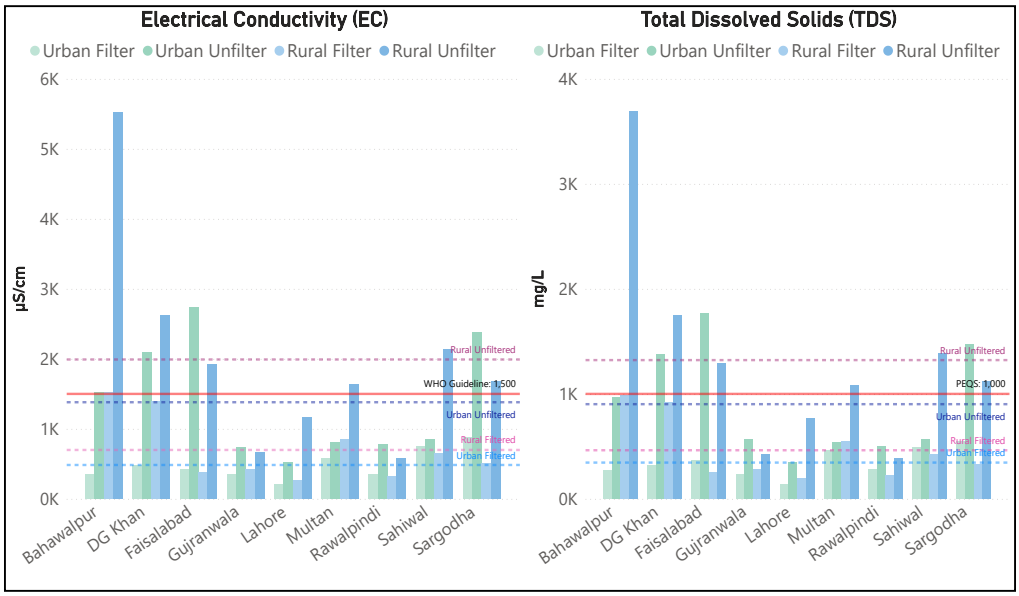


Figure 4-13: Physical parameters (EC and TDS) monitored in consumer end water samples

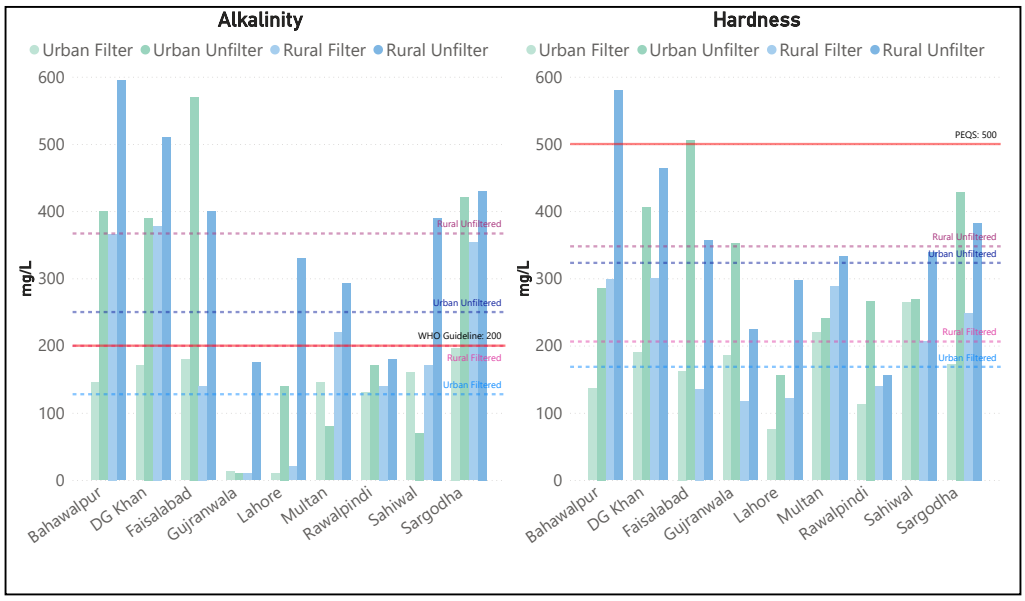


Figure 4-14: Chemical parameters (Alkalinity and Hardness) monitored in consumer end water samples

11 Rehman, F., Azeem, T., Hashmi, R. A., Siddique, J., Shahab, A., & Mustafa, S. (2023). Drinking and irrigation quality of groundwater and health risk assessment due to arsenic exposure in Sheikhupura district, Punjab, Pakistan. 50(3), 368-375.

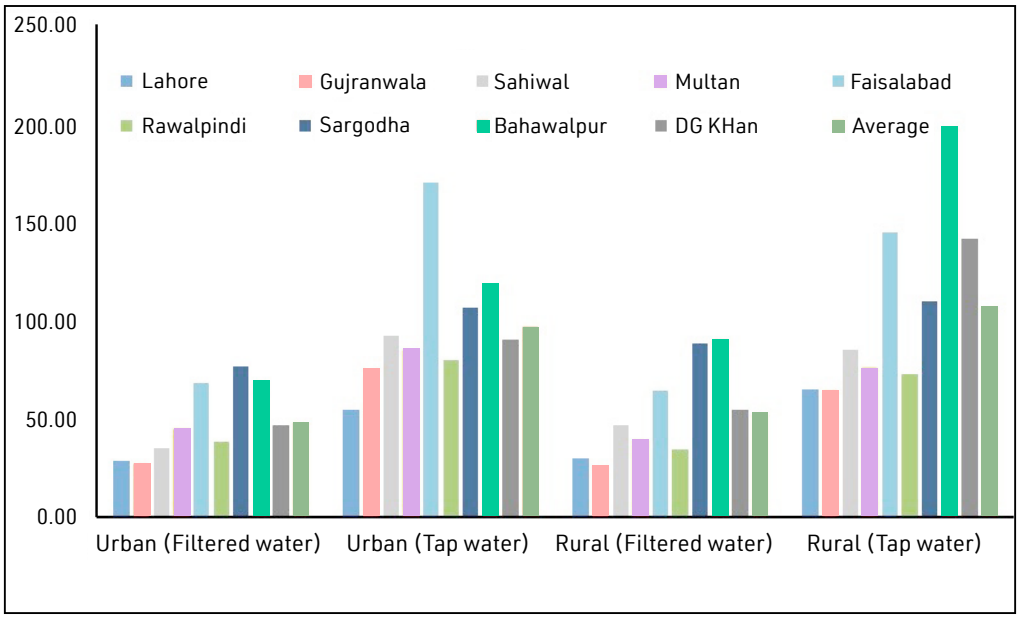


Figure 4-15: Water Quality Index (WQI) of filtered/unfiltered (tap) drinking water collected from the selected urban and rural areas in all nine divisions of Punjab

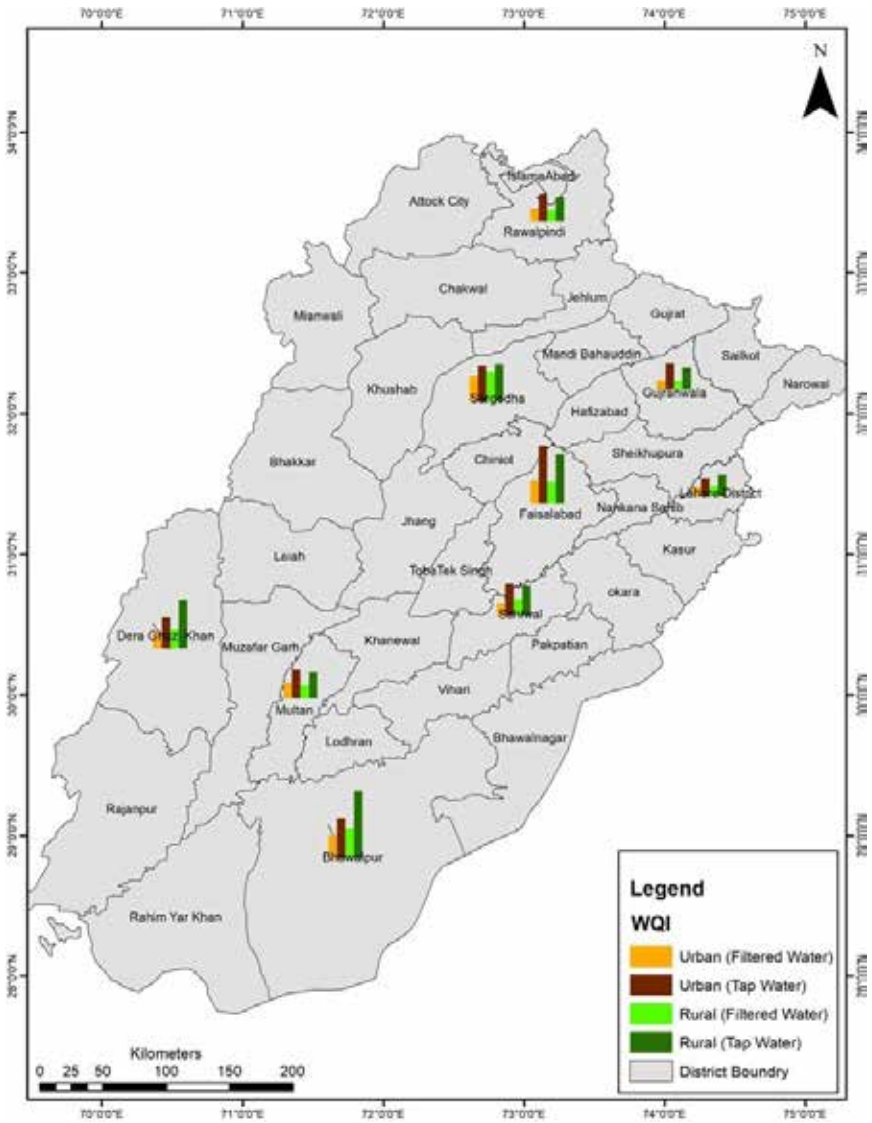


Figure 4-16: Composite Water Quality Index (WQI) map of filtered/unfiltered (tap) drinking water collected from the selected urban and rural areas in all nine divisions of Punjab

exceeding both the national standards and WHO standard values for drinking water[12]. The study's findings reflected that despite the good physicochemical quality of the water samples at source, about 50% of the tests results showed bacterial contamination before the monsoon. After the monsoon, this number increased up to 75%. The study has highlighted the cross connections between the sewer and water mains as the potential source of bacteriological contamination. The study has also reported the water borne diseases (typhoid followed by diarrhea, hepatitis, and gastroenteritis) were also reported in the most of the residents during the past three years. The WQI of most of the study areas depicted that water was unsuitable for drinking purpose (WQI > 100). Moreover, human health risk and carcinogenic risk assessment demonstrated that drinking water may impinge high risk to adults and children[13].

The levels of some parameters such as Magnesium (52mg/L), Calcium (89mg/L), Chloride (342mg/L), and Sulphate (412mg/L) in drinking water samples collected from Morgah, Dhokekala Khan, Scheme-III, and Bahria Town of Rawalpindi were recorded higher than WHO and Pakistan Standards and Quality Control Authority (PSQCA) guidelines. Furthermore, the water samples obtained from Dhoke Kashmirian, Gulshan Dadan Khan and Pandora Satellite Town, depicted bacterial contamination and yeast which may pose water-borne illnesses such as diarrhea, dysentery, and Typhoid fever[14].

Forty-one water samples (6 from water supply and 35 from electric pump) were obtained from district Vehari. Adulteration of coliform and E. coli was noted in water samples of C-Block, D-Block and F-Block of tehsil Vehari. Findings proved that the levels of numerous parameters i.e., electrical conductivity, total dissolved solids, Sodium, Calcium (Ca^{+2}, Potassium, Chloride, and Nitrate surpass WHO guidelines in Sharqi Colony, Lalazar, Health Colony, TMA Sharqi Colony, Y-Block, 9-11 WB, College Town and 13-WB areas of district Vehari. Moreover, survey results indicated that 48.6% of the respondents disagreed regarding provision of safe drinking water[15].

The bacterial analysis of drinking water samples collected from DG Khan showed that 9 out of 50 samples (18%) contained pathogens . Moreover, findings depicted that the pH as well as EC levels in drinking water acquired from some sampling sites of DG Khan surpassed the WHO standards[16].

Results indicated that most of the water samples collected from Faisalabad were polluted with microbes including and Total Coliform as well as numerous water samples indicated higher levels of hardness, turbidity and Total Dissolved Solids (TDS)[17]. Drinking water samples of Faisalabad city revealed that biological (and Total coliform) and some physico-chemical parameters especially pH, chloride, TDS and arsenic surpassed the permissible limit of PEQS and WHO guidelines. Similarly, the findings of water quality index demonstrated that < 6% exhibit unsuitable, < 8% show very poor and < 56% water samples indicate poor drinking water quality[18].

Out of 30, drinking water samples collected from Multan city, 73% and 80% samples were observed surpassing maximum residual limits (MRL) for $As^{3/5+}$ and F^{-}, respectively, whereas 53% samples contained both F^{-} and $As^{3/5+}$ values higher than MRL[19]. Study was conducted to evaluate the water quality of Sargodha city and it was observed that all the samples from house connections were tainted with bacteria before and after the monsoon[20].

Findings of the research revealed that concentration of EC, TDS, sodium, alkalinity and nitrate was noted higher than WHO guidelines in ground water samples obtained from Sargodha[21]. The mean content of chromium was revealed greater than WHO and PEQS in all the 20 samples (tap, filter plant, hand pump and tubewell) acquired from district Sahiwal Conversely, the mean value of arsenic and lead in aforesaid samples were recorded within PEQS guidelines[22].

2.5 Industrial Pollution Loads

Untreated industrial effluents are amongst the leading causes of water pollution along with agricultural runoffs and municipal wastewater/sewerage. With the prime intent to gauge compliance of PEQS, 8 EPA laboratories in major districts conducted monitoring and assessment of industrial effluents/wastewater in the province. Samples were collected from 504 industrial units grouped into 36 industrial categories to monitor the quality of industrial effluents.

12 Majeed, A., Shahid, S., Ali, S., & Firdous, N. (2022). Safety assessment of water purification plants of Lahore. 50(2).
13 Nawaz, R., Nasim, I., Irfan, A., Islam, A., Naeem, A., Ghani, N., Irshad, MA., Latif, M ., Nisa, BU., & Ullah, R. (2023). Water quality index and human health risk assessment of drinking water in selected urban areas of a Mega City. 11(7), 577.
14 Ali, H., Shaheen, I., & Wattoo, F. H. (2019). Chemical and microbial analysis of drinking water of different localities in Rawalpindi.
15 Khalid, S., Murtaza, B., Shaheen, I., Ahmad, I., Ullah, M. I., Abbas, T., ... & Imran, M. (2018). Assessment and public perception of drinking water quality and safety in district Vehari, Punjab, Pakistan. 181, 224-234.
16 Saeed, M. A., Murtaza, G., Ali, S., Aziz, H., Albeshr, M. F., Mahboob, S., ... & Sajjad ur Rehman, M. (2022). Assessment of drinking water quality and associated socio-economic impacts in arid mountainous regions. 14(19), 12567.
17 Zulfiqar, H., Abbas, Q., Raza, A., & Ali, A. (2016). Determinants of safe drinking water in pakistan: a case study of faisalabad. 4(01), 40-45.
18 Mahfooz, Y., Yasar, A., Sohail, M. T., Tabinda, A. B., Rasheed, R., Irshad, S., & Yousaf, B. (2019). Investigating the drinking and surface water quality and associated health risks in a semi-arid multi-industrial metropolis (Faisalabad), Pakistan. 26, 20853-20865.
19 Earnest, I., Nazir, R., & Hamid, A. (2021). Quality assessment of drinking water of Multan city, Pakistan in context with Arsenic and Fluoride and use of Iron nanoparticle doped kitchen waste charcoal as a potential adsorbent for their combined removal. 11, 1-15.
20 Haydar, S. S., & Qasim, M. M. (2013). A study of water quality of Sargodha City.
21 Riaz, O., Abbas, T., Nasar-u-Minallah, M., ur Rehman, S., & Ullah, F. (2016). Assessment of groundwater quality: A case-study in Sargodha city, Pakistan. 28(5), 4715-4721.
22 Hayat, K., Zahir, M., Tufail, S., Hassan, A., & Qureshi, Z. (2018). Analysis of water in the area of District Sahiwal for Heavy metals (a case study): heavy metals analysis in Sahiwal Water. 61(3), 138-144.

The assessment conducted by the EPA laboratories revealed that only 0.8% of industrial units from the sampled group comply with the PEQS standards for all the monitored parameters. Whereas the other 99.2% industrial units exceeded prescribed PEQs limits in at least one of the parameters[23]. Generally, 65.5% environmental standard breaches were reported in various parameters by the industrial units. Most of the industrial units were found non-compliant with parameters such as BOD (95.7%), COD (94.4%), Sulfide (91%), temperature (84.4%) and TSS (81.7%). Figures 4-17-4-24 illustrate the results of industrial effluent monitoring, wherein the most polluting industrial sector for a particular parameter on basis of sectoral average (the outlier) is displayed separately from the rest of the sectors.

The leather and tanning industry was identified as the most polluting and only industrial sector where none of the PEQS limits were found to be complied with parameters tested. The difference with PEQS limits was even starker in case of COD, Chloride, TSS and TDS wherein the average concentrations for this sector exceeded industry concentration averages by at least a factor of ≈3.5 times. The other main pollution causing industries included protein manufacturing, pesticides, textiles, sugar mills, mining, and paper industries.

The average concentration of COD (1,778 mg/l) was found 12 times higher than the prescribed PEQS threshold. Only 5.6% of the industries were found within prescribed limits. The leather and tanning industry sector having the highest COD (5,849 mg/l) exceeded the PEQS limit by a factor of 39. Whereas, effluent from protein and pesticide manufacturing factories had the COD concentrations exceeding the PEQS limit by factors of 10.3 and 9.8 respectively (Figure 4-17).

The concentration of sulfide was not in compliance with PEQs limits (< 1.0 mg/l) in 36% of the industrial units assessed, while the effluent from sugar mills had the highest concentration of sulfide (290 times the PEQS limit) followed by the leather and tanning industry sector (55 times the PEQS limit). The average industry Sulfide monitoring evaluation was found to be 20.6 times the PEQS limit (Figure 4-18).

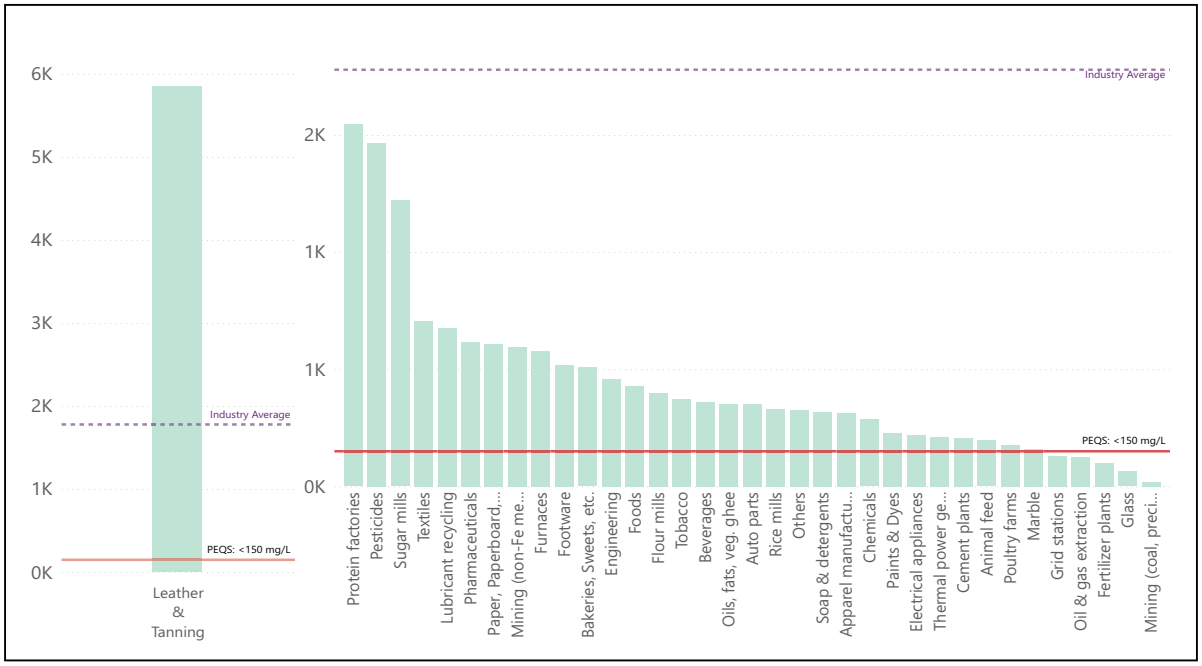


Figure 4-17: Average concentration of COD monitoring for sampled industrial units

23 PEQS limits for this section refer to the "Punjab Environmental Quality Standards for Municipal and Liquid Industrial Effluents" as notified by the Government of the Punjab on August 12, 2016. They can be assessed on the EPCCD website at <https://epd.punjab.gov.pk/peqs>.

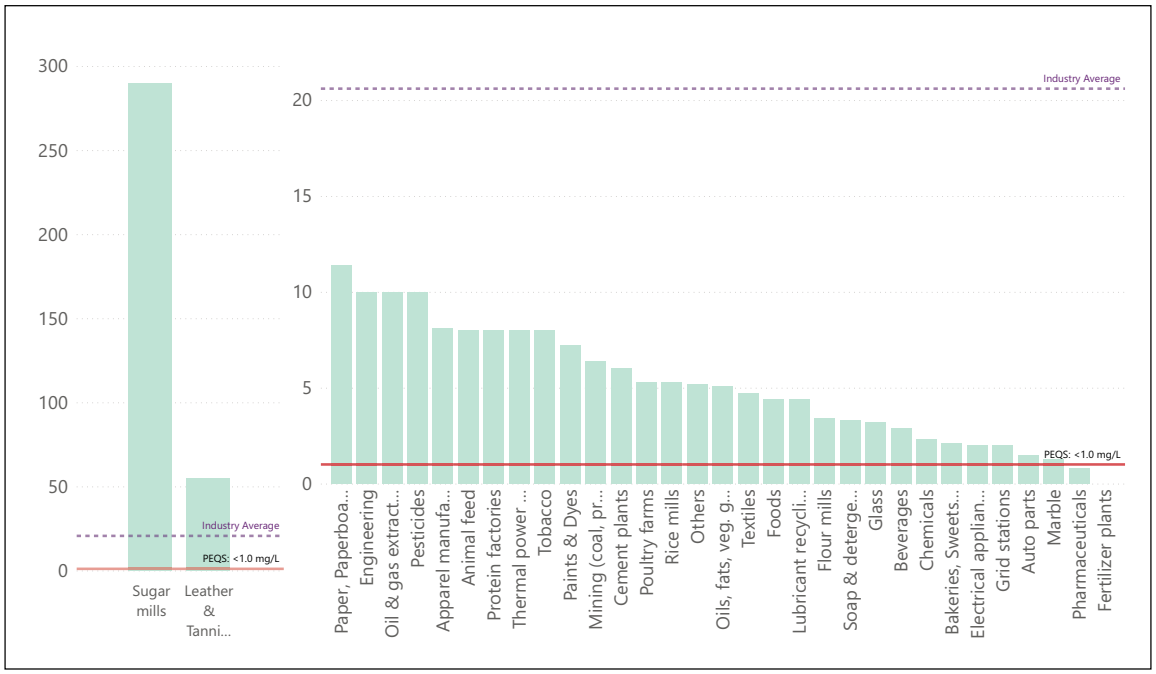


Figure 4-18: Average concentrations of sulfide monitored across sampled industrial sectors

The sulfate concentration exceeded PEQS (< 600 mg/l) in 39% of the industrial units across 12 industry sectors (Figure 4-19). Leather & tanning industry had the highest concentration of sulfate (1,869 mg/l), followed by mining (947 mg/l) and marble sectors (936 mg/l). Similarly, 38% of the industrial units belonging to 16 industrial sectors had chloride concentration more than PEQs (< 1,000 mg/l). Figure 4-20 shows that the leather and tanning industry sector had the highest concentration of chloride (average of 12,662 mg/l) followed by lubricant recycling industry.

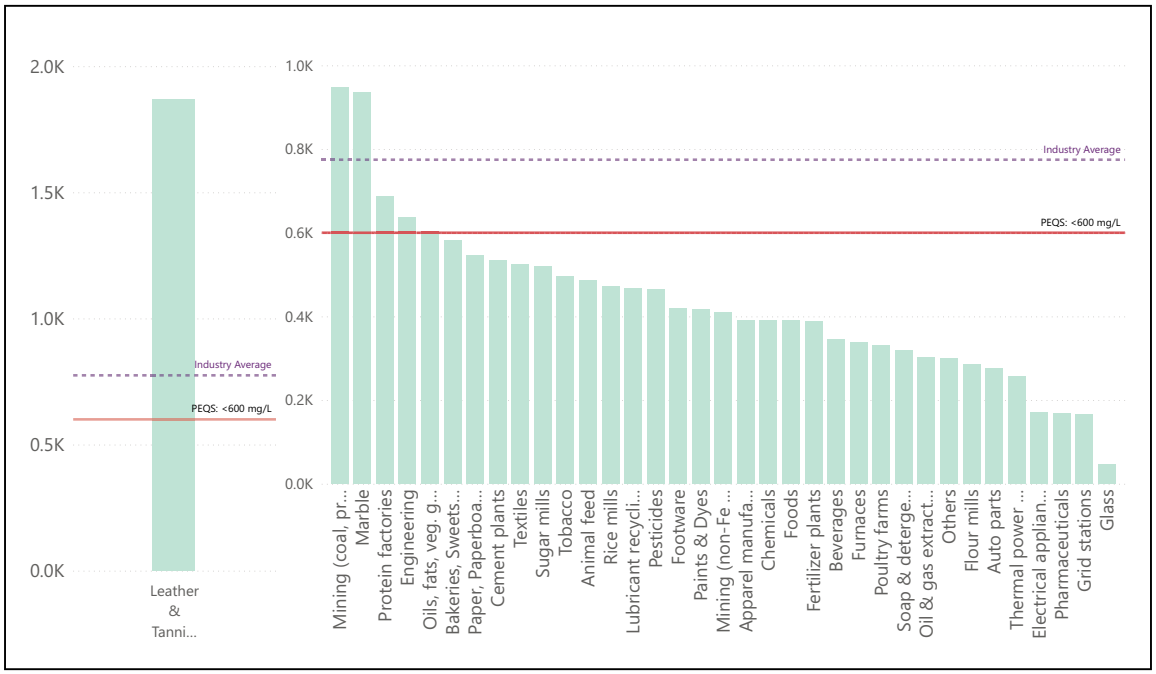


Figure 4-19: Average Sulfate monitoring for sampled industrial sectors

PEQS limits (< 200 mg/l) were majorly non-conformed in the case of TSS monitoring, with 81.3% of the industrial units failing to meet the compliance standards (Figure 4-21). The average industry TSS (1,548.3 mg/l) was found to exceed the PEQS limit threshold at a factor of 7.7. The leather & tanning industries (average: 5,442 mg/l; 27.21 times the PEQS limit) and protein factories (average: 3,245 mg/l; 16.23 times the PEQS limit) were the prime perpetrators, with concentration limits exceeding industry averages by more than twice (351% and 210% of the industry averages, respectively). The former sector including the most TSS polluting industrial unit with the discharge assessment of 96,155 mg/l (480.8 times the PEQS limit; 62.1 times the industry average).

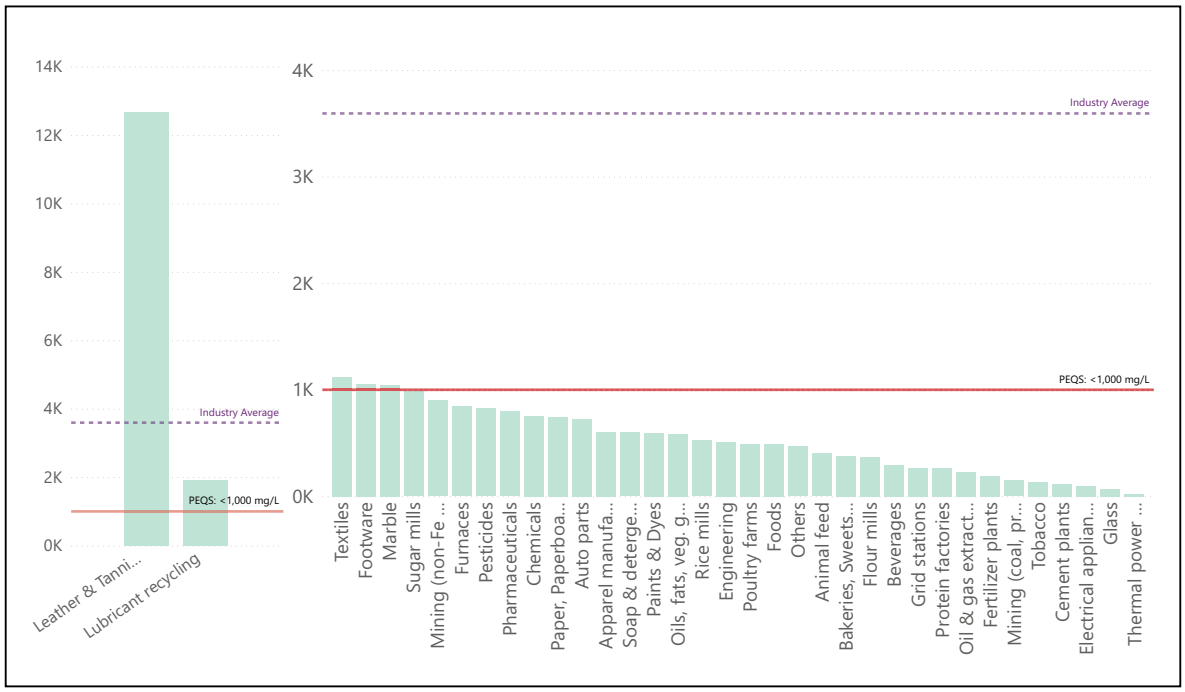


Figure 4-20: Average Chloride monitoring for sampled industrial sectors

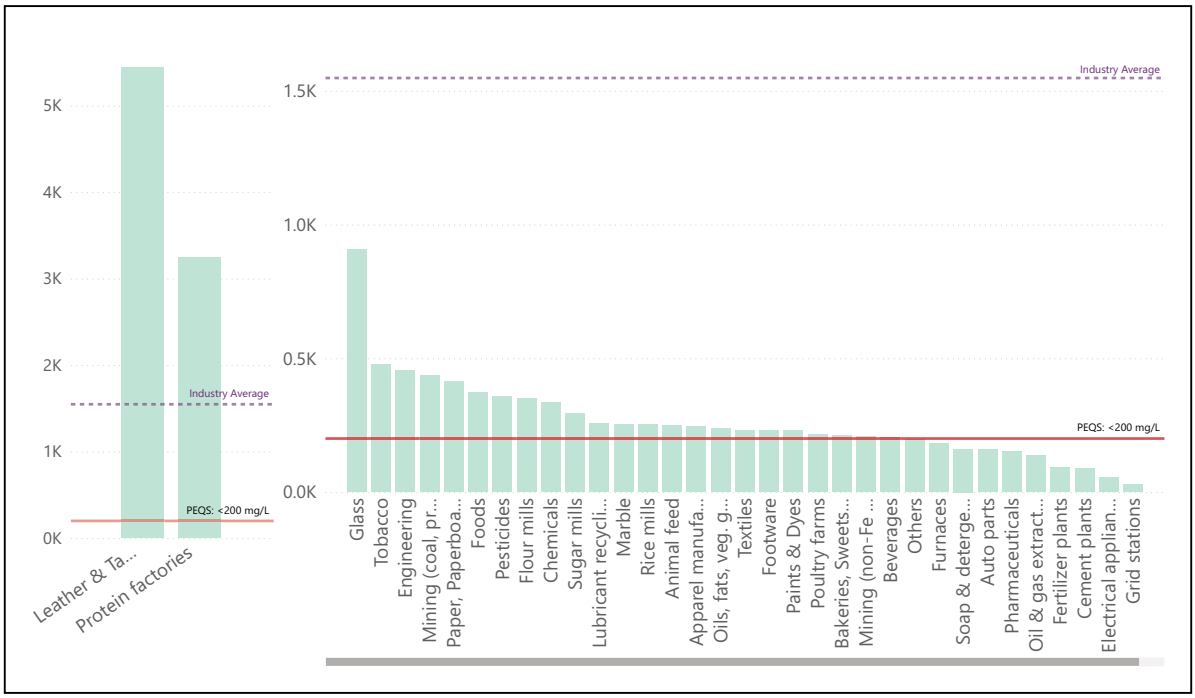


Figure 4-21: Average TSS monitoring for sampled industrial sectors

About 42% (21 industrial sectors) of the industrial units exceeded the PEQS limits for TDS (3,500 mg/l). There were only 2 industrial units out of 504 that comply with stricter USEPA Limits (500 mg/l). The effluent from leather and tanning industry sector showed the highest concentration of TDS (Figure 4-22).

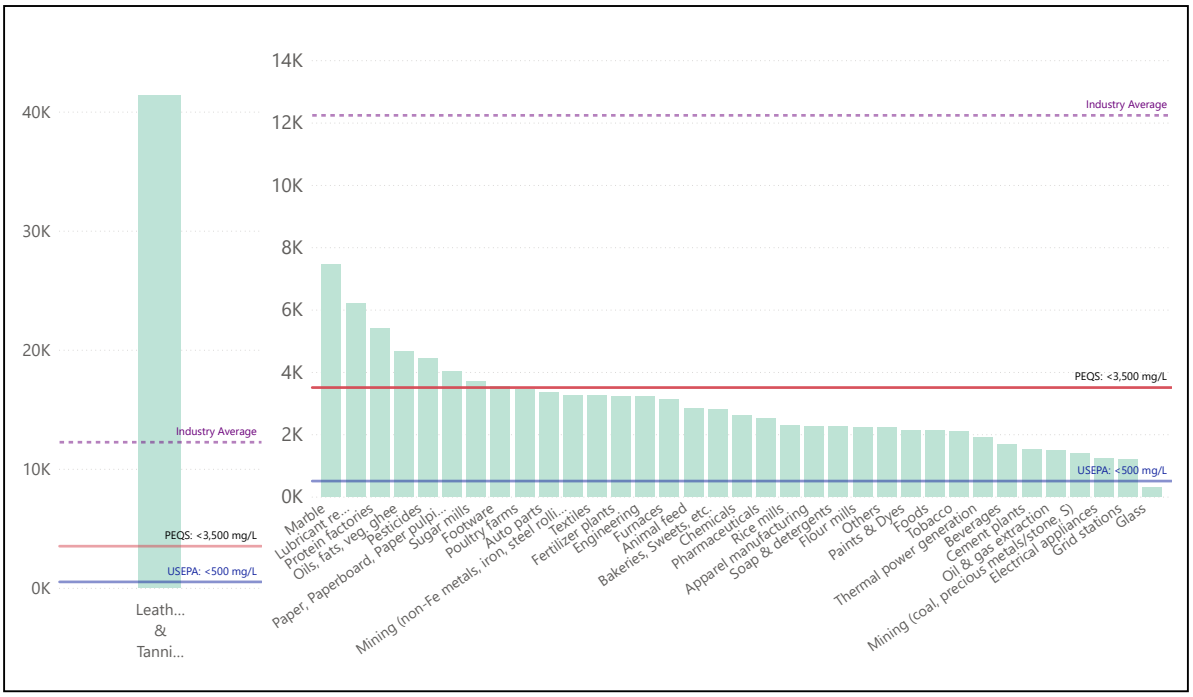


Figure 4-22: Average TDS monitoring for sampled industrial sectors

BOD is a crucial parameter in monitoring water quality, indicating the amount of oxygen required by aquatic organisms for their survival and overall health. Nearly 40% of industrial units across 20 sectors failed to meet the PEQS limit threshold of 80 mg/l. The average industry monitoring rating, at 1,921 mg/l, exceeded this threshold by a staggering 24 times. Once again, the leather and tanning sector emerged as the primary source of pollution, with its average BOD discharge of 3,015 mg/l surpassing the PEQS limit by 37.7 times and exceeding the industry average by 1.57 times (Figure 4-23).

pH is a key water quality indicator, with PEQS recommended limits of 6-9. It was found that about 60.3% of the sampled industrial units did not comply however, the average pH value (6.8) was well within the recommended limits. The food industry sector was with the highest pH (11.1), while the lowest pH (1.5) was recorded for a unit within the leather and tanning industry (Figure 4-24).

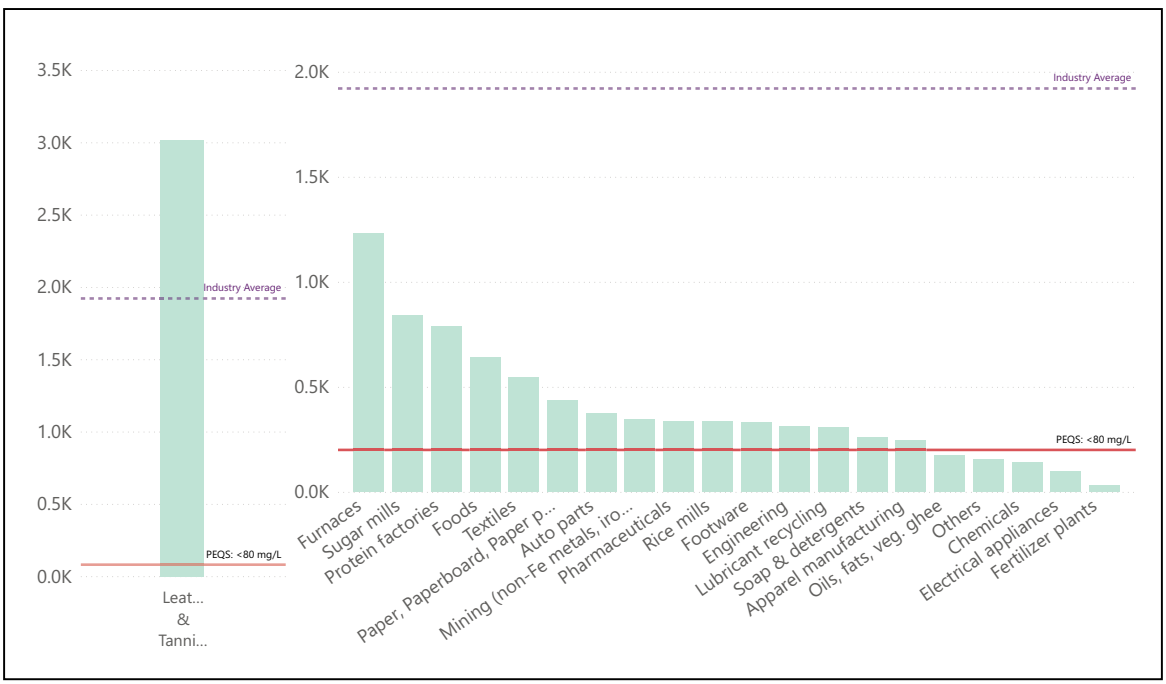


Figure 4-23: Average BOD monitoring for sampled industrial sectors

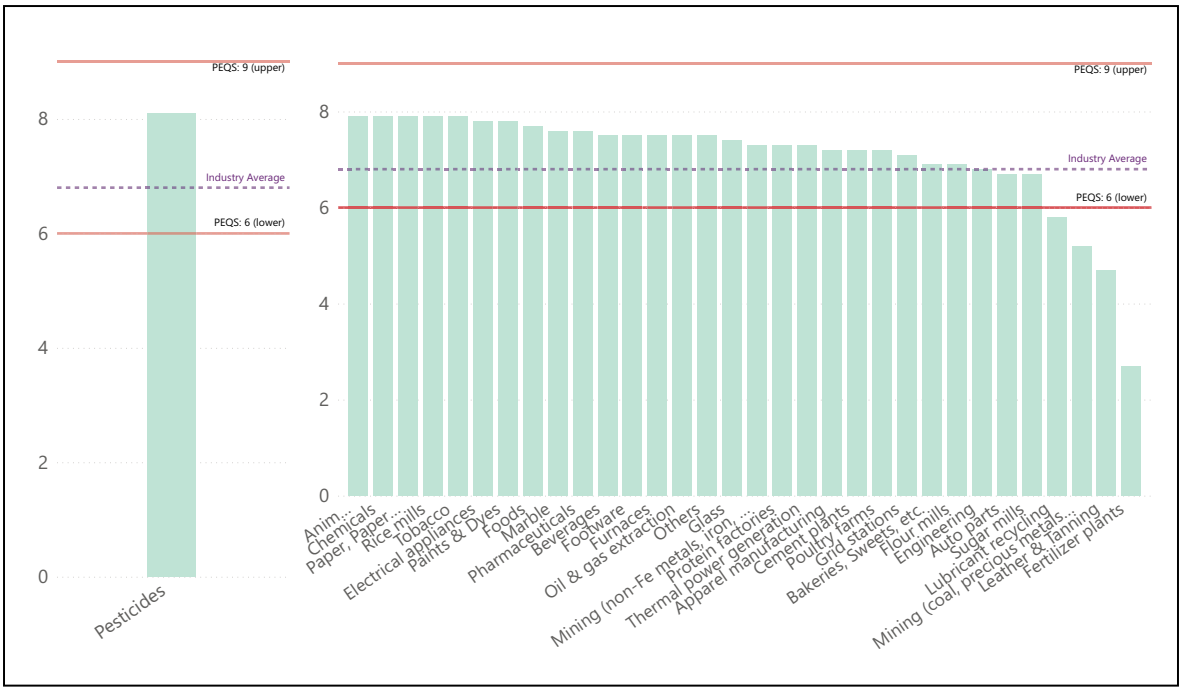


Figure 4-24: Average pH monitoring for sampled industrial sectors

2.6 Overall Assessment

The overall quality of surface water in rivers and canals was found 'Moderate', while of drain it was rated as 'Very Poor'. Overall groundwater quality for irrigation was rated 'Moderate' Quality of urban filtered drinking water was rated 'Good' while both unfiltered urban and rural waters were 'Poor' and unfit for drinking along with rural filtered water having high Arsenic content. Industrial effluents exceeding most of the PEQS limits for monitored parameters were rated as 'Very Poor'.

