PUNJAB STATE OF THE ENVIRONMENT REPORT 2022






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DISCLAIMER

This “Punjab State of Environment Report, 2022” is published for the first time and is based on limited primary data. Therefore, a significant portion of the information relies on secondary sources. While every effort has been made to ensure accuracy, errors, and omissions are expected. Readers are advised to exercise caution and cross-reference information with additional reliable sources.

MESSAGE
SECRETARY, ENVIRONMENT

I am pleased to present Punjab's State of Environment (SOE) Report for the year 2022, marking a significant milestone in fulfilling one of the key responsibilities of the Environment Protection Agency (EPA) Punjab, as mandated by the Punjab Environmental Protection Act, 1997 (PEPA) under section 6(1)(d).

This report provides a comprehensive assessment of our local environment and covers a wide range of environmental indicators, including air and water quality, soil health, waste management, pollution control, and related plans and initiatives. At present, our region is grappling with a challenging environmental situation, characterized by imminent resource scarcity and associated issues such as health concerns, food security, mobility, and socioeconomic hardships. In this context, the report serves as a valuable tool, offering evidence-based insights into our environmental status and facilitating effective management and remedial actions. Through rigorous analysis of primary and secondary data, it highlights critical environmental challenges that demand immediate attention and proposes appropriate mitigation measures.

The report also outlines the noteworthy accomplishments of the Environment Protection Department (EPD). We have undertaken significant policy and regulatory reforms to support our goals, including the establishment of a Health Advisory System for critical air pollution events, and notification of Provincial Review of IEE/EIA Regulations, 2022, among others. Additionally, we have taken important steps to enhance environmental governance, such as anti-smog campaigns, establishment of the EPD Control Room, initation of deployment of real-time state-of-the-art air and water quality monitoring stations, and the creation of the Environmental Endowment Fund (EEF).

While the report highlights some encouraging findings, it also underscores areas of concern that require immediate attention. To achieve a more favourable outlook, it is imperative that we expedite the implementation of the actions outlined in the Environmental Action Plan.

Looking ahead, the department envisions regular publication of the future state of environment reports. By learning from the gaps identified in this report and undertaking appropriate interventions to address them, the EPD aims to progressively report an improved state of the environment in the province over time.

Dr. Sajid Mahmood Chauhan
Secretary to the Government of the Punjab
Environment Protection Department
June 8th, 2023

MESSAGE
DIRECTOR GENERAL, EPA

I am happy to share the first ever State of the Environment Report for the Punjab. I feel elevated on fulfilling a legal obligation which requires to prepare and publish State of the Environment Report under Section 6(1)(d) of the Punjab Environmental Protection Act 1997.

The Government of the Punjab is much sensitized of the challenges and long-lasting impacts of environmental degradation and is putting significant efforts to integrate the environmental aspects into all kinds of development interventions. There is a need to make more efforts to sensitize maximum population in order to ensure an all-inclusive environmental action in the province.

In this report, chapter one provides methodology for analysis and preparation of State of the Environment Report. The chapter two gives an account of ambient air quality in Lahore and snapshot of air quality in Divisional Headquarters of Punjab augmented by Satellite based monitoring of atmospheric trace gases and monitoring of industrial and vehicular emissions. The chapter three gives an insight into water quality, both ground and surface, along with monitoring of industrial liquid effluents. The chapter four and five deals with soil quality and its assessment and environmental performance of waste water treatment plant and solid waste management facilities. Chapter two to chapter four also contains the regulatory framework. Chapter six signifies the measures taken to control pollution and improve environmental quality. Chapter seven briefly descries the environment complaints redressal procedure and action taken. The stakeholder consultation and public feedback is also present at chapter eight. The Environmental Action Plan at chapter nine deals with the future interventions to be required for the next three years.

The publication of State of the Environment Report is one of the major steps to educate and aware major stakeholders about the current state of environmental factors in the province. This report is based on primary and secondary data and efforts have been made to provide holistic scenario about all important environmental components. Being first ever state of environment report, it may contain certain errors & omissions.

EPA Punjab looks forward for a regular publication of its State of the Environment Report in future and expects positive payback for making improvements in the next State of the Environment in upcoming years.

Zaheer Abbas
Director General
Environmental Protection Agency, Punjab
June 8th, 2023

ACKNOWLEDGEMENTS

We are pleased to announce the launch of the inaugural report on the state of the environment in Punjab. This report is the result of meticulous efforts by a dedicated team of technical experts with extensive field experience, drawing upon insights from institutional knowledge, stakeholder consultations, and public feedback.