Water Quality Assessment

Assessment: Rivers and Canals — **Overall quality: Moderate**

Very Good | Good | Moderate | Poor | Very Poor

Assessment: Drain — **Overall quality: Very Poor**

Very Good | Good | Moderate | Poor | Very Poor

Assessment: Groundwater Quality (Irrigation Purpose) — **Overall quality: Moderate**

Very Good | Good | Moderate | Poor | Very Poor

Drinking Water Quality

Assessment: Overall Fitness Water Distribution Networks (WASA) — **Overall quality: Moderate**

Very Good | Good | Moderate | Poor | Very Poor

Assessment: Unfiltered Water (Urban and Rural) — **Overall quality: Poor**

Very Good | Good | Moderate | Poor | Very Poor

Assessment: Urban Filtered Water (All Divisions Except DG Khan) — **Overall quality: Good**

Very Good | Good | Moderate | Poor | Very Poor

Assessment: Rural Filtered Water (Arsenic) — **Overall quality: Poor**

Very Good | Good | Moderate | Poor | Very Poor

Assessment: Industrial Effluent — **Overall quality: Very Poor**

Very Good | Good | Moderate | Poor | Very Poor

3. Management

3.1 DPSIR Framework

The DPSIR Framework for water resource management system in Punjab (Figure 4-27) identifies the challenges and requisite responses as follows:

Drivers

The proliferating population growth and rapid urbanization coupled with improved living standards of citizens has intensified the water demand in the province. Unplanned industrialization has resulted in the discharge of pollutants into water bodies, contaminating water sources and reducing their quality. Poor agricultural practices including ineffective irrigation methods and chemical runoff has not only placed the pressure on water availability but has also deteriorated its quality. Transboundary pollution due to shared discharge in many rivers has also contributed to the water pollution in the province. Furthermore, the distribution and availability of water are disrupted by weather patterns altered by climate change, placing further strain on already vulnerable water sources.

Pressures

Inappropriate agricultural and industrial practices contribute to resource wastage, ultimately impacting per capita water availability. Polluting factors, notably untreated sewage from municipal sources, untreated industrial effluents, and agricultural runoffs, further strain freshwater resources. Industries discharge significant volumes of effluents into nearby water bodies, significantly deteriorating their overall quality. Moreover, siltation and increased sediment load in dams has reduced the water storage capacity of dams.

State

In Punjab, river and canal water quality is moderate. Groundwater for irrigation is moderate, with only 58% samples meeting EC, SAR, and RSC standards of irrigation water quality. Distribution system water is also moderate in fitness (majorly because of biological contamination), urban filtered drinking water is good (except DG Khan), while rural filtered water is poor in quality (high Arsenic). Unfiltered drinking water both urban and rural have poor quality and are unfit for drinking. Industrial effluents exceed most limits, and are rated very poor.

Impacts

Per capita water availability in Punjab is declining and soon the province will touch water severe scarcity level. The current water stress level has already put pressure on food and water security in Punjab. Compounded with these factors, the level of water pollution has increased burden of disease in the province. The nation is fighting with these challenges which are affecting their health and socioeconomic wellbeing.

Pakistan Council of Research in water resources (PCRWR) reported that around 80 to 90% of water quality in various cities is below the suggested standards[24]. Numerous researchers have reported that the water quality of different districts in Punjab have exceeded arsenic level and diarrhea was also detected due to deteriorated water quality[25,26]. More than 90% of the water samples in Faisalabad showed considerable level of K, Cl, Na, SO_4 and TDS because of insufficient treatment of industrial wastewater[27].

It has been reported that the concentration of nickel, chromium, manganese, and arsenic were higher than the permissible limits suggested by WHO in different areas of Punjab province such as Lahore, Jhang, Multan and Vehari[28]. Exposure to heavy metals through water causes various diseases in humans such as kidney and respiratory problems, cancers and neurological disorders[29].

Limited or no access to clean and safe drinking water can have significant and far-reaching impacts on health, socioeconomic conditions, and the environment. Some of the key amongst them are listed below:

Health Impacts: Contaminated water is a breeding ground for waterborne pathogens such as bacteria, viruses and other parasites, thereby resulting in high incidence of waterborne diseases. Diseases like cholera, typhoid, hepatitis, dysentery and various gastrointestinal and blood-related infections are often linked to the consumption of unsafe water. Consumption of drinking water contaminated with various anions and heavy metals (such as Cr, Co, Cd, Ni, Hg, Zn and Pb etc.) leads to major adverse human health effects. Exposure to heavy metals through water causes various

24 PCRWR, 2021. Drinking Water Quality in Pakistan Current Status and Challenges.
25 Khalid, S., Murtaza, B., Shaheen, I., Ahmad, I., Ullah, M. I., Abbas, T., & Abbas, S. (2018). Assessment and public perception of drinking water quality and safety in district Vehari, Punjab, Pakistan. 181: 224-234.
26 Shakoor, A., Zahid, M. K., Farid, H. U., Sultan, M., Aftab, A. K., Ahmad, I., & Azmat, M. (2018). Groundwater vulnerability mapping in Faisalabad district using GIS based drastic model. Paper presented at the MATEC web of conferences.
27 Daud, M., Nafees, M., Ali, S., Rizwan, M., Bajwa, R. A., Shakoor, M. B., & Murad, W. (2017). Drinking water quality status and contamination in Pakistan. 2017.
28 Hussain, S., Habib-Ur-Rehman, M., Khanam, T., Sheer, A., Kebin, Z., & Jianjun, Y. (2019). Health risk assessment of different heavy metals dissolved in drinking water. 16(10), 1737.
29 Sall, M. L., Diaw, A. K. D., Gningue-Sall, D., Efremova Aaron, S., & Aaron, J.-J. (2020). Toxic heavy metals: impact on the environment and human health, and treatment with conducting organic polymers, a review. 27: 29927-29942.

diseases in humans such as kidney pathology, respiratory problems, cancers and neurological disorders[30]. Especially, if children don't have access to clean drinking water, it affects their health, education, nutrition and learning aptitudes, thus influencing numerous aspects of their lives. According to an estimate, about 53,000 children in Pakistan under five die annually from diarrhea because of poor water and sanitation[31].

Poor water quality can contribute to malnutrition, especially in children. Moreover, diarrheal diseases resulting from contaminated water can lead to nutrient loss and hinder the absorption of essential nutrients, thereby impacting seriously health.

Data from public healthcare facilities throughout the province regarding OPD walk-in patients[32] for waterborne diseases (including diarrhea, cholera, gastroenteritis, typhoid and other related infections) for CY 2023 was collated and analysed for impacts, for the purposes of this report. Monthly and district-wise monitoring enumerations are depicted in Figure 4-25 and Figure 4-26. It can be seen that, generally, the 15-49 y age group reported the most patients throughout the year and across all districts in the province, followed by 5-14 y and 1-4 y age groups. The least number of OPD patients belonged to less than one month, 1-2 m and 3-5 m age groups (perhaps, this may be due to the fact that such patients were covered in separate paediatric OPDs and wards). Most OPD patients visited public healthcare facilities in the Lahore district, followed by Faisalabad, Muzaffargarh and Gujranwala districts. It was also noted that there were slight gender disparities amongst different age groups, with close to an even split in overall numbers. May, closely followed by August, were the most 'infection-reporting' months, whereas the least number of patients visited OPDs in December and January.

Environmental Impacts:

- Pakistan Council of Research in Water Resources (PCRWR) narrated in a report that around 80 to 90% of water quality in various cities is below the suggested standards[33]. Numerous researchers have reported that the water quality of different districts in Punjab have exceeded arsenic level and diarrhea was also detected due to deteriorated water quality[34]. More than 90% of the water samples in Faisalabad showed considerable level of K, Cl, Na, SO_4 and TDS because of insufficient treatment of industrial waste[35].
- Unsafe disposal of industrial and municipal wastes can contaminate groundwater, a vital source of water for drinking and irrigation use. Groundwater contamination can persist for long periods and is challenging to remediate. Furthermore, unabated discharge of pollutants into water sources can seriously harm aquatic ecosystems. Besides humans and land-based animals, such contaminants may affect all aquatic life, thereby disrupting balance of the

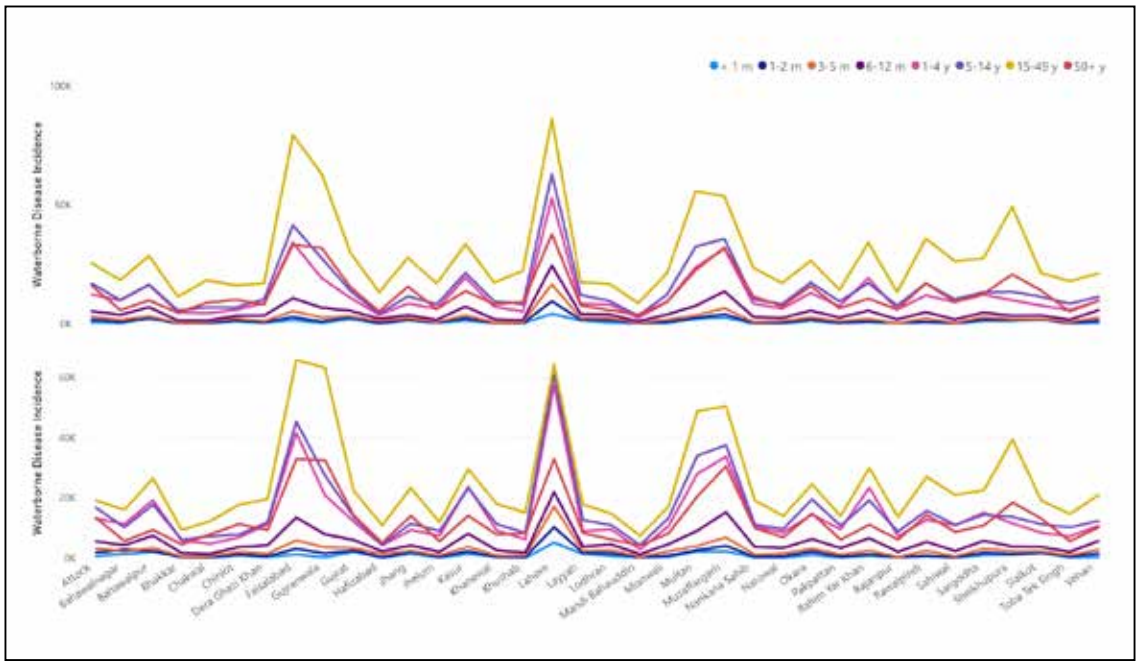


Figure 4-25: Incidence of waterborne diseases in Punjab

30 Sall, M. L., Diaw, A. K. D., Gningue-Sall, D., Efremova Aaron, S., & Aaron, J.-J. (2020). Toxic heavy metals: impact on the environment and human health, and treatment with conducting organic polymers, a review. 27: 29927-29942.
31 Zahid, J. (2018). Impact of clean drinking water and sanitation on water borne diseases in Pakistan
32 This data merely relates the number of patients visiting OPDs for waterborne diseases, and does not delineate on the final diagnosis, severity of disease, outcome of visit and next course of action. Moreover, this does not include data for hospitalizations, either post of without going to OPD.
33 PCRWR, 2021. Drinking Water Quality in Pakistan Current Status and Challenges.
34 Khalid, S., Murtaza, B., Shaheen, I., Ahmad, I., Ullah, M. I., Abbas, T., & Abbas, S. (2018). Assessment and public perception of drinking water quality and safety in district Vehari, Punjab, Pakistan. 181: 224-234.
35 Daud, M., Nafees, M., Ali, S., Rizwan, M., Bajwa, R. A., Shakoor, M. B., & Murad, W. (2017). Drinking water quality status and contamination in Pakistan. 2017.

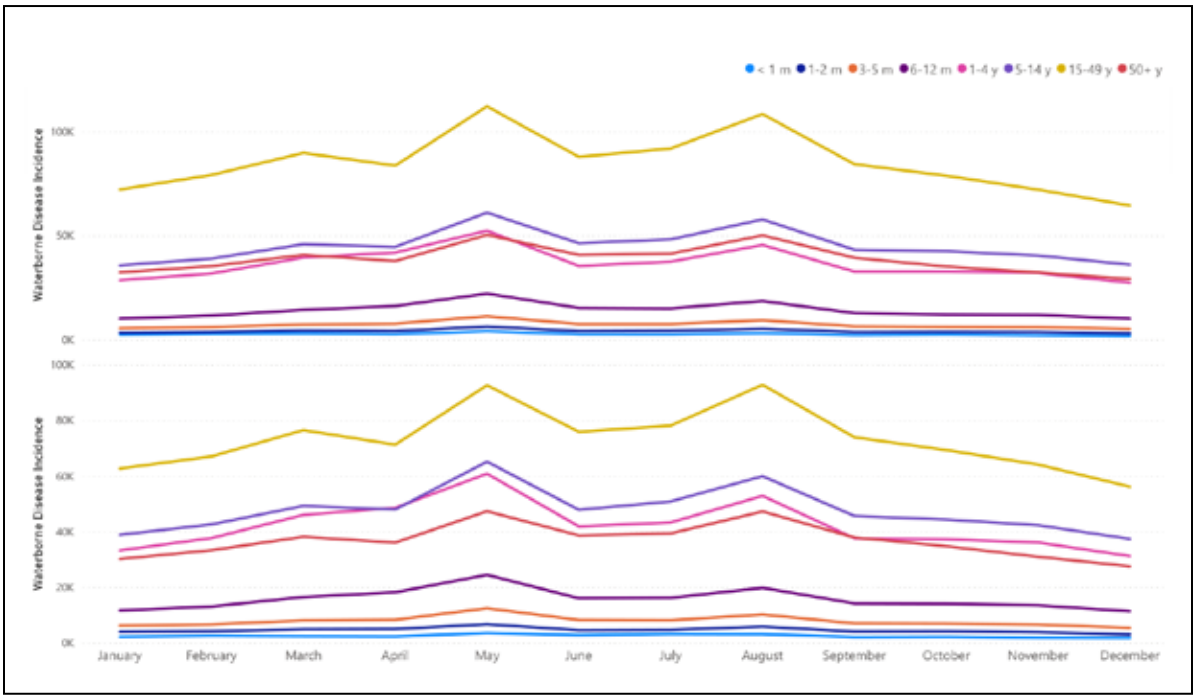


Figure 4-26: Incidence of waterborne diseases during CY 2023

ecosystem and impacting biodiversity. Agricultural runoff containing mostly toxic pollutants from contaminated water can lead to soil degradation, which, in turn, affects crop yields and dwindles agricultural productivity.

Socioeconomic Impacts: Poor water quality and scarcity significantly inflate healthcare costs, as treating waterborne diseases places a heavy burden on healthcare systems. This not only results in increased medical expenses but also reduces productivity due to illness. Individuals afflicted by waterborne illnesses may experience a sharp decrease in work or school attendance, mobility and productivity, leading to long-term economic consequences for affected communities. Given that unsafe drinking water is commonly linked with impoverished and undereducated communities, the economic strain of waterborne diseases can perpetuate a vicious cycle of poverty, diverting resources from income-generating activities to address health issues. About 30% people in urban areas lives in slums, with insufficient sewage dumping facilities and sanitation. Severe health issues are seen in people who live areas near sewers and open drains. About 14% deaths are observed in children under five years due to diarrheal diseases. Approximately, 670,000 children miss school every day due to lack of proper water sanitation system and diseases[36]. Diseases and miseries inflicted to public by poor sanitation and unsafe drinking water cause economic burden of PKR 112 billion per annum on Pakistan's economy[37].

- Social and Cultural Impacts: In some cases, communities with limited access to safe and clean water may be forced to displace from their ancestral homes and relocate in search of better water sources. Such migration can lead to social disruption and the loss of traditional ways of life. Water quality and access issues may also lead to widening of gender disparities, as women and children are often disproportionately affected by lack of access to safe water.

Response

Punjab is rapidly approaching water stress due to its dense population and intensive use of water in agriculture, presenting serious challenges in terms of water quality, availability, and access. Global initiatives targeting sustainable development goals aim to enhance water quality and accessibility. Urgent proactive measures in legal and policy domains are crucial for effective water resource management in Punjab. Implementing appropriate legal frameworks can safeguard water resources and combat pollution, while improving water management practices can reduce environmental costs following are the key responses.

- Government initiated 10-year strategic plan for water, sanitation, and hygiene (WASH) (2014–2024)
- Draft Punjab Drinking Water and Sanitation Policy (2019) emphasizes water quality monitoring, compliance enforcement, investment in recycling, and wastewater treatment
- Punjab Water Vision 2050 includes upgradation of hydrological modeling, equitable water distribution, and effluent disposal compliance
- Tariff collection from water consumers stressed for sustaining drinking water supply projects
- Asian Development Bank aiding construction of 110 km canal for drinking and irrigation water in Jalal Pur Jattan District
- Punjab Government dedicated to achieving SDG 6.1 and 6.2 through various policies and initiatives

36 Qamar, K., Nchasi, G., Mirha, H. T., Siddiqui, J. A., Jahangir, K., Shaeen, S. K., & Essar, M. Y. (2022). Water sanitation problem in Pakistan: A review on disease prevalence, strategies for treatment and prevention. 82.

37 Zahid, J. (2018). Impact of clean drinking water and sanitation on water borne diseases in Pakistan.

- Installation of 15 online Water Quality Monitoring Stations for evidence-based policy making
- Pilot study for low-cost wastewater treatment plants in rural areas, to be completed by 2024
- ADB-funded Punjab Intermediate Cities Improvement Investment Programme improving water access in intermediate districts
- Punjab Rural Sustainable Water Supply and Sanitation Project (PRSWSSP) aims to upgrade sanitation and provide clean drinking water in rural areas
- Agriculture Department working on various on-farm water management projects, including:
  - Punjab Resilient and Inclusive Agriculture Transformation (PRIAT)
  - National Program for Improvement of Watercourses in Pakistan (Phase-II) - Punjab Component
  - Command Area Development of Jalalpur Irrigation Project (CAD-JIP) (Revised)
  - National Program for Enhancing Command Area in Barani Areas of Pakistan (Punjab Component)
  - Development of Culturable Waste Land in Riverine Areas Through Development of Irrigation Conveyance Network
  - Promotion of Gram Cultivation through Climate Smart Technologies in Thal Areas of Punjab
  - Water Productivity Enhancement Through Regenerative Climate Smart Agriculture (WP-RCA) (Pilot Project)

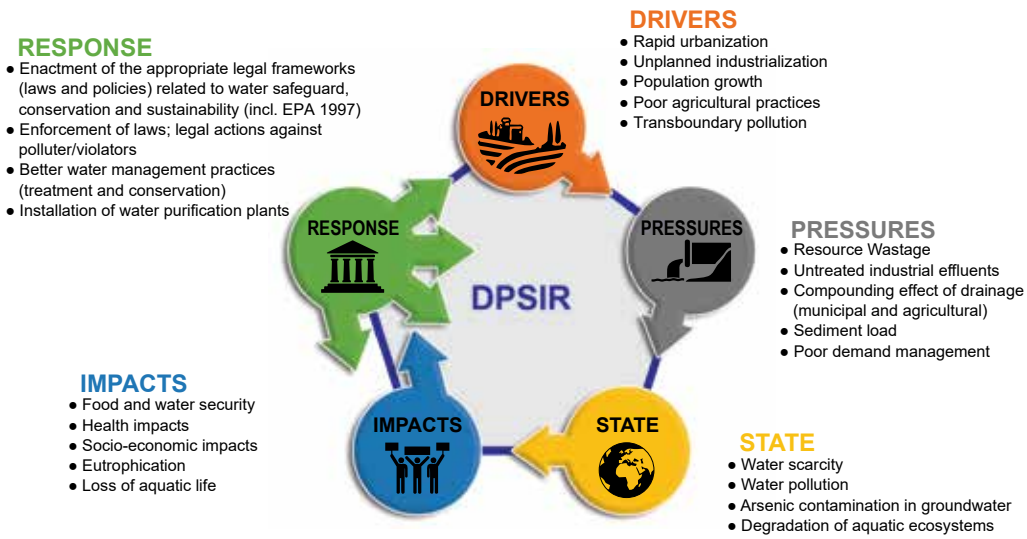


Figure 4-27: DPSIR framework of water quality in Punjab

4. Way Forward

Water quality and security are crucial across various dimensions including household, economic, urban, environmental, and resilience to water-related disasters underscoring their paramount importance. Findings of this report will serve as a valuable resource for policymakers, environmental agencies, researchers and other environmental stakeholders to offer insights into the current state-of-affairs regarding water resources within the province. By highlighting key environmental indicators and potential concerns, the assessment aims to inform strategic decision-making, policy formulation and sustainable resource management practices. Following are some recommendations for addressing the challenges related to water quality:

Strengthening Regulatory Framework: Strengthening of relevant regulatory framework, enactment of 'missing laws' related to environment and establishment of enforcement mechanisms are crucial to monitor and control pollution from industrial effluents, agricultural runoff, and other sources. The government may address the key issue of water quality through enactment and promulgation of appropriate, legal covenants and policies aimed at safeguarding water quality, and ensuring its conservation and sustainability.

Water Monitoring System: Survey and identification of all point and non-point pollution sources causing ground, surface and drinking water contamination should be undertaken as a priority with the core intent of mitigating them. The public sector should institute and maintain baseline data on both quantity and quality of all surface, ground and drinking water resources in the province.

There should be establishment of drinking water quality testing labs and recruitment of relevant human resource at each divisional headquarter in order to monitor and publish water quality status on monthly and yearly basis.

Integrated Water Resource Management, Governance and Stewardship: Implement integrated water resource management approaches that consider the interconnectedness of surface and groundwater systems. Develop coordinated strategies for watershed management, land-use planning, and water allocation to ensure sustainable utilization of water resources while protecting water quality.

Investment in Water Infrastructure: Upgrade and expand water treatment facilities to ensure that water supplied for

domestic, agricultural, and industrial purposes meets quality standards. Laying down new water supply infrastructure and replacement of fractured and broken waste water and drinking water networks on priority basis. The sewage/ effluent carrying lines should be separated from drinking water supply lines to avoid mixing of waste water with clean water. There should be advance water purification/filtration plants at each union council and village level to provide safe, healthy, pure, safe and clean drinkable water.

Promotion of Sustainable Agriculture: Encourage the adoption of sustainable agricultural practices aimed at reducing reliance on chemical fertilizers and pesticides, thereby mitigating the potential contamination of groundwater and surface water reservoirs. Promote precision irrigation techniques and the use of organic farming methods to reduce water pollution and preserve soil health.

Community Engagement and Awareness: Raise awareness among communities about the importance of water conservation and pollution prevention. Empower local stakeholders, including farmers, industries, and households, to actively participate in water management initiatives and adopt practices that promote water quality improvement.

Research and Innovation: Support research and innovation in water treatment technologies, pollution monitoring techniques, and sustainable water management practices. Collaborate with academic institutions, research organizations, and industry partners to develop cost-effective solutions for addressing water quality challenges in Punjab.

Assessment and monitoring of health risks associated with water borne-diseases: Assessment and monitoring of health risks associated with water borne diseases (diarrhea, giardiasis, dysentery, typhoid fever, infection, and salmonellosis, hepatitis and cholera etc.) in public consuming poor quality drinking water

Revision of PEQS: It is imperative to undertake revision of Punjab Environmental Quality Standards for drinking and industrial effluents in line with international, WHO and USEPA environmental standards. Moreover, quality standards for surface water should be designed on priority basis.

Geo-mapping and geo tagging of water resources: Undertaking geo-mapping and geo-tagging initiatives for groundwater, surface water, and drinking water quality and quantity is crucial.

Soil is Earth's living canvas, nurturing life's roots and anchoring the promise of a thriving ecosystem for posterity.

5 SOIL QUALITY

5. Soil Quality

1. Overview

Soil types and quality vary in Punjab, owing to various factors such as topography, climate and geological formations. The primary soil types found in Punjab include alluvial soils which are formed by the deposition of sediments carried by rivers, especially the Indus River. Certain areas in Punjab contain clayey soil texture, which can retain water for longer period. While clayey soil is fertile, proper drainage is essential to prevent waterlogging. Some areas in Punjab especially south Punjab, show sandy soil which is good for drainage but may require more frequent irrigation due to its lower water retention capacity. Many areas in Punjab experience issues with soil salinity or alkalinity which impacts fertility.

Effective soil management practices are essential to address these challenges. It is important to understand that the distribution of soil types varies within different districts and regions of Punjab. Local variations may occur, impacting agricultural practices and the choice of crops. Conducting soil tests is a common practice for farmers and experts to analyze soil characteristics accurately and make informed decisions regarding crop selection and soil management.

2. Environment

2.1 Sampling and Monitoring Plan

A comprehensive soil quality assessment was conducted for all the 09 HQs of the province. The survey involved the collection of soil samples from distinct categories, namely urban, industrial, agricultural areas, and lands irrigated with treated and untreated industrial effluent. In total, 108 soil samples were meticulously collected across the study area (Figures 5-1 and 5-2). The sampling procedures are provided in detail as **Annexure D.**

The geographical and environmental features of the study area are presented in **Annexure E.**

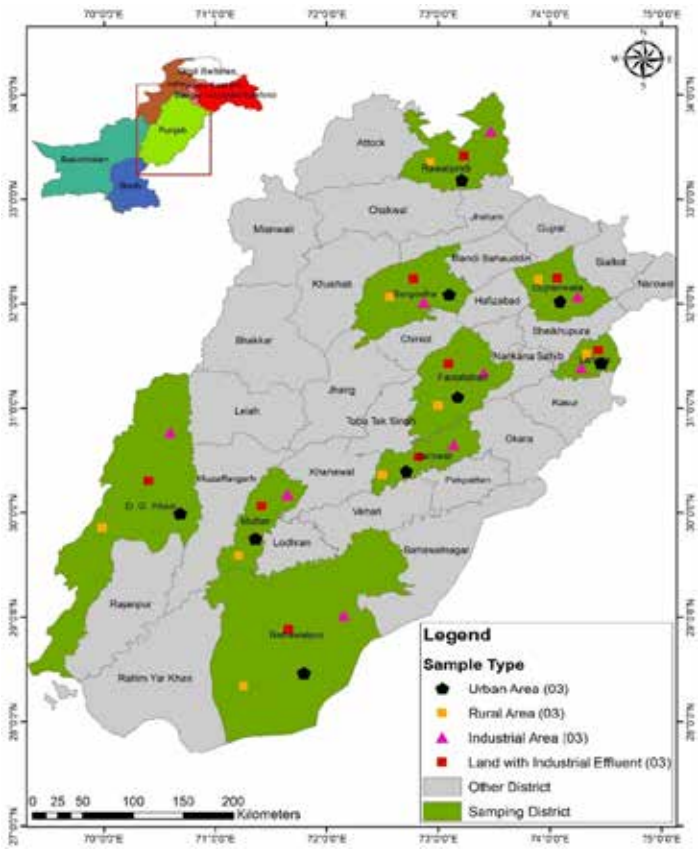


Figure 5-1: Sampling & Monitoring Plan (Soil Quality)

KEY FINDINGS

- Overall quality assessment of tested samples of soil types from nine divisions of Punjab in terms of pH and salinity is rated as 'Good'.
- Sodicity of agriculture and effluent irrigated land is rated as 'Poor' while it is 'Moderate' for urban and industrial soils.
- Fertility status for Nitrogen, Potassium and Iron in all soil types is 'Good' whereas level of Phosphorus is 'Moderate'. Level of Zinc in agriculture soils and land irrigated with effluents is also rated as 'Good' while it is 'Moderate' for urban and industrial soils.
- Heavy metal contents (Pb, As, Cd, Hg and Se) of all soil types in Punjab were within permissible limits.
- Pollution Load Index showed moderately polluted soil types in all divisional HQs. Rawalpindi and Multan divisions had highest values.
- Adopting soil health management systems, diverse crop rotations, and no-till/strip-till cropping systems are recommended for improving soil quality.

2.2 Soil Quality

The soil quality was tested for 14 parameters i.e., pH, Electrical Conductivity, SAR, Cadmium, Lead, Arsenic, Mercury, Selenium, Zinc, Iron, Magnesium, Sodium, Potassium, Nitrogen and Phosphorus. The results were compared with international soil quality standards for heavy metals[1]. For soil salinity Water and Power Development Authority, Pakistan

1 Alloway, B.J. (1990) Heavy Metal in Soils. John Wiley and Sons, New York, NY, USA.

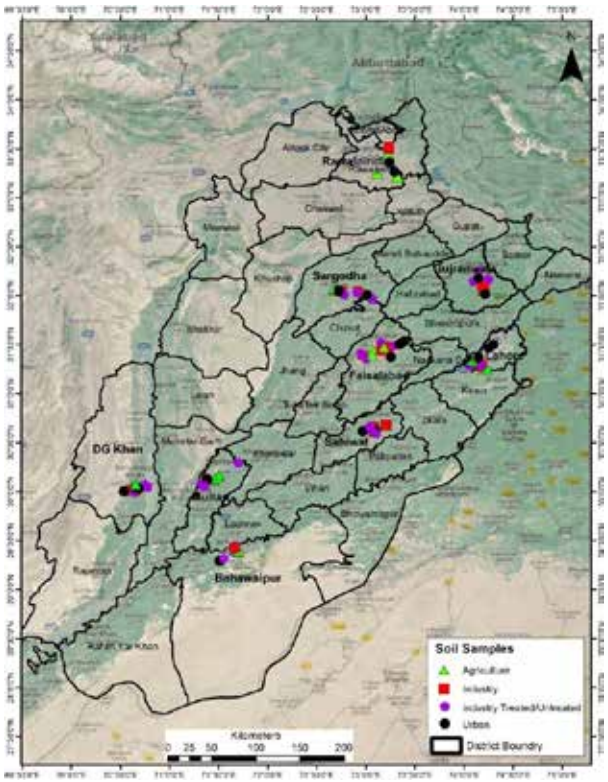


Figure 5-2: Soil Quality Sampling Locations

classification[2] was used and for fertility assessment standards referred in International Center for Agricultural Research in the Dry Areas were used[3].

2.2.1 Soil Salinity and Sodicity

As per results, pH for all soil types varied between 6.7 to 8. The urban soils in all divisions had relatively neutral pH values except DG Khan Division (7.6) with slightly alkaline urban soil. Soil pH remained slightly alkaline for industrial soils of Lahore (7.6) and DG Khan (7.7) divisions. with maximum (8) in case of land irrigated with in Multan. pH values of agriculture soils of all divisions were also around neutral. Comparatively higher pH value (in alkaline range) was recorded in the lands irrigated with wastewater in Multan Division (8) (Figure 5-3a).

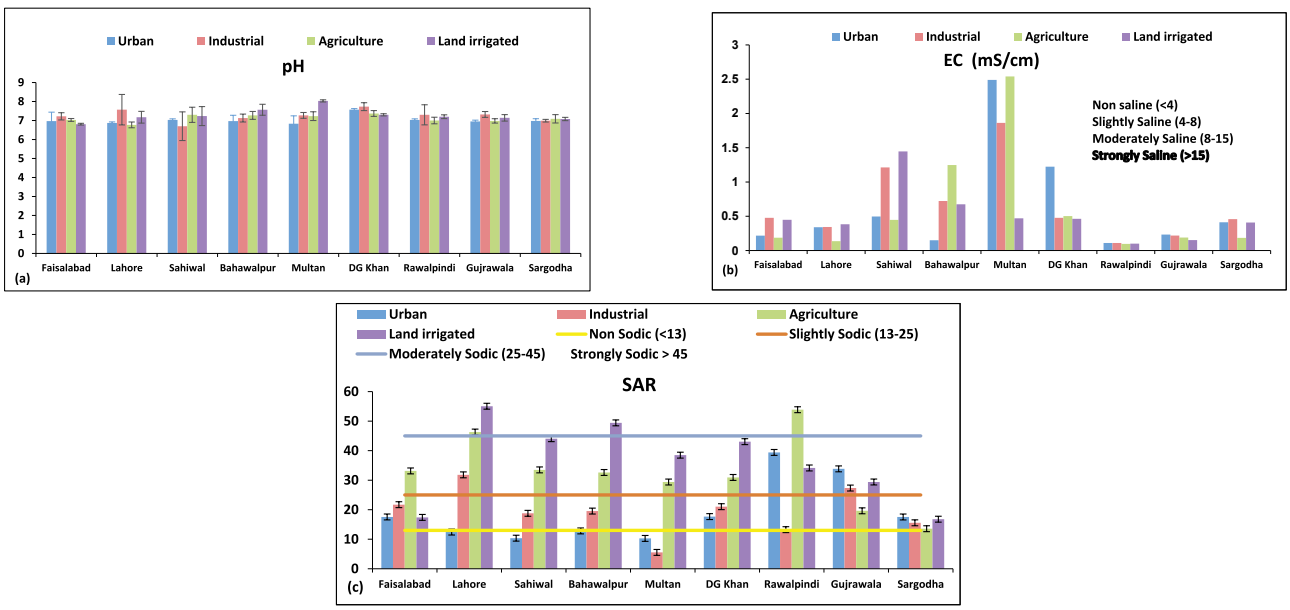


Figure 5-3: pH (a), EC (b) and SAR (c) in four soil types of selected divisions in Punjab

All the tested soil samples were non-saline with low EC values showing the presence of low salt concentrations in soils.

2 Water and Power Development Authority (1981).

3 Ryan,J., George Estefan and Abdul Rashid. 2001. Soil and Plant Analysis Laboratory Manual. Second Edition. Jointly published by the International Center for Agricultural Research in the Dry Areas (ICARDA) and the National Agricultural Research Center (NARC). Available from ICARDA, Aleppo, Syria. x +172 pp.

However, urban, industrial, and agricultural soils in Multan division and land irrigated with effluents in Sahiwal division, showed comparatively higher levels of EC among all samples (Figure 5-3b).

Sodium adsorption ratio values of all soil types ranged from 5-55 showing the presence of non-sodic to strongly sodic soil types. The urban soils of Lahore, Sahiwal and Multan divisions were non-sodic, while they were slightly sodic for Faisalabad, DG Khan and Sargodha and moderately sodic for Gujranwala and Rawalpindi. All industrial soil types were either slightly or moderately sodic except for Multan where value of sodium adsorption ratio was 5 so soil was categorized as non-sodic. SAR levels were strongly sodic for agriculture soils of Lahore (46) and Rawalpindi (54) and for Lahore (55) and Bahawalpur (49) divisions' lands irrigated with industrial effluent. Rest all the soil samples in these two categories were even slightly or strongly sodic (Figure 5-3c).

The level of Sodium was significantly high in the urban, industrial, agriculture and irrigated soils of Sargodha division while comparatively low levels were recorded in urban soil of Sahiwal, industrial soil of Rawalpindi, agriculture soil of Gujranwala and land irrigated of Faisalabad divisions (**Annexure D** Table D-2).

2.2.2 Soil Fertility

The level of nitrogen in all soil types were found to be adequate with maximum nitrogen concentration found in urban soils of Sahiwal, industrial soil of DG Khan, agriculture soil of Sargodha and irrigated land of Rawalpindi divisions (Figure 5-4a).

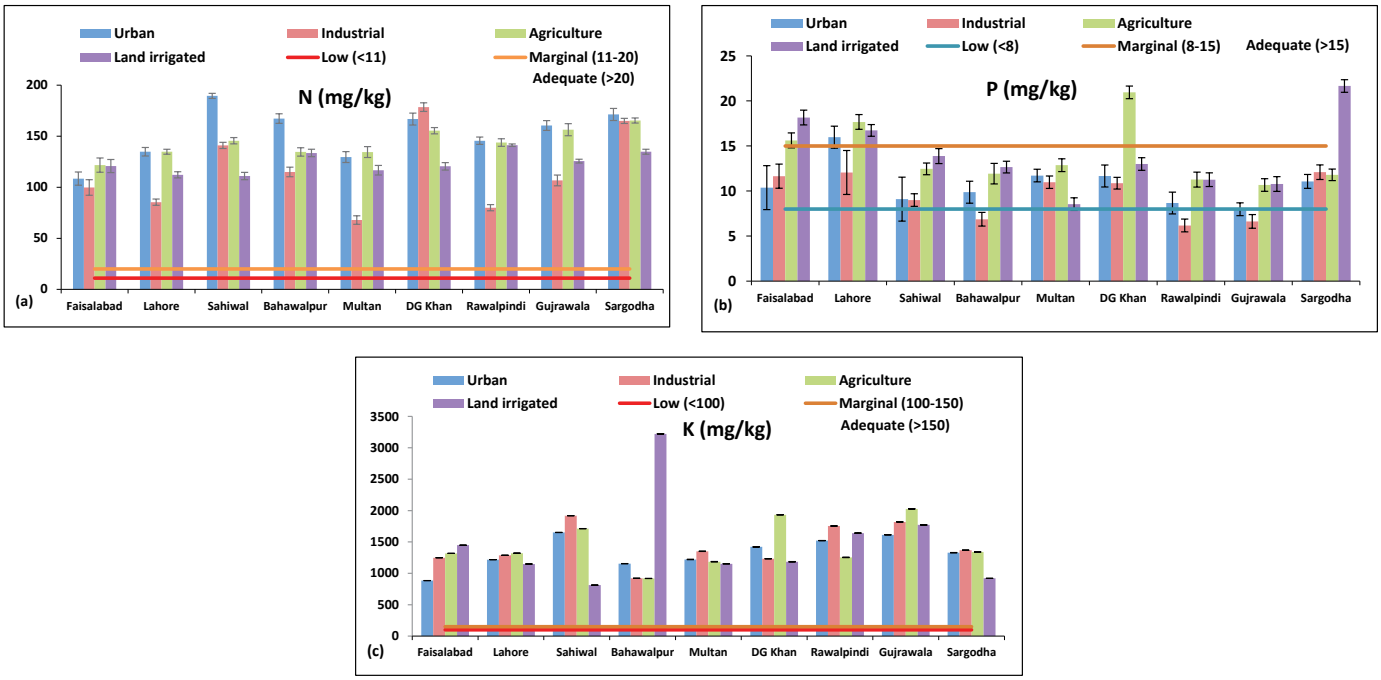


Figure 5-4: Nitrogen (a), Phosphorus (b) and Potassium (c) in four soil types of selected divisional HQs in Punjab

Phosphorus deficiency was observed in the soils of industrial areas of Rawalpindi, Bahawalpur and Gujranwala while it was marginal for other three soil types. Concentration of phosphorus was marginal in all soil types of Sahiwal and Multan. Adequate levels of phosphorus were recorded in some soil types of the selected divisions with highest in agriculture soil of DG Khan and land irrigated with effluent in Sargodha (Figure 5-4b).

The concentration of Potassium in all soil types across the selected nine divisional HQs in Punjab was found to be adequate. Comparatively higher Potassium levels were present in lands irrigated with effluent in Bahawalpur, agriculture soil of Gujranwala and DG Khan and in urban and industrial soils of Sahiwal (Figure 5-4c).

The level of Calcium (Ca) was comparatively higher in urban soils of Multan, industrial and agriculture soils of Sahiwal and irrigated land of Faisalabad. Comparatively low level of Ca was recorded for urban and agriculture soils of Rawalpindi, industrial soil of Faisalabad and irrigated land of Bahawalpur. Level of Magnesium (Mg) was highest in urban, industrial and effluent treated lands of Rawalpindi and agriculture soils of Bahawalpur division while comparatively low levels of Mg were reported for urban and industrial soils of Sahiwal, agriculture soil of Lahore and effluent treated land of Faisalabad divisions (**Annexure D** Table D-2).

2.2.3 Heavy Metals

The concentration of heavy metals (mg/kg) in all soil types of Punjab were found within the permissible limits set by International Standards. Agriculture soils of Punjab have adequate levels of Zinc. The concentration of Zinc is also adequate in industrial soil and irrigated land of Bahawalpur, DG Khan, Gujranwala and Sargodha divisions. Marginal

levels of zinc were found in urban soils of six out of nine selected divisions while Zinc deficiency was recorded in irrigated land of Faisalabad, industrial soil of Lahore and Rawalpindi and urban soils of Rawalpindi and Sargodha divisions (Figure 5-5a).

The selected soil types across the nine divisions had adequate levels of Iron with maximum levels reported in irrigated land of Faisalabad, agriculture and urban soils of Lahore and industrial soil of DG Khan (Figure 5-5b). Cadmium (Cd) concentration was comparatively higher in the effluent irrigated land of Multan and Rawalpindi, industrial and urban soils of DG Khan and agriculture soils of Multan division (Figure 5-6c).

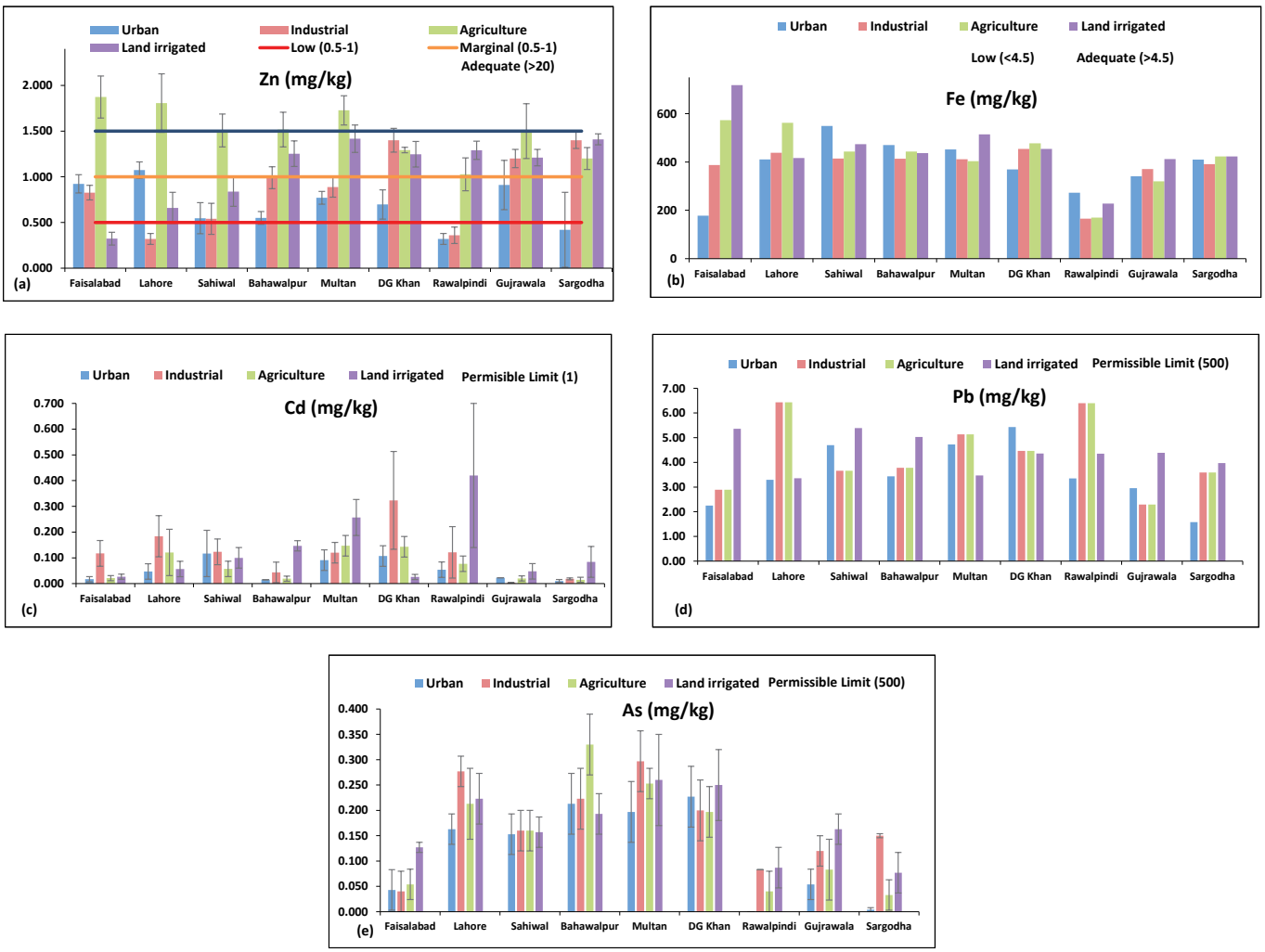


Figure 5-5: Heavy Metals in four soil types of selected divisional HQs in Punjab

Comparatively higher concentration of Lead (Pb) was found in urban soils of Sahiwal, Multan and DG Khan, industrial and agriculture soils of Lahore and effluent irrigated land of Faisalabad (Figure 5-5d).

Arsenic (As) levels were also within the permissible limits. Comparatively higher levels of As were recorded for urban soils of DG Khan, industrial soils and effluent irrigated land of Multan and agriculture soils of Bahawalpur division (Figure 5-5e). Mercury (Hg) and Selenium (Se) were not detected in any of the soils of selected divisions of Punjab (**Annexure D** Table D-2).

Though the primary data revealed that the heavy metal concentrations were within the permissible limits set by International Standards, however, the secondary data and literature confirms the presence of heavy metal contamination at different locations in Punjab, particularly the ones irrigated with industrial wastewater. In a study[4] conducted in DG Khan District of South Punjab, the soils and vegetable/crops irrigated with the industrial effluents exhibited that although the heavy metal levels in the soils were within permissible limits, the transfer of heavy metals from soil to plants was quite evident in the study area. Chromium, nickel, lead and manganese were exceeding the FAO/WHO acceptable limits, posing serious threats to the consumers of the contaminated crops which included the tomato, brinjal, red corn and apple etc. Similarly, the soils and groundwater of District Kasur were found contaminated with chromium, iron, nickel,

4 Atta MI, Zehra SS, Dai D-Q, Ali H, Naveed K, Ali I, Sarwar M, Ali B, Iqbal R, Bawazeer S, Abdel-Hameed UK and Ali I (2023) Amassing of heavy metals in soils, vegetables and crop plants irrigated with wastewater: Health risk assessment of heavy metals in Dera Ghazi Khan, Punjab, Pakistan. Front. Plant Sci. 13:1080635. doi:10.3389/fpls.2022.1080635

cadmium, lead, zinc, cobalt and manganese. The soils were found particularly contaminated with chromium (in a range of 1970 to 2980 mg/kg), which was relatable to the presence of leather tanneries in Kasur[5]. In another study in Kasur Cr concentration was found to be 724 mg/kg in soils attributed to the presence of tannery industries[6].

A study conducted at Faisalabad has reported accumulation of Pb above the recommended levels in plants and soils being irrigated by the city effluents. Furthermore the industrial zones of Lahore, Sheikhupura and Kala Shah Kaku indicated soil and water contamination of heavy metals in their respective areas[7]. Among heavy metals Arsenic concentration was found to be very high (43.9 mg/kg) in soils of Khushab[8]. Soils of Faisalabad city have been reported to contain toxic heavy metals like Pb, Cu and Ni[9].

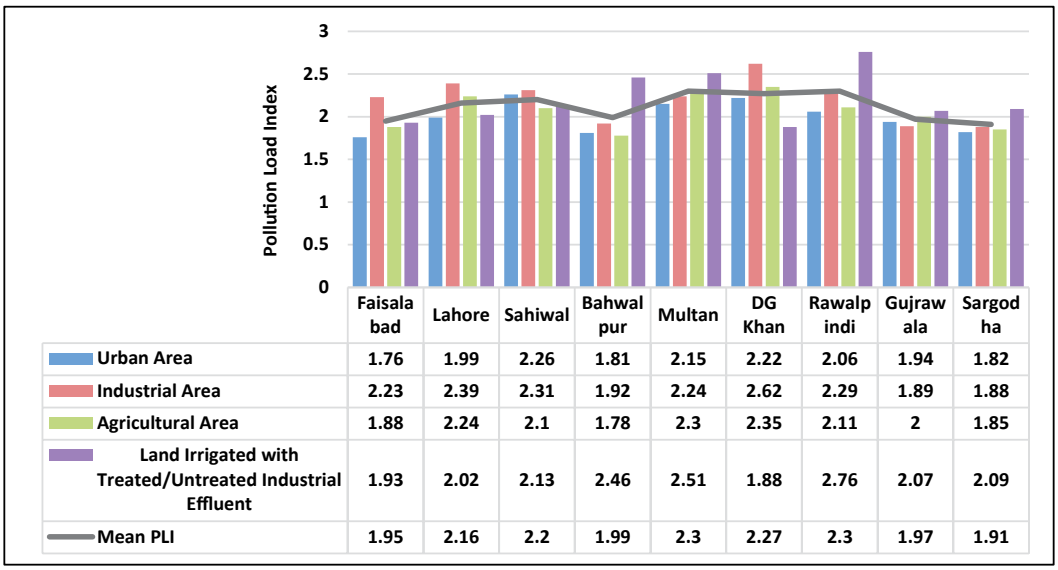
2.2.4 Pollution Load Index

Pollution load index (PLI) was calculated (Eq. 1) for various divisions of Punjab. The PLI can be measured via a scale from 1 to 6: 0 = none; 1 = none to medium; 2 = moderate; 3 = moderate to strong; 4 = strongly polluted; 5 strong to very strong; 6 = very[10]. In this study, it was observed that all the divisions showed PLI = > 1 thus showing medium to moderate polluted soils in all divisions of Punjab.

$$PLI = (CF_1 \times CF_2 \ldots \times CF_n)^{1/n} \quad (1)$$

Where CF is the contamination factor and n is the number of metals.

The highest PLI was obtained in Rawalpindi and Multan followed by DG Khan and Sahiwal divisions while comparatively lowest in Sargodha (Figure 5-7).



	Faisalabad	Lahore	Sahiwal	Bahawalpur	Multan	DG Khan	Rawalpindi	Gujranwala	Sargodha
Urban Area	1.76	1.99	2.26	1.81	2.15	2.22	2.06	1.94	1.82
Industrial Area	2.23	2.39	2.31	1.92	2.24	2.62	2.29	1.89	1.88
Agricultural Area	1.88	2.24	2.1	1.78	2.3	2.35	2.11	2	1.85
Land Irrigated with Treated/Untreated Industrial Effluent	1.93	2.02	2.13	2.46	2.51	1.88	2.76	2.07	2.09
Mean PLI	1.95	2.16	2.2	1.99	2.3	2.27	2.3	1.97	1.91

Figure 5-6: Pollution Load Index (PLI) of soil samples collected from various divisions of Punjab

2.2.5 Overall Quality Assessment

Soil quality is the capacity of a typical type of soil to function sustainably, in an ecosystem (natural or managed), in order to support the productivity and habitats. It is pertinent to mention here that the soil quality assessment in this report is based on the results of the samples collected and analyzed particularly for the sake of this report. As the sample size was limited so it might not be representative for the whole of the region particularly in case of heavy metals where secondary data shows presence of contaminated soils especially in the industrial and effluent irrigated lands in Punjab.

The overall quality assessment of all soil types of selected divisional HQs of Punjab in terms of pH and salinity (mS/cm) is rated as 'Good'. The sodicity levels varied among soil types. Sodicity of agriculture and effluent irrigated land is rated as 'Poor' while it is 'Moderate' for urban and industrial soils. Fertility status for Nitrogen, Potassium and Iron in all soil types is 'Good' whereas level of Phosphorus is 'Moderate'. Level of Zinc in agriculture soils and land irrigated with effluents is also rated as 'Good' while it is 'Moderate' for urban and industrial soils in Punjab.

5 Afzal, M; Shabir, G; Iqbal, S; Mustafa, T; Khan, QM; Khalid, ZM (2014) Assessment of Heavy Metal Contamination in Soil and Groundwater at Leather Industrial Area of Kasur, Pakistan http://dx.doi.org/10.1002/clen.201100715

6 Riaz, M., Yasmeen, T., Arif, M. S., Ashraf, M. A., Hussain, Q., Shahzad, S. M., et al. (2019). Variations in morphological and physiological traits of wheat regulated by chromium species in long-term tannery effluent irrigated soils. 222, 891–903.

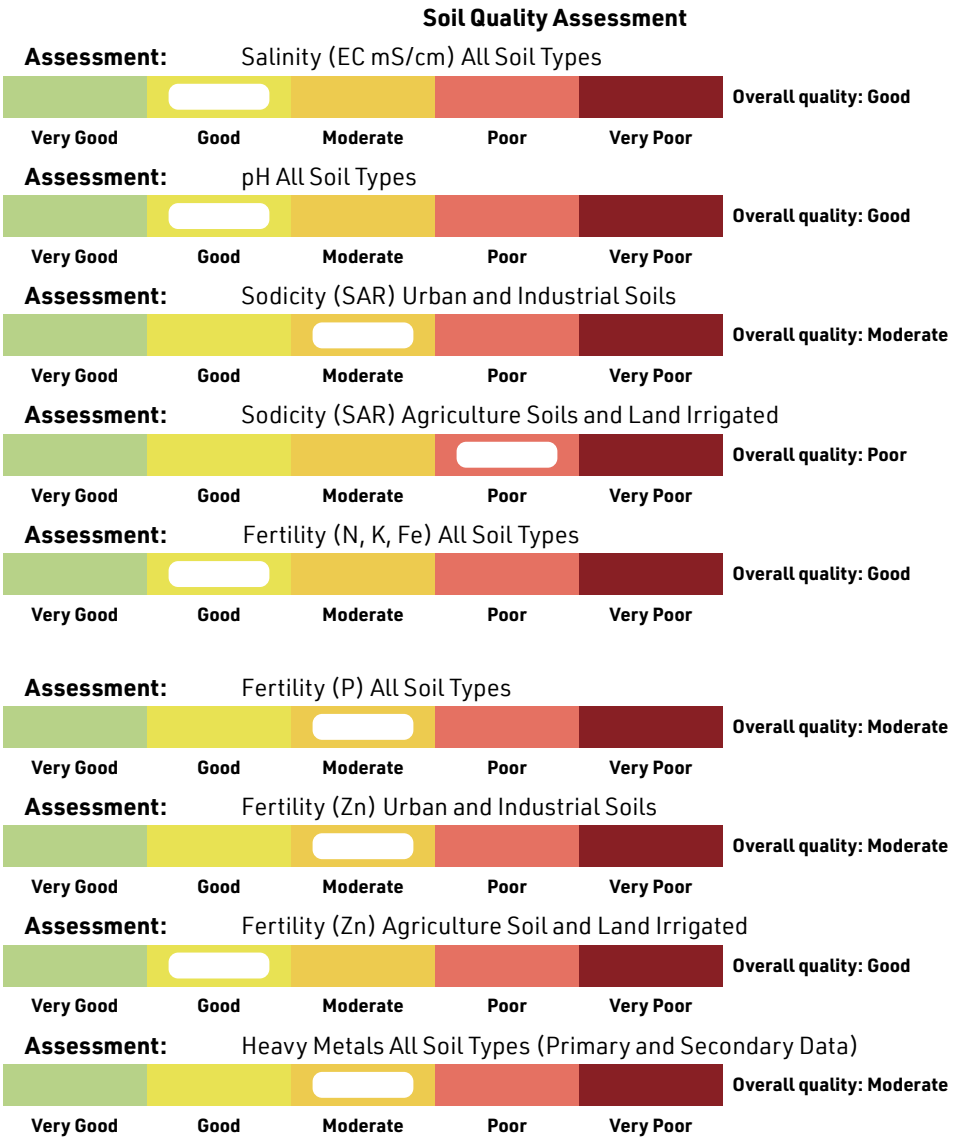
7 Lone, M. I., Aslam, R and Khan, K. S. 2000. Water quality and soil contamination in some industrial areas of Pakistan. 18: 1-6.

8 Khan, Z. I., Ahmad, K., Akram, N. A., Mehmood, N., & Yasmeen, S. (2017). Heavy metal contamination in water, soil and a potential vegetable garlic (Allium sativum L.) in Punjab Pakistan. 49, 547–552.

9 Farid, G., Sarwar, N., Saifullah, A.A., Ghafoor, A. and Rehman, M., 2015. Heavy metals (Cd, Ni and Pb) contamination of soils, plants and waters in Madina town of Faisalabad metropolitan and preparation of GIS based maps. 4(2), 693-706.

10 Tomlinson, D.L., Wilson, J.G., Harris, C.R. and Jeffrey, D.W.(1980). Problems in the assessment of heavy-metal levels in estuaries and the formation of a pollution index. 33, 566-575.

Heavy metal contents based on primary and secondary data of all soil types in Punjab are rated as 'Moderate' based on the prescribed limits available for each of the indicator parameters. Higher SAR values show a higher level of sodium. Excess sodium can cause soil dispersion and breakdown of clay particles thus negatively affecting soil structure. Soil particles are dispersed reducing soil infiltration and permeability which could lead to poor water movement within soil causing waterlogging issues. Although lead concentration was within permissible limit but trend showed that the concentration might increase in future due to extensive use of wastewater for irrigation, pesticides and fertilizers.



3. Management

Soil has an important role in maintaining ecosystem health which is essential for the survival of living organisms. Being an agriculture backbone of country's economy, joint efforts must be taken by all public and private sectors to maintain and preserve soil quality in Punjab. Thus, collaboration between farmers, government bodies and agricultural experts are essential for the success of soil quality management initiatives.

3.1 Soil Salinity and Waterlogging

Soil salinity is defined as the concentration of various salts in the soil. The major salts which trigger the salinity problem include potassium nitrate, magnesium sulfate, sodium chloride and sodium bicarbonate. Sodium chloride is the major salt among all which is responsible for the salinity. Salinity originates from various sources. Anthropogenic sources include land development and agriculture[11]. Agriculture practices and industries discharge effluents which have high quantity of salts. Excess irrigation causes a rise in groundwater table.

Water-logged soil is defined as water-saturated soil. Waterlogging leads to salinity which affects agricultural soils. Waterlogging and salinity restrict crop production. Excess water and increased concentration of salts are hazardous for soil health and biota.

11 Thal Doab, Chaj Doab, Rachna Doab and Bari Doab Pakistan Council of Research in Water Resources. (2019). Annual Abridged Report 2021-2022, Institute of Soil Chemistry and Environmental Sciences, Ayub Agricultural Research Institute, Faisalabad.

It has been reported that about 7,044,000 acres of agricultural land in Punjab has become unproductive because of waterlogging and salinity while fruits, grains and vegetables are being cultivated on 36,700,000 acres of land[12]. This issue has become a serious threat to the sustainability of irrigated agricultural land particularly in the Punjab province, wherein nearly more than 50 percent of the pumped groundwater is saline thus is a potential threat for the irrigated soils[13].

Waterlogging and salinity are strongly interconnected problems in various parts of Punjab, and pose substantial challenges to the agriculture sector. The management of groundwater table is very important and if the groundwater table is relatively high, this can result in waterlogging, and occurrence of salts in groundwater leading to salinity problems. Efforts by government, agricultural sector, and local farmers are important for implementing sustainable solutions to address both waterlogging and salinity problems in Punjab. This could involve various practices such as improved drainage and irrigation practices, use of salt-tolerant crops and soil management methods.

3.2 Soil Fertility and Use of Agrochemicals

The organic matter in the soil, which consists of animal and plant material at various stages of decomposition, plays a significant role in soil fertility. Organic matter not just provides nutrients but has significant role in enhancing soil water retention capacity, soil porosity, recycling of fertilizers and flourishing of soil organisms. Thus, soil rich in organic matter causes enhanced crop yields when cultivated. A study suggest that the cultivated land in various areas of Punjab has stayed stable over the past 40 years[14]. However, since most of the ploughable land in the province is already cultivated, fertilizers and pesticide usage are relatively higher with subsequent effects on soil quality.

3.3 Physical Properties of Soil

The physical and hydraulic characteristics of soil play an important role in its quality and fertility. A study showed that loam, silt loam and sandy loam are major soil textures in the Potohar region. The sandy texture decreases with the increasing depth. The major reason is again the large-scale erosion and rainfall in the region. The soil textures were noted as almost the same in the Doab region. However, texture varied with the depth because the washing down of top layers was reported in Potohar and a little in Doabs as the plains in Doabs are largely ploughed and are exposed to surface erosion. It was also reported that soil strata are more diverse in the Potohar region than Doabs.

3.4 DPSIR Framework

The DPSIR framework (Figure 5-6) is described below:

Drivers

Several factors affect the physicochemical properties of the soil notably environmental, topographic, and human-drivers. As discussed in SOE Report 2022, the high food demands, urbanization, industrialization, conventional agricultural practices with high rates of fertilizer and pesticide use and variable topography in Punjab are the major drivers affecting soil quality in the province. In addition, the extreme weather events and disasters, including the floods, extreme rainfalls, storms, etc. also deteriorate the soil quality in the affected areas.

Pressures

The drivers identified above, exert pressure on the soil quality in the form of change in land use, overgrazing, use of agricultural biomass for commercial and non-commercial purposes, soil contamination and erosion. The land-use change in Punjab, especially in its southern region is evident from many research findings, as quoted in SOE Report 2022[15]. These drivers are expected to put further pressure on the soil quality determinants over time, resulting in various phenomena, such as:

- Soil Pollution: Heavy metals are deposited in the soil through natural processes but various anthropogenic activities also contribute to this problem, such as improper waste disposal.
- Salinity: Increasing rates of evapotranspiration in arid or semi-arid regions result in high soil salinity due to salt accumulation over time. Moreover, salts are being added into soils through use of saline underground water and from industrial wastewater irrigation systems.
- Desertification: The possibility of desertification is high in areas where degradation of soil has been caused by excessive erosion, overgrazing and through various sources of pollution. Desertification can have significant and long-lasting effects on food security.
- Variable physio-hydraulic properties: Anthropogenic activities such as urbanization, farming on slopes, and practices that promote the process of erosion contribute to soil degradation.

12 https://tribune.com.pk/story/1797858/food-security-waterlogged-not-barren
13 Thal Government of Punjab (GOP). 2009. Groundwater Monitoring in Punjab, Directorate of land Reclamation, Irrigation Department, Lahore.
14 Xu, P., Wang, Z., Huang, Z., Yong, Z., Lin, R., & Zhao, Y. (2022). Land Degradation Assessment in Pakistan based on LU and VCF.
15 Environmental Protection Agency, Punjab (2023). Punjab's State of the Environment Report 2022. Strategic Planning and Implementation Unit, Punjab Green Development Program, Environment Protection Department, Government of the Punjab, Pakistan. https://epd.punjab.gov.pk/system/files/SOE%20Report%202022%20Final%20IA.pdf

State

- Pollution load index, SAR and Na levels were found to be high in this study thus having potentionally negative impacts on soil quality.
- Overall, the soils of the study area showed polluted state according to PLI which often causes decreased fertility, leading to less crop yields and resulting in food insecurity.

Impacts

- Reduced plant cover due to poor soil quality results in soil erosion which can lead to destruction of valuable topsoil and affecting significantly both agricultural crop yields and water quality.
- Nutrient cycling is also very important to ensure the availability of nutrients to plants and various organisms in soils. Deteriorating soil quality can disturb cycling process causing nutrient imbalances/deficiencies thus affecting overall health of the ecosystems.
- Human health is also impacted by polluted soil and poor soil quality for example, nutritional content of edible crops grown on poor soils are low thus leading to nutritional deficiencies in diets of people relying on those crops.
- Specifically, high sodium concentration in soils can cause various harmful impacts on plant growth, soil quality and overall ecosystem health. The major impact is that high sodium concentration relative to other essential elements such as magnesium, calcium, and potassium can displace these ions from soil particles, causing breakdown of the soil aggregates and negatively impacting soil structure. Poor water movement through the soil profile results in waterlogging and increased sodicity and salinity levels in the root zone. Soil fertility is therefore compromised and availability of essential nutrients is also disrupted leading to reduced microbial activity.

Response

- Tree plantation improves the soil structure and enhances its organic and nutrient contents. Forest Department is efficiently engaged in plantation activities, which also improves the soils health. Moreover. The Department is also developing multiple schemes for upgrading, rehabilitating and maintaining various reserve forests and national parks, thereby improving soil quality and stability. In agriculture sector, shift towards organic farming, sensible use of fertilizers, careful use of pesticides and zero tillage, are the key to improve soil fertility and quality.
- Agriculture Department is striving for improved research and development as well as the enhanced soil quality monitoring across Punjab. The relevant projects initiated by Agriculture Department during 2023 include the Upgradation of GIS-Remote Sensing Based Crops' Estimates & Strengthening of Area Frame Sampling Methodology in Punjab, Provision of Micronutrient Analysis Facility in District Soil and Water Testing Labs in Punjab, Mitigating the Emerging Issues of Pesticide Residues in Vegetables and Rice through Capacity Building of Farmers and Extension Agents, Mapping of Soil Series in Selected Areas of Sargodha District under Citrus Orchards and Infrastructure Improvement of Soil Survey of the Punjab, Strengthening of GIS Labs of Soil Survey of Punjab to Evaluate the Impact of Human Interventions on Different Soil Series of Punjab.
- Agriculture Department is also spreading awareness about the best soil and crop management techniques. Moreover, the department is also providing education and extension services to farmers on soil health, conservation practices and sustainable agriculture.
- Work on rehabilitation of eroded, gullied land through soil conservation measures in hill torrents/barani areas of southern Punjab has also been carried out by Agriculture Department.

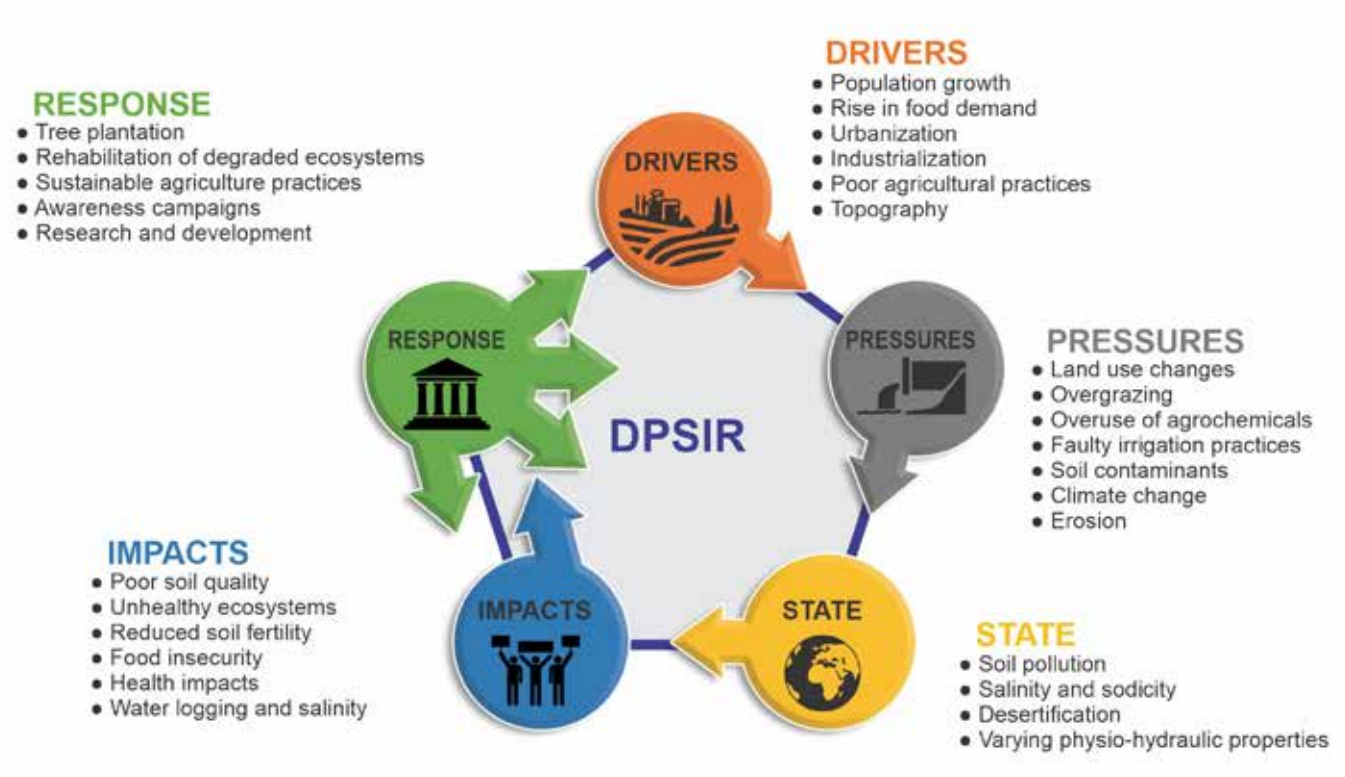


Figure 5-7: DPSIR framework of soil quality in Punjab

4. Way Forward

There are different techniques and methods for improving soil quality as listed below

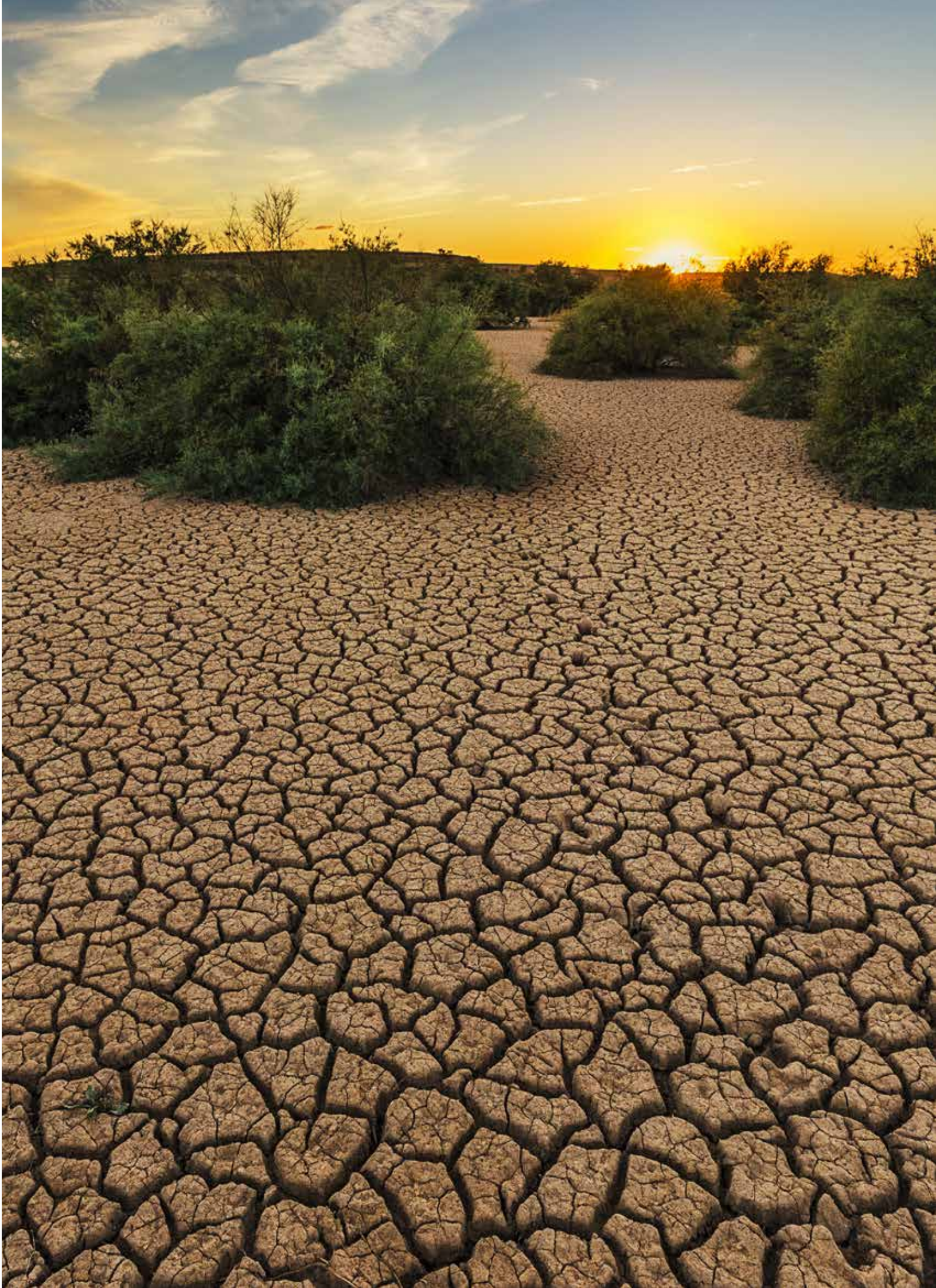
- Adopting a soil health management system can increase crop cover, and diverse crop rotations with high residue can also benefit the soils. Employing crop rotation helps retard pest and disease cycles while improving nutrient levels. Cover cropping reduces erosion and enhances organic matter and soil structure. Adopting organic farming techniques lessens the reliance on synthetic pesticides and fertilizers, improving biodiversity and microbial activity.
- No-till/Strip-till cropping systems should be used to reduce erosion and loss of top soil. Conservation tillage reduces soil disturbance, maintaining its structure and moisture retention.
- Nutrient and grazing management are important factors for marinating and improving soil quality. The overall analysis of different soils would be helpful for better management. Incorporating compost, biochar, or manures improve nutrient content and microbial activities of soils.
- Comprehensive planning at the governmental level is required for soil quality improvement. Policymakers should prioritize various sustainable land management activities, offering incentives for farmers to adopt conservation strategies such as cover cropping, crop rotation, and organic farming.
- Government-led research studies can support the development of advanced technologies and practices which enhance soil health. Regular soil testing is also crucial to develop specific strategies based on the soil's unique needs. Hence, there is an urgent need to mobilize public and private organizations to conduct research projects on soil quality assessment in Punjab province.
- Investing in educational programs for the farmers to raise awareness about sustainable soil management practices is important for ensuring healthy soils.
- Collaborative efforts with the research institutions, NGOs, and agricultural sectors can lead to a holistic approach to soil quality management, ensuring long-term productivity and health of agricultural lands. There is a need to

establish monitoring systems to determine soil health and quality on regular basis at a national level. Moreover, local soil quality standards for soils must be developed at the national level.

- Establish widespread soil testing facilities to regularly assess soil health and nutrient levels. Promote agroforestry practices, integrating trees and shrubs into agricultural landscapes to improve soil stability and fertility.
- Encourage the use of organic fertilizers, such as compost and manure, instead of chemical fertilizers. This can improve soil structure, enhance microbial activity, and increase nutrient availability. Develop and enforce regulations to prevent overuse of chemical fertilizers and pesticides, and promote environmental stewardship among farmers.
- Develop and maintain proper drainage systems to prevent waterlogging and salinity, particularly in areas with poor natural drainage.

Climate change is not just an environmental issue, it's a human issue.

6 CLIMATE CHANGE



6. Climate Change

1. Overview

The world is experiencing a climate emergency. With each passing day we are moving closer to a precipitous decline brought on by our lack of readiness and protracted climate action. Saying that climate change is reshaping the global resource and resilience map wouldn't be an exaggeration. Average global variation in temperature is a key determinant of climate change. During 2023, the world has observed the hottest recorded summer, as NASA[1] has reported that the months of June, July, and August were 2.1°F (1.2 °C) hotter than the mean summer recorded temperatures between 1951-1980.

South Asian region, like rest of the globe is coming across a "new climate normal" along with the subsequently augmenting extreme weather events e.g., ranging from intensified heat waves to the devastating floods, with its disparate impacts on the vulnerable groups of population. More than half of this region has encountered several climate-driven extreme events during 2001-2021. It is projected that the estimated economic loss resulting from climate change for South Asian states are more than the global average of losses by about 7%, with Pakistan facing a potential loss of 10% by 2100[2].

KEY FINDINGS

- The climatic normal in Punjab (1991-2020) shows 17.1°C and 30.1°C to be the mean annual minimum and maximum temperatures, whereas the mean annual precipitation has been recorded as 49.8 mm.
- Cooler than normal average temperatures (1991-2020) were observed in Punjab during the months of March-July, 2023. However, the overall mean temperature recorded in the country were 0.51°C above normal.
- Highest temperature during 2023 was 46.6°C recorded in Noorpur Thal, District Khushab on June 22, whereas the highest rainfall in 24-hours was recorded by meteorological station at Lahore airport, measuring 226.0 mm on June 26.
- Punjab's Indus tributaries are under water stress. The average annual availability of all the rivers that comprise the Indus River System's flows for canal withdrawals fell from 145.20 to 124.90 MAF between 1976 and 2020.
- Around 863 million people have been impacted by the floods that have historically occurred between 1973 and 2022.
- The water levels on the Sutlej at the Ganda Singh Wala village gauging station were recorded to be highest in 35 years in August 2023.
- During 2023, Districts Bahawalnagar, Bahawalpur, Lodhran, Kasur, Vehari, Okara, Pakpattan and Multan were affected by urban flooding from August, 17 to September, 30.
- In the afflicted areas, the floods damaged 467 villages/basti/mozas, almost 24,000 homes, and 545,270 acres of farmed land.
- Kharif crops (cotton, sugarcane, rice, maize, moong, sesame, fodder and vegetables) have undergone production losses due to the floods/torrential rains during 2023.
- Punjab has experienced a remarkable increase in disease outbreaks like dengue and cholera (250 confirmed cholera cases from May 2022 to April 2023).
- Several initiatives have been taken by the government departments (Energy, Transport, Agriculture, Finance, Irrigation and Forest etc.) to combat climate change like policy reforms, solarization projects, electric buses, water conservation strategies and climate financing to name a few.

2. Environment

2.1 Punjab's Climate Change Outlook

Pakistan ranks as the 5th most vulnerable country to climate change, facing serious threats from abrupt climate change events. The sectoral distribution of GHG emissions in Pakistan reveals agriculture as the primary contributor, accounting to 45.6%, closely followed by energy at 44.7%, with industrial processes and waste contributing 5.3% and 4.43%, respectively[3].

Currently, Punjab lacks a greenhouse gas (GHG) inventory, essential for estimating emissions across various sectors. Being the most populous province of the country, Punjab is particularly susceptible to the impacts of climate change. The manifestations of climate change in province include increased riverine, flash, and urban flooding frequency and intensity, as well as heat waves. These events have multiple secondary effects on the vulnerable sectors, including but not limited to water resources, agriculture, health and ecosystems.

Though the 'emissions' side of climate change is at a rapid rise in the province, vulnerability, adaptation, institutional capacity and resilience remains at the top priority in context of climate action.

1 https://www.nasa.gov/news-release/nasa-announces-summer-2023-hottest-on-record/
2 Climate Change Action Plan 2021-2025 South Asia Roadmap (2021) The World Bank Group
3 Ministry of Climate Change, Government of Pakistan. Pakistan's Second National Communication on Climate Change-to United Nations Framework Convention on Climate Change (UNFCCC); Ministry of Climate Change: Islamabad, Pakistan, 2018.

2.2 Weather Patterns and Climate Normals

As highlighted in SOE Report 2022, Punjab has a diverse climate, ranging from semi-arid to arid in the southern regions to cool and humid in the northern areas (north to the Salt Range). The climatic normal recorded from 1991-2020 depict that in Punjab, the mean annual minimum and maximum temperatures remained as 17.1°C and 30.1°C, respectively, whereas the mean annual precipitation has been recorded as 49.8 mm[4] (Figure 6-1).