The unwavering support and facilitation provided by the EPD and EPA throughout this endeavour have been indispensable. Without their constant assistance, the completion of this report would have been exceedingly challenging. We would like to express our profound appreciation for the continuous support and motivation provided by the Secretary, EPD. His encouragement has been instrumental in our success. This task would never be achievable without active participation of Director General, EPA. We are grateful to him for continuously guiding his staff for the timely completion of these tasks.

Additional Secretary of the EPD Samia Saleem led a committee to oversee the activities and ensure timely preparation and publication of the state of the environment report. Under her leadership and guidance, the committee, consisting of esteemed individuals such as Dr. Amir Farooq, Director (Planning and Coordination) of the EPA, Dr. Anber Raheel, Director (Environment Policy & Planning) of the Strategic Planning and Implementation Unit (SPIU), Noor Ahmad, Director (Monitoring Laboratory & Implementation), Farooq Alam, Deputy Director (Lab) of the EPA, Asim Rehman, Deputy Director (Environmental Planning Expert) of the SPIU, Ms. Azmat Naz, Deputy Director (Information and Services) of the EPA, Dr. Shazia Pervaiz, Deputy Director (Technical) of the EPA, and Ms. Ahad Khan, Deputy Program Manager (Program Coordination Unit-PGDP), of Planning & Development Board, worked tirelessly to ensure the successful completion of this task.

The administrative and technical support from Muhammad Tahir, Deputy Secretary (Technical) of the EPD, and Dr. Sana Bashir, Section Officer (Technical) of the EPD, was invaluable in the successful completion of this report. Furthermore, we also acknowledge the dedicated field officers of the EPA who made remarkable contributions by providing field-level data and information as needed.

We would also like to acknowledge the support provided by the SPIU team during the writing of the report. These include Ghulam Sughra, Deputy Director (Social Safeguard), Rabeya Yasmeen, Deputy Director (Environmental Policy Expert), Khurram Waqas Malik, Deputy Director (Environmental Economist) and Dr. Hassan Siddique, Deputy Director (Communication Specialist). The contribution of Mr. Shakir Abbas, Assistant Director (Geographic Information System), in preparing GIS maps and graphs, and further developing a database for data entry was exceptional. We extend our gratitude to the support staff, particularly Hafiz Umer Daraz (computer operator) and Muhammad Adnan Mushtaq (Office Secretary), for their valuable assistance in data entry and other tasks.

We would also like to acknowledge several key government departments who collaborated with us through consultations and the provision of data and analyses. We would like to express our gratitude to the Excise, Taxation & Narcotics Control Department, Industries, Commerce, Investment & Skills Development Department, and Irrigation Department of the Government of Punjab, as well as associated public sector entities including the Pakistan Meteorological Department (PMD), Pakistan Space and Upper Atmospheric Commission (SUPARCO), Pakistan Council of Research in Water Resources (PCRWR), Water and Sanitation Agency (WASA) Faisalabad, WASA Gujranwala, WASA Lahore, WASA Rawalpindi, The Urban Unit, and Ayub Agricultural Research Institute, Faisalabad, for their facilitation regarding data provision.

The SPIU, under the adept guidance of the Project Director, played an instrumental role in overseeing the effective completion of the State of Environment report. The Environmental Planning & Policy Cluster of the SPIU, led by Dr. Anber Raheel, Director (Environment Policy & Planning), devoted key resources to lead this endeavour professionally. Additionally, Asif Iqbal, Director (Admin Finance & Procurement), ensured the smooth provision of logistical support to the team.

This report would not have been possible without the concerted and gracious support of all the stakeholders mentioned above.

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ADP	Annual Development Program
AQI	Air Quality Index
AQMS	Air Quality Monitoring Stations
BOD5	Biological Oxygen Demand
BRBD	Bambawali-Ravi- Bedian Canal
BTK	Bull's Trench Technology
CGP	Clean Green Pakistan
COD	Chemical Oxygen Demand
CY	Calendar Year
DCAPEC	District Critical Air Pollution Events Committee
DHQ	Divisional Headquarter
DLI	Disbursement Linked Indicator
DPSIR	Drivers, Pressures, State, Impacts and Responses
EAs	Environmental Approvals
EC	Electrical Conductivity
EEA	European Environment Agency
EEF	Environment Endowment Fund
EIA	Environmental Impact Assessment
EMC	Environmental Monitoring Centre
EPA	Environment Protection Agency
EPC	Environmental Policy Centre
EPD	Environment Protection Department
ETC	Environmental Technology Centre
FAO	Food and Agriculture Organization
FIR	First Investigation Report
GAINS	Greenhouse gas air pollution interaction and synergies
GCISC	Global Change Impact Studies Centre
GHG	Greenhouse gases
GoP	Government of the Punjab
HAS-CAPEs	Health Advisory System for Critical Air Pollution Events
HQ	Head quarter
IEE	Initial Environmental Examination
IOD	Indian Ocean Dipole
LG & CD	Local Government & Community Development
LWMC	Lahore Waste Management Company
MAF	Million Acre Feet
MCs	Municipal Corporations
MEAs	Multilateral Environmental Agreements
MICS	Multiple Indicator Cluster Survey
MOCC	Ministry of Climate Change