During 1880s to 2020, the extreme records of minimum and maximum temperatures in Punjab show that the lowest minimum temperature has been recorded to be -12°C (in Northern Punjab), whereas, the highest maximum temperature has been recorded to be 50.8°C (in Southern Punjab)[5] (Figure 6-2). The wide gap between these temperature extremes depicts the high variability of temperatures across province.

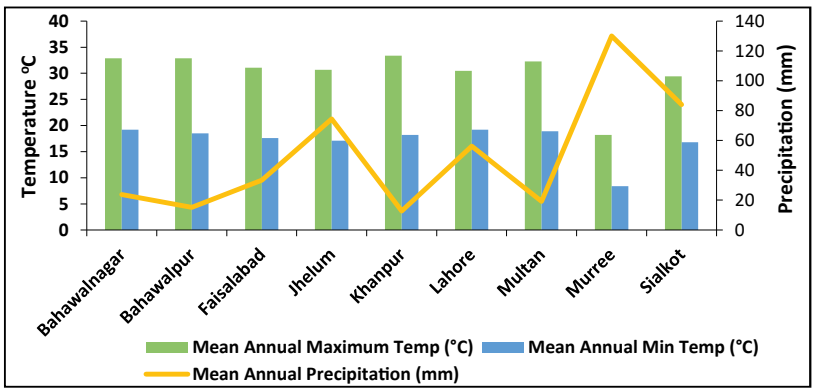


Figure 6-1: Climate Normals in Punjab (1991-2020)

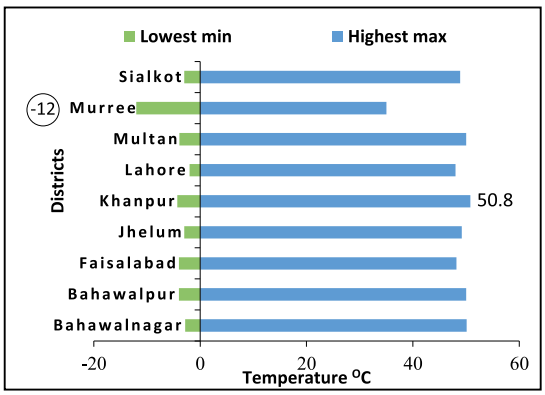


Figure 6-2: Extreme Temperature Records in Punjab (1880s to 2020)

2.3 Weather Anomalies-2023

i. Temperature

In 2023, the world experienced its highest summer temperatures on record. Notably, summer temperatures in the Indian Subcontinent and eastern Pakistan have been significantly lower this year, especially when compared to the surface air temperatures reported in 2022, as depicted Figure 6-3a & b[6].

It was reported that a strong storm of low air pressure that emerged in the continent's west drove humid winds from the Arabian Sea over the area caused a historically low temperature to occur in May of 2023 in India. This resulted in the dense clouds, reducing the sunlight along with the above-normal precipitation and a record colder temperature reported by Indian Met stations[7]. The cooler than summer normal temperatures have also been observed in Punjab (eastern Pakistan) and the same is confirmed by Pakistan Meteorological Department (Figure 6-4). However, the overall mean temperature recorded in the country were 0.51°C above – normal[8] and 0.18°C above normal in Punjab.

It is pertinent to mention here that the cooler temperatures due to inter-annual variability do not refute the phenomena of global warming - led climate change. It cannot be inferred that global warming is occurring uniformly over all the regions on the Earth. Rather, it is just the average increase in global temperature that is recorded in context of climate

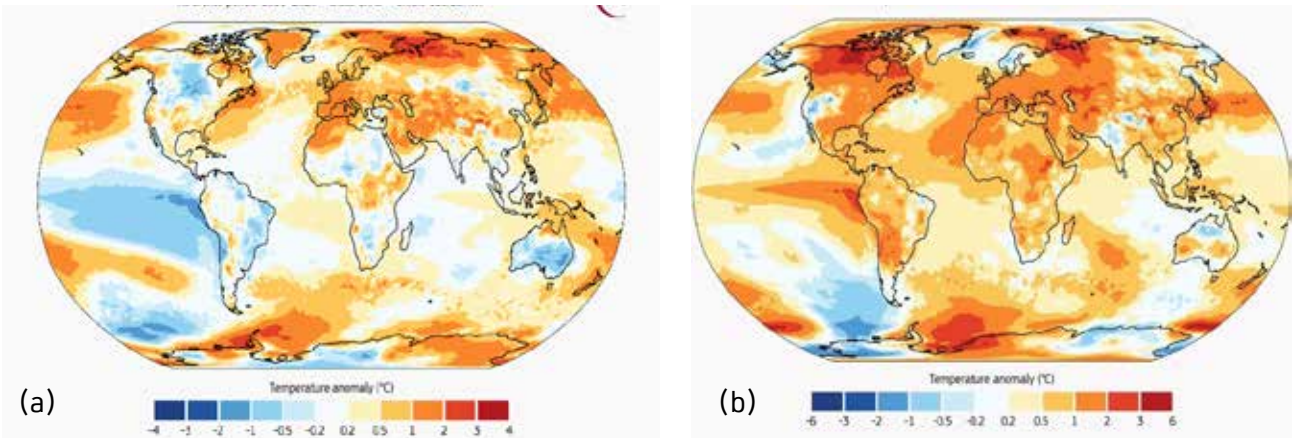


Figure 6-3: (a) Surface air temperature anomalies – 2022 (b) Surface air temperature anomalies - 2023

4 Pakistan Meteorological Department (PMD)
5 PMD
6 Copernicus Climate Change Service (https://climate.copernicus.eu/global-climate-highlights-2023)
7 https://www.theguardian.com/environment/2023/may/05/weather-tracker-unusually-chilly-start-may-india-us
8 State of Pakistan's Climate – 2023, Pakistan Meteorological Department

change. The regional weather patterns keep varying, depending on several parameters including, but not limited to the local and regional atmospheric pressures, wind patterns, cloud density, solar radiation, geography and topography[9].

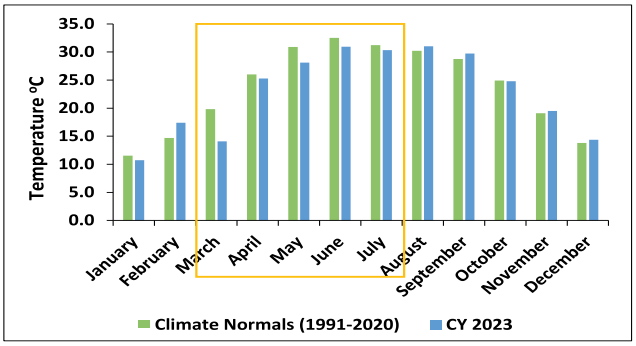


Figure 6-4: Comparison of Punjab's Mean Monthly Temperatures of Climate Normals (1991-2020) and CY 2023 (Recorded from 09 Met Stations)

ii. Precipitation

The precipitation patterns showed remarkable anomalies round the year 2023 (Figure 6-5). Departure from normal remained higher for the months of May, October and November receiving higher while months of January, February, August and December received below average rainfall.

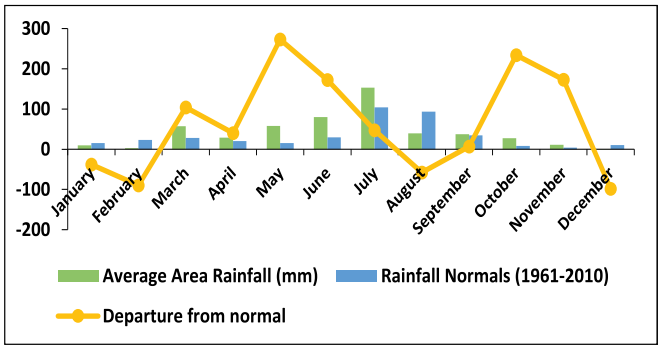


Figure 6-5: Rainfall Anomalies Recorded During - 2023

2.4 Extreme Weather Records - 2023

The highest temperature during 2023 was 46.6°C recorded in Noorpur Thal, District Khushab on June 22, whereas the highest rainfall in 24-hours was recorded by meteorological station at Lahore airport, measuring 226.0 mm on June 26. The extreme events recorded in Punjab during 2023 are detailed in Figure 6-6.

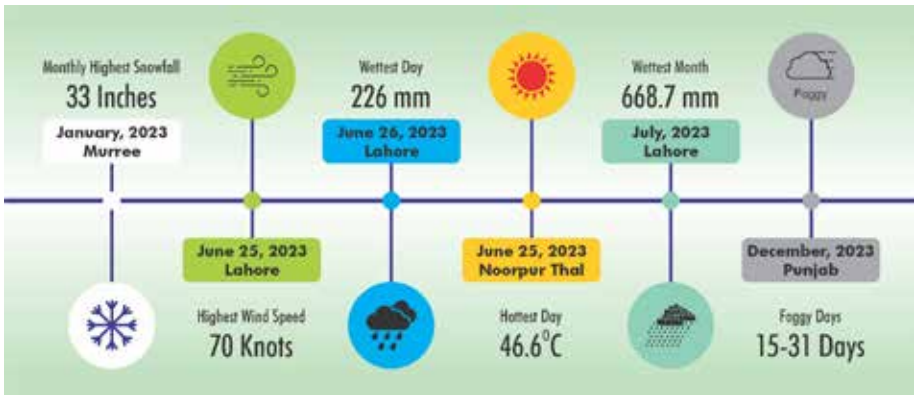


Figure 6-6: Extreme weather records in Punjab - 2023

2.5 Sectoral Impacts of Climate Change in Punjab

Climate change affects every sector of the economy in different ways. There is complex nexus between the climate change and its inter- and intra-sectoral implications. So far, no in-depth data is available with quantified impacts of climate change and its subsequent hazards on the economic sectors of Punjab. A glimpse of these impacts based on the available data is given below

2.5.1 Water Sector

Water sector is highly vulnerable to the impacts of climate change. Punjab is experiencing water-stress situation along Indus tributaries. Irrigation Department, Punjab reported that between 1976-2020 the average yearly availability of all the rivers that make up the Indus River System's flows for canal withdrawals decreased from 145.20 to 124.90 MAF. Out of the 37 large aquifers studied between 2003 and 2013, a study carried out by NASA found that Indus Basin aquifer was the second most overstressed and was being depleted at an alarming rate. This situation has led to a high pressure on groundwater resources of the province. Recent survey conducted by Punjab Irrigation Department, indicates that over abstraction has led to falling of groundwater to lower than critical limits in seven districts of Punjab including Lahore, Multan, Khanewal, Vehari, Lodhran, Pakpattan and Sahiwal.

The higher temperatures consequent from the climate change cause higher rates of evapotranspiration in the agricultural fields, leading to higher water demands and burden on the surface and groundwater resources. A study conducted in 2020

9 NOAA (2020) (https://www.climate.gov/news-features/climate-qa/does-global-warming-mean-it%E2%80%99s-warming-everywhere)

confirms decreased water productivity in semi-arid area of Punjab, reported to be due to high temperatures and extreme rainfall events[10]. Percentage of area with unfit groundwater quality increased by 35%, 38% and 49% in the year 2010, 2014 and 2020, respectively. Recurring flood events caused major damages to irrigation and drainage infrastructure in the preceding years 2010 (River Indus), 2014 (River Chenab), 2022 (Hill torrents in DG khan & Rajanpur) and 2023 (Eastern rivers).

2.5.2 Agriculture and Livestock Sector

Farmers in districts Muzzaffargarh, D.G Khan and Faisalabad have reported rising challenges of food security due to climatic disasters (floods and droughts) followed by pest attack, rainfall, wind and hailstorms[11]. Consequent upon the Floods-2022, the Rabi season crops have shown higher yield, which has partly compensated the crop damages of the Kharif season, leading to an overall growth of agriculture sector to 1.55%. However, the growth rate reported in 2022-2023 was second lowest in the country since 2017 (Figure 6-7)[12].

The kharif crops i.e., cotton, sugarcane, rice, maize, moong, sesame, fodder and vegetables have undergone production losses due to the floods/torrential rains during 2023[13] (Figure 6-8).

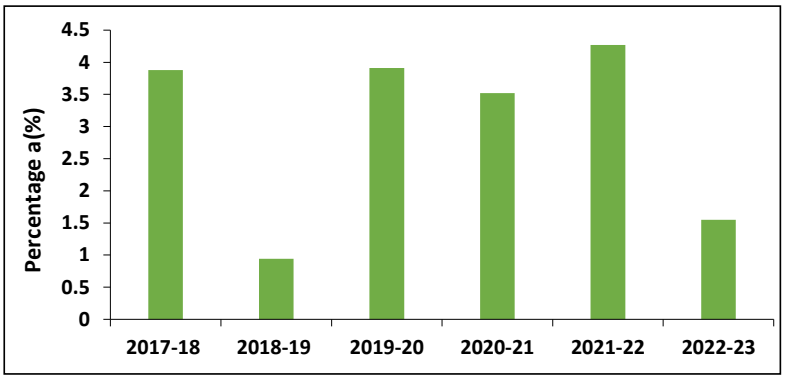


Figure 6-7: Agriculture Sector Growth Rates 2017-2023

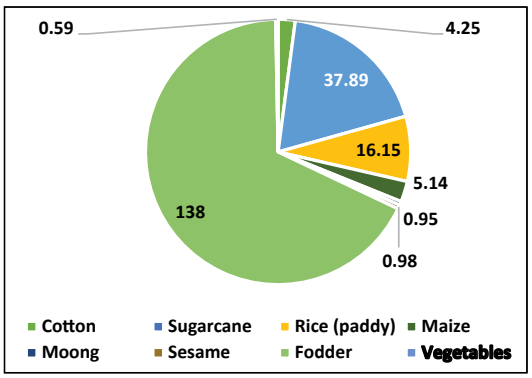
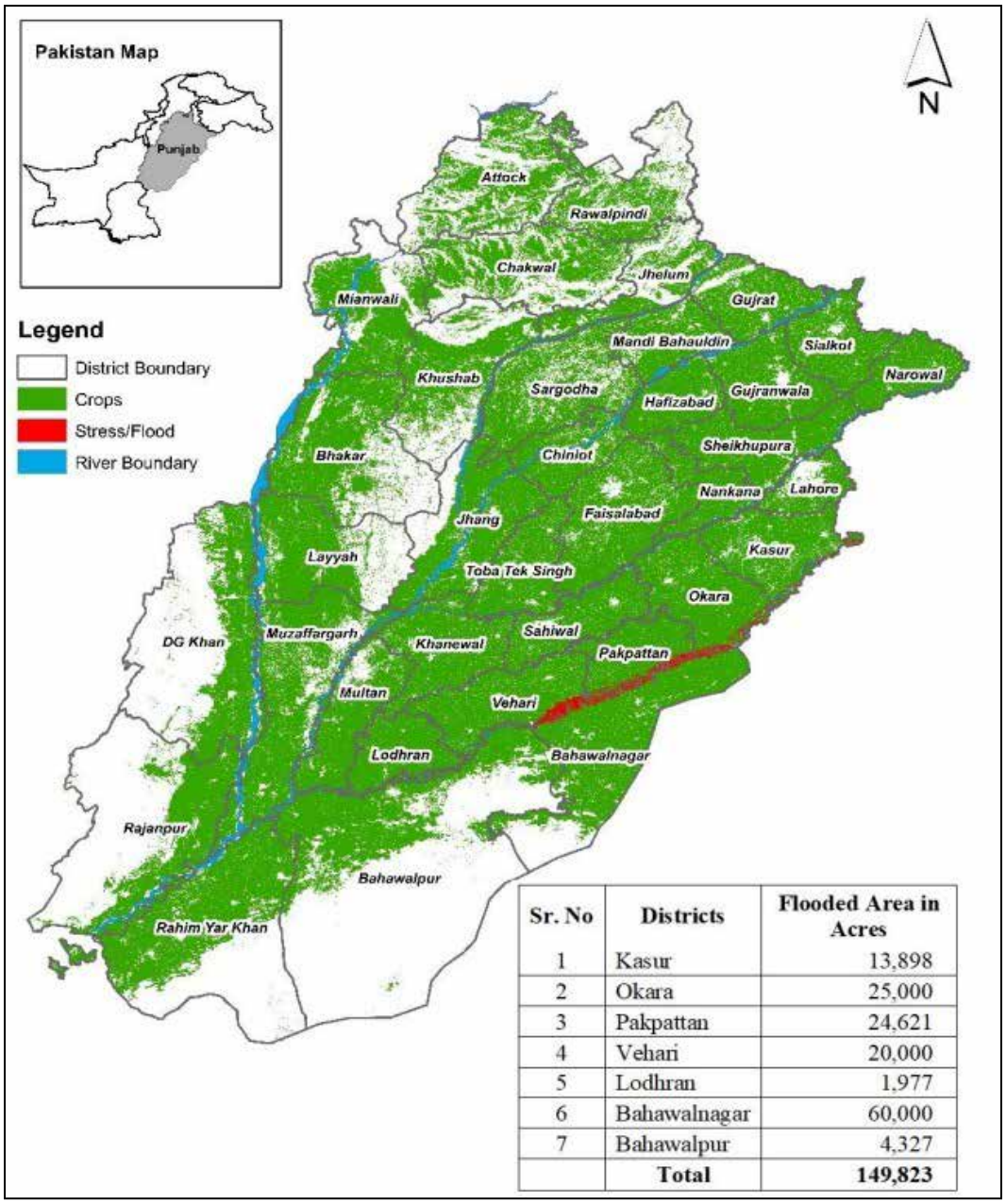


Figure 6-8: Production Loss of Kharif Crops from Floods/Rainfalls (000 Tons)

Unforeseen variability in weather patterns puts stress on the crop health and growth, which is calculated by the Normalized Difference Vegetation Index (NDVI). The stress map of crops (Figure 6-9)[14] indicates that severe stress was found on the crops cultivated in Kasur, Pakpattan, Okara, Vehari, Bahawalpur and Bahawalnagar districts due to flood water in River Sutlej, affecting an area of 60,000 acres. Floods of 2022 have had a devastating impact on the livestock as well. According to NDMA updates dated 18-11-2022, estimated 1,164,270 livestock heads perished due to 2022 floods with 205,106 (17.6%) in Punjab[15]. The sector has also been affected by the floods in 2023 as well, as discussed in upcoming section (6.3).

10 Waqas MM, Shah SHH, Awan UK, Waseem M, Ahmad I, Fahad M, Niaz Y, Ali S. Evaluating the Impact of Climate Change on Water Productivity of Maize in the Semi-Arid Environment of Punjab, Pakistan. Sustainability. 2020; 12(9):3905. https://doi.org/10.3390/su12093905
11 Civil Society Coalition for Climate Change (2018). Food Security and Challenges of Climate Change: A Case Study of Punjab, Pakistan
12 Pakistan Economic Survey 2022-23 (Agriculture)
13 Crop Reporting Services, Agriculture Department, Government of the Punjab
14 Crop Reporting Services, Irrigation Department, Government of the Punjab
15 Pakistan Economic Survey 2022-2023 (Agriculture)



Sr. No	Districts	Flooded Area in Acres
1	Kasur	13,898
2	Okara	25,000
3	Pakpattan	24,621
4	Vehari	20,000
5	Lodhran	1,977
6	Bahawalnagar	60,000
7	Bahawalpur	4,327
	Total	**149,823**

Figure 6-9: Stress Map of Crops, September 2023

2.5.3 Health Sector

Climate change poses threats to human health in both direct and indirect ways. The direct impacts arising from the climate change and its manifestations include illnesses, injuries and deaths resulting from heat/cold waves, forest fires, droughts, floods, storms, sky lightning, land sliding and other events. However, the indirect health effects of climate change stem from its effects on food production, the environment (air and water quality), the spread of infectious diseases, and the emergence of chronic illnesses and allergies.[16] During May 2022 to April 2023, about 250 cholera cases were confirmed in Punjab[17]. Out of cumulative total of 25,932 confirmed dengue cases in Pakistan during 2022, 6483 (29%) cases were reported from Punjab[18]. The disease patterns related to poor air quality and contaminated water are discussed in respective Chapters.

2.5.4 Urban Sector

According to certain urban development statistics for Punjab, the urban sector is highly vulnerable to climate change, which not only makes urban areas less able to adapt to extreme weather events and disasters but also increases their exposure, particularly to vulnerable populations. Some of the impacts are detailed below;

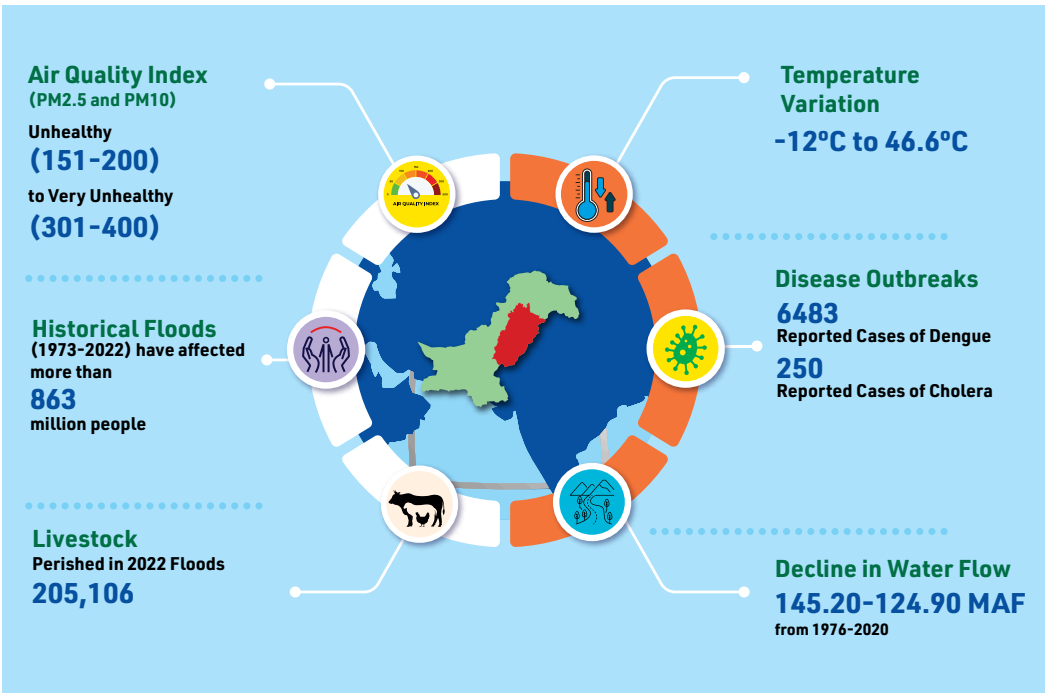
a. The population of Punjab has reached 127.6 million as per Population Census 2023 with an annual growth

16 Iqbal, M.P., 2020., Effect of Climate Change on Health in Pakistan, Pakistan Academy of Sciences (PAS) (https://www.paspk.org/wp-content/uploads/2021/02/LS-624.pdf)
17 World Health Organization, Pakistan Floods Situation Report, Health Emergencies Program (Situation Overview), Issue No. 33, 19th May 2023
18 World Health Organization, Disease Outbreak News (Dengue - Pakistan), October 2022

rate reported as 2.53%[19]. Cities have grown incredibly, which has resulted in changes in land use, unlawful encroachment, environmental issues, and incompatible service usage. Housing shortage is evident from Lahore's statistics where 3.4 persons are living per room, which is higher than India (2.7), Sri Lanka (2.2) and Turkey (1.3). There is a total backlog of nearly 400,000 units with annual demand of 78,000 houses per year[20]

b. Air pollution is on the rise in urban areas due to multiple factors, including environmental problems, inefficient energy use, a rapid increase in the number of vehicles, industrial activities without adequate air emission control, and the open burning of solid waste, including plastic. The Air Quality Index, (calculated on basis of $PM_{2.5}$ and PM_{10}) during smog season 2023 is continuously being recorded between unhealthy for sensitive groups (151-200) to very unhealthy (301-400) in Lahore[21].

c. Urban flooding due to heavy rainfalls has become a serious concern in the cities of Punjab. This occurs due to poor planning and inadequate drainage and infrastructure in the cities causing streets and low-lying areas to be submerged in water affecting mobility, and creating other issues to the residents.



2.5.4 Loss and Damages

The extreme events arising from the changing climate have led to devastating loss and damages throughout the country, specifically during past few decades. An overview of the losses and damages brought on by extreme weather occurrences in Punjab province are shown below.

2.5.5 Floods

Punjab experiences flooding in Monsoon season, mostly due to torrential rains and hill torrents. During mid-June each year a monsoon system due to low depression originates in the Bay of Bengal, the northeastern segment of Indian Ocean. The system enters Punjab from India from the West or North West and then moves towards North. Punjab's rivers get substantial inflows due to the persistent, heavy rainfall in the northern mountain ranges. The summertime high glacier melt combined with these large inflows causes floods in Punjab's plains. In addition to the riverine floods, Punjab also experiences flash and urban flooding during the months of June-October. However, the intensity of flooding varies depending on the intensity and frequency of precipitation.

Since 1970's the floods have caused severe loss and damages to the infrastructure and human life. According to the Provincial Disaster Management Authority (PDMA) Punjab, the historical floods (1973-2022) have affected more than 863 million people in all. The loss and damages to the households, cropped area, livestock and human lives have also remained significant during these events (Figure 6-10). More than 3000 people have lost their lives during these floods[22] (Figure 6-11).

19 Pakistan Population Census 2023
20 Punjab Board of Investment and Trade (PBIT) (http://www.pbit.gop.pk/infrastructure)
21 Environment Protection Department (EPD) Punjab (https://epd.punjab.gov.pk/index.php/aqi)
22 PDMA, Punjab

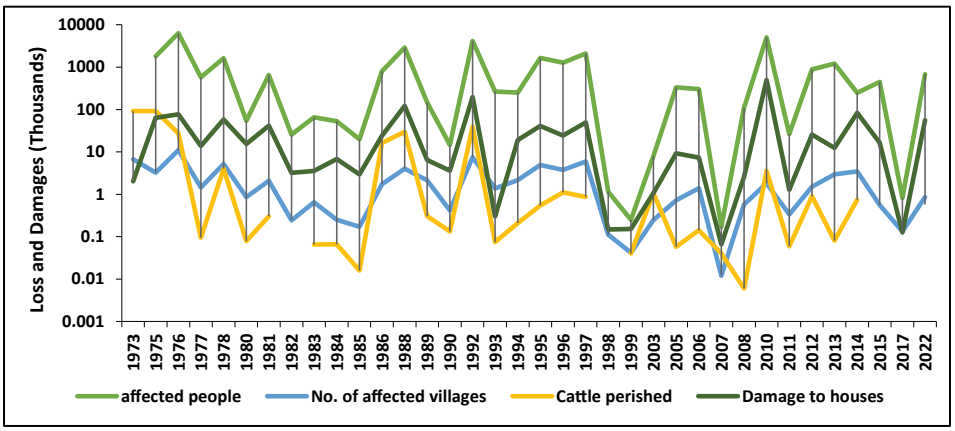


Figure 6-10: Loss and Damages in Punjab during Historic Floods (Logarithmic scale)

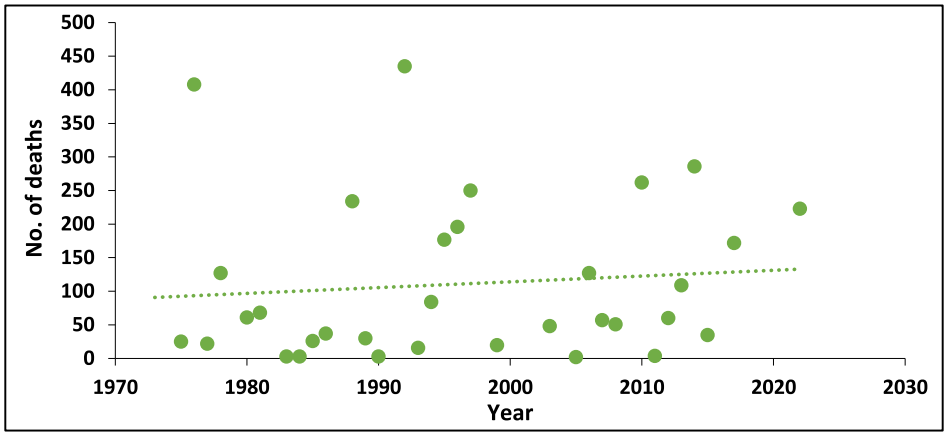


Figure 6-11: No. of deaths reported during historical floods in Punjab (1973-2022)

Most recently, Punjab has faced flooding along Sutlej River in August, 2023. The water levels on the Sutlej at the Ganda Singh Wala village gauging station, 7 km west of Ferozepur, were recorded to be highest in 35 years[23]. According to PDMA, flood season was observed from 17th of August, to 30th September during which Districts Bahawalnagar, Bahawalpur, Lodhran, Kasur, Vehari, Okara, Pakpattan and Multan were affected by urban flooding. The floods affected 467 villages/basti/mozas with more than 24,000 houses and 545,270 acres of cultivated land in the affected districts. Around 300,000 livestock was transported for rescue purposes, whereas 11 persons were reported injured and 10 reported dead as a result of these floods[24].

2.5.6 Torrential Rains and Thunderstorms

In addition to the floods, the torrential rains along with the thunderstorms also pose threat to human and animal lives as well as to the infrastructure. According to PDMA, Punjab during 2023 the torrential rains and thunderstorms have not only damaged the infrastructure (Figure 6-12) but have also resulted in more than 300 injuries and 124 deaths due to sky lightning, structural collapse and heat stroke events in different districts of Punjab.

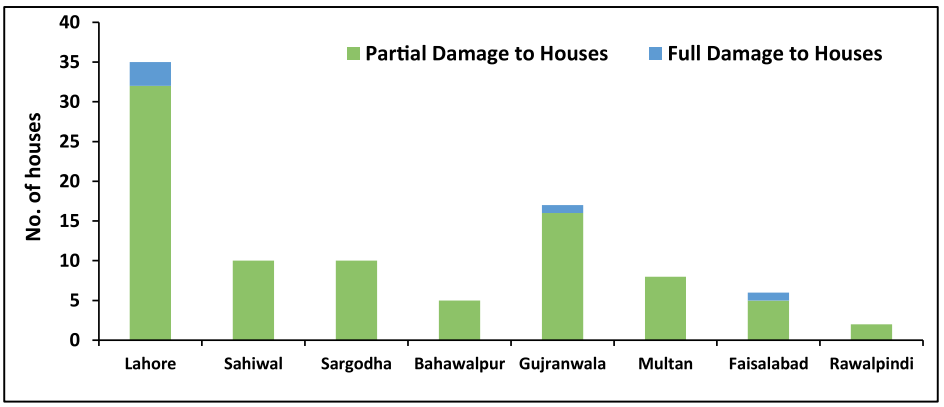


Figure 6-12: Damage to Houses due to torrential rains and thunderstorms during 2023

23 Pakistan Meteorological Department
24 Flood Situation Report (17th Aug 2023 To 30th Sep 2023), PDMA, Punjab

3. Management

3.1 Initiatives taken by the Government

Government of the Punjab is well sensitized about the risks and consequences related to climate change and is taking crucial initiatives in terms of climate change mitigation, adaptation, resilience and climate finance. Some imperative endeavors by Government of the Punjab pertaining to climate action are as follows:

3.1.1 Energy, Transport and Industry Sector

i. Energy savings of 55 GWh are anticipated in public institutions through solarization projects initiated by Energy Department under Punjab Green Development Program.
ii. Government of the Punjab is piloting 27 electric buses in the province, which would be a groundbreaking step towards provincial contribution to the commitments made by the country in its Nationally Determined Contributions (NDCs)
iii. About 500 micro-enterprises, covering five industrial sectors i.e., stone crushing, rice husking, re-rolling units and steel furnaces are being financially supported by Industries Department for adopting Resource Efficient and Cleaner Production (RECP) Technology under Punjab Green Development Program (PGDP).

3.1.2 Agriculture Sector

Followings initiatives have been taken by the Punjab Government for climate change mitigation/adaptation in agriculture sector:

i. Field experiments are being carried out to increase fertilizer use efficiency, which will lower fertilizer losses and GHG emissions.
ii. Experiments are being conducted on use of green manures and farm yard manures to increase yields, improve soil health and increase carbon sequestration. All these steps increase soil health.
iii. Soil and water samples from fields are being taken and advisory service is provided to the farmers which results in proper use of inputs under climate change scenario.
iv. All the developed technologies are being disseminated to the farming community through production plan, farmer days and other media.
v. Installation of high efficiency irrigation system on 3,200 acres of land.
vi. Installation of solar system to operate coupled high efficiency irrigation system on 2,000 acres.
vii. Construction of 55 farm pounds and 55 dug wells in barani areas of the Punjab.
viii. Improvement in lining of 732 watercourses.
ix. Rehabilitation of 445 irrigation schemes outside canal commands.
x. Provision of 300 LASER land leveling units to the service providers/ farmers.
xi. Furthermore, the Agriculture Extension Wing is also providing information and guidance to the farmers on coping heatwave conditions and adapting their agricultural practices accordingly. This includes educating them on appropriate irrigation techniques, crop selection, and timing for planting and harvesting to minimize heat stress on crops etc. (Figure 6-13).

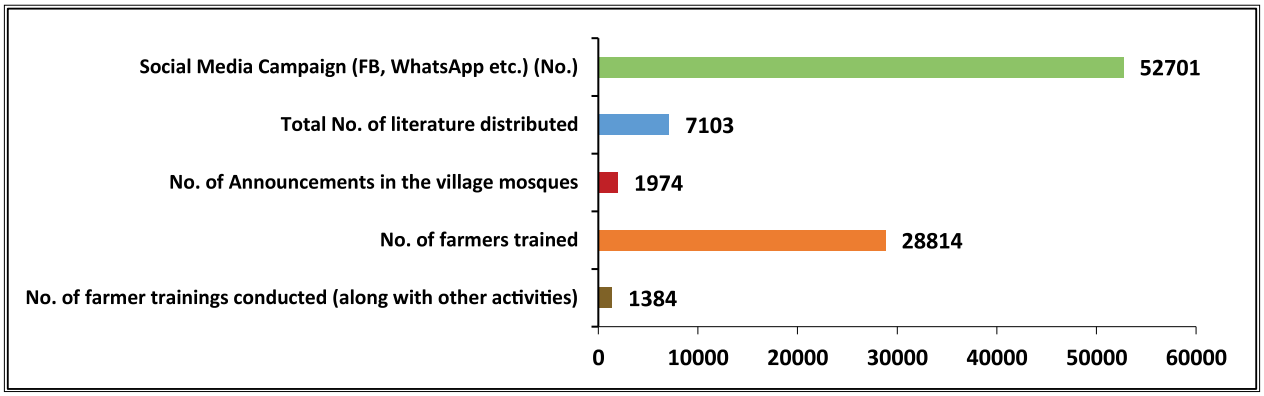


Figure 6-13: Awareness Activities on Climate Change by Agriculture Department, Punjab

xii. Advisory services along with other activities are provided regarding improving water use efficiency, conservation tillage practices, manure management, alternate measures to puddling like direct seeding for rice crop etc.
xiii. Aggressive tree planting initiatives are carried out annually at farmer fields and agriculture offices, which will be crucial in reducing atmospheric pollutants. As per the current year 2023 report from the field offices, 67,480 saplings have been planted in offices and farmer fields.
xiv. For the development and introduction of drought resistance crop varieties, many major crops related Institutes like wheat, rice, maize, cotton, sugarcane, pulses, oil seeds etc. are working under the umbrella

of Ayub Agricultural Research Institute (AARI), Faisalabad are engaged in research activities to combat climate change.

xv. Climate Change Research Center (CCRC) was also established at AARI, Faisalabad under certain term of references (TORs) in 2015 and it is effectively working. Therefore, to meet the challenges of current environmental and climatic scenarios, following Climate Smart Agriculture Technologies/activities are being considered:

- Climate-smart management for rice production
- Drip irrigation as a Climate-smart practice
- Assessment of climate-smart breeding needs
- Planting cotton crop in raised Beds/ridges
- Regulated Deficit Irrigation (RDI) an optimization approach
- Awareness of weather data/early warning system
- Re-defining and updating the Agro Ecological Zones (AEZs)
- Crop residue and farm waste management
- Developing a Climate Smart Agriculture plan

3.1.3 Irrigation Sector

Government of the Punjab is striving for climate adaptation and resilience in following domains through multiple projects initiated by Irrigation Department:

i. Demand management measures to increase water use efficiency and productivity
ii. Construction of large and small reservoirs, rain water harvesting and storage, groundwater recharge, groundwater management etc. to improve inter seasonal water availability
iii. Strengthen resilience and adaptive capacity to climate related disasters

Furthermore, the interventions by EPCCD with co-benefits in climate mitigation are detailed in Chapter eight.

3.1.4 Forestry Sector

Urban tree plantations were carried out in 2023, both by the Forest Department's plantation efforts and to meet the requirements of environmental approvals. A total of 328,428 trees were planted throughout Punjab.

3.1.5 Climate Finance

- The government is allocating US$ 273 million for environmental and climate sector reforms and green development under PGDP until May 2025.
- A Green Financing Strategy has been crafted for Punjab, addressing environmental challenges, climate vulnerabilities, and commitment to international agreements.
- A Green Climate Fund project titled "Transforming Indus Basin with Climate Resilient Agriculture and Water Management" is ongoing between GoPb and FAO, aiming to enhance climate resilience among vulnerable farmers in the Indus basin.
- Climate budget tagging (CBT) is adopted to provide decision support in the provincial climate change framework, prioritized in the Government of Punjab Planning and Development (P&D) Board.
- An Environment and Climate Change Cell is operational in P&D Board Punjab, assisting in climate-related actions and financing and supporting accreditation for Green Climate Fund (GCF).
- The Punjab Budget Strategy Paper (2022–2025) commits to setting aside funds for climate event mitigation and adaptation, alongside department-specific allocations.
- Disaster Risk Finance is integral to Punjab's Public Financial Management Reforms Strategy 2025, aiming to manage fiscal risks from disasters.
- Under the World Bank's Punjab Resource Improvement and Digital Effectiveness (PRIDE), several activities are executed by the Government of Punjab through its Finance Department to support climate change mitigation and adaptation, including inclusion of environmental costs in the macro-fiscal framework, formulation of Disaster Risk Financing Strategy (DRFS), regulatory framework improvements for LG responsiveness to disaster risks, performance grant mechanism for LGs, and SOPs for E-waste management.

4. DPSIR Framework

The DPSIR framework for Climate Change is depicted in Figure 6-14

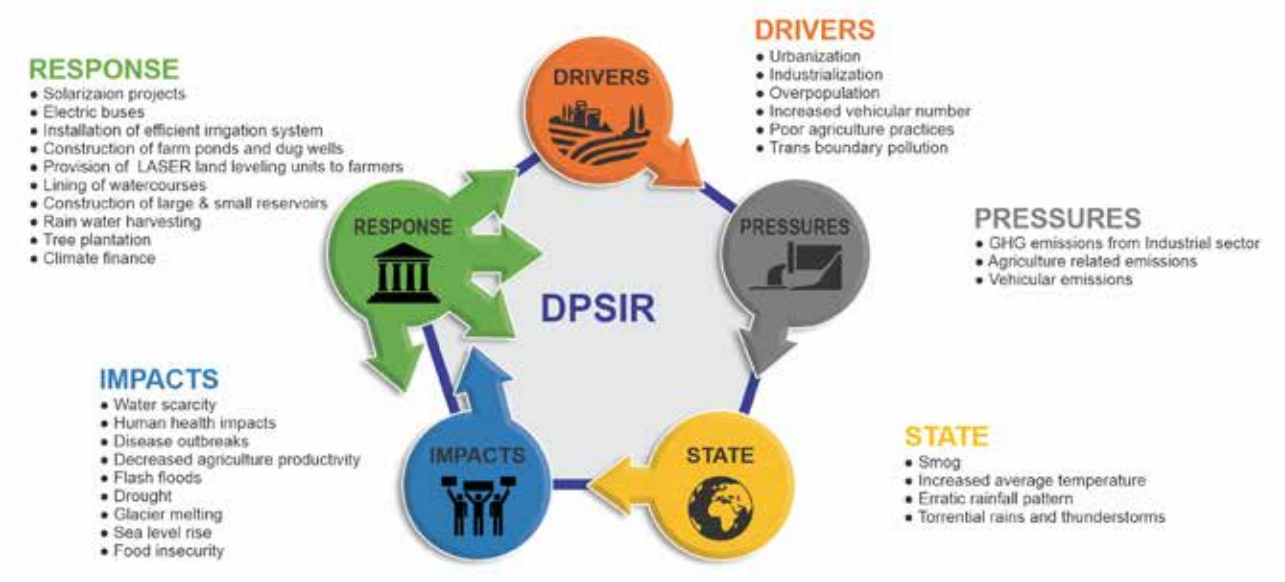


Figure 6-14: DPSIR framework for climate change in Punjab

5. Way Forward

Punjab, though proactively engaged in the climate action may consider following interventions for expeditious and effective outcomes to combat climate change:

Building Climate Profile and Database of the province: There is no regularly updated data on climate change trends at the provincial level. There is need of capacity building, institutional strengthening, technology transfer, research and development to establish, maintain and update the data on GHG emissions, sectoral carbon footprints, climate-resilience of province and climatic variability over time for better policy decisions, leading to visible positive strands in Punjab's climate action.

Climate and gender mainstreaming: Integrating climate adaptation, with specific consideration of gender as an essential component of the planning (programs and projects), policy –, and decision – making as well as the regulatory functions of the department.

Planning for adaptation: Formulating strategic plans for Punjab to reinforce its adaptive capacity and resilience to climate-driven disasters, food and water insecurity, loss and damage to infrastructure and human lives.

Encouraging climate-resilient investments across province: Exploring the international climate funding and grants, development and management of climate funds and formulation of Punjab's financial framework for Climate Change Adaptation.

Role-playing for the International Commitments: developing linkages between the provincial climate actions and the international obligations related to climate adaptation and mitigation.

Managing waste responsibly today ensures a sustainable tomorrow for generations to come.

7 ENVIRONMENTAL PERFORMANCE OF WASTEWATER TREATMENT AND SOLID WASTE MANAGEMENT FACILITIES

7. ENVIRONMENTAL PERFORMANCE OF WASTEWATER TREATMENT AND SOLID WASTE MANAGEMENT FACILITIES

1. Overview

This chapter delves into the assessment of wastewater treatment plants operating within various industries across Punjab, along with an examination of solid waste management facilities, encompassing municipal and hospital waste disposal facilities.

2. Environment

2.1 Industrial Wastewater Treatment Plants (WWTPs)

During 2023, field formation of EPA has carried out a detailed surveys for the identification of wastewater treatment plants installed in their respective territories across Punjab. The survey has two major components i.e.

i. Verification of wastewater treatment plants identified and reported previously during 2022.

ii. Identification and mapping of further wastewater treatment plants.

An online module was developed for EPA field formation to collect and update information on WWTPs. The module allows verification of previously added records, their updation as well as addition of new records.

Depending on the treatment technology, three categories of WWTPs were included in the survey i.e., primary, secondary, and tertiary. Primary WWTPs are those which use physical operations to eliminate floatable and settle able solids from wastewater. The secondary WWTPs are those where the majority of organic matter is removed through biological and chemical processes. Whereas, in tertiary WWTPs additional processes are employed to eliminate constituents that were not removed during secondary treatment[1]. During the survey, a total of 434 waste water treatment plants were identified (Figure 7-1).

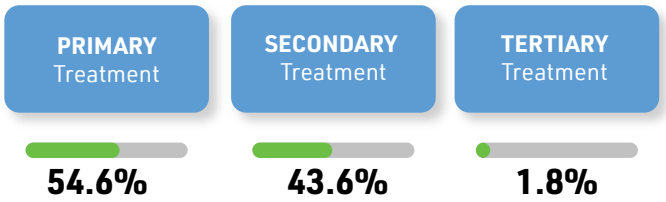


Figure 7-1: The percentage of wastewater treatment facilities in the Province

The geographical spread of these WWTPs is given in Figure 7-2.

Highest numbers of wastewater treatment plants were found in Faisalabad (28%) followed by Lahore (20%), Sheikhupura (08%), Kasur (06%), Gujranwala (04%) Okara (03%), Sahiwal (03%), Khanewal (03%), Muzaffargarh (03%) and Rahim Yar Khan (02%).The remaining districts have 1 to 8 WWTPs in numbers. The district-wise identified number of WWTPs is given in Figure 7-3.

KEY FINDINGS

- During survey in 2023, total 434 industrial WWTPs were identified in Punjab.
- Amongst these plants, primary, secondary and tertiary WWTPs are 54.6%, 43.6% and 1.8%, respectively.
- Highest numbers of WWTPs have been found in Faisalabad (28%) followed by Lahore (20%), Sheikhupura (08%), Kasur (06%), Gujranwala (04%), Okara (03%), Sahiwal (03%), Khanewal (03%), Muzaffargarh (03%) and Rahim Yar Khan. (02%).
- Highest number of WWTPs were found in the textile sector followed by sugar mills, leather, food, rice mills, chemical projects, oil and fats vegetable ghee, beverages, thermal power generation and pharmaceuticals.
- In most of the WWTPs, BOD_5 COD and Sulfide remained higher than the PEQS after treatment.
- Punjab's average MSW collection is poor and is 50% below the optimal level of 75%.
- Poor MSW management in Punjab results in soil, water and air pollution, negatively impacting its surrounding environment.
- Leachate from landfills exceeded prescribed limits for BOD_5, COD, and TSS, whereas air pollution near landfill sites surpassed limits for Suspended Particulate Matter and $PM_{2.5}$.
- Incinerators showed high levels of unburnt carbon and heavy metals (chromium, lead and copper) were detected in some ash samples.
- Solid waste disposal is rated as 'Poor'. However, waste recycling is rated as 'moderate'.
- Addressing Punjab's waste management crisis requires an integrated approach incorporating legal, technological, financial and community efforts.

1 https://www3.epa.gov/ttnchie1/ap42/ch04/final/c4s03.pdf

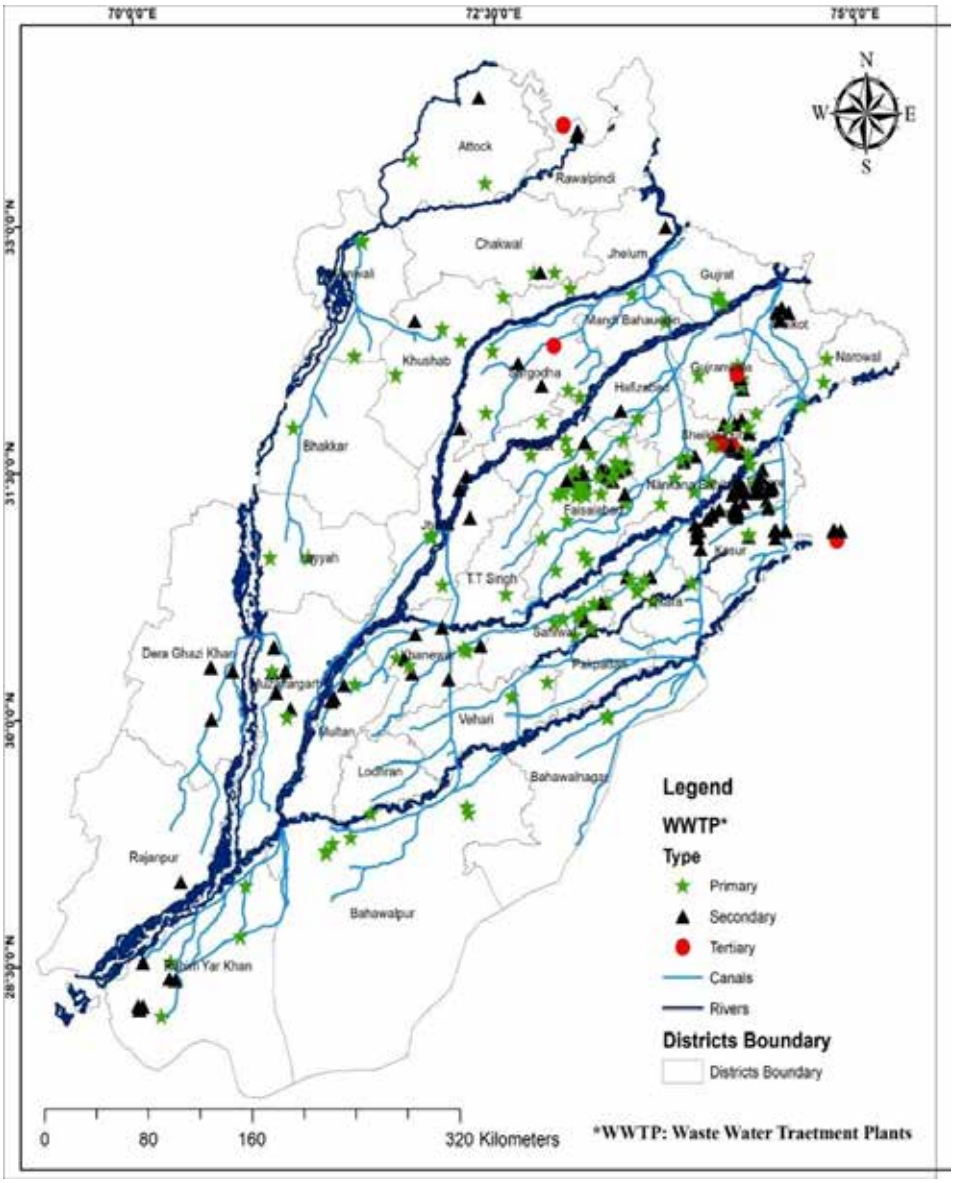


Figure 7-2: Geographical Spread of Wastewater Treatment Plants in Punjab

These WWTPs are installed in various industrial sectors i.e. textiles, sugar mills, food, rice mills, paints and dyes and cement plants etc. The highest number of WWTPs were found in the textile sector followed by sugar mills, leather, food, rice mills, chemical projects, oil and fats vegetable ghee, beverages, thermal power generation and pharmaceuticals. Industrial sector-wise distribution of WWTPs is given in Figure 7-4.

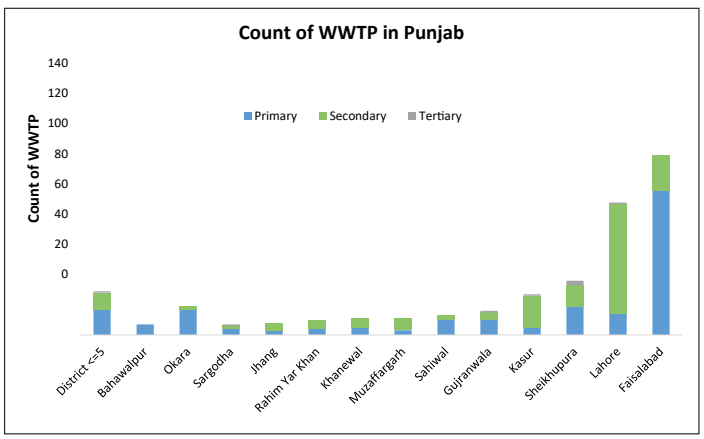


Figure 7-3: District-wise installation of WWTPs

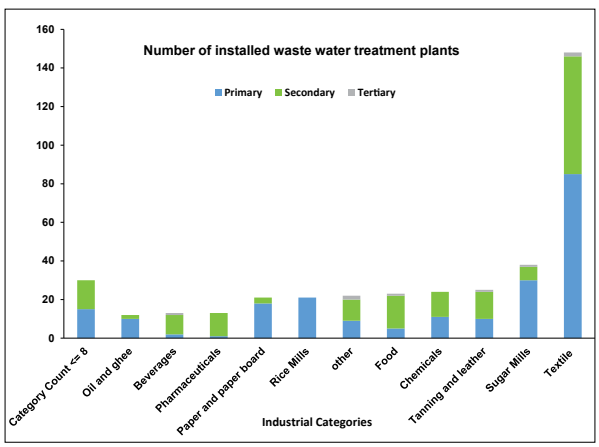


Figure 7-4: Industrial sector-wise distribution of WWTPs

2.1.1 Environmental Performance of Industrial WWTPs

In order to gauge the environmental performance of wastewater treatment plants, EPA Laboratories analysed liquid effluents before and after treatment, to evaluate the compliance of the PEQS for Municipal and Liquid Industrial Effluents, 2016[2]. The sample were analysed for temperature, pH, BOD_5, COD, Sulfate, Chloride, TSS and TDS.

The analysis of effluent of WWTPs installed at various sectors is as follows.

- **In Textile sector**, pH was already within the prescribed limits of PEQS. After the treatment, the average value of Sulfate was reduced within the PEQS limits. Whereas BOD_5 (520 mg/l), COD (719 mg/l), Sulfide (12.62 mg/l), Chloride (1094 mg/l), TDS (4849 mg/l) and TSS (220 mg/l) remained higher than the PEQS values even after treatment.
- **In Sugar Mills**, pH and Sulfate were already within the prescribed limits of PEQS. After the treatment, the average value of Chloride was reduced within the PEQS limits. Whereas BOD_5 (1094 mg/l), COD (1381 mg/l), Sulfide (5.0 mg/l), and TDS (3558 mg/l) and TSS (259 mg/l) remained higher than their PEQS values even after the treatment.
- **In Food Sector**, pH, Sulfide, Sulfate and Chloride. were already within the prescribed limits of PEQS. After the treatment, the average value of BOD_5, TSS and TDS were reduced within the PEQS limits. However, COD (383 mg/l) remained higher than their PEQS values even after the treatment.
- **In Rice Mills**, pH, Sulfate, Chloride, TSS and TDS were already within the prescribed limits of PEQS. After treatment the average value of Sulfide was reduced within PEQS limits.
- **In Others Sectors**, pH, Sulfate, Chloride, TSS and TDS were already within the prescribed limits of PEQS. However, BOD_5 (109 mg/l) and COD (235 mg/l) remained higher than their PEQS values even after the treatment.
- **In Paints and Dyes**, pH, Sulfate, Chloride and TDS were already within the prescribed limits of PEQS. The average value of TSS was reduced within the PEQS limits. However, BOD_5 (100 mg/l) and COD (227 mg/l) remained higher than their PEQS values even after the treatment.
- **In Cement Plants**, pH, Sulfate, Chloride and TDS were already within the prescribed limits of PEQS. However, Sulfide (2.4 mg/l) remained higher than the PEQS value even after the treatment.
- **In Pharmaceutical Plants**, pH, Sulfate, Chloride, TSS and TDS were already within the prescribed limits of PEQS. The average value of Sulfide (0.9 mg/l) was reduced within the PEQS limits after treatment.
- **In Waste-to-energy generation**, pH, Sulfate, Chloride and TDS were already within the prescribed limits of PEQS. However, COD (282 mg/l) and Sulfide (4.00 mg/l) remained higher than their PEQS values even after treatment.
- **In Thermal Power Generation**, pH, Sulfate, Chloride, TSS and TDS were already within the prescribed limits of PEQS. However, COD (158 mg/l) and Sulfide (4.00 mg/l) remained higher than their PEQS values even after the treatment.
- **In Beverages,** pH, Sulfate, Chloride and TSS were already within the prescribed limits of PEQS. After the treatment, the average values of Sulfide (0.8 mg/l) and TDS (1575 mg/l) were reduced within the PEQS limits.
- **In Tobacco Industries,** pH, BOD_5, Sulfate, Chloride and TDS were already within the prescribed limits of PEQS. The

2 https://epd.punjab.gov.pk/system/files/Punjab%20Environmental%20Quality%20Standards%20for%20Muncipal%20And%20Liquid%20Industrial%20Effluents%20final_0.pdf

average value of TSS (180 mg/l) was reduced within the PEQS limits after treatment, while COD (164 mg/l) remained higher than the PEQS value even after treatment.

- **In Engineering Industries,** pH Sulfate and Chloride were already within the prescribed limits of PEQS. Average value of TDS (3450 mg/l) was reduced within the PEQS limits after treatment. Whereas COD (192 mg/l) and Sulfide (4 mg/l) remained higher than the PEQS values even after the treatment.
- **In Petroleum Refineries**, pH, Sulfate, Chloride, and TDS were already within the prescribed limits of PEQS. However, COD (162 mg/l) and Sulfide (4 mg/l) remained higher than the PEQS values even after the treatment.
- **In Paper and Paperboard, Paper Pulping Industries,** pH, Sulfate and Chloride were already within the prescribed limits of PEQS. However, TSS (922 mg/l) and TDS (8800 mg/l) remained higher than their PEQS values even after the treatment.
- **The analysis of effluents**, before and after treatment shows that the wastewater was complying with the PEQS for tested parameters in Marble Sector, Manufacturing of Apparel including Dyeing and Printing sector. While in Chemical Projects only BOD and COD values exceeded the PEQS values that to fell under compliance limits after treatment.

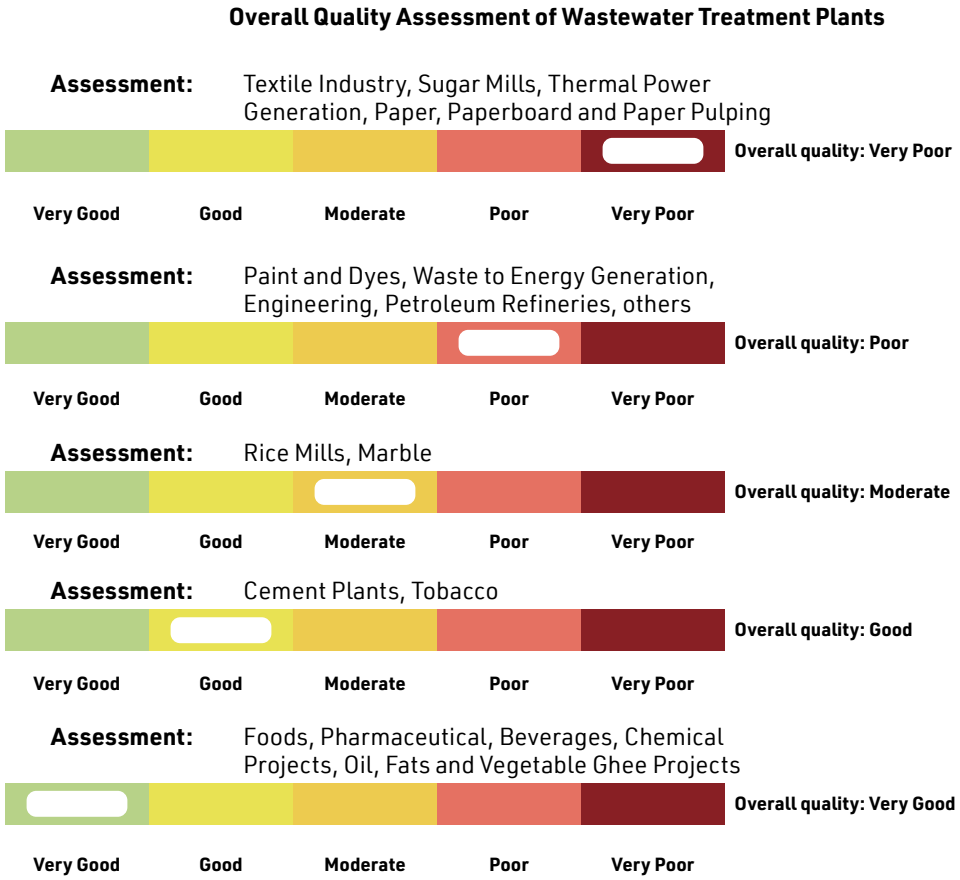
The average values of various parameters before and after wastewater treatment are given at Table 7-1.

Table 7-1: Average values of parameters before and after treatment in wastewater treatment plants.

Type of Industry	pH		BOD (mg/l)		COD (mg/l)		Sulfide (mg/l)		Sulfate (mg/l)		Chloride (mg/l)		TSS (mg/l)		TDS (mg/l)	
	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*
Textile	8.9	8.7	795	520	921	719	4.1	12.6	625	566	1289	1094	283	220	5363	4849
Sugar Mills	6.2	6.5	1958	1094	2732	1381	6.4	5.0	533	445	1172	927	344	259	4000	3558
Foods	8.3	7.9	198	50.5	610	383	0.8	0.8	430	333	603	474	209	124	3565	2960
Rice Mills	7.4	7.9	NA	N.A	381	355	1.1	1.1	495	484	600	579	166	146	2827	2708
Paint & Dyes	6.3	6.8	2566	100	5683	227	N.A	N.A	255	174	368	280	1957	140	2311	1387
Cement Plant	7.7	7.5	224	72	324	148	8.4	2.4	279	210	433	326	239	124	2331	1876
Pharmaceutical	7.3	7.1	229	61	517	132	1.1	0.9	168	135	198	158	160	30	1075	910
Waste to Energy generation	8.6	8.6	N.A	N.A	344	282	8.0	4.0	428	384	432	378	238	194	2842	2654
Thermal power generation	7.9	7.8	N.A	N.A	256	158	8.0	4.0	334	298	402	316	78	40	1908	14282
Beverages	7.5	7.2	172	64	172	130	4.2	0.8	312	198	175	45	110	50	3926	1575
Tobacco	7.2	7.2	368	54	940	164	N.A	N.A	168	134	100	175	1140	180	1080	1010
Engineering	6.7	7.1	N.A	N.A	274	192	8.0	4.0	416	342	342	358	298	256	3842	34500
Petroleum refineries	7.2	7.4	N.A	N.A	194	162	8.0	4.0	428	372	526	498	202	186	2608	1826
Paper, paperboard, and paper pulping	8.2	8.2	N.A	N.A	5980	5440	4.0	4.0	540	520	784	546	1040	922	8900	8800
Others	7.8	7.6	707	109	1381	2345	N.A	0.5	234	184	405	393	378	77	1721	1543
PEQs Values	**7-9**		80		150		1.0		1.0		1000		200		3500	

B* = Before treatment, A*= After treatment, N.A=Data not available, Green color=Within PEQs limits, Red color= Beyond PEQs limits

2.1.2 Overall Assessment of Industrial Wastewater Treatment Plants



2.2 Assessment of Environmental Performance of Solid Waste Management Facilities in Punjab

2.2.1 Municipal Solid Waste Management in Punjab

Generation

The physical composition of MSW in Punjab includes plastics, rubber, textile waste, paper, food, glass, leaves, grass, animal waste, demolition waste, ashes, and residues. The quantities of these components vary in the waste depending upon the source. Waste generation rates depend on the population, consumption level and lifestyles. Around 51 million people live in urban areas and 76 million in rural areas of Punjab[3]. The average waste production in Divisional HQs of the Punjab ranges from 115 tons/day (DG Khan) to 5,000 tons/day (Lahore), reflecting that the waste generation rates are higher in large metropolises.

Collection and Transport

A variety of vehicles are used for transporting or transferring solid waste collected from different collection points. The province's waste collection and transport equipment include open trucks, tractors/trolleys, arm roll containers/ trucks, handcarts, and animals carts for primary collection. Sweepers and sanitation workers collect MSW from outside the houses and small heaps using wheelbarrows. The waste is stored in formal and informal depots, and streets and roads are swept. Individuals usually keep recyclable materials such as paper, plastic, metals, and glass and sell them for recycling to waste dealers or street vendors. Scavengers collect mixed garbage, including recyclables, from various dumpsites.

Disposal

The waste collected by the workforce is dumped at designated dump sites in each district. However, these dumpsites are not the scientifically designed landfills. Each district has usually only the one designated dump site. The state of municipal solid waste management in the province is summarized in Table 7-2[4].

3 Population Census of Pakistan, 2023
4 Local Government and Community Development Department, Punjab (2023)

Table 7-2: Municipal Solid Waste Generation, Collection and Disposal in Punjab

Solid Waste Generation (tons/day)	Solid Waste Collection Rate (Tons/day)	Area of Each Dumping Site (Acres)	Quantity of Waste Dumped (Tons)		
			Daily	Monthly	Annually
LAHORE					
5500	5000	200	5,000	135,000	1,620,000
RAWALPINDI					
850	641	73	1229	37342	448101
FAISALABAD					
1600	1275	48	1275	36,975	443,700
GUJRANWALA					
1251.50	880	62.5	880	21,081	252,979
SARGODHA					
330	250	163	250	7500	91000
MULTAN					
1018	750	7	800	21015	275,466
BAHAWALPUR					
418	293	25	293	8778	106,945
DG KHAN					
260	220	37.5	220	6800	81600
SAHIWAL					
135	135	7	135	4050	49140

Environmental Issues

Open waste burning and dumping along roadsides, drains and canal banks is a common practice in the province, leading to air pollution and disease spread. Primary issues include improper waste disposal and inadequate waste collection. The release of pollutants and leachate from the landfill sites to the environment makes these facilities a significant health and environmental risk. The problem is exacerbated by inadequate transportation and collection systems.

2.2.2 Environmental Performance of Solid Waste Management Facilities

The environmental performance of SWMFs located in Punjab was assessed like the one carried out for SOE Report 2022. However, the study area was scaled up from the four districts i.e., Rawalpindi, Lahore, Faisalabad, and Multan in SOE Report 2022 to 09 Divisional HQs for SOE Report 2023. In the following section, city names have been abbreviated as: Lahore (LHR), Rawalpindi (RWP), Bahawalpur (BWP), Faisalabad (FSD), Multan (MN), Sargodha (SGD), Sahiwal (SHW), DG Khan (DGK), and Gujranwala (GJW). The following sections discuss the study's findings for both types of SWMFs i.e., landfill/open dumping sites and incineration facilities.

i. Landfills/Open Dumping Sites

A. Leachate

The parameters tested from the leachate of MSW landfill/dumping sites included the COD, BOD_5, TSS, Ammonia (NH_3), Arsenic (As), Cadmium (Cd), Arsenic (As), Zinc (Zn), and Iron (Fe). The results were compared with the PEQS for Municipal and Liquid Industrial Effluents (2016) pertaining to the non-availability of specific PEQS for leachate. Two leachate samples were collected from each of the selected (nine) landfill sites. All parameters were within acceptable limits except the COD, BOD_5, and TSS.

COD results have shown higher values than the PEQs standard (400 mg/l) in all the leachate samples. Excessive COD indicates high levels of organic pollution, which can lead to reduced oxygen levels in receiving water bodies, affecting aquatic life. BOD_5 values are also very high in all the leachate samples, with the highest in LHR. High BOD_5 levels suggest a high organic load, potentially from sewage or decaying matter. It also may reflect high levels of organic pollutants. All the leachate samples showed higher TSS values than the standard value, with the highest

value recorded in SGD. Results on leachate are shown in Figures 7-5.

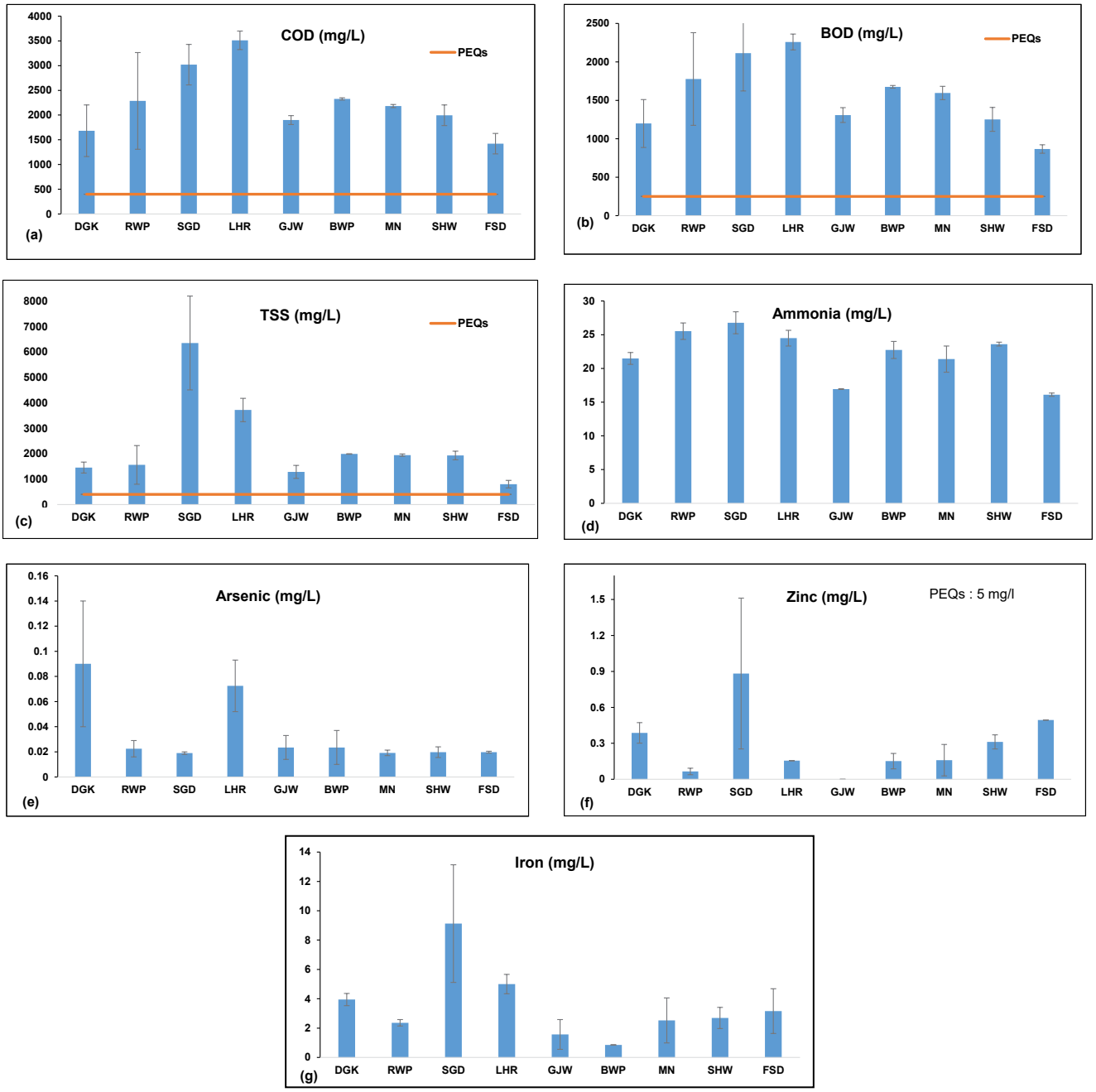


Figure 7-5: Leachate Analysis from Landfill Sites.

B. Soil

Soil from landfill sites was analysed for pH, Electrical Conductivity (EC), Cadmium (Cd), Arsenic (As), Lead (Pb), Zinc (Zn), and Iron (Fe). The results were compared with US International Standards of Soil Quality[5]. Cadmium was found below the detection level in all samples. All other parameter values were in compliance with the standards except pH. The highest pH value was observed from GRW sample. Electrical Conductivity (EC) values of the soil range from low to highly saline. Soil of landfill sites in MN was highly saline, as revealed by its highest EC value. The results of the tested parameters are shown in Figures 7-6.

5 Alloway, B.J. (1990) Heavy Metal in Soils. John Wiley and Sons, New York, NY, USA

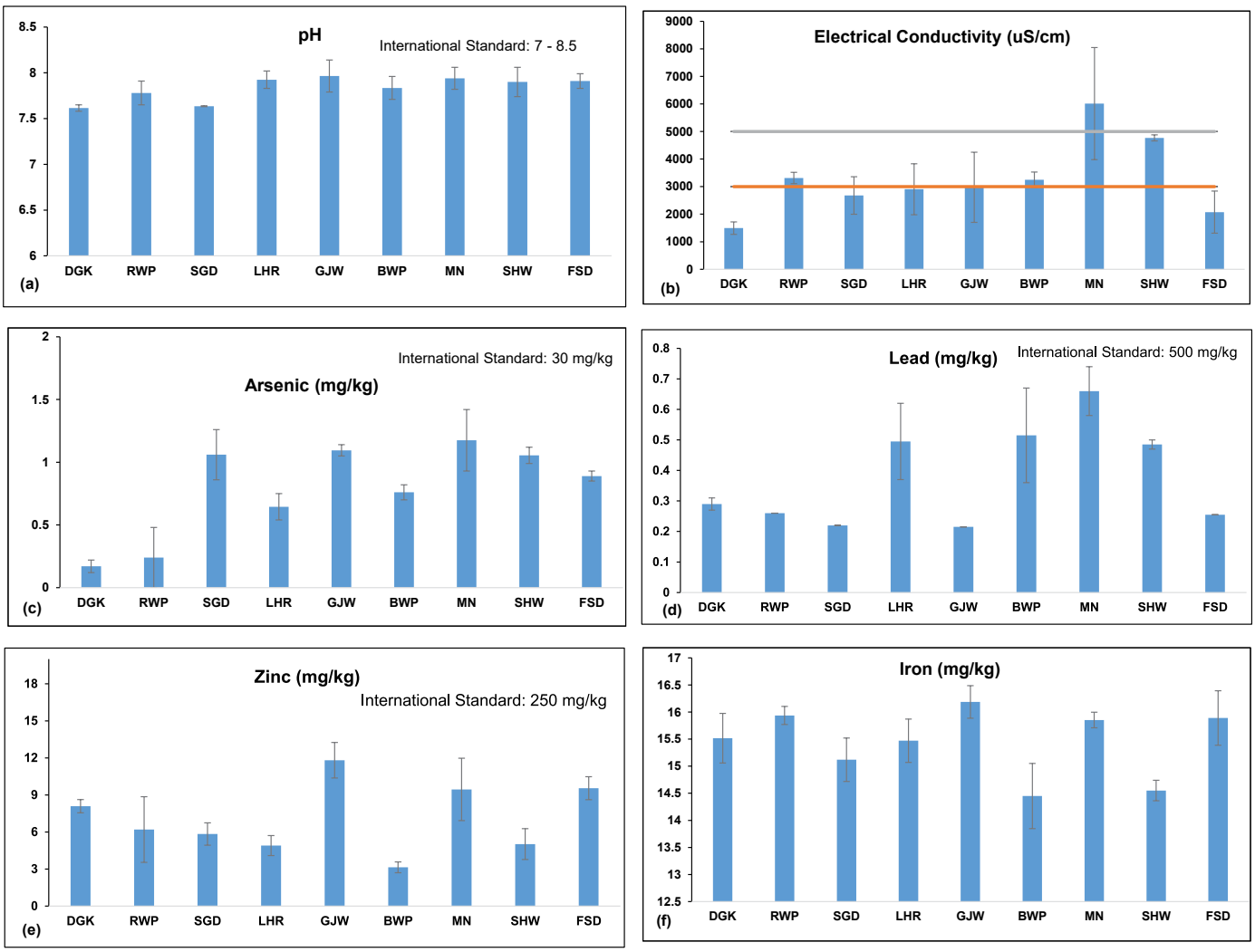
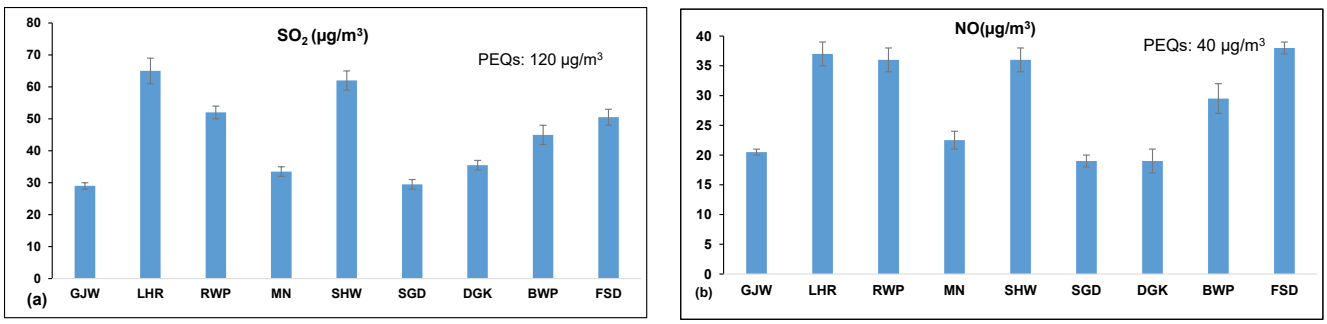


Figure 7-6: Soil Analysis from Landfill Sites

C. Ambient Air

Ambient air in the surrondings of landfill sites was analysed for SO_2, NO, NO_2, Ozone, SPM, PM_{10}, and $PM_{2.5}$. The results were compared with the PEQs for Ambient Air 2016. SO_2, NO, NO_2, and Ozone parameters were under the PEQs values, while the SPM, PM_{10}, and $PM_{2.5}$ exceeded standard values. Most sites have ozone levels within limits; however, RWP Site-I and LHR Site-II were approaching the standard limit. SPM levels exceeded standards in LHR, RWP, MN and SWL, indicating poor air quality. $PM_{2.5}$ levels were mostly within the standard range, though several sites were close to exceeding it. The results of ambient air monitoring are given in Figures 7-7.



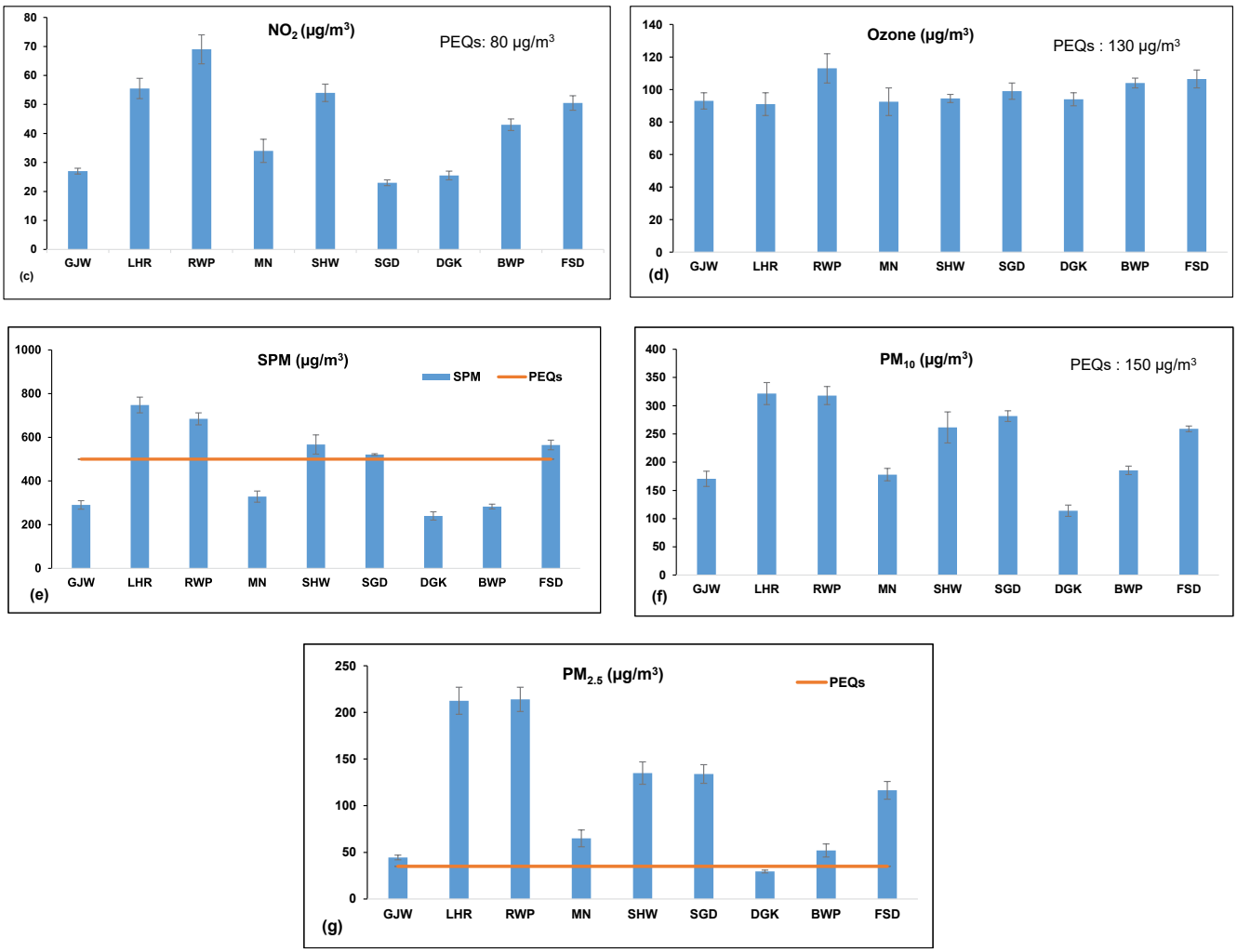
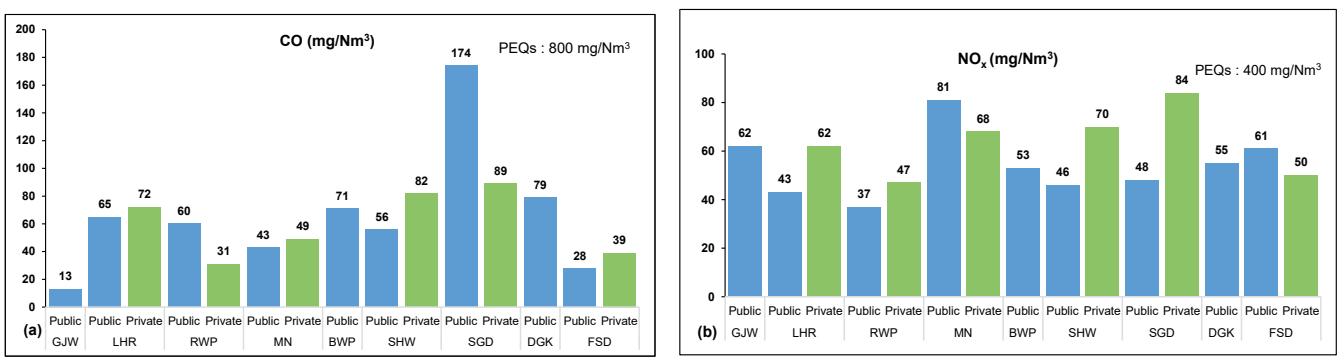


Figure 7-7: Ambient Air Analysis from Landfill Sites

ii. Incineration Facilities

A. Stack Emissions

Stack emissions were measured from various public and private incineration facilities. The parameters assessed included CO, NO_x, NO_2, NO, SO_2, HCl, and particulate matter. The results indicate that emissions for all measured pollutants were within the permissible limits set by the PEQS. This compliance is indicative of effective pollution control measures in place at these incineration sites. The results of stack emissions are shown in Figures 7-8.