MSW	Municipal Solid Waste
NASA	National Aeronautics and Space Administration
NTU	Nephelometric Turbidity Unit
PAD	Program Appraisal Document
PAK-EPA	Pakistan Environmental Protection Agency
PCRWR	Pakistan Council of Research in Water Resources
PDMA	Provincial Disaster Management Authority
PEPA	Pakistan Environmental Protection Act
PEPC	Punjab Environmental Protection Council
PEQS	Punjab Environment Quality Standards
PERI	Provincial Environmental Reference Lab
PET	Punjab Environmental Tribunal
PGDP	Punjab Green Development Program
PITB	Punjab Information Technology Board
PM	Particulate Matter
PMD	Pakistan Meteorological Department
PSDF	Punjab Sustainable Development Fund
RECP	Resource Efficient and Cleaner Production
ROF	Right of Way
SPIU	Strategic Planning & Implementation Unit
LWMC	Lahore Waste Management Company
GWMC	Gujranwala Waste Management Company
FWMC	Faisalabad Waste Management Company
SWMC	Sialkot Waste Management Company
BWMC	Bahawalpur Waste Management Company
MWMC	Multan Waste Management Company
RWMC	Rawalpindi Waste Management Company
TSS	Total Suspended Solid
TDS	Total Dissolved Solid
PEQS	Punjab Environmental Quality Standards
UC	Unburnt Carbon
SPM	Suspended Particulate Matter
CO	Carbon Monoxide
PM2.5	Particulate Matter 2.5
PM2.10	Particulate Matter 2.10
NO	Oxides of Nitrogen
CY	Calendar Year
HAS-CAPE	Health Advisory System for Critical Air Pollution Events
NGOs	Non-Government Organizations

EXECUTIVE SUMMARY

The Punjab State of Environment Report, 2022 is the first-ever report published in over 25 years. Publication of this report provides a comprehensive assessment of the conditions of various aspects of the environment such as air, water, soil, wastewater and solid waste management in Punjab. It aims to inform policymakers, stakeholders, and the general public about the environmental conditions, their implications for human well-being and deciding way forward in achieving Sustainable Development Goals. Population growth, rapid urbanization and industrialization in the Province are deteriorating the quality of air, water (surface and ground) and soil with heaps of solid waste accumulating in the megacities. The report highlights a number of environmental challenges viz; pollution abatement, halting land degradation and deforestation and tackling climate change that require immediate attention in Punjab.

In Punjab 56% of total geographical area is cultivated, which is mainly attributed to its rich, fertile alluvial soils and extensive irrigation system. Punjab is providing over 68% of the national annual yield of food grains and is known as the bread basket of Pakistan. Punjab has a great diversity of forest reserves, protected areas, biodiversity, rivers and canals network, alluvial plains, coal and mineral resources that make up significant contributions to the economy of Pakistan. The strategic location of the Province, its fertile agricultural land and its well-developed infrastructure make it the economic hub of the country.

Punjab is the most populous province in the country and therefore state of the environment in the province holds significant importance in deciding the economic growth of the country. Proliferating human population and the intensified demand for resource consumption and production have resulted in deteriorated environmental conditions in the Province. Punjab is facing the consequences of climate change at a faster pace. Over the past 30 years (1975–2005), the minimum temperature of Punjab has increased by 0.97°C and the maximum temperature by 1.14°C, putting it on the list of most vulnerable regions to climate change. Increased intensity of floods, droughts and heat waves are the direct outcomes of climate change and it is also making the national food security vulnerable. In 2022 Punjab experienced torrential rains and severe floods damaging over 438,000 acres of crops/orchards, 733,000 livestock and up to 50% of water systems. Cost of loss and damages from 2022 floods in Southern Punjab was estimated to be 566 and 515 million USD respectively. Water seepage from unlined canals has resulted in rise of water table in the vast irrigated plains causing the issues of waterlogging and soil salinity. The cost of degradation of Indus River basin is estimated to be over 216 million USD per year, with 50% from agricultural losses due to waterlogging and soil salinity and 50% from loss of ecological services of Delta.