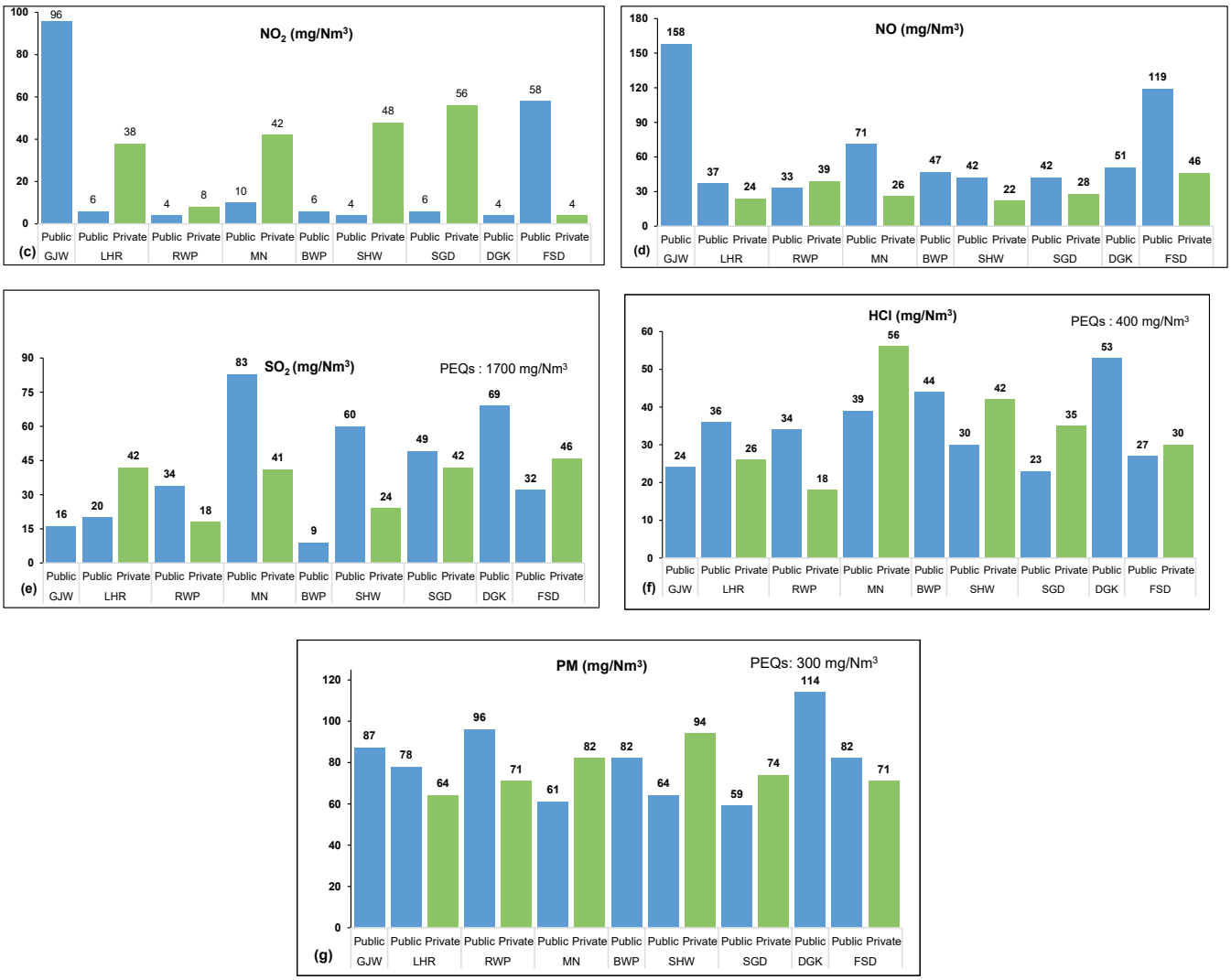
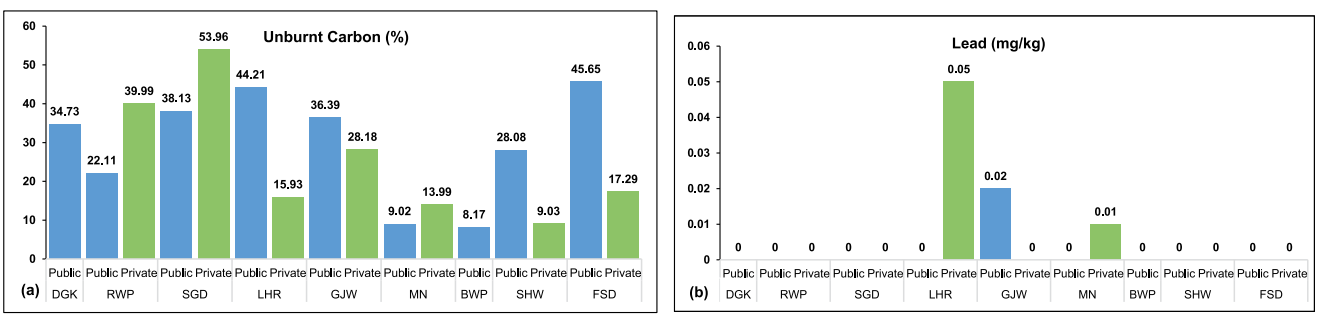


Figure 7-8: Stack Emissions Analysis from Incinerators

B. Ash Analysis

Ash was also analysed from incinerators to test the levels of unburnt carbon, chromium, lead, copper and microbial contamination. It is noteworthy that there are no such PEQs standards for ash analysis, so the results could not be compared with any limit. A high percentage of unburnt carbon showed incomplete combustion. Only three samples showed lead concentration, while others were below the detection level. Private incinerators from Gujranwala and Sahiwal showed some chromium content. Private incinerators from Rawalpindi and Faisalabad have shown copper concentration. The results of the ash analysis are given in Figures 7-9.



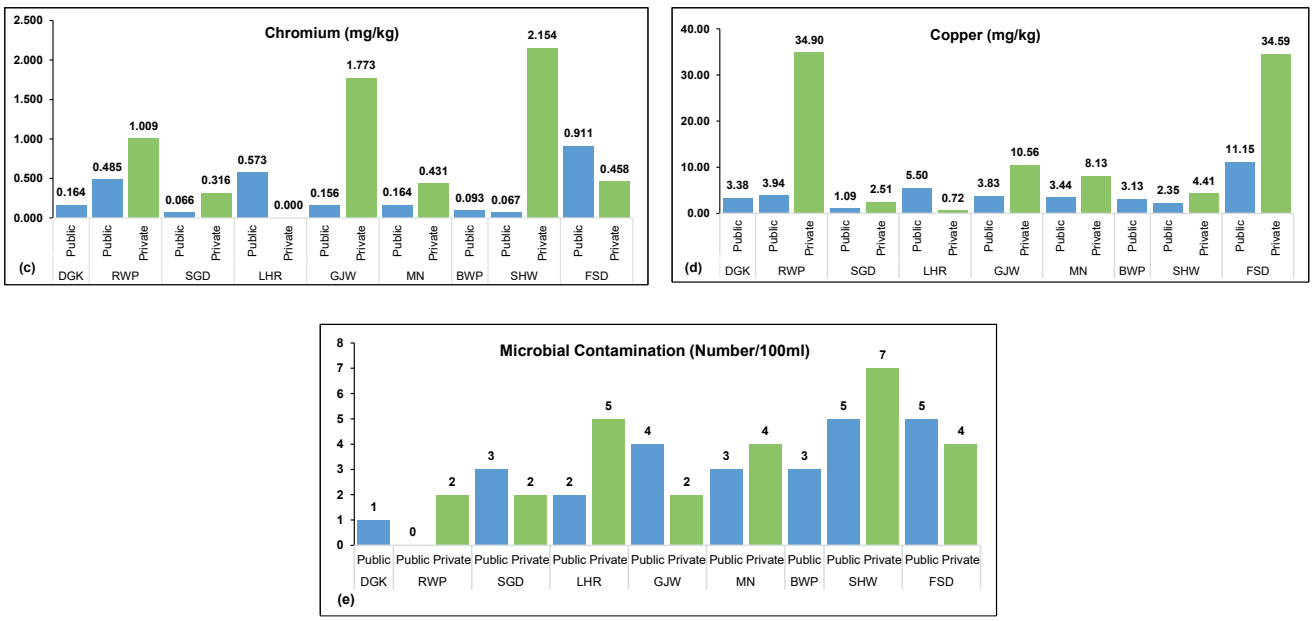


Figure 7-9: Ash Analysis from Incinerators

2.2.3 Overall Assessment

Overall Quality Assessment of Solid Waste Management Facilities

Assessment: Overall Solid Waste Management System

Overall quality: Poor

Very Good | Good | Moderate | Poor | Very Poor

Assessment: Waste Collection

Overall quality: Poor

Very Good | Good | Moderate | Poor | Very Poor

Assessment: Waste Disposal

Overall quality: Poor

Very Good | Good | Moderate | Poor | Very Poor

3. MANAGEMENT

Addressing the issues of SWM in Punjab requires a comprehensive and interdisciplinary approach. Therefore, legal, and institutional implementation, with environmental, technological, and economic methodologies, are required to establish an appropriate SWM system for Punjab. Additionally, a social and policy approach is imperative to increase public awareness regarding SWM in Punjab. Residents' active participation and understanding of the importance of proper waste treatment are fundamental for the success of SWM.

3.1 DPSIR Framework

DPSIR framework of wastewater and solid waste facilities is as follows (Figure 7-10):

Drivers

a. Punjab is witnessing a rapid population growth, urban expansion and industrialization that greatly strains its waste management systems (both solid and waste water), placing further demands upon waste removal and advanced solid waste management techniques.

b. Resource deficiencies hinder effective waste management methods.

c. Lack of public awareness is also considered a driver in the waste management.

Pressures

a. Greater volumes of industrial effluents produced.

b. With an increasing population, utilities and waste production usage have also increased.

c. Limited waste collection, segregation and treatment infrastructure.

State

a. The environmental assessment conducted across nine Divisional HQs in Punjab revealed varying results. Landfill

soil samples showed generally uniform concentrations of pH, cadmium, arsenic, lead zinc and iron across sites, while electrical conductivity readings suggested variations in salinity levels that were particularly prevalent at the Multan landfill site. Leachate analysis revealed significantly higher COD, BOD_5, and TSS, exceeding permissible limits, suggesting significant organic pollution.

b. Ambient air quality assessments and incineration facility emissions showed mixed results. Air quality near landfills revealed elevated levels of suspended particulate matter (SPM), PM_{10}, and $PM_{2.5}$ particles that may pose risks to respiratory and cardiovascular health even while other pollutants like SO_2, NO, and NO_2 remain within safe limits.

c. Stack emissions from incinerators fell within permitted levels, indicating effective pollution control measures in place.

d. Findings of unburnt carbon and heavy metals suggest room for improving combustion efficiency in private incinerators.

e. The overall state of solid waste management cannot be regarded as upto the mark, underscoring the necessity for ongoing oversight and improvement within waste management practices.

Impacts

a. Improper liquid solid waste management has severe consequences that affect human health, the environment, and socio-economic factors.

b. Poor waste management can lead to increased burden of related diseases and epidemics.

c. Environmental implications of inadequate solid waste management include air, soil, and water quality degradation.

d. Sociological concerns involve increased vector breeding sites, impaired aesthetics and odor issues.

Response

e. To improve waste management practices, it is important to strengthen institutional frameworks. The establishment of a provincial authority/entity is imperative for overall supervision of solid waste management in the province.

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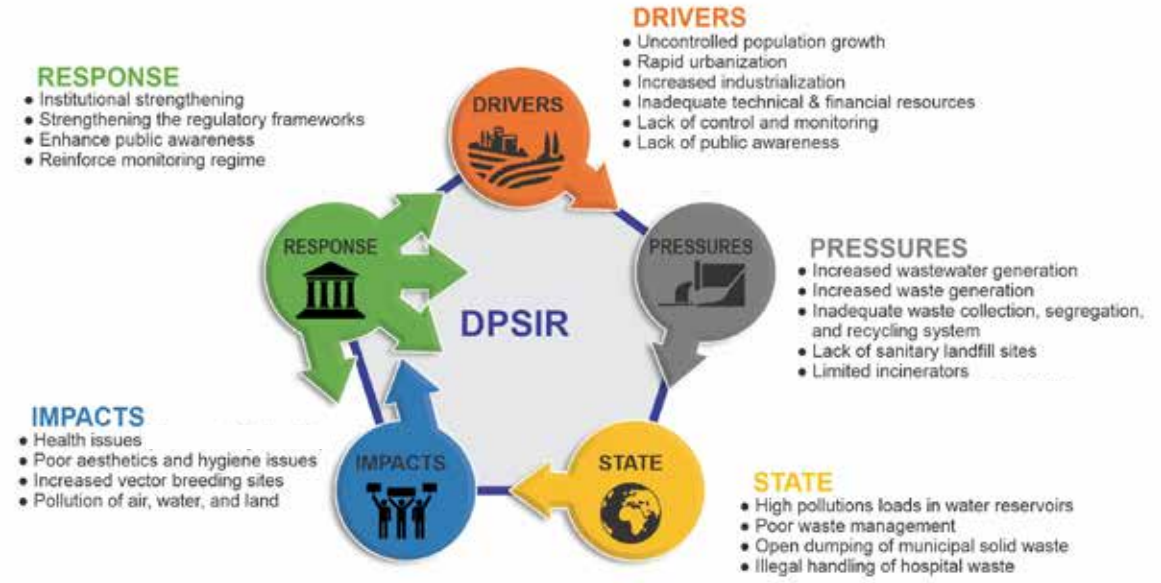


Figure 7-10: DPSIR Framework for solid waste management and wastewater treatment in Punjab

4. Way Forward

There is need to upgrade the treatment efficiency of each plant in terms of non-compliance parameters of PEQS. Every industry should take lead in installation of state-of-the-art WWTPs that are latest in technology and latest in development cycle. In order to monitor the efficiency and environmental performance of each WWTP, there is a dire need to establish a monitoring dashboard having direct access to the quality being discharged from WWTP into the environment. There is need to adopt recycling practices that significantly decrease the volume of landfill-bound waste. Furthermore, the public should be made aware about the importance of waste management. Establishing sanitary landfills to meet international standards and minimize pollution risks and public health threats is of utmost significance to improve solid waste management in the province. In addition, a comprehensive legal framework that standardize waste management practices is also required for effective waste management.

The best pollution control is prevention:
let's act today to safeguard tomorrow.

8 MEASURES TAKEN TO CONTROL POLLUTION AND IMPROVE ENVIRONMENTAL QUALITY

8. Measures Taken

1. Overview of the Department's 'Response' to the 'State' of the Environment

EPD Punjab has made significant progress in improving its environmental protection and pollution control functions in the year 2023. The department has advanced through institutional, regulatory and policy reforms, capacity building initiatives, research and development, environmental and social safeguards and awareness activities in addition to its regular operations. An overview of the Department's 'Response' to the 'State' of the environment in Punjab is shown in Figure 8-1 and details are provided in the proceeding sections.

Figure 8-1: Measures taken to control environmental pollution by EPCCD during 2023

KEY FINDINGS

- Environment Protection Department has been renamed as Environment Protection and Climate Change Department.
- Remarkable advancement for the establishment of divisional environmental complexes was made during 2023.
- EPCCD Punjab is developing a 'green building' for its offices. The building will be certified in compliance with the LEED Gold Standard.
- Nine additional AQMS are going to be installed in Lahore and 21 AQMS will be installed in other districts
- Policy reforms (being notified/approved/revised) include Punjab Clean Air Policy-2023; Smog Prevention and Control Rules, 2023; Plastic Management Strategy; Punjab Environmental Protection (Production and Consumption of Single Use Plastic Product) Regulations, 2023; Revision of Existing PEQS and Development of Industry-specific EQS.
- Anti-smog actions taken in 2023 included, constitution of special smog prevention squads, powers delegation under Smog Prevention and Control Rules-2023, launch of Android Application, Complaint Line and challaning of vehicles, water sprinkling/mechanical sweeping, registration of FIRs for stubble burning etc.

1.1 Institutional Reforms

1.1.1 Enhancing the Sectoral Regime

EPD Punjab is improving its sectoral regime, by incorporating climate change into its business regulations. The department is now known as the Environment Protection and Climate Change Department (EPCCD).

1.1.2 Divisional Environmental Complexes

Currently, all of the regional labs and EPA field offices are located on the campuses of other government agencies or in rented facilities. Under the approved EPCCD restructuring plan, remarkable advancement for the establishment of environmental complexes at divisional level was made during 2023. Three important offices will be housed in the DECs:

i. Office of Divisional Director (Environment)

ii. Office of Deputy Director (Environment)/District Head

iii. Office of Deputy Director (Labs)/EPA regional Lab

During 2023, the construction work for the establishment was commenced in 07 districts. Construction of these complexes would improve the province's environmental governance by streamlining the environmental approvals process thus promptly and effectively enforcing PEPA.

1.1.3 Green Building

EPCCD Punjab is developing a multistory office building (Figure 8-2) to house its secretariat and HQs of its

Figure 8-2: Planned view of the EPCCD green building (artistic impression)

allied agencies. It would be a 'green building'[1] to be certified in compliance with the USGBC[2] LEED[3] Gold Standard. As such, this initiative is intended to ensure a minimum negative impact on the environment during construction and subsequent operations. A seminal endeavor in Punjab, the EPCCD Green Building would be the first-of-its-kind office building in the public sector. Its development will entail ensuring sustainable site development, water savings, energy efficiency, green complying material selection, and enhanced indoor environmental quality.

The development of the building was approved by the Provincial Development Working Party. The Infrastructure Development Authority of the Punjab has been commissioned for the design and construction of the building infrastructure. It is expected to be completed and handed over to EPCCD by the end of March 2026.

1.1.4 Establishment of Punjab Environment and Climate Change Endowment Fund

Punjab has created an Environment Endowment Fund as a long-term source of support for environmental initiatives, studies and activities as stated in SOE Report 2022. Operationalizing EEF is a priority for the Punjab government.

With the intention of achieving this goal, the Punjab Sustainable Development Funds (PSDF) Board has recommended decided to incorporate a Section 42 company in Securities and Exchange Commission of Pakistan, subject to the approval by the Cabinet. It will turn into a steady source of funding for green and environmental initiatives that are put forth by the public and commercial sectors, as well as civil society to pilot and showcase environmentally beneficial projects.

The government has also named this fund as Punjab Environmental and Climate Change Endowment Fund (PECCEF). Besides environmental projects, this fund will also consider projects related to climate mitigation and resilience.

1.1.5 Automation Regime of EPCCD

The implementation of the project 'Automation Regime of EPCCD Punjab" is being geared up. PITB has been mobilized for development of six components: E-Environmental Approvals, E-Enforcement, E-Laboratories, E-Industrial mapping, E-Monitoring System and E-Information Sharing. Procurements of hardware has also been initiated.

1.2 Policy Reforms

1.2.1 Punjab Clean Air Policy-2023

Government of the Punjab approved and notified the Punjab Clean Air Policy along with phased Action Plan in April 2023, in line with fundamental rights under Constitution of Pakistan (1973), UN Sustainable Development Goals, Clean and green Pakistan movement and Nationally Determined Contributions, 2021. The goal of the policy is to maintain clean air in the province by reducing emissions and promoting sustainable development that will increase access to a more livable environment. The policy is equipped with a phased action plan with defined roles and responsibilities of all relevant sectors.

The policy has strengthened and enhanced the existing regulatory and inspection regime of air pollution control in the province. The relevant departments have initiated the implementation of the policy and action plan in their respective jurisdictions.

1 Green or Sustainable Building is a structure that uses processes that are environmentally responsible and resource-efficient throughout the building's life cycle (siting, design, construction, operations, maintenance and demolishing).
2 United States Green Building Council
3 Leadership in Energy and Environmental Design

1.2.2 Smog Prevention and Control Rules-2023

Government of the Punjab notified the Punjab Environmental Protection (Prevention and Control of Smog) on June 7, 2023, which provide standard operating requirements for brick kilns, industrial units, resource recovery units and pyrolysis plants to ensure prevention of air pollution contribution by these units. The rules further restrict the stubble burning and open waste burning in the province.

1.2.3 Plastic Management Strategy

The Punjab Environmental Protection Council constituted under the PEPA has approved the Plastic Management Strategy, framed under DLI-4 of PGDP, in 2023. The strategy is based on 5 pillars and 22 targets. A three-phase Action Plan up to 2030 is proposed for implementation of the strategy. Pillars of strategy include the; (i) Induction of Plastics Regulatory Regime (ii) Technological Innovation and Recycling Infrastructure (iii) Economic Incentives and Levies (iv) Institutional Capacity Building, and (v) Citizens Engagement and Awareness. The strategy proposes establishment of "Provincial Steering Committee" under the Chairmanship of Chief Secretary, establishment of a plastic management cell, compulsory registration, setting-up of a plastic management information system, mandatory Extended Producers Responsibility and awareness.

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

In addition to the Plastic Management Strategy, the government of Punjab has regularized the production and consumption of single use plastics by notifying regulations thereon in June-2023. The regulations are applicable to the single-use plastic producers, consumers, collectors and recyclers. The regulations ban the production and consumption of certain single-use plastic products such as plastic cotton bud sticks, plastic balloon sticks, plastic sticks of flags, disposable plastic cutlery, etc.

1.2.5 Revision of Existing Punjab Environmental Quality Standards (PEQS) and Development of Industry-Specific Environmental Quality Standards (EQS)

EPCCD is executing an ADP scheme titled "Development of Missing Environmental Quality Standards (EQSs) & Revision of Existing Environmental Quality Standards for Punjab".

The project was divided into two components i.e. Component-A for Development of Missing Environmental Quality Standards and Revision of Existing Standards for Punjab and Component-B for Development of Industry Specific Punjab Environmental Quality Standards for sixteen industrial sectors

A Panel of Experts including experts/specialist from relevant departments and organizations (academia, PCSIR and PCRWR) was designated to review the draft PEQS and give recommendations thereof. In addition to the series of meetings of panel of Experts, eight consultative sessions with stakeholders from relevant industries, chambers of commerce, government departments, NGOs and academia were conducted to seek their opinion/feedback on the draft PEQS. In the light of feedback received during stakeholder consultative sessions and recommendations by the Panel of Experts, the final reports draft has been updated accordingly.

1.2.6 Punjab Climate Change Policy

Draft Punjab Climate Change Policy has been matured up to the stage that a panel of experts, comprising members from United Nations entities, GIZ Pakistan and senior academics have endorsed the document. The policy has been drafted with a thorough consultation and contributions from concerned stakeholders from government sector. Four working groups, comprising 25 government departments were constituted to finalize the policy document.

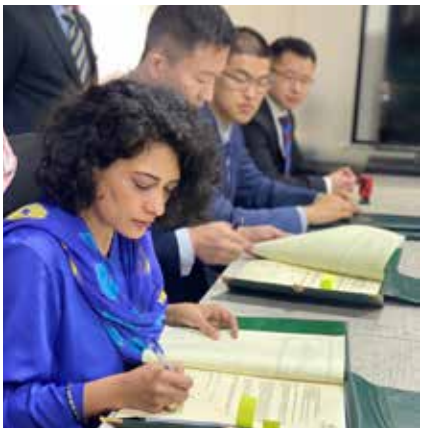
A consultative session to finalize the draft policy, after its review from gender perspective, was also organized in last quarter of CY 2023, in the follow – up of which, the policy draft was revised to make it gender – inclusive and gender – responsive.

1.3 Environmental Monitoring

The department is underway of expanding and strengthening its one of the most important areas of jurisdiction, i.e. environmental monitoring. DLI-2 of the PGDP is particularly focused on the enhanced environmental monitoring regime of EPCCD Punjab. Updated progress on certain initiatives related to environmental monitoring are:

1.3.1 Air and Water Quality Monitoring Stations

Under DLI-2, thirty AQMS are being installed in ten districts of the Punjab including eight in Lahore district. Twenty-five of these will be fixed, while five will be mobile AQMS that can be moved anywhere in the province on need basis. SP&IU, and Norico International (Pakistan Branch) has inked a deal for procurement of AQMS in October 2023.



Furthermore, work has been awarded to international consulting firms for installation of 15 Water Quality Monitoring Stations at the major water bodies in Punjab. Priority has been given to surface waters (rivers, canals, drains and lakes) for installation of stations for collection of real-time data on water quality.

1.3.2 Industrial Inspections

Under the PGDP (DLI 1), EPA has actively conducted more than 2,000 inspections for industrial effluents and 250 inspections for stack emissions. Throughout 2023, the EPA, has successfully completed half of these inspections, comprising 1000 checks for industrial effluents and 125 assessments for stack emissions. These milestones have been meticulously recorded, emphasizing the commitment and thoroughness demonstrated during these inspections.

1.4 Technology Transfer

1.4.1 Combined Effluent Treatment Plant (CETP)

Sialkot located in north-east Punjab along the Indus basin is one of Pakistan's most important industrial cities with export-oriented economy. There are over 250 tanneries located in 10 different clusters scattered in and all-around Sialkot city. These tanneries produce large volumes of waste water and lack proper wastewater treatment facilities which is considered to be a major threat to ground and surface water especially during floods.

Recognizing the importance of the issue, it was planned to shift the tanneries at a dedicated standard tannery zone away from the main city, having a Combined Effluent Treatment Plant with a capacity of 12000 m^3/day. Initially 1st Module (Phase-I) of CETP for the treatment of 4000 m^3/day of tannery effluent will be constructed.

1.4.2 Devising Solution for Solid Waste Management of Leather Sector in Sialkot Tannery Zone

UNIDO is implementing a Global Environment Facility project titled "Mainstreaming Climate Change Adaptation through Water Resource Management in Leather Industrial Zone Development" in Sialkot to control environmental hazards from the tanning industry and improve climate change adaptation. The project aims to centralize tanneries, providing facilities like common effluent treatment plants and flood management.

STZ, in collaboration with UNIDO and WWF Pakistan, is developing the Sialkot Tannery Zone to create an international standard tannery zone in Sialkot. They are specifically working on "Devising Solutions for Solid Waste Management of Leather Sector in Sialkot Tannery Zone".

1.4.3 Safe Disposal of Mercury from Compact Fluorescent Lamps (CFLs)

For disposal of lights and bulbs being replaced by the energy efficient appliances under DLI-5 of PGDP, a CFL machine has been procured by the Energy Department and housed at CERAD Lab, UET Kala Shah Kaku campus during 2023. Purpose of the machine is to safely extract the mercury from CFLs using mercury absorption filters. Subject filters are to be disposed of in an environment friendly manner under expert supervision.

1.4.4 Pilot Project for Low-Cost Wastewater Treatment Plants

EPCCD is also underway to pilot low-cost wastewater treatment technologies particularly for municipal wastewater generated from housing societies and rural communities. For this purpose, the department has engaged NESPAK to provide detailed design and engineering estimation for the construction of low-cost WWTPs that will use natural wastewater treatment technology and have low CO_2 footprint.

1.5 Public Communication Campaign on Single-use plastics

A comprehensive Public Communication Campaign was executed throughout November and December 2023 across the province of Punjab under DLI-4 of PGDP. The primary goal of the campaign was to heighten public awareness regarding

the negative environmental and health impacts of single-use plastics.

The campaign utilized a diverse array of media tools, messaging strategies, and a well-organized set of communication activities. Various channels, such as seminars, awareness sessions in schools, outdoor campaigns, print/electronic/social media advertisements, and bulk SMS, were employed to effectively convey the message.

Moreover, non-governmental organizations played a crucial role through active engagement with plastic producers, chambers of commerce, large retailers, civil society organizations, primary and secondary schools, and the media.

An upcycling event was organized by the SP&IU at the Punjab Institute of Language, Art & Culture. The event actively engaged children in transforming waste plastic products into practical and useful items.

SP&IU also conducted a Short Video Competition to combat the harmful effects of Single-Use Plastics. Over 35 talented student entries were received from across the Punjab, spreading awareness message to over 20,000 people on social media. These incredible short films captivated audiences at the National History Museum Cinema Hall during the award ceremony.

1.6 Capacity Building

Under PGDP, SP&IU intends to strengthen and enhance institutional capacities of implementing government departments and other entities in the Punjab regarding socio-environmental safeguard instruments through introduction of a concrete capacity building program. This capacity building program will generally focus on Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) and Environmental and Social Impact Assessment (ESIA) vis-á-vis Environment and Social Systems Assessment (ESSA) of PGDP. It will also cover environmental and social considerations in project management, planning, monitoring and decision-making in line with best international practices.

1.7 Regular Operations

1.7.1 Environmental Approvals

EPA Punjab is regulating the industrial and development projects under Section 12 of the PEPA. During 2023, IEEs and EIAs were approved by EPA Punjab for the projects located in major districts of the Province.

1.7.2 Anti-Smog Campaign, 2023

Anti-smog campaign, 2023 was launched well-before the onset of critical air pollution episodes, as a preemptive measure for pollution control. Following activities were carried out during the campaign:

i. Constitution of special smog prevention squads

Special anti-smog squads were notified in May, 2023 in major districts of Punjab, including Lahore, Gujranwala, Faisalabad, Multan, Rawalpindi, Sheikhupura and Sialkot. In Lahore, the squads stayed active 24/7 with day and night shifts. The squads were assigned with the duty of enforcement activities i.e., inspections, inquiries, investigations and personal hearings under the PEPA, against any activity that may contribute in smog formation and subsequent adverse environmental effects. The squads were facilitated by the online dashboard and android app namely 'EcoWatch' developed in assistance with PITB, where they could upload the geo-tagged monitoring data of industrial units inspected, while the control room monitored and tracked the movement of squads.

ii. Powers delegation under Smog Prevention and Control Rules, 2023

The in-charge officers of anti-smog squads of major districts were authorized to exercise the powers conferred under the said rules for their effective implementation and enforcement in Punjab. The squads were to perform their duties in close coordination with Punjab Police and EPA Field offices.

iii. Android Application and Complaint Line

The WhatsApp complaint number and dashboard launched for receiving complaints on the pollution sources from all over the province remained active throughout the year and received complaints from different districts. Details are provided in Chapter 9.

iv. Anti-smog actions taken by stakeholder departments

EPCCD, through its control room, coordinated with other stakeholder departments for actions taken by them to control anti-smog activities (Figure 8-3).

1.7.3 Enforcement Activities

While exercising the powers vested under Section 16 of the PEPA, EPA carried out enforcement activities throughout Punjab and initiated legal actions against air polluting industries, including the steel re-rolling mills, stone crushers and BTK brick kilns (Figure 8-4).

During these inspections, a fine of PKR 467 million was imposed to the units violating the PEQS, whereas, 5970 air polluting industrial sources were sealed by the anti-smog squads of EPA. Enforcement actions were also taken against the smoke emitting vehicles (Figure 8-5). A glimpse on inspections carried out by EPA Punjab is depicted in Figure 8-6.

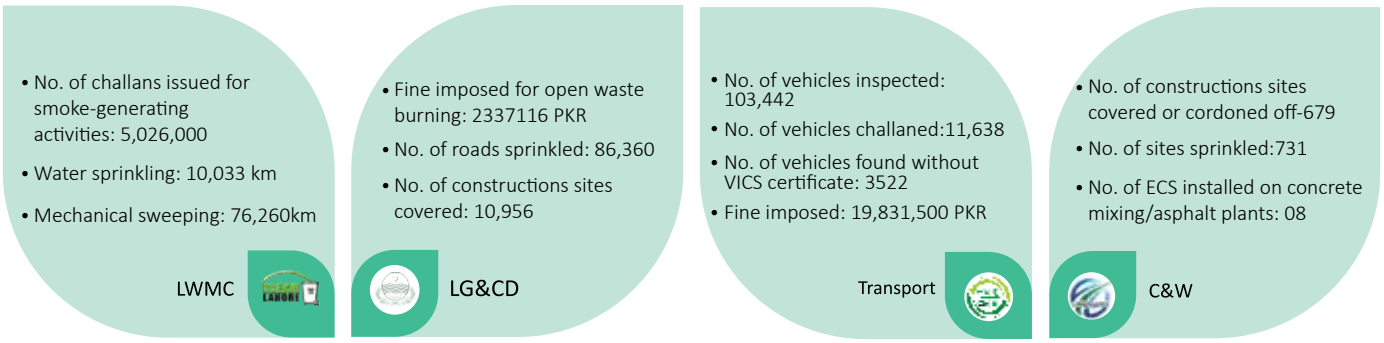


Figure 8-3: Anti-smog activities by other departments reported to EPCCD Control Room

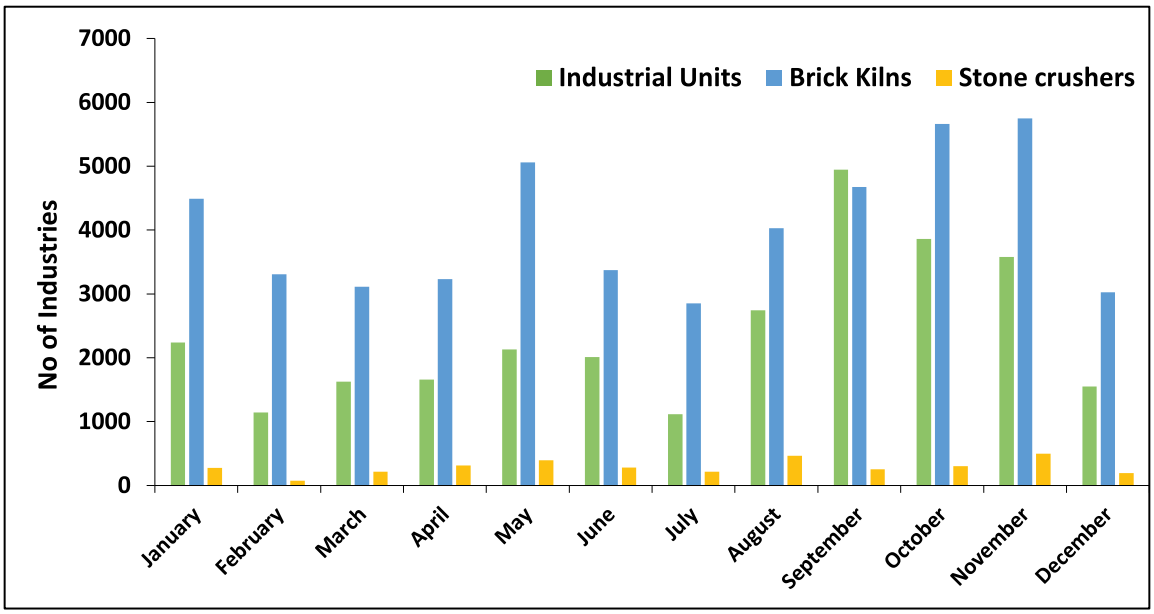


Figure 8-4: Inspections of polluting industries during 2023

By EPCCD		EPCCD with City Traffic Police		
No. of Vehicles Inspected	No. of Smoke Emitting Vehicles	Fine Imposed (PKR)	Vehicles Impounded	FIRs Lodged
211,467	**107,725**	**48 million**	**9,694**	**62**

Figure 8-5: Actions taken against smoke - emitting vehicles during 2023

In addition to the actions taken to control air pollution, other environmental issues including the water pollution were also addressed by EPA. During CY 2023, more than 3500 notices were issued to the water polluting industrial units. Additionally, in response to directives from EPA Punjab, over 300 air pollution control devices were installed in various industrial units. In order to ensure the compliance of Section 13 of the PEPA, EPA is also regularly reviewing the cases of import of waste/scrap by the recycling units located in Punjab.

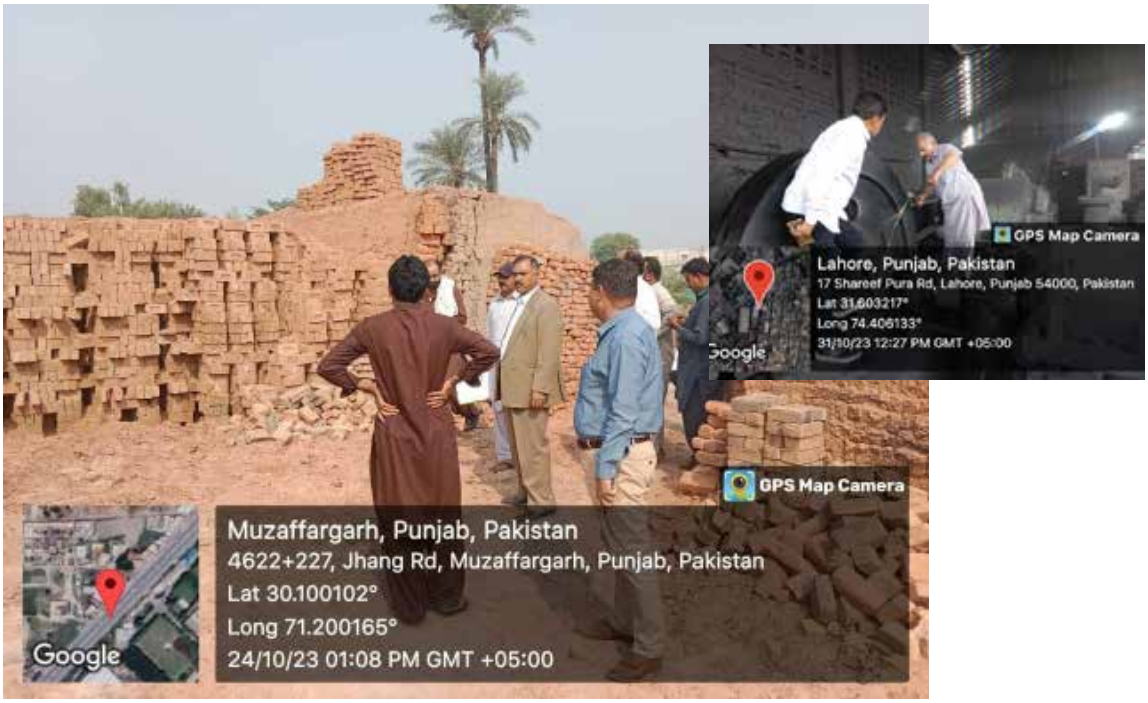


Figure 8-6: Environmental inspections in different industrial sectors of Punjab during (2023)

Dengue vector surveillance

The department is engaged in dengue vector surveillance at five designated areas (including the under-construction sites, petrol pumps, CNG Stations, Service Stations). In 2023, following activities were carried out during annual anti-dengue campaign:

d. Nomination of Dengue Squads
e. Setting the dengue visit targets and inventories of assigned areas
f. Preparation of Visit Micro-Plans
g. Android sets registration
h. Distribution of Anti-Dengue Surveillance Kits
i. Refresher Training course

The sources of mosquito breeding were removed to avoid dengue virus incubation. The detailed progress on dengue vector surveillance during 2023 is given in Figures 8-7 and 8-8.