Monitoring of the ambient air quality of the capital city Lahore in the year 2022 revealed that there were only 17 days of good or satisfactory AQI ($PM_{2.5}$) out of the total 309 monitored days. One-day monitoring of the other nine divisional headquarters during November and December shows moderate air quality with 5 out of 9 cities showing good/satisfactory AQI ($PM_{2.5}$) values. Long-term exposure to particulate matter puts serious health implications on public health such as exacerbation of respiratory infections, allergies, eye infections and cardiac diseases. The health costs and productivity slowdown of air pollution will continue to burden economic growth of the country. The rate of deaths attributable to air pollution (including indoor $PM_{2.5}$, and ozone) in Pakistan is also well above global averages. World Bank estimates Pakistan's annual burden of disease from outdoor air pollution to be responsible for around 22,000 premature adult deaths and 163,432 DALYs. Avoidable deaths attributed to ischemic heart disease and lung cancer in Pakistan accounts to over 2 million people and the total cost related to this mortality is 1 billion USD. WHO reports that the exceeding levels of air pollution have resulted in the loss of 5.3 and 4.8 years of life expectancy from 1998-2016 among populations of Lahore and Faisalabad cities, respectively. Strengthening of regulatory framework, enhanced air quality monitoring with apportionment studies, controlling industrial emissions by implementation of resource efficiency and cleaner production technologies and vehicular emissions by increasing public transportation, strengthening of vehicular inspection certification system, retiring excessively old vehicles, installation of catalytic converters/diesel particulate filter, adoption of

latest Euro Standards for vehicular emissions and vehicle manufacturing are required for the betterment of air quality.

Water scarcity and water pollution are the other key issues in the Province. Poor agricultural and industrial practices are leading to resource wastage thereby affecting per capita water availability. Over 90% of food production in the country comes from irrigated agriculture. In spite of having the world's largest contagious irrigation system in the Province, there is a gap between supply and demand and the deficit is covered by the supply from groundwater. Currently, over 75% of groundwater is supplied for irrigation purposes. The rapidly drying water resources are not only threat to the economy but also to the national food security. Due to high Arsenic (As) and coliform contamination the quality of shallow groundwater is 'poor' in Punjab but is ranked 'moderate' in case of deep groundwater. Drinking water quality at source is also ranked as 'moderate' because of the potential hazard of Arsenic contamination though the presence of E. coli is addressed by WASA through chlorination at source. Drinking water quality at distribution networks has high incidence of bacterial contamination in major cities of Punjab because of leakages from sewage pipelines indicating increase in disease burden resulting from waterborne infections. Drains in Punjab have the poorest water quality getting loads of domestic sewage and industrial effluents with high BOD, COD and heavy metal contents. Rivers have 'moderate' water quality for irrigation purposes as the drains containing highly polluted water end up in the rivers and factories are also directly discharging huge volumes of effluents in them thus affecting water quality. The released heavy metals can travel through the food chain and pose serious health impacts. Establishment of efficient monitoring system, enforcement of water and related environmental legislations, strong institutional mechanisms, treatment of wastewater, construction of more water infrastructure and revision of PEQS are required to sustainably manage our water resources. There is a dire need to construct underground storm/rain water recharge galleries in public as well as private establishments. Further, relevant authorities (like WASAs, municipal authorities) shall go for water metering for both domestic and industrial connections.

Punjab has rich, fertile alluvial soils with extensive irrigation systems making the land favorable for cultivation. More than half (56%) of the geographic area of Punjab is currently under cultivation. Human activities like disposal of solid waste, sewage and industrial discharges, leachate contamination from landfill sites, deposition of air pollutants in soil and unsustainable agricultural practices have greatly degraded the soil quality. Land degradation due to salinity, waterlogging and overgrazing are rendering lands unfit for cultivation purposes. About 6.3 million hectares of land in Pakistan is salt affected and over half of this lies in the Canal Command Area. Secondary salinization in Punjab is mostly due to seepage of water through unlined canals in the Indus plains causing a rise in water table thus resulting in waterlogged conditions and salinity. High salt concentration in irrigation water, accumulation of salt due to faulty irrigation practices, poor soil drainage are also among the main causes of secondary salinity in Punjab. The salts brought in by the rivers and their tributaries are estimated at 23 million tons (Mt) annually causing salts to build up in the soil over time. Economic impacts of such land degradation indicate an annual loss of over 2326 million USD in the Cotton-Wheat, Rice-Wheat and Mixed cropping regions of Punjab. The Forest Department, Government of the Punjab manages over 6 million rangelands. The rangelands are mostly located in Potwar, Thal and Cholistan regions. About 0.4 million farmers /grazers living in the vicinity of these rangelands are directly advantaged by grazing about 1.2 million animals. Overgrazing causes desertification of land due to loss of vegetation cover, trampling and soil compaction so these rangelands are managed on rotational basis.

The discharge of untreated wastewater and sewage disposal are leading to heavy metal contamination in soils. The soils in agricultural land irrigated with industrial wastewater contain significant levels of heavy metals that bio-accumulate in plants and travel in the food chain posing serious health threats to the consumers. Although the average value of heavy metals such as Chromium, Copper, Lead and Nickel in soils were within permissible limits,

however, the transfer of these metals from soil to the plants is significant due to biological magnification. The overall quality of various types of soils in Punjab in terms of salinity is rated as 'Good' (agriculture), 'Moderate' (urban), and 'Poor' (industrial). While the fertility status of all soil types are rated as 'Good' based on presence of essential micronutrients. Establishment of a continuous soil quality monitoring and reporting system, lining of the canals to prevent water seepage, research for the development of salt tolerant varieties and policy development and investment in the adoption of sustainable agricultural practices are required for maintaining soil quality.

There are 392 industrial wastewater treatment plants in Punjab comprising of primary (206), secondary (180), and tertiary (6) treatment facilities. The limited industrial wastewater treatment facilities are not only deteriorating the aquatic ecosystems but also hampering trade opportunities with many countries. Meeting international standards of trade require effective environmental management by the industrial units such as optimizing resource utilization and treating waste before their discharge from the industry. Moreover, performance efficiency of wastewater treatment facilities installed in various industrial sectors is very low with 'very poor' performance for sugar and paper mills. Whereas, performance is 'poor' for leather and tanning, power looms, foods, oil, fats and ghee and animal feed industries,

Punjab daily generates approximately 47,300 tons of solid waste. Municipal solid waste (MSW) management companies are operating in only seven districts of Punjab i.e. Lahore, Faisalabad, Multan, Rawalpindi, Gujranwala and Sialkot. There is a single environmentally approved landfill site in Punjab, based in Lakhodair area, District Lahore. In rest of the districts, the collected municipal waste is dumped at open sites without proper landfill. Lahore contributes most in waste generation of Punjab (29%) followed by Rawalpindi (10%), Multan, Kasur and Faisalabad (9% each), Gujranwala (6%), Sheikhupura (5%) and Sialkot (3%). Whereas, the rest of the 28 districts produce 21% of Punjab's waste. Inadequate solid waste management and disposal system prevailing in the province pose significant environmental and health risks arising from release of harmful pollutants during waste burning, seepage of leachate into the soil and underground water and vectors breeding at the unmanaged dumpsites in addition to the odour and other aesthetic issues. Leachate from open MSW dumpsites had Cadmium, Ammonia, Arsenic, Zinc, COD, BOD, TDS and TSS values higher than the PEQS for municipal and liquid industrial wastewater indicating it as a source for soil and underground water contamination. This necessitates the need for on-site leachate collection and treatment system in all the landfill/ dumpsites in Punjab. Hospitals with more than 20 beds generate about 2.8 tons of infectious waste per day while the incineration capacity is lower than the collection rate. District Kasur has both highest collection rate (27%) and the largest incineration capacity (30.2%) followed by Lahore, Faisalabad, Khanewal, Attock, Rawalpindi, Sargodha, Sheikhupura, Gujranwala, Multan, and Sahiwal. Strengthening monitoring and control frameworks, developing comprehensive legal framework and guidelines for wastewater and municipal solid waste management, identifying and implementing latest treatment technologies, improving collection efficiency, segregation of garbage at source, formalizing recycling and promoting the 5R's are some of the management interventions suggested for sustainable wastewater and MSW management.

An integrated effort by all the stakeholders including government departments, public and private sector and local communities can help in achieving environmental sustainability. EPD Punjab is taking several measures to prevent environmental degradation in the Province and to halt the adverse impacts. For example, EPD launched an anti-smog campaign in 2022 as a preventive measure to control air pollution levels. The campaign included many institutional arrangements, enforcement and monitoring based anti-smog activities. EPA inspected 2169 public and private hospitals to check the implementation of Punjab Hospital Waste Management Rules (2014). Subsequent to these inspections, around 832 hearing notices and 123 Environmental Protection Orders were issued to the non-compliance hospitals. A total of 705,650 trees were planted under the supervision of EPA field offices across Punjab in collaboration with multiple stakeholders. Environment Protection Department is executing

Punjab Green Development Program to strengthen environmental governance and promote green investments in the Province. Under this Program, a network of 30 Air Quality Monitoring Stations (AQMS) stations and 15 water quality monitoring stations will be installed across the Punjab with a central control room in Environmental Monitoring Centre located in Lahore. EPD Punjab got notified a Health Advisory System for Critical Air Pollution Events (HAS CAPEs) targeting vulnerable population groups. Also, the execution of project proposal for Establishment of Missing Environmental Quality Standards (EQS) and revision of existing Standards and development of industry-specific EQ standards initiated in year 2022.

The Punjab Environment Protection Act, 1997 provides a unique set of arrangements for the redressal of environmental complaints proactively across Punjab through a formalized established Grievance Redressal Mechanism. EPA receives complaints of different natures regarding various environmental issues and addresses them by taking corrective measures, lodging FIRs or by sealing polluting source units. EPA has received a total of 1091 complaints from 36 districts across Punjab in the year 2022, of which 63% complaints were resolved. Almost 47% of the complaints were related to air pollution showing public concerns towards clean air. This report has been prepared in consultation with key stakeholders (representatives from chambers of commerce, industrial associations, civil society organizations, media, academia and donors). Stakeholder sessions were conducted in two phases viz; one on the proposed contents of the report and another on the draft report. Findings of the consultation process have been incorporated in the report to the extent possible.

This report outlines area specific road map for future actions. This state of the environment report sets foundation for further actions and decision making regarding environmental sustainability and would act as the benchmark for future progress and improvements. The report would help EPD and other stakeholders to evaluate the effectiveness of different environmental initiatives and required interventions.

1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1. OVERVIEW

1.1 Mainstay for state of environment report

The Constitution of Pakistan provides every citizen the 'Right to Information' in all matters of public importance. After the 18th amendment, the subject of 'environment and ecology' has been devolved to provinces, giving rise to the emergence of provincial environmental laws. Pakistan Environmental Protection Act, 1997 was amended and adopted by the Government of Punjab in 2012. The Act ibid (Section 6) provides certain functions and powers to Environmental Protection Agency, Punjab, whereby the Agency has been entitled to publish an annual report on the state of Punjab's environment.

1.2 Purpose of report

Punjab's first State of Environment Report (2022) provides an insight on the prevailing environmental conditions and issues in the province, remedial measures taken by EPD and other relevant departments and the way forward for environmental protection and conservation. Though this report provides limited environmental data, it may be used as a baseline for preparation of upcoming reports. The regular publishing of state of environment reports of Punjab will enable the policy- and decision makers to keep abreast of environmental trends, leading to sustainable development planning.

1.3 Methodology

This Report comprises the following components:

I. Evaluation of air, surface water, groundwater and soil quality based on available monitoring data
II. Determination of pollution sources along with a list of pollutants and their intensity that add to air, water and soil pollution.
III. Evaluation 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 thereto
VII. Annual environmental action plan of the Punjab Government for the calendar years (CY).

The approaches and data streams used to meet the above-listed requirements have been tabulated in **(Annexure I).**

1.4 DPSIR Framework

Indicators of environmental quality and the effects of current and future policy decisions on the environment may be presented in form of DPSIR framework (Figure 1-1). This Framework has been used in sector 2,3,4 and 5 of this report. The DPSIR framework postulates a chain of causal links beginning with 'driving forces' (economic sectors, human activities) and progressing through 'pressures' (emissions, waste), 'states' (physical, chemical, and biological), 'impacts' (on ecosystems, human health and functions), and 'responses' (prioritization, target setting, indicators).

1.5 Limitations in Reporting

Publishing the Punjab's 1st State of Environment Report has been a challenging task. Although many limitations were faced during the process, some noteworthy limitations are briefed below:

KEY FINDINGS

Punjab, population-wise largest (residing 110 million people) and geographically the second largest province of Pakistan, (occupying 25.8% of the total land of Pakistan) is a land of five rivers, with a rich natural resource base.

Punjab has a great diversity of forest reserves, protected areas, biodiversity, rivers and canals network, alluvial plains, coal and mineral resources that make up significant contributions in the economy of Pakistan.

The quality of environment in Punjab is fast deteriorating. With a population density escalated from 183 persons/km^2 in 1972 to 536 persons/km^2, coupled with rapid industrialization and urbanization, the quality of air, water and soil is deteriorating, with the heaps of solid waste accumulating in mega cities. Pollution , land degradation, deforestation, declining biodiversity, and climate change are significant issues that demand urgent action.

Punjab comprises around 11% of forest area and 56% cultivated area of the country with around 15 million hectares of irrigated land.

Punjab is facing the consequences of climate change at a faster pace. Minimum temperature of Punjab has increased by 0.97°C and maximum temperatures by 1.14°C over the past 30 years (1975–2005). In 2022, an anomaly of 0.88°C in the annual area-averages mean temperature has been reported in Punjab, making it the sixth warmest year for the province.

The agricultural industry, which is responsible for providing jobs to 47% of the labor force is vulnerable to environmental and climate change risks including spread of pests and pathogens, pollution, excessive rainfall, high air temperature and other hazards.

In 2022, Punjab experienced fire incidents (in forests and factories), smog, heat-waves, torrential rains and severe floods. The Floods in southern Punjab damaged over 438,000 acres of crops/orchards, 733,000 livestock and up to 50% of water systems.

A timely and integrated management approach can turn the things around. The report highlights a number of serious environmental challenges that require immediate attention in Punjab. An integrated effort by all the stakeholders including government departments, public and private sector and local communities can help in achieving environmental sustainability.

a. Data Limitations: Limited data availability for year 2022 has remained a challenge throughout the process, however, efforts have been made to abridge the data gaps through some field surveys and the secondary data, adequately available for this and previous years, to raise the alarms on the fast-deteriorating environmental conditions of Punjab.
b. Heterogeneity of data: The environmental monitoring system in the public and private sectors of the province needs to be upgraded. Though, substantial information, based upon local studies and research works is available, the data is quite heterogeneous and scattered, with limited geographical scopes (covering only one or few districts of the Province).
c. Data acquisition: The cooperation and support extended by other government departments and organizations, in collecting the required information for the report was remarkable. However, the data was not available at hand. A formal channel had to be followed to acquire data from stakeholder departments, which resulted in time constraints for detailed data analyses.

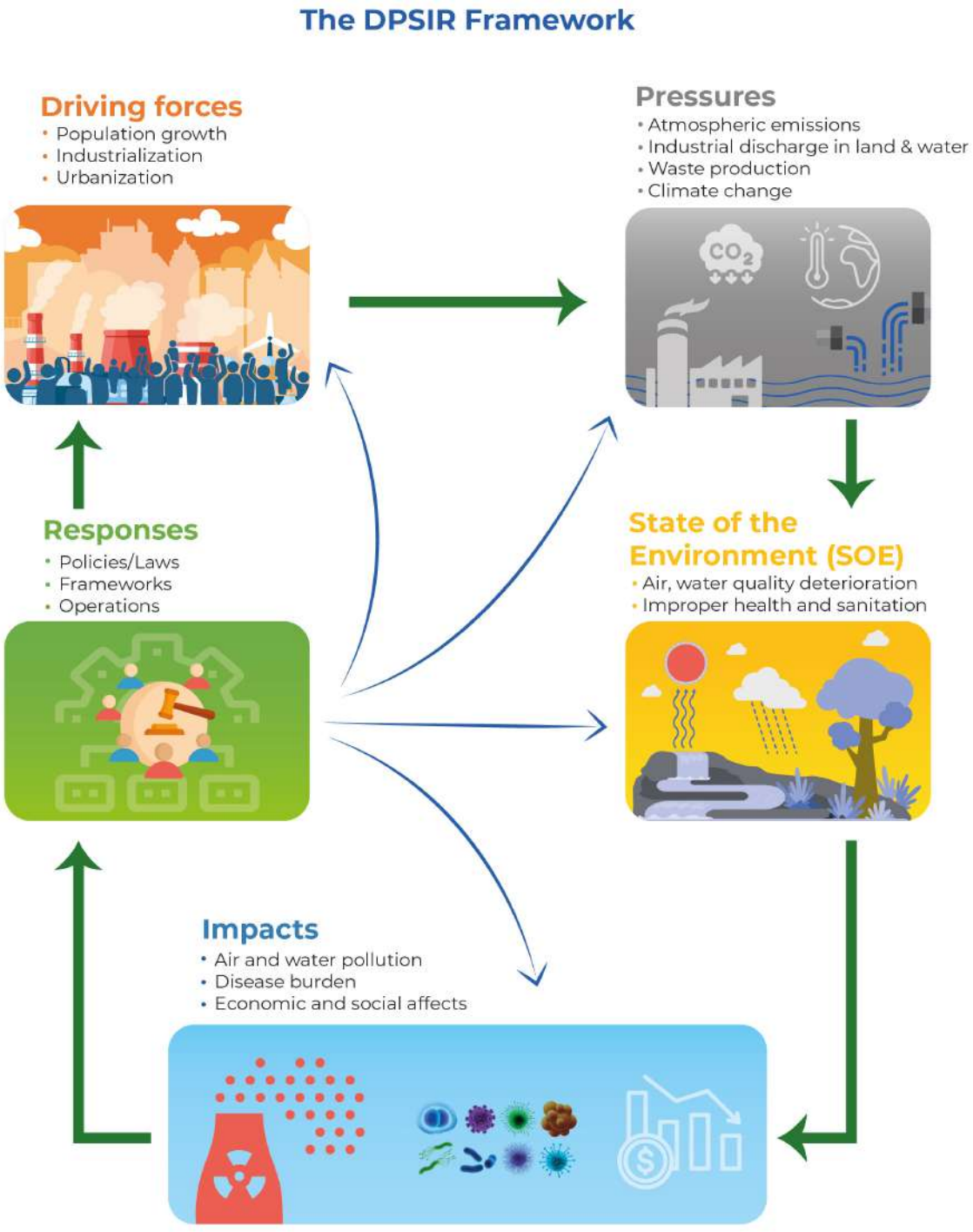


Figure 1-1: Components and working flow-sheet of DPSIR framework

2. ENVIRONMENT

2.1 Ecosystem services and human wellbeing

The services essential for the survival and well-being of humans, including 'health', are provided by a clean and healthy ecosystem. Ecosystems serve mankind in form of provisioning services (goods produced by ecosystem, like food and water), regulatory services (benefits obtained from regulation of ecosystem process, like disease and pest control), cultural services (non-material benefits from ecosystem, like spiritual and recreational benefits), and supporting services (necessary for production of other ecosystem services) like nutrient cycling that keep the life on Earth sustaining (Figure 1-2). The Indus River Basin, an ecosystem with its main stretches in Punjab, has served Pakistan from its mountains to the sea for over a period of 5000 years[2].

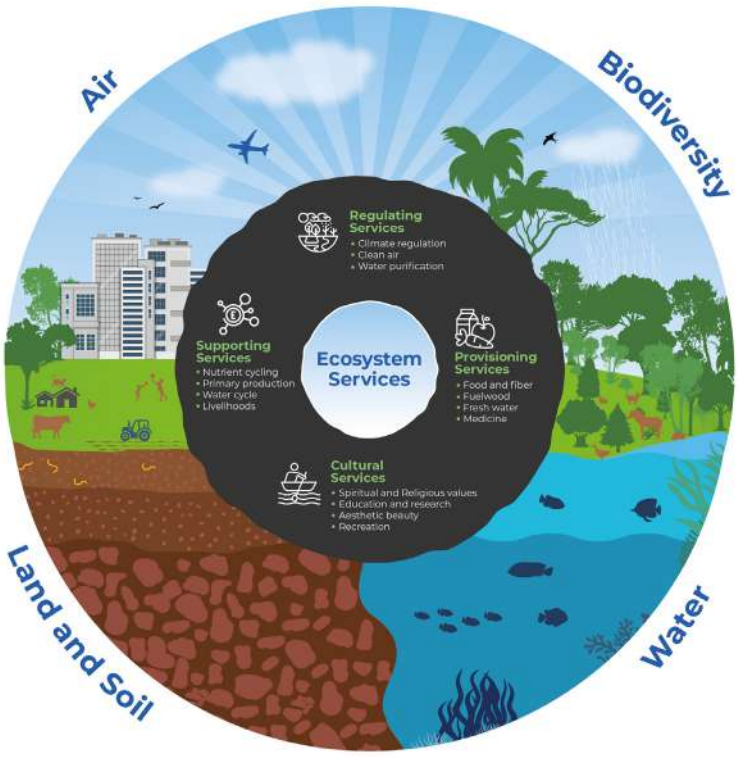