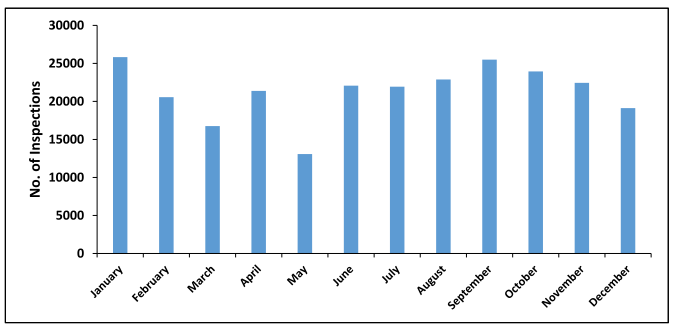


Figure 8-7: Number of Inspections for Dengue Surveillance during 2023

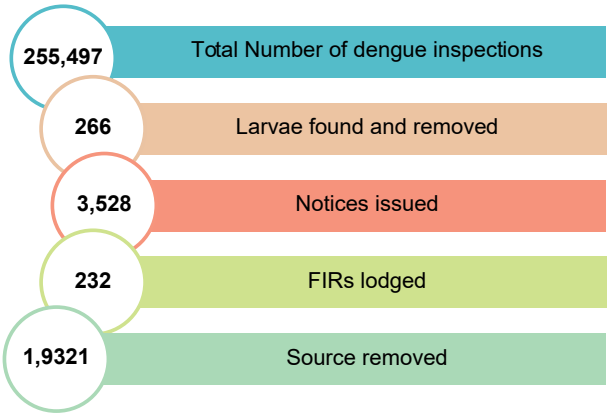


Figure 8-8: Progress of Anti-Dengue Campaign, 2023

In addition to surveillance activities, awareness raising on dengue virus and disease was also conducted during 2023 in all districts of Punjab, where 23,162 various kinds of awareness materials were distributed among general public throughout the province.

Figure 8-9: Dengue awareness activities during 2023

1.1.1 Hospital Waste Management

EPA stepped into an advanced level of hospital waste management during 2023. Special round-the-year campaign was initiated in January 2023 to control the illegal handling and pilferage of hospital waste. 1334 junkyards were inspected (Figure 8-10), hospital waste was confiscated by EPA Punjab, sealing 35 units engaged in illegal handling and storage of hospital waste.

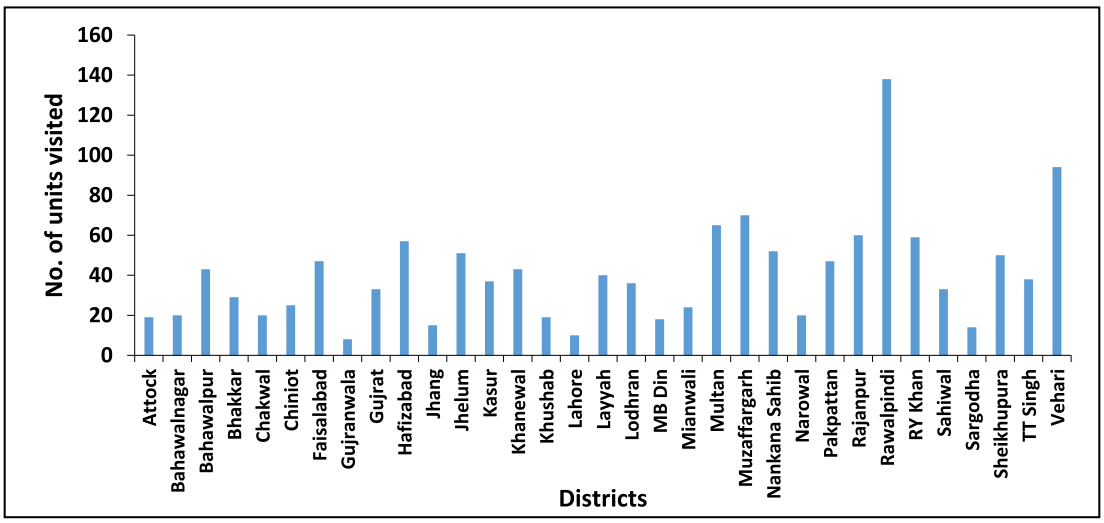


Figure 8-10: Inspections of junkyards to control the illegal handling and pilferage of Hospital Waste

A special dashboard, connected to an android application was developed to facilitate the field formation of EPA to upload their activities against the violators of Punjab Hospital Waste Management Rules, 2014. A total of 3250 hospitals were inspected to check compliance of the rules throughout Punjab during CY 2023.

1.7.10 Tree Plantation

Urban tree plantation was carried out round the year 2023, through the conditions imposed in environmental approvals as well as during the plantation drives initiated by the Forest Department. A total of 328,428 trees were planted throughout Punjab. District-wise detail of plantations is shown in Figure 8-11.

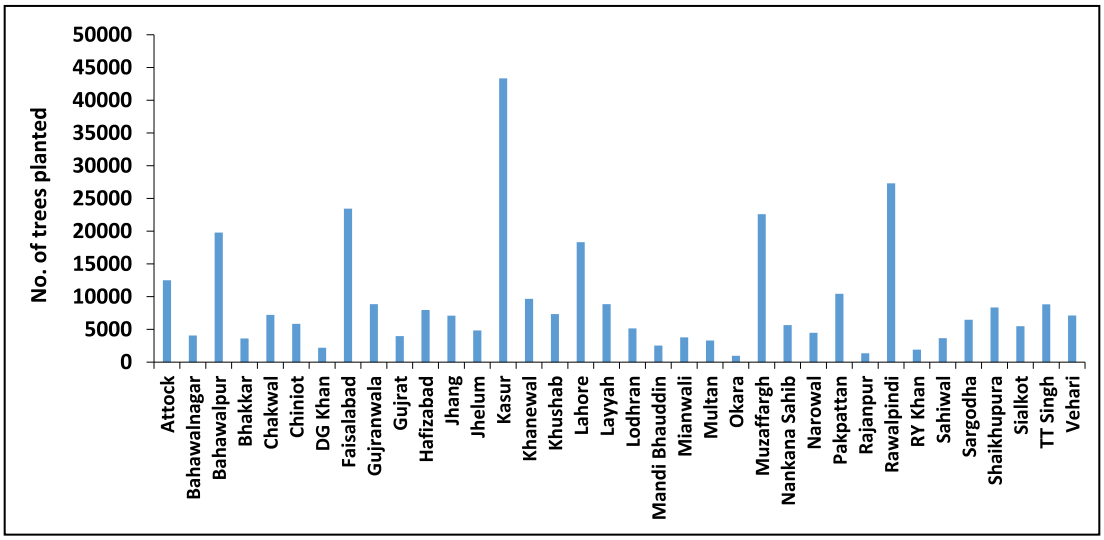


Figure 8-11: District-wise numbers of trees planted in Punjab during 2023

2. Conclusion

During CY 2023, EPCCD has achieved multi-dimensional endeavors in environment sector. The department foresees further strengthening of environmental governance in the province through the planned activities related to institutional, policy, monitoring and regulatory reforms along with enhanced coordination with stakeholders.

Effective grievance redressal is not just about solving problems; it's about restoring trust and confidence in the system.

9 ENVIRONMENTAL COMPLAINTS

9. Environmental Complaints

1. Overview

PEPA has a distinctive set of institutional arrangements through a formalized established Grievance Redressal mechanism (GRM) for proactively resolving environmental complaints across Punjab. Pertaining to Section 6 sub-section 2 (a) of the PEPA, the Agency may undertake, inquires or carry investigation into environmental issues, either at its own accord or upon complaint from any person or organization. GRM is an effective avenue for expressing the concerns for community and bringing positive social change by adopting remedial measures. It is a mean of fulfilling an individual's right to effective remedy and providing a direct, accessible way for individuals and communities to complain directly to the department or by using other channels (by email, web or mail) linked with compliant redressal.

GRM operates through an efficient, responsive, and accessible complaint handling system as described below Figure 9-1.

Easily accessible
Maintaining easily accessible complaint handling channels (email, web, or postal mail)
Time-bound and efficient
Providing time-bound and efficient preliminary analysis of all incoming complaints, with a public registry and notice of all eligible complaints to department.
Transparent
Operating under a set of protocols defining the procedures for complaints resolution
Highly Responsive
Facilitating resolution of complaints through a variety of means.

Figure 9-1: Grievance Redressal Mechanism of EPCCD

2. Grievance Redressal Mechanism

A number of channels are available to any aggrieved persons to access EPA through different media and institutional arrangements:

- To the Office of the Chief Minister, Chief Secretary, Secretary Environment, Director General EPA, Commissioner, Deputy Commissioner and Environment officer of the relevant districts in person.
- Electronically through Prime Minister Delivery Unit, Chief Secretary complaint cell or by sending an email to the quarters concerned
- By mail/post, through posting a hard copy of the complaint to the concerned office

3. Grievance Redressal in 2023

Contrary to the year 2022 where 1091 complaints were received by the EPCCD, 908 complaints were received in 2023. Faisalabad district received the highest number of complaints (131), followed by Gujranwala (77), Lahore (75) and Sheikhupura (66) (Figure 9-2). Majority of the complaints lodged in Faisalabad and Gujranwala districts were against the foundries, brick kilns, pyrolysis plants, rice sheller, woolen looms, steel mills, welding plants, melting furnaces, dying units, generators, power looms, metal works, ceramics and textile industries.

KEY FINDINGS

- ECCPD has established an easily accessible, efficient, transparent and responsive Grievance Redressal Mechanism for addressing environmental complaints, which is working proactively across Punjab.
- Environmental issues can be reported to the EPCCD through various channels and media including in-person at the concerned offices and via email.
- Total 908 complaints were registered during 2023 related to various environmental issues, with the majority pertaining to air pollution (50%).
- Faisalabad district received the highest number of complaints (131) and remained at the top among all 36 districts.
- 552 registered complaints were successfully resolved, while 32 complaints are currently being processed in the Environmental Tribunal.
- 83 units were sealed, and 42 FIRs were filed in 2023 due to non-compliance with the Punjab Environment Protection Act, 1997, read with PEQS.
- Most of the complaints (56%) were lodged through PMDU channel.
- Under PGDP, a formal Grievance Redressal Mechanism has been established since August 2023 to address the grievances pertaining to the program.

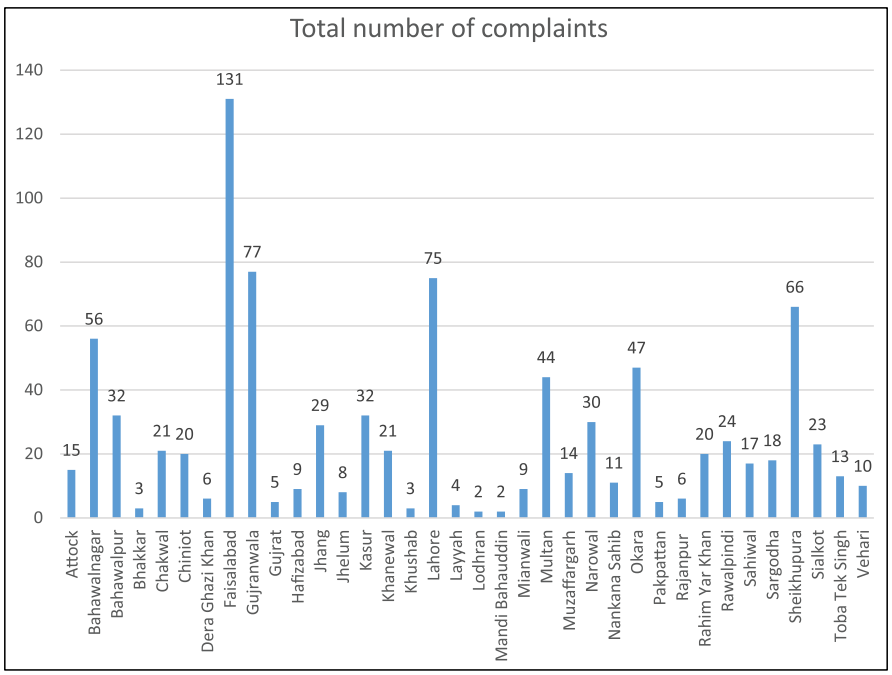


Figure 9-2: Total number of complaints received in each district of Punjab in 2023

The registered complaints were related to a wide variety of environmental issue as air pollution, noise pollution, hazardous/hospitals/municipal solid waste, sub-standard fuel used for combustion, cancellation of environmental approval/operation without environmental approval, soil pollution/land degradation and others (poly-ethylene bags, dust, spray polish, crop residue burning, odor and traffic management etc.).

4. Actions Taken Against Complaints

Highest number of complaints were related to air pollution (50%) (Figure 9-3). Out of these, 552 complaints were resolved. 32 complaints are being processed in PET. In response to the complaints, EPA sealed 83 units and filed 42 FIRs due to non-compliance with. Gujranwala and Faisalabad districts remained at top with maximum number of sealed units (25) and registered FIRs (09). Some of the complaints (108) are in process and 59 have been forwarded to the relevant departments for further action. Figure 9-4 shows the details of actions taken by the EPA for redressal of environmental complaints.

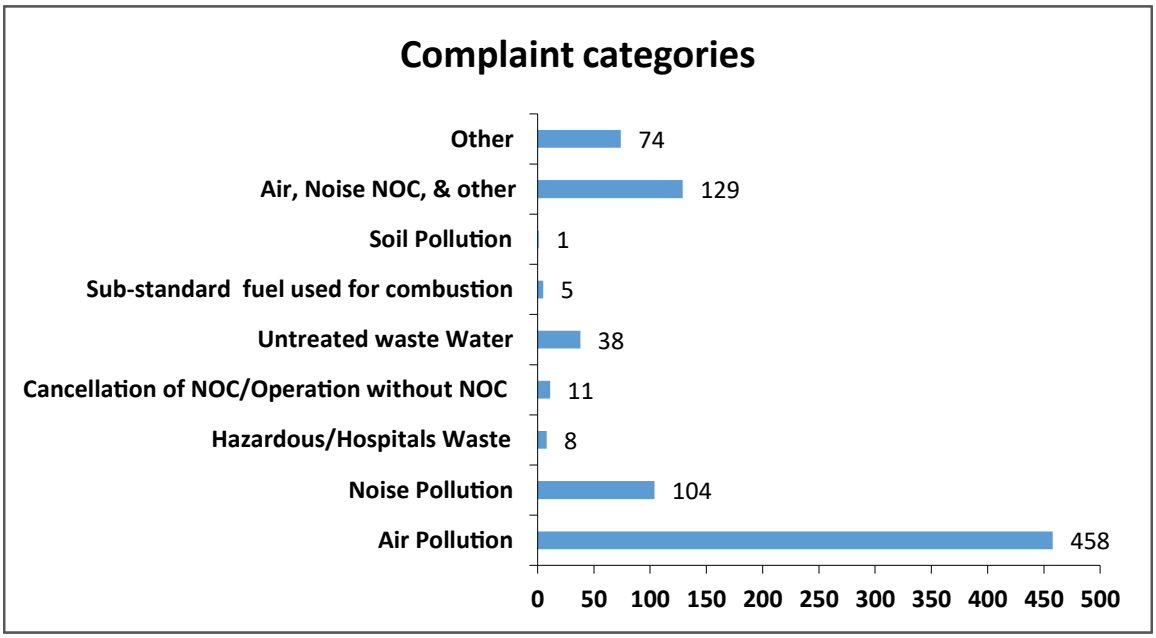


Figure 9-3: Complaints received in different categories

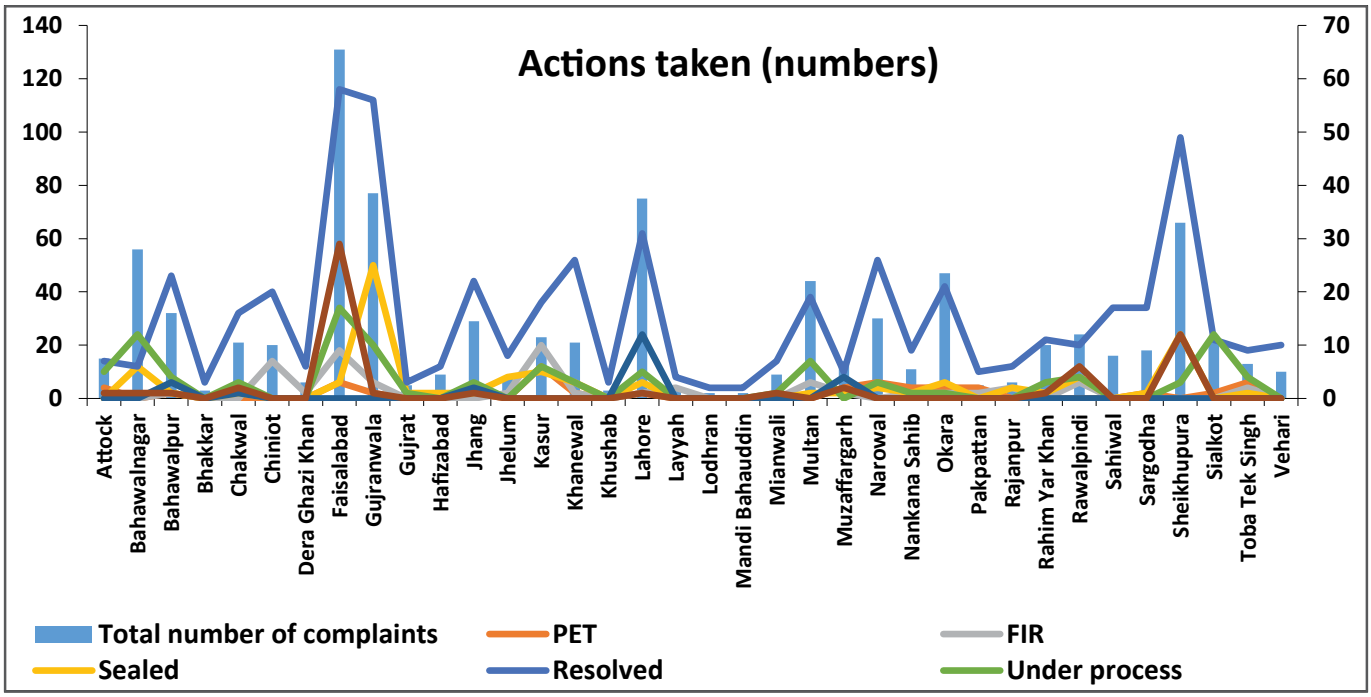


Figure 9-4: Actions taken in the year 2023 against filed complaints

Figure 9-5 is shows the number of fines imposed to the non-compliant industries. Total 61 units were fined with an amount ranging from PKR. 20,000 in Narowal to of PKR. 3.2 million in Jhang.

Under PGDP, a formal and organized GRM has been established to address complaints related to the program execution regarding environment and social issues in concurrence with Environment and Social Systems Assessment (ESSA). It is supported through a two-tiered structure established at divisional and SPIU level.

The complaints can be directly filed using the online complaint form available at PGDP website (**http://idm.pgdp.pk:8081**) or forwarded through offices of Deputy Director (field formations) via in-person visits.

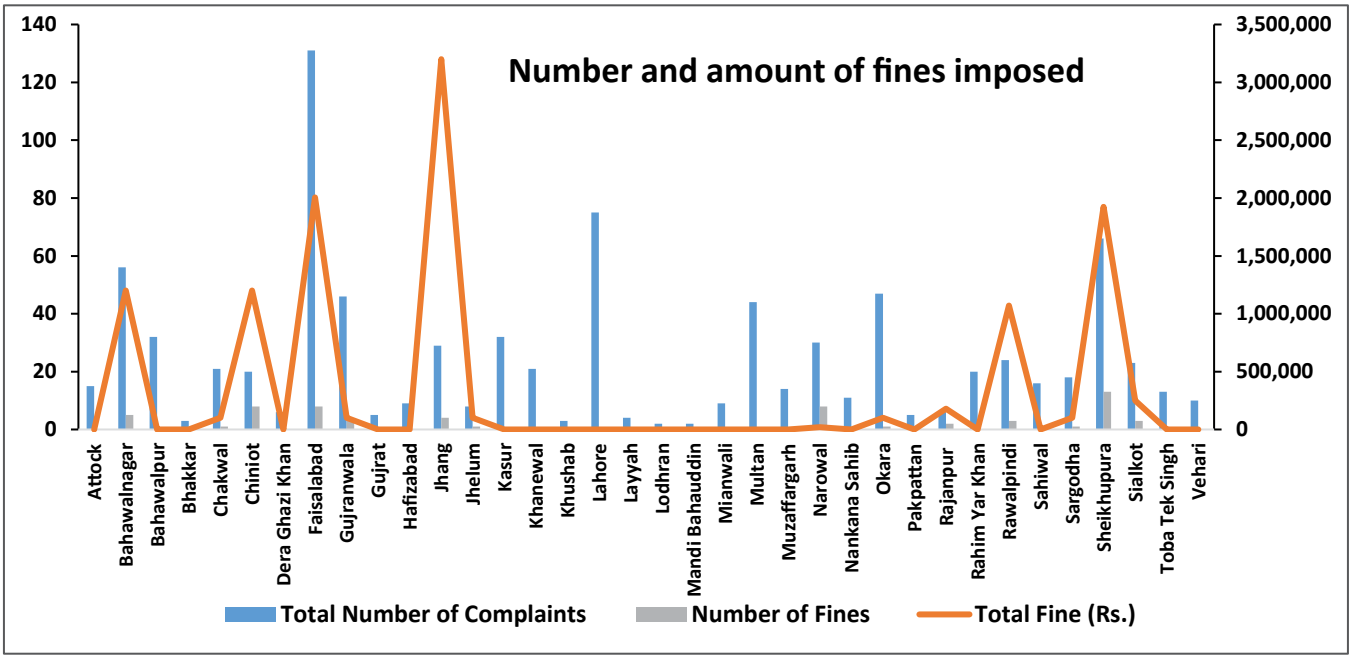


Figure 9-5: Number and amount of fines imposed on the non-compliant industries during 2023

5. Way Forward

- Promoting an awareness and arranging capacity building sessions regarding grievance resolution will enhance accountability and encourage continuous learning.
- Introduction of automated digital system by eliminating the need for physical visits will contribute to the improvement of public services for redressal of complaints and promote e-governance.
- District-wise generation of GRM reports explaining the total number of complaints, their resolution and

showing public concerns for betterment of the environment as well as addressing the social conflicts can be an important measure to make the system more transparent.

- There is need to implement a complaint tracking system that allows complainants to monitor the status of their complaints in real-time.
- There should also be a mechanism to get feedback on the complaint management from the public to assess the satisfactory level among masses.

An environmental action plan is a roadmap to a sustainable future, guiding us towards harmony with nature.

10

ENVIRONMENTAL ACTION PLAN

10. Environmental Action Plan

Environmental action plan is a strategic document that outlines specific goals, measures and initiatives designed to address the environmental challenges and to achieve sustainable development. The aim of this action plan is to mitigate the negative environmental impacts arising from anthropogenic activities, conserving the natural resources and fostering environmentally sustainable practices. It is a commitment amongst the stakeholders for taking corrective actions within stipulated timeline. Action plan contain a set of interventions, sub-interventions, responsibilities with specific timelines. The details are as follows;

- Interventions: Interventions are the broader areas where actions are to be taken.
- Sub-Interventions: Sub-interventions are the details and explicit actions to be taken under respective interventions.
- Responsibilities: Responsibilities are the duties entrusted to the Government organizations in the action plan for carrying out the interventions and sub-interventions.
- Timelines: Timelines means the time duration envisaged for carrying out sub-interventions.

SOE Report, 2022 contains the Environmental Action Plan based on ***Short Term*** for Calendar year, 2023 (CY-23), ***Medium Term*** for Calendar year 2024 (CY-24) and ***Long Term*** for Calendar year, 2025 (CY-25) measures. The progress on actions initiated/completed during CY-23 (short term) is described in first part of the chapter. In the second part, the Environmental Action Plan for SOE Report, 2023 (starting from CY-24) is given. Hence, all the sub-Interventions pertaining to Medium Term CY-24 (in SOE, 2022) are now Short Term CY-24 (in SOE, 2023), and Long Term CY-25 (in SOE, 2022) are now Medium Term CY-25 (SOE, 2023).

1. Status of Implementation of Environmental Action Plan - SOE (2022)

The SOE Report, 2022 included a thorough Environmental Action Plan that outlined a set of interventions and sub-interventions to be taken by certain departments for improvement and betterment of the environment. Responsibilities for execution of these interventions with timelines ranging from CY-23 to CY-25 were also mentioned. The status of this Environmental action plan is as follows;

- Interventions & sub-interventions: There were 11 interventions in this Environmental action plan (Table 10-1)

Table 10-1: Interventions in Environmental Action Plan, 2022

Sr. No	Intervention	Sr. No	Intervention
1	Legislative	7	Solid/Hospital/Industrial waste
2	Citizen Engagement	8	Punjab Sustainable Development Fund
3	Industries	9	Fugitive Dust Control
4	Vehicular	10	Remodeling Environmental Governance
5	Monitoring	11	Others
6	Water and wastewater		

- Responsibilities: The implementation of these interventions and sub-interventions were distributed among the respective agencies[1] from where focal persons are nominated for the successful implementation of the environmental action plan. These focal persons are working as pioneers in their respective departments for betterment of the environment (Table 10-2).

Table 10-2: Agencies and Focal Persons for Implementation of Environmental Action Plan

No	Agencies	Focal Person	No	Agencies	Focal Person
i	Federal Board of Revenue	Ms. Angel David, Second Secretary (Rule & SROs)	ii	Traffic Police	Mrs. Kishwar Sultana, DSP/SO
iii	Energy Department	Nureen Arif, Manager (Environment), PMU	iv	Forest Department	Syed Asim Azhar Naqvi, The Conservator of Forests, Extensions & Publicity Circle, Lahore
v	Transport Department	Suleiman Majeed, Director (Planning)	vi	Industry Department	Mr. M. Ahad Gill, Industrial Expert, PDU, PSIC

1 Agencies mean Government Departments its attached departments and autonomous bodies etc.

No	Agencies	Focal Person	No	Agencies	Focal Person
vii	LG&CD	Mr. Barak-u-llah, Secretary, Punjab Local Government Board	viii	WASA Faisalabad	Hafiz Moin-u-Din, Deputy Director (Non-Tech) / Senior Research Officer
ix	C&W Department	Asif Ali, Deputy Director, O/o Chief Engineer (South), Punjab Highway Department, Lahore.	x	WASA Multan	Omar Zafar, Deputy Director, Water Supply
xi	Irrigation Department	Chief, Strategic Planning/ Reform Unit	xii	HUD & PHE Department	Mirza Mansoor Baig, Section Officer, UD-II
xiii	WASA Rawalpindi	Mr. Suleman Manzoor, Assistant Director (Water Quality) / JRO	xiv	WASA Gujranwala	Mr. Muhammad Khurram Nabeel, Deputy Director (P&D),
xv	WASA Lahore	Ms. Zoya Farooq, Deputy Director, P&D Directorate	xvi	EPCCD	Farooq Alam, Deputy Director (Labs), EPA Punjab
xvi	Mines and Minerals	Mr. Aurangzeb, Deputy Director (Minor Minerals),			Muhammad Nawaz, Deputy Director (EDH), EPA Punjab

- Timelines: Total 71 sub-interventions under the given 11 interventions were outlined on a specific time scale i.e., 21 Short Term (CY-23), 33 Medium Term (CY-24) and 17 Long Term (CY-25). These interventions were either initiated or to be completed during the stipulated timeframe.

The progress on the interventions/sub-interventions for the actions required to be initiated/completed during CY-23, as stipulated in SOE report 2022, is given in **Figures 10-1 to 10-4.**

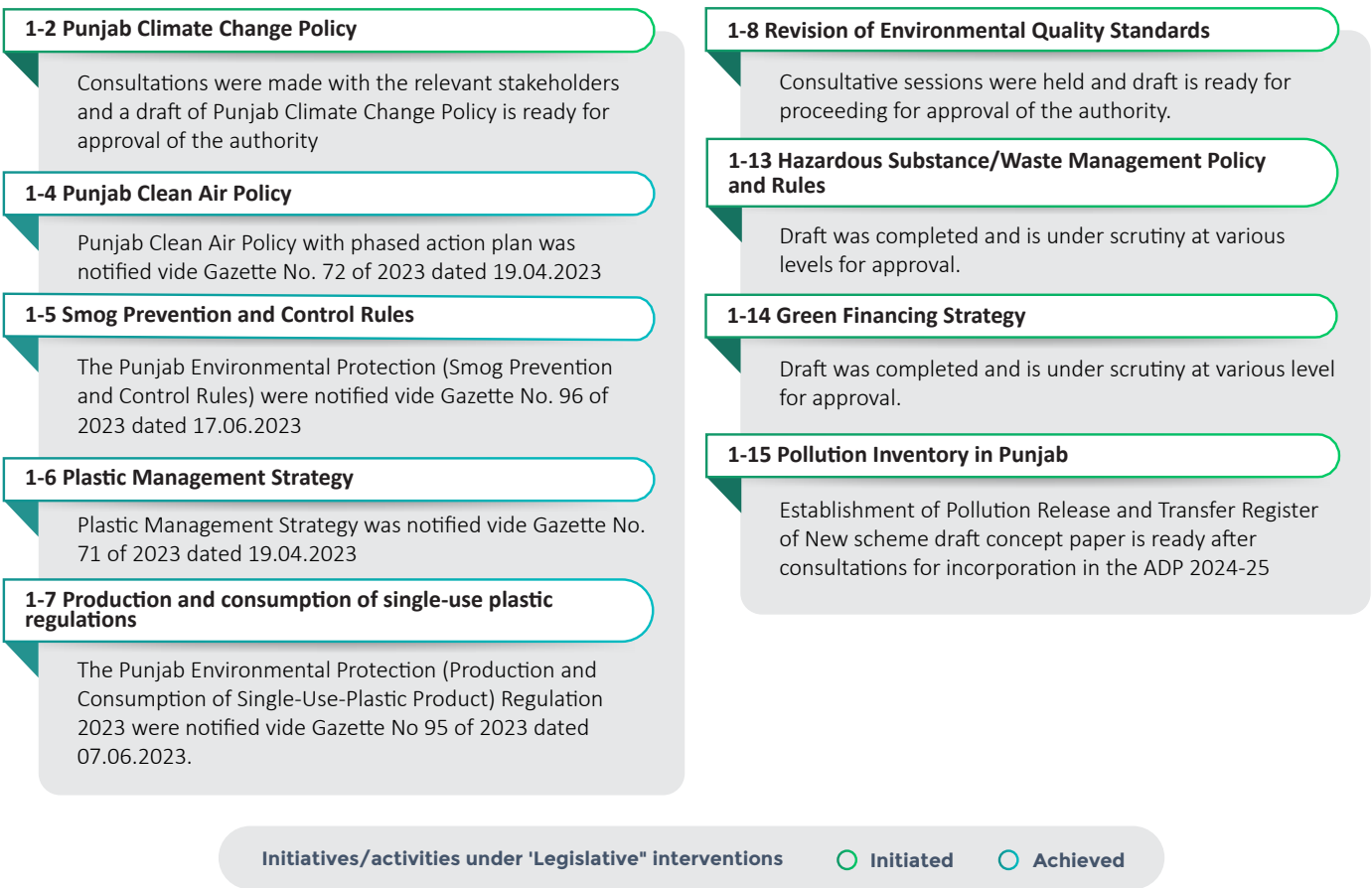


Figure 10-1: Key achievements for Legislative interventions in 2023

EPCCD

2-1 Establishment of hotline

PITB is added in revised PC-I. Work is going to be allotted.

2-2 Establishment of Interactive Data Portal

For getting public input on environmental management. Beta version has been designed & deployed at https://idm.pgdp.pk/ippi.

2-5 Disclosure of environmental information through electronic means

PC-I revised with provision of consultancy services for development of formats and protocols for disclosure of environmental information. Recruitment of project staff is under process.

Initiatives/activities under "Citizen Engagement" interventions

○ Initiated ○ Achieved

EPCCD/Industry

3-1 Geo Tagging of Industries

Module has been developed and will be deployed for the data input i.e., https://idm.pgdp.pk/admin/pim/industrydetail/

3-5 Financial Assistance to Green Micro-Enterprises

For "Punjab Economic Stimulus Program (support to Micro Enterprises)" was merged into "Punjab Rozgar Scheme" to achieve the target of DLR 7-3 of PGDP. Under this scheme, the Bank of Punjab has disbursed 582 green loans amounting Rs. 776 Million (approx.) to ME/Microenterprises.

Initiatives/activities under "Industries" interventions

○ Initiated ○ Achieved

Figure 10-2: Key achievements of Citizen Engagement and Industries in 2023

Transport

4-1 Retiring excessively old vehicles and installation of catalytic converters/diesel particulate filter

Devising mechanism in the vehicles.

Initiatives/activities under "Vehicular" interventions

○ Initiated ○ Achieved

EPCCD

5-4 Establishment of a GIS Cell in EPCCD

After consultations a new scheme is going to be introduced titled as "Establishment of a Climate Adaptation and Resilience Support Center (CARSC)", which will contain the component of GIS Cell. Draft concept paper is ready for incorporation in the ADP 2024-25.

Initiatives/activities under "Monitoring" interventions

○ Initiated ○ Achieved

Figure 10-3: Key achievements for Vehicular and Monitoring interventions in year 2023

EPCCD

8-1 Operationalization of Environment Endowment Fund Management Unit

A Section 42 company named "Punjab Environment & Climate Change Endowment Funds" was going to be incorporated in SECP.

8-2 Devising Operational Guidelines for the Disbursement of the Fund

PC-I is under the process of revision for hiring a consultancy firm for the said task.

EPCCD

10-1 Automation Regime to Expedite the Public Service Delivery in EPCCD

Development of six modules i.e., E-Industrial Mapping, E-Environmental Approvals, E-Monitoring System, E-Enforcement Sharing and E-Laboratories. Procurement of IT equipment was initiated.

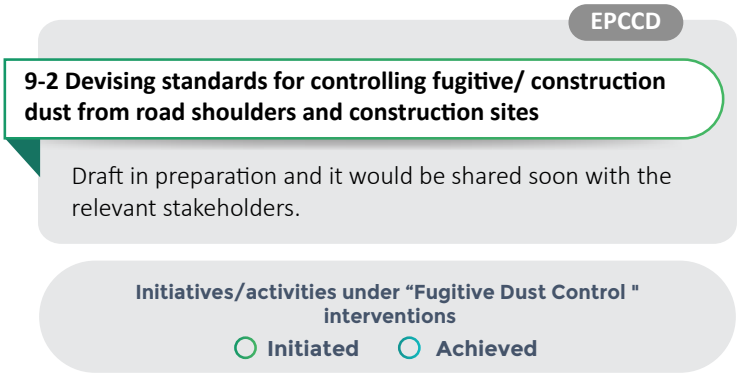
10-2 Establishment of Environmental Policy Center

For hiring human resource, draft service rules were sent to Authority for approval. For hiring of office building, procurement of machinery and equipment and for allied expenditures, draft concept paper is ready for incorporation in the ADP 2024-25.

Initiatives/activities under "Remodeling Environmental Governance " interventions

○ Initiated ○ Achieved

Figure 10-4: Key achievements of Sustainable Green Financing, Fugitive Dust Control and Remodeling Environmental Governance in year 2023



2. Environmental Action Plan for SOE, 2023

Environmental Action Plan, 2023 is also a three years plan starting from CY-24 and ending at CY-26. All the interventions and sub-interventions of previous environmental action plan are adjusted accordingly. In addition to these, some new interventions/sub-interventions are added. Two new interventions namely "Air" and "Climate Change" have been added. Description of Short Term, Medium Term and Long Term interventions is given at Table 10-3.

Table 10-3: Timeline to complete/initiate sub-interventions of Environmental Action Plan.

Short Term (CY-24)	The targets under Short-Term category include immediate interventions. These sub-interventions are to be completed/initiated in calendar year 2024
Medium Term (CY-25)	The targets under Medium-Term category require implementation of modern strategies and policy support. These sub-interventions are to be completed/initiated in calendar year 2025
Long Term (CY-26)	Long Term category targets are to be completed/initiated till 2026. These sub-interventions require sustained policy measures.

Sub-interventions and respective responsibilities on the time scale were redefined as given in Table 10-4.

Table 10-4: Environmental Action Plan

1-Legislative		
Term	**Sub-interventions**	**Responsibility**
Short Term (CY-24)	1-1 Notification of rules & regulations under the Punjab Environmental Protection Act, 1997 (like Hazardous Substance Rules and implementation of MEAs given in the Schedule (e.g., Green House Gases/UNFCCC, Biodiversity etc.)	EPCCD
Short Term (CY-24)	1-2 Certification and labeling system for green, energy-saving products	Energy Department
	1-3 Energy conservation standards for newly built urban buildings and industrial establishments	Energy Department
	1-4 Energy saving renovations/retrofitting in existing buildings and improved energy efficiency guidelines/ regulations/rules	Energy Department
	1-5 E-Waste Management Rules	EPCCD
Long Term (CY-26)	1-6 Additional legislative arrangements other than the Environment Act	EPCCD

2-Citizen Engagement			
Short Term (CY-24)	2-1	Establishment of air and water web-based data portal. Further, engage public, private and civil sectors in the development of joint policy framework to address environmental challenges like air, water quality	EPCCD
	2-2	Public communication campaigns on negative environmental and health impacts of single use plastic	EPCCD
Medium Term (CY-25)	2-3	Public communication campaigns on water conservation, rain water harvesting, and environment conservation etc.	EPCCD
Short Term (CY-24)	2-4	Implementation of health advisory in the wake of critical air pollution events	EPCCD
Long Term (CY-26)	2-5	Effective participation of stakeholders and public-private sector cooperation in decisions making-processes	EPCCD
Long Term (CY-26)	2-6	Enhancement of environmental health awareness and environmental concerns	EPCCD

3-Industries			
Short Term (CY-24)	3-1	Implementation of resource efficiency and cleaner production technologies	Industry Department
Medium Term (CY-25)	3-2	Implementation of zero water discharge/water conservations schemes in the water intensive industries like textiles, sugar etc.	Industry Department/ EPCCD
Medium Term (CY-25)	3-3	Introduction of carbon neutrality regime	EPCCD
Short Term (CY-24)	3-4	Evaluation of impacts of pollution sources on the soil quality	EPCCD
Medium Term (CY-25)	3-5	Installation of continuous emission monitoring systems	Industry
Long Term (CY-26)	3-6	Designing, Development and implementation of technologies for prevention of pollution at source	EPCCD
Long Term (CY-26)	3-7	Introduction of measures for the prevention of the production of hazardous wastes at the source	Industry/ EPCCD
Long Term (CY-26)	3-8	Increasing collaboration with the academia for research and development for sustainable development	EPCCD/ Universities

4-Monitoring			
Short Term (CY-24)	4-1	Installation of at least 30 ambient air quality monitoring stations	EPCCD
	4-2	Installation of at least 15 water quality monitoring stations	EPCCD
	4-3	Establishment of a reference laboratory	EPCCD
	4-4	Establishment of noise and vibration monitoring networks	EPCCD
	4-5	Environmental monitoring of industrial effluents deteriorating the quality of river Ravi in Sheikhupura and Faisalabad	EPCCD

5-Vehicular		
Term	**Sub-interventions**	**Responsibility**
Short Term (CY-24)	5-1 Enhancing the area of jurisdiction of vehicles inspection and certification regime to the private vehicles[2]	Transport Department
	5-2 Mandatory vehicle inspection certificate prior to sale and purchase of any vehicle regarding emission compliance	Excise Department
	5-3 Promote mass transport facilities in the major urban centers of the province	Transport Department
	5-4 Piloting of electric buses in Lahore, Punjab	Transport Department
	5-5 Devising mechanism to increase road denials of excessively old/ pollution causing vehicles	Transport Department/ EPCCD
Medium Term (CY-25)	5-6 Green transportation, standards, action plans & solutions	Transport Department
Short Term (CY-24)	5-7 Road Engineering for removing traffic congestions in the major roads of the urban centers[3]	Traffic Police/ Development Authorities/ MC
Medium Term (CY-25)	5-8 Increase the counters for issuance/renewal of fitness certificates/ route permits	Transport Department
Medium Term (CY-25)	5-9 Deploy the teams to check vehicles plying on road without fitness certificates & route permits	Transport Department/ Traffic Police

6-Air		
Short Term (CY-24)	6-1 Enactment of "The Punjab Clean Air Act"	EPCCD
Short Term (CY-24)	6-2 Area pollution and dust control/urban dust management	EPCCD/ Housing Authorities/ C&W
Short Term (CY-24)	6-3 Implementation of zero sand spillage regime regarding sand moving trolleys[4]	Mines & Minerals/ District Govt./ Traffic Police
Term	**Sub-interventions**	**Responsibility**
Short Term (CY-24)	6-4 Investigation of sources of particulate matter for informed decision making	EPCCD
Medium Term (CY-25)	6-5 Implementation of Punjab Clean Air Policy (with phased Action Plan)	EPCCD
Short Term (CY-24)	6-6 Implementation of health advisory in the wake of critical air pollution events	EPCCD
Medium Term (CY-25)	6-7 Establishment of pollution inventory and pollution release and transfer register	EPCCD

2 Traffic Police Punjab during CY-23 apprised that a special campaign has recently been launched against vehicles plying on road without or with expired fitness certificates & route permits.

3 Traffic Police Punjab during CY-23 apprised that all districts have prepared the reports regarding road engineering required for removal of traffic congestion in urban areas and concerned authorities will be approached to do the needful within timeline.

4 Traffic Police Punjab during CY-23 apprised that more than 7,000 uncovered vehicles/trolleys have been issued challans and about 15,000 have been impounded.

7-Water & Waste Water			
Medium Term (CY-25)	7-1	Construction of storm/rain water underground water recharge galleries in establishments (including public as well as private)	LG&CD/C&W Department
Short Term (CY-24)	7-2	Water metering for every connection of domestic and industrial establishments alongwith provision of clean surface water	WASAs and municipal authorities
Medium Term (CY-25)	7-3	Rehabilitation of dams, rivers, drains, and canals. Also ensure the implementation of watershed management practices and increase in water storage capacity of the province[5]	Irrigation Department
	7-4	Conservation of natural habitats especially the Ramsar sites	EPCCD
	7-5	Installation of municipal waste water treatment plants against each existing disposal station	LG&CD/ Housing Authorities/ WASA's
	7-6	Construction of industrial waste water treatment plants	Private/EPCCD
	7-7	Mandatory provision of construction of municipal waste water treatment plants in new establishment of disposal stations	LG&CD

8-Solid Waste & Hospital/ Industrial waste			
Medium Term (CY-25)	8-1	Establishment of Integrated solid waste management facilities in each urban as well as rural areas	LG&CD
Short Term (CY-24)	8-2	Waste minimization at source (reduce, recycle, and reuse)	LG&CD
	8-3	Improve waste collection efficiency	LG&CD
Medium Term (CY-25)	8-4	Installation of waste to energy projects	LG&CD/Energy Department
Short Term (CY-24)	8-5	Provision of hospital waste management facilities by large private hospitals (having more than 30 beds)	Private/ Health Department
Medium Term (CY-25)	8-6	Provision of industrial waste management facilities in industrial or cluster levels	Industry Department
Long Term (CY-26)	8-7	Piloting and handing over of a catalytic hydrodechlorination unit for treatment of PCBs and similar hazardous chemicals	EPCCD & LG&CD

9-Climate Change			
Short Term (CY-24)	9-1	Establishment of a Climate Adaptation and Resilience Support Center (CARSC)	EPCCD
Term		**Sub-interventions**	**Responsibility**
Medium Term (CY-25)	9-2	Establishment of Early Warning System for extreme weather events in Southern Punjab	EPCCD
Medium Term (CY-25)	9-3	Mapping the climate change vulnerability to develop a Climate Adaptation and Resilience Plan (CARP) for South Punjab	EPCCD
Medium Term (CY-25)	9-4	Piloting of a community conserved area in South Punjab for protection of desert ecosystems	EPCCD

5 Irrigation Department has informed that following projects will be completed by June 2025 Remodeling of Nikki Deg Drain (1,133million PKR), Flood protection of Kamoki & adjoining areas Sheikhupura (2,175 million PKR), Channelization of Deg Nullah (Land Acquisition Punjab Component)/Sheikhupura (3,175 million PKR), Management of Hill Torrents in DG Khan, Rajanpur (2,035 million PKR), Construction of Jalapur Irrigation Project and its System/Jhelum, Khushab (32,721 million PKR), Rehabilitation and Modernization of Islam Barrage (2,993 million PKR), Rehabilitation and up gradation of Trimmu Barrage, Punjab Head Works/Jhang (16,800 million PKR) and construction of small Dams (11 on-going and 37 identified potential sites).

10-Remodeling Environmental Governance		
Short Term (CY-24)	10-1 Establishment of Environmental Technology Transfer Center	EPCCD
	10-2 Incentivization of the environmentally compliant industries[6]	EPCCD/ MOCC/ FBR
Medium Term (CY-25)	10-3 Collaboration/regional dialogues on transboundary water and air pollution	EPCCD/MOCC
Short Term (CY-24)	10-4 Establishment of Environmental Policy Center	EPCCD
Long Term(CY-26)	10-5 Provision of financial resources to NGOs and collaboration with them for sustainable development	EPCCD
Short Term (CY-24)	10-6 Implementation of Plastic Management Strategy	EPCCD

11-Others		
Short Term (CY-24)	11-1 Construction of Green Buildings in Lahore	EPCCD
Medium Term (CY-25)	11-2 Research and development for developing/adoption of indigenous technologies for pollution abatement preferably through industry academia licenses	EPCCD
	11-3 Establishment of woodlands especially in urban centers of indigenous and environment-friendly species	Forest Department
Short Term (CY-24)	11-4 Establishment of noise-free zones in Punjab	EPCCD/ Development Authorities
Medium Term (CY-25)	11-5 Preparation of local environment action plans at the district levels with special reference to environmental protection and pollution prevention	LG&CD/ EPCCD
Medium Term (CY-25)	11-6 Land-use classification of each district to gauge the urban sprawl, development pattern etc.	LG&CD/ Development Authorities
Long Term (CY-26)	11-7 Tapping of domestic and external sources of finance to investments for environmental protection and climate change	EPCCD/EPC
Long Term (CY-26)	11-8 Intensification of R & D activities for abatement of air and water pollution	EPCCD
Long Term (CY-26)	11-9 Establishment of a Noise prevention cell under EPA Punjab	EPCCD
Medium Term (CY-25)	11-10 Development of policy instruments to deal with the problem of noise pollution	EPCCD

6 During CY-23 the FBR responded that Pakistan being under Stand by Arrangement signed with IMF whereby, Pakistan is bound to avoid granting any new tax exemption/concession or preferential tax treatment, hence cannot incentivize the environmentally compliant industries. The Punjab EPD is requested to implement the Action Plan through non-tax incentive measures for example by penalizing the non-compliant industries. Therefore, the mandate to the respective provincial laws.

3. Monitoring & Evaluation

A dashboard will be established for current Environmental Action Plan by EPCCD for continuous monitoring and updating of this action plan. Every sub-intervention will be systematically divided into small, measureable steps, with timelines, to better monitor the pace of the sub-interventions. The focal persons will play a pivotal role in the implementation of this plan at their respective organizations.

ANNEXURES

ANNEXURES

Annexure _ A

Comments recieved during public hearings for State of Environment Report, 2023

A-Lahore (24th August 2023)

Commenter	Comments	Response
Mian Ahmad Saeed, Chairman, Sahiwal Chamber of Commerce	Much efforts have to be made for conservation of natural resources as well as water conservation. Agricultural Land is being converted into housing schemes and there are heavy rains and cloud burst episodes especially in urban centers. More legislation regarding regulations and stern fines has to be imposed against smog emitting vehicles and against violators of environmental laws. There is always a threat of flooding due to release of water by the India. In the present environmental regime, there are no efforts related to the conservation. However, much efforts regarding recycling are observed in the State of Environment Report, 2022.	Comment is about an environmental issue, not on the Table of contents of report
Dr. Atta-ul-Haq, Chief Executive Officer, Techno Clean Field	The proposed Table of Contents at serial No. 7.1 requires the effectiveness of industrial waste water treatment plants and what about the effectiveness of municipal waste water treatment plants? At serial No. 7.2 there is a description of solid waste management facilities. It is pertinent to mention that there is only one scientific landfill site in Lahore across the Punjab. There are other waste management companies in Gujranwala, Sheikhupura, Faisalabad and Bahawalpur but identification and availability of landfill site is the key bottle neck in establishment of an effective solid waste management system. Further, the report may also contain the description HSE and work place and intervention may be carried out for handing over of 160 vehicles from LWMC to the small cities to improve the State of Environment.	Effectiveness of industrial WWTPs will be discussed in the chapter in context of their environmental performance. There are no municipal wastewater treatment plants in Punjab. The number and capacities of landfill sites of Punjab will be discussed in report. HSE is not a component of environment as defined in PEPA 1997 and is not usually discussed in state of environment reports
Prof. Dr. Ghulam Murtaza, Professor/Director, University of Agriculture Faisalabad	There are no waste water treatment plants and solid waste management facilities for the industrial as well as Municipal waste water and Solid waste. Everywhere, industrial effluent is being mixed with the municipal effluent. Similarly, hospital waste is being mixed with the municipal solid waste. We all are cleaning our homes and dumping the solid waste in the neighborhood. At present, there are big cities, at least some new cities may be developed. In SOE, 2022 Arsenic is highly reporting with regards to contamination but it is not a big problem. Care shall be taken to report secondary data from the research Journals as research quality is being compromised over quantity. It is further suggested that in the proposed content following arrangement may be made i.e., "soil" may be change as "soil health", "physical" may first come then "chemical" and then "heavy metal contamination" and then "fertilizers" and then "pesticides".	Secondary data will be quoted carefully from authentic sources
Samina Arshad, Director Punjab, Rahnuma - Family Planning Association of Pakistan (FPAP)	There is severe need to review climate changes verses over population. The impacts of population have to be examined in the context of environment. Further, there is an urgent need for creating awareness about the Government initiatives. There are small villages, rural areas which require special attention from the Government especially in terms of safe drinking water and solid waste management facilities.	Climate change, its population – related drivers and WASH sector will be discussed in the report

Commenter	Comments	Response
Shakeel Ansari, Member Faisalabad Chamber of Commerce	Earlier we have much resource of natural gas which is now depleted. Throughout the world, the energy is being produced by burning the municipal solid waste what action has been taken by us in this regard? There are various contributing factors regarding the air quality which needs to be addressed. Gas availability to the industry has to be ensured, as the use of local coal may cause number of diseases.	General comment. Energy sector of Punjab will be discussed briefly in the report
Shah Nawaz Khan, Relationship Manager, Strengthening Participatory Organization (SPO) Formed the Punjab Climate Action Network (PCAN)	There is a severe challenge of open defecation in the rural areas which require corrective measures. The Punjab Environmental Protection Policy needs to be promulgated at the earliest.	General Comment
Azhar Hussain, Deputy Chief Plan, Agriculture Department	Much discussion has always been made on the land conversion from agriculture to the residential category but lesser discussion is referred regarding efforts of the Agriculture Department wherein 200 bulldozers are being used for the land development. This may also be added in the upcoming report.	Response on environmental issued from government departments will be added in each relevant chapter
Fareeha Fatima, Section Officer (Tech-II), HUD & PHED Department	The ground water aquifer is being used for drawing of drinking water across the Punjab which results in depletion of ground water resources. We have to shift towards the surface water and also promote the rain water harvesting.	General comment
Noureen Arif, Manager Environment, Energy Department	The Government has to take lead in the renewable technology. There are grid emission factors available through which GHG emissions may be calculated further the contribution of energy resources in terms of thermal verses renewable may be consider for this report.	General comment
Ushna Tariq, Gender Management System, Women Development Department	The percentage of women in the population of Punjab has been increased to more than 51% and they are considered as vulnerable. Therefore, their representation/description may be added into the report, appropriately.	Gender will be discussed in report
Amber Aleem, Program Manager, The Urban Unit	Clarity may be provided regarding 10 Divisional Headquarters against which the report is going to be compiled. Noise quality is a neglected area which may be included into the upcoming report.	Names of Divisional Headquarters will be clearly mentioned in report. Noise data is not so far available. However, actions regarding noise quality monitoring and regulations will be added in the action plan so that the future reports may discuss this issue
Dr. Rana M. Atif, Deputy Director, Pakistan Meteorological Department	The report shall contain, air quality modelling as well as climate change modelling to the extent of the Tehsil level. There is data available and efforts have to be made with regards to the inclusion of academia for betterment of air quality.	Any data available with PMD pertaining to environmental and climate change context will be added in the report
Dr. Gul Zareen Ghafoor, Assistant Professor, Sustainable Development Study Centre (SDSC), Government College University Lahore	The report contains the data of the WASA across the Punjab which is not true representation as focus has to be made on distribution as well as household service. Further, there are standards not available for surface water quality and as well as soil quality.	Tap water quality will be added in the report to cover the consumption side of water. Available international standards will be used where local standards are not available.
Syed Mujahid Mumtaz, Director General, Sheikhupura Chamber of Commerce	While considering the potential of renewable energy their negative effects may also be considered.	General comment

Commenter	Comments	Response
Shahid Habib, Deputy Director, Irrigation Department	While discussing the action taken by the Government Departments to measure and control pollution it will be also beneficial if their laws, rules and regulations may also be discussed in the report.	As the report will contain the actions taken by Government Departments during 2023, previous laws, rules and regulations may not be discussed
Umer Hayat, Assistant Professor, Sustainable Development Study Centre (SDSC), Government College University Lahore	We have to focus on the contributing factors of the climate change. Until and unless we are unaware about the contributing factors, we will not be able to address the concerns. Further, heavy metals in soil may be reported. Globally attention is drawn towards micro plastic pollution, this year's World Environment Day theme was also related to plastic and we have to focus on it. Multilateral environmental agreements and their compliance has to be reported in the report along with transboundary pollution contributing factor.	Drivers of climate change will be discussed in the report. Heavy metals will also be discussed in soil chapter. MEAs and their implementation will be strengthened in future along with the institutional strengthening of EPCCD Punjab under PGDP and the future reports would discuss the MEAs in detail. Transboundary element of air pollution will be discussed in the report.
Naeem Bajwa, President, Lahore Conservation Society	Solid waste contains 60 to 70% organic – a pure resource – which is being wasted. At source waste segregation has to be carried out to minimize the waste into the environment. Tetra Pack have been found at everywhere even in the lake of Saif-Ul-Malook. There has to be a concept of extended producers' responsibility. Presently cities are not walkable there has to be multiple centers. The influence of EPD has to be on master planning of the cities. Carbon off setting needs to be done. Rain water harvesting is a neglected area. We have to engage academia and social sector for completion of feedback loop.	General comments
Nadia Tahir, Director Environment, Ravi Urban Development Authority	Urban development is facing severe issues of encroachment, re-settlement and rehabilitation. Such issues need to be addressed. We have highest number of laws in the world but they are not being implemented. Laws needs to be implemented.	The urban settlement issues will be discussed in climate change chapter briefly.

B-Sahiwal (05th March 2024)

Commenter	Comment	Response
Irshad Mohsin, Deputy Director Social Welfare Department	• There is a major issue of air pollution form Sahiwal coal power plant. • Plastic Management Strategy to be implemented.	• Comment noted • PMS is being implemented
Muhammad Wasim Afzal, Anjuman-e-Islamia, Sahiwal	• There are rules of regulation on several environmental issues but there are so any implementation gap for example solid waste management is an adequate both in terms of collection and save disposal	• General comment. endorsed
Ashknaz Khokhar, HRCN- MTATO Colony, Sahiwal	• There must be adequate number of dustbin available for solid waste management in the province • Attention should be paid to the availability clean drinking water. • Request to share the presentation, particularly Sahiwal's data. • Lahore is facing an air pollution since many years. • Raise concern of tree cutting and respiratory illnesses associated with operation of coal power plant.	• General comment. Endorsed • General comment. Endorsed • Drinking water section has been well addressed in the report • Presentation shared • Issue of air pollution in Lahore has been highlighted in the report • General comment. Endorsed
Imtiaz Butt, Awaz Society	• Highlighted the issue of open waste burning. • The sustainability of planting trees is more important than plantation of new trees as thousands matured trees of are cut for sake of development with the condition to plant new trees in replacement. However, new plants cannot be the alternative of Echo system services provided by the mature trees.	• Open waste burning has been discussed in the report • General comment. Endorsed
Khalil Hussain, DFC	• Open waste burning is a critical environmental issues. • Why we cannot control climate change? • What are the impacts of climate change on ozone layer? And what we are doing for it? • The world is installing solar panels and liquid/mechanical trees. So we should focus on innovative technologies.	• Open waste burning has been discussed in the report • Government is striving to combat climate change • Climate change and ozone depletion explained to the participant • Responded by informing about the solarization efforts in Punjab
Khalil Hussain, DFC Prof. Jamil Butt FANSA	• There is need to spread awareness among masses regarding pollution NGOs and CSOs should be engaged for this purpose. • Empowerment/enforcement of EPCCD is too week. • Raised concerned of in adequate solid waste management smog coal power plant and rising sea level.	• Responded by informing awareness activities of EPCCD Punjab • Comment noted • Comment noted and responded
Malik Amjad, Rahimia Welfare Society	• Efforts should be made to protect trees from cutting during sewerage and construction work in Sahiwal. • There should be good coordination between the Government and CSOs. • Civil society should also be engaged in report making.	• Comment noted • Comment noted. CSOs are invited in the hearings
Tariq Shah Bukhari, Patient Welfare Society	• 75% of the population in rural they should be awared about environmental issues during Juma Prayer.	• Comment noted

C-Multan (06th May 2024)

Commenter	Comment	Response
Muhamad Zahid Zahoor, Roshni Welfare Organization	• Action plan in corporate in report but there are gaps in their follow up • There is no solid waste recycling in Punjab for example Multan produces thousand tons of waste per days but there is no recycling system.	• Responded while hearing. Implementation status of EAP 2022 has been added in the report. • Issue of inadequate solid waste management has been highlighted in the report.
Mr. Ali Ijaz, Farmers Development Organization (FDO)	• In which key areas are the budget allocations in environment sector? • Which budget priority this report highlights? • More than hundred civil society organizations are present in Multan but not one is engaged with EPCCD? • There is need to promote collaboration between CSOS with department	• All the key initiatives for which budget is being allocated in environment sector have been added in the report • The report highlights that strengthening environmental governance is the key priority in the environment sector • EPCCD engages CSOs in all consultative events • Comment noted
Mr. Pervaiz Iqbal, Farmers Development Organization (FDO)	• What kind of unsustainable agriculture practices are being refereed in the report and what are their solutions? • What is the status of Plastic management strategy and its implementation? • There is no data of PCRWR and HUD&PHED department on the surface water quality mentioned in the report? • Please explain the transboundary causes of air pollution in Punjab?	• Responded during hearing. Unsustainable agricultural practices referred in the report include the stubble burning, conventional use of pesticides and fertilizers, etc. • PMS is notified now and implementation is in progress. • PCRWR provided data for last report as it had the data available under a project. But data was not available with PCRWR for current year. For surface water quality, data of EPA labs was used. • Trans-boundary causes of air pollution were explained during hearing.
Imtiaz Ali Asad, Shab-o-Roze khanewal	• The ban on single use plastics going to be imposed on 5th June 2024 is not implementable unless source is not remove so there should be a ban on manufacturing of SUPs and alternatives to the SUPs must be introduced. There is need to educate common man about the SUPs issues.	• Comment noted, endorsed and responded as EPCCD is already working on the awareness activities on SUPs
Dr. Muhammad Shoaib, BZU	• EPCCD arrival to Multan for this event is well appreciated. • Action plan should give interventions for climate change and air quality issues • Even the filter tap water is not for drinking • EPCCD should enhance its environmental monitoring network • Social media and educational syllabus should be used for environmental awareness purposes	• Acknowledged • Interventions for climate change and air quality have been added in the EAP 2023 • Drinking water issue has been included in the report • EPCCD is enhancing its monitoring network by installing 30 AQMS and 15 WQMS in Punjab • Comment noted
Muhammad Mujahid Malik, Early Wood Seeds	• EPA Punjab NOC procedure is too lengthy	• Not related to SOE report, however responded in terms of informing the participant about automation regime
Mr. Kumail Hassan Lodhran Pilot Project	• Climate smart agriculture must be considered as a key intervention to tackle the issue of climate change	• CSA added as proposed intervention in the chapter
Surayya Faiz, Lodhran Pilot Project	• Gender parity and noise pollution should be also be discussed in the report.	• Gender parity discussed in the report already. Regarding noise, comment noted for next SOE Report pertaining to non-availability of data on noise so far
Hassan Mukhtar HR Manager Lipton Khanewal	• The short term actions should be focused for implementation. • The environmental awareness must be started at individual level.	• Comments noted and endorsed
Shahid Mehmood Ansari, Shaoor organization	• Shaoor Tarqiati Tanzeem needs support for government as it is working since 20 years for environment without any governmental support.	• Not relevant to SOE Report, but noted and endorsed

Commenter	Comment	Response
Dr. Muhammad Dawood, Associate Professor, BZU Environmental Science	• The department should rely on its on testing data • Why PCRWRs data has not been incorporated • Sample size is not adequate the report should over whole of the Punjab • Micro plastic should also be discussed in report	• Department is striving to enhance its monitoring regime under PGDP to generate adequate data to be relied upon for the report purposes • Responded as above • Admitted. Sample size would be enhancing with enhanced capacity building of the department in terms of human and physical resources • Comment noted and endorsed
Dr. Ahmad Muhammad, Muhammad Nawaz Shareef University of Agriculture, Multan	• Extreme weather events should be reported in the report. There should be data on greenhouse • Economic impacts should also be discussed in addition to the health impacts	• Extreme weather events added in the report. So far, no data on GHG available. Reflected in the report • Noted for next SOE Report
Farooq Khan, IMS/BZU	• There is need to environmental racism in the report • Nehr no bahar entering into Multan from sabzimandi turns into a drain just after 6.2 kilometers crossing the subzwari colony • There are speakers on every car causes noise pollution	• Comment noted for next SOE Report • General comment • General comment
Prof. Dr. Amir Nawaz Chairperson Horticulture Department, BZU	• There is need to plant specific please	• General comment
Alishba Batool, Student, The Women University Multan	• Why general public have not been invited in the event?	• All the participants in the hearing were representing public. Advertisement was given in newspapers to invite public
Mr. Rifat Hayat Lodhi, Multan Industrial Estate	• There are not EQS for specific industries. • Nehr no bahar is so polluted there is issue of arsenic in drinking water. There are not proper dumping sites and segregations facility for solid waste	• Industry specific standards are being developed • General comment
Muhammad Umar, Deputy Director, Social Welfare Department, Khanewal	• There are 104 NGOs in Multan which may be collaborated in environmental awareness	• General comment
Mr. Mudassir Hussain, President NFC IET, Multan	• Why only 0.8 percent industry is compliant to PEQS for industrial effluents	• Comment noted. EPCCD is striving hard to strengthen environmental governance in the province
M. Atif Journalist	• Commented against the tree cutting and removal of vegetable covers for conversion of land into commercial and residential areas	• General comments

Annexure _ B

Component-wise data streams for State of Environment Report, 2023

Sub-Component	Data requirements	Coverage/Scope	Data sources
1. Assessment of ambient air, surface water and groundwater, and soil quality, as extracted from the available monitoring data			
Air Quality	Ambient Air Quality (AQI)	Districts with AQMS availability	• EPA Lab, Lahore • SUPARCO
	No. of patients reported for respiratory and cardio-vascular diseases	All over Punjab	Health Department
Water Quality	Surface water quality	---	• PCRWR • EPA Lab, Lahore
	Ground/drinking water quality	Divisional Headquarters/ as per availability of data	• WASA Gujranwala • WASA Multan • WASA Rawalpindi • WASA Lahore • WASA Faisalabad • EPA labs
	Status of aquifers and groundwater quality		Irrigation Department
	River and canal discharges		
Soil & Land	Soil monitoring from residential, agricultural and industrial areas	The sites sampled for SOE Report 2022	Experts/consultant
	Heavy metal contamination in the soil exposed to industrial wastewater	Divisional Headquarters	Experts/consultant
	Soil texture, organic matter and fertility	All over Punjab	Agriculture Department (extension wing)
	Land degradation	All over Punjab	Secondary data
2. Assessment of pollution sources that contributed to air, water, and soil pollution, including a summary inventory of pollutants, detailing time and intensity thereof			
Sources of Air Pollution	Industrial Stack Emissions	All over Punjab	EPA labs
Sources of water pollution	Industrial sources	All over Punjab	Directorate of (ML&I), EPA Punjab, EPA Labs
Sources of soil pollution	Industrial sources	Divisional Headquarters	Consultant
3. Assessment of environmental performance of wastewater treatment facilities and solid waste management facilities			
Effluent	Testing before and after treatment	All over Punjab	EPA Labs
Sludge & Emissions	Sludge and CH_4 testing	Divisional Headquarters	Consultant
Solid Waste (Municipal and Hospital waste)	Mapping of solid waste disposal facilities with capacity, waste generation, collection rates	All over Punjab	• LG&CD • WMCs
	Assessment of environmental performance based on air, leachate, soil analyses (for MSW) and ash and stack emissions (for incinerators)	Divisional Headquarters	Consultant (through EPA certified lab and PCSIR)
4. Suitable course of actions taken to control pollution and improve environmental quality			

Sub-Component	Data requirements	Coverage/Scope	Data sources
Regular operations of EPD Punjab and other departments for environmental protection and pollution control	• Actions taken under Sections 11, 12, 13 and 16 of PEPA 1997 • Other initiatives, policy instruments, regulatory reforms, institutional arrangement, etc. • ADP	All over Punjab	• EPA Punjab • Other Departments • SP&IU
5. Summary of environmental complaints received classified by type of environmental issue, as well as actions taken in respect thereof			
Complaints data	All types of complaints	-do-	EPA Punjab
6. Public feedback on the report and EPD's responses thereto			
			Public consultations in 3 different cities
7. Government of Punjab's environmental action plan for the calendar years			
• Review of progress of EAP given in SOE 2022 • Preparation of EAP 2023	As per stipulated actions	-do-	Role – players of Environmental action plan (SOE 2022)

Annexure _ C

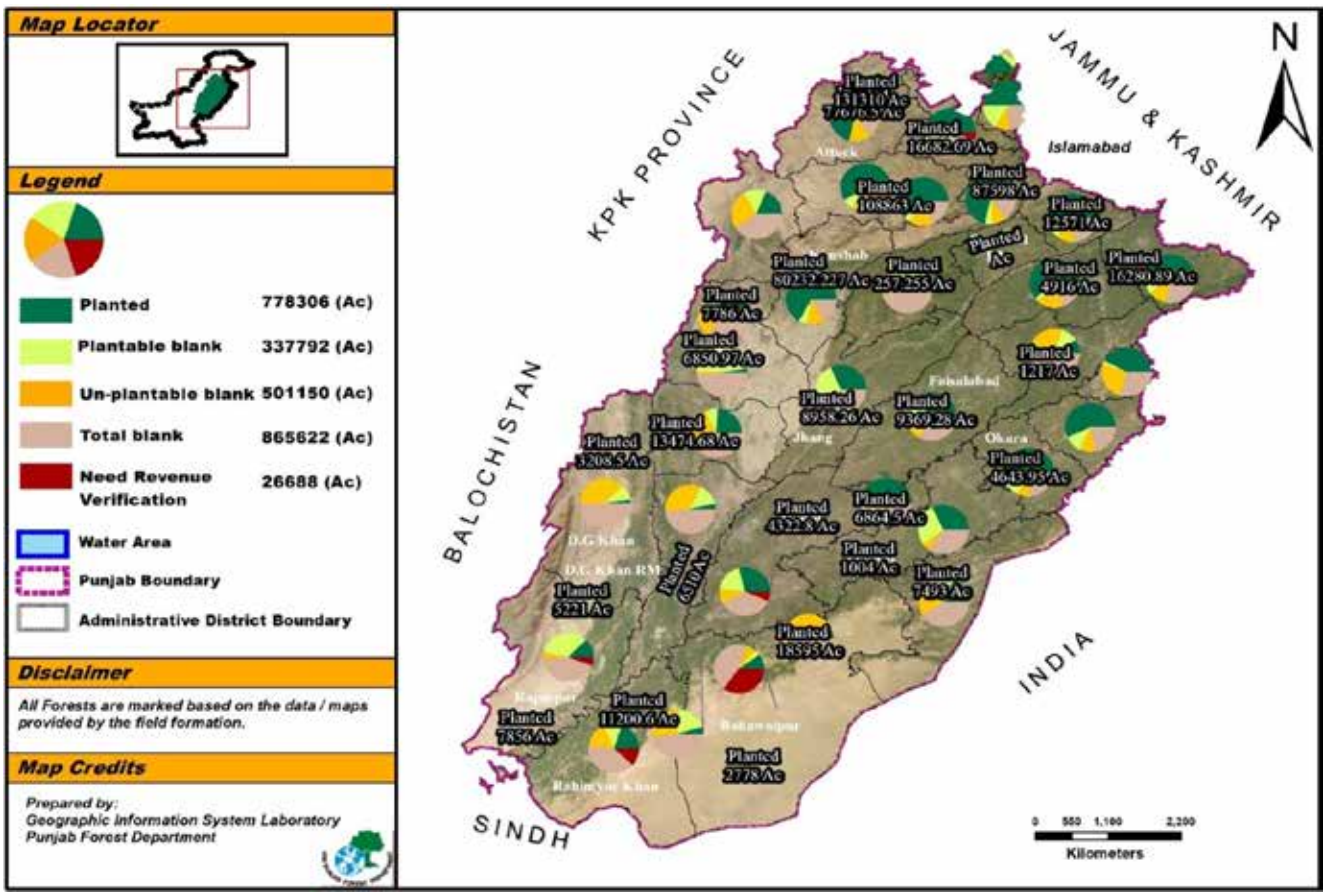


Figure C-1: Forest map of Punjab (2021)

Annexure _ D

SAMPLING PROCEDURES FOLLOWED FOR SOIL SAMPLING

A. Pre Sampling Protocol

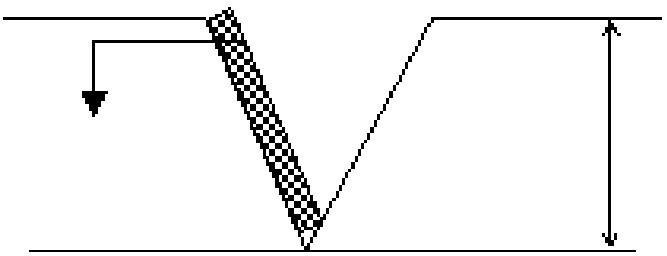
Following points were considered during the sampling of soil in the study area.

- Randomized (spatially well-distributed) samples, representative of urban area (including green belts, parks and household vicinities etc.) were collected
- Random homogenous grab soil samples were collected from the Industrial areas of the study area.
- For agricultural soil, sample were collected from the standing crop (between rows). Dead furrows, wet spots, areas near main bund, trees, manure heaps and irrigation channels were avoided while sampling.
- Soil samples were collected from land irrigated with treated and untreated industrial effluent from closed proximities of the study area.

B. Sampling Procedures

Following sampling procedures were opted during the soil sampling in the study area.

- Field was divided into different homogenous units based on the visual observation and farmer's experience.
- The surface litter was removed at the sampling spot.
- Auger was driven to a plough depth of 15 cm – 20 cm and the soil sample was drawn.
- 10 to 15 samples were collected from each sampling unit and were placed in a bucket or tray.
- Where the auger was not available, a 'V' shaped cut was made to a depth of 15 cm – 20 cm in the sampling spot using spade.
- Thick slices of soil were removed from top to bottom of exposed face of the 'V' shaped cut and placed in a clean container.



1 inch / 2.5 cm 6 inches (15 cm)

- The samples were thoroughly mixed and foreign materials like roots, stones, pebbles and gravels were removed.
- The bulk was removed to about half to one kilogram by quartering or compartmentalization.
- Quartering was done by dividing the thoroughly mixed sample into four equal parts. The two opposite quarters were discarded and the remaining two quarters were remixed and the process repeated until the desired sample size was obtained.
- Compartmentalization was done by uniformly spreading the soil over a clean hard surface and dividing into smaller compartments by drawing lines along and across the length and breadth. From each compartment a pinch of soil was collected. This process was repeated till the desired quantity of sample was obtained.
- Sample was collected in a clean cloth or polythene bag.
- The bag was labeled with information about name of the farmer, location of the farm, survey number, previous crop grown, present crop, crop to be grown in the next season, date of collection, name of the sampler etc.

C. Processing and Storage

All the standard protocols were observed during the lodging, processing and storage of collected samples in the study area.

D. Parameters monitored

The parameters of soil quality including pH, EC, As, Cd, Se, Hg, Zn, Mg, Fe, Pb, K, P, N and SAR, were analyzed according to the American Public Health Association protocols (***Table 6***).

The pH and EC were analyzed using the pH and EC meters, receptively by following the methods as described above. The heavy metals were determined using atomic absorption spectrophotometer. Potassium was determined using flame photometer while nitrogen was determined using Kjeldahl method in soil samples. Sodium absorption ratio was determined from the concentration of Ca, Mg and Na values by using the formula as given below (Eq. 2)

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \qquad (2)$$

Table-D1: Methods used for testing soil quality parameters

Sr. No.	Parameters	Unit	Method
1	pH	---	APHA 4500-H+ B
2	EC	µS/cm	APHA 2510B
3	Arsenic	mg/kg	APHA 3114 C
4	Cadmium	mg/kg	APHA 3500 D
5	Zinc	mg/kg	APHA 3500 B
6	Iron	mg/kg	APHA 3111 B
7	Lead	mg/kg	APHA 3111 B
8	Selenium	mg/kg	APHA3500
9	Mercury	mg/kg	APHA 3112 B
10	Potassium	mg/kg	APHA 3500 B
11	Magnesium	mg/kg	APHA 3111 B
12	Phosphorus	mg/kg	APHA4500-P
13	Nitrogen	mg/kg	APHA4500-N
14	SAR	mg/kg	IS 11624:1986 (RA 2009)

APHA = American Public Health Association

Table-D2: Summary of soil quality in the study area

City	Heavy metals (all soil types)		Urban	Industrial	Agriculture	Land Irrigated	Urban	Industrial	Agriculture	Land Irrigated	Urban	Industrial	Agriculture	Land Irrigated
	Hg	Se	Na (mg/kg) ± SE				Ca (mg/kg) ± SE				Mg (mg/kg) ± SE			
Faisalabad	ND	ND	785 ± 148	885 ± 258	1557± 283	951 ± 148	12.28 ± 0.7	11.3 ± 0.76	14.84 ± 0.65	21.22 ± 0.71	66 ± 7.17	29.33±12.81	43.33 ± 6.64	32.33 ± 6.36
Lahore	ND	ND	661 ± 236	1325±262	2451± 390	2428 ± 61	19.65±0.76	11.4 ± 0.83	19.75 ± 0.83	12.38 ± 0.82	41 ± 4.58	40 ± 9.07	33.33 ± 5.78	54.33 ± 6.64
Sahiwal	ND	ND	555 ± 86	1021± 153	1858 ± 69	2215 ± 60	20.1 ± 0.82	21.23±0.65	21.72 ± 1.22	16.8 ± 0.89	36 ± 9.17	26 ± 3	36.33 ± 6.69	53.67 ± 5.78
Bahawalpur	ND	ND	698 ± 116	954 ± 203	1654± 218	2128± 103	20.14±0.89	15.77±1.22	16.37 ± 0.64	11.49 ± 0.7	53.47 ± 2.11	52.55 ± 5.08	71.73 ± 2.93	58.67 ± 3.71
Multan	ND	ND	561 ± 85	822 ± 57	1625± 267	1917 ± 55	20.68±0.71	164± 1.8	20.2 ± 0.82	15.77 ± 1.22	43.66 ± 3.45	53 ± 6.11	68.33 ± 10.4	70 ± 11.93
DG Khan	ND	ND	851 ± 85	922 ± 173	1592± 243	2395± 217	15.77±1.08	12.28 ± 0.7	17.3 ± 0.88	20.68 ± 0.69	41.33 ± 0.68	52.33 ± 1.67	63.67 ± 2.4	63.33 ± 6.44
Rawalpindi	ND	ND	1621±351	588 ± 181	2265 ± 28	1785± 437	9.82 ± 1.14	11.94±0.83	10.47 ± 0.7	17.34 ± 0.76	69.33 ± 5.88	69.33 ± 7.69	67.67 ± 9.35	77.67±12.14
Gujranwala	ND	ND	1433±406	1250± 218	970 ± 162	1622± 336	11.89± 1.28	14.64±1.47	15.87 ± 1.14	20.78 ± 0.89	39 ± 3.12	27 ± 4.04	60 ± 7.02	52 ± 3.51
Sargodha	ND	ND	8791±131	8441 ± 19	6729± 186	8435 ± 22	16.8 ± 1.29	20.68±1.39	16.81 ± 1.22	17.39 ± 1.14	51.1 ± 5.2	36 ± 2.51	42 ± 6.36	39.12 ± 1.2

Annexure _ E

Study Area

District	Geographical Location	Total Area	Rivers	Common Soil Types	Climate
Lahore	Latitude: 31° 20 to 31° 50 N Longitude: 74° 05 to 74° 37 E	1,772 km^2	Ravi (North Side)	Silty clay loam, sandy loam, and clay loam	Semi-arid
Gujranwala	Latitude: 31° 51 to 32° 24 N Longitude: 73° 46 to 74° 30 E	3,622 km^2	Chenab	A blend of various soil types; Silty clay loam (67.7%), sandy loam (4.15%), sandy clay loam (13%), silty loam (9.41%) and loam (1.4%).	Semi-arid Summer temperature: 27-40˚C Winters: 5-19 ˚C Annual precipitation: 872 mm
Sahiwal	Latitude: 30° 02 to 30°40 N Longitude: 72° 20 to 73° 06 E	3,201 km^2	Sutlej and Ravi	Silt loam	Semi-arid (dry and hot) Summer temperature: 38-48°C Winters: 5-22 °C Annual precipitation: 150 to 300 mm
Multan	Latitude: 29° 22′ to 30° 45′ N Longitudes: 71° 04′ to 72° 04′ 55″ E	3,721 km^2	Built on a mound east of the Chenab River	Low, alluvial plains created by sediment deposits in the river	Summer temperature: up to 49°C Winters: Low as 1°C Annual precipitation: 127 mm
Faisalabad	Latitude: 30° 42 to 31° 47 N Longitude: 72° 40 to 73° 40 E	5,857 km^2	Chenab River (north) Ravi River (south)	Rich alluvial loess soils with calcareous properties	Semi-Arid (Hot, muggy summers and cool, dry winters)
Rawalpindi	Latitude: 33° 24 N Longitude: 72° 59 E	5,286 km^2	Soan and Koran	Loamy and clayey soils with varied fertility levels	Humid sub-tropical mean temperature: 21°C average precipitation: 1255 mm
Sargodha	Latitude: 31° 34′ N to 32° 36′ N Longitude: 72°10′ E to 73°18′ E	5,854 km^2	Jhelum	The alluvial soil deposited by Indus River and its off-shooting streams. (contains a moderate amount of sand, clay, gravel, and silt, collectively making up the alluvial formation)	Hot and semi-arid Average temperature: 24°C Annual precipitation: 410 mm
Bahawalpur	Latitude: 29° 22′ N Longitude: 71° 37′ E	24,830 km^2	Sutlej	sandy clay loam texture with 33% clay	Arid Harsh, with hot summers (48°C) and cold dry winters (7°C). Annual Precipitation: 150-200 mm
DG Khan	Latitude: 30° to 30° 05′ 28″ N Longitude: 73° 35′ 33″ to 73° 41′ 41″ E	11,922 km^2	Located in the floodplain of the Indus River	Rocky, sandstone with colours ranging from light grey to dark grey, fine to coarse grains, limonitic colouring in some areas	Arid Temperature: Cold-mild winters with average temperature of 13°C, hot summers with average temperature of 50°C Mean annual precipitation: 150 mm (primarily during July-August)

Following points were considered during the sampling of soil in the study area.

Category of Vehicles	CO	HC	CO+CO2	Noise Test	Smoke Density
Petrol Vehicles manufactured prior to 2014	6%	600ppm	12%	-	-
Diesel vehicles (20 or more than 20 years old)	-	-	-	-	60%
Stroke Petrol and CNG Emissions for Rickshaws and Motorcycles (2014)	6%	600ppm	-	-	-
New Petrol Vehicles Emission (2015-16)	4.5%	400ppm	12%	-	-
Stroke Petrol and CNG Emissions for Rickshaws and Motorcycles (2015-16)	6%	8000ppm	12%	-	-
Diesel vehicles (20 or more than 20 years old)	-	-	-	-	40%
Nosie Test	-	-	-	85db	-

Environmental Protection Agency
Government of the Punjab

Gate No. 8, National Hockey Stadium
Gaddafi Stadium, Ferozepur Road, Lahore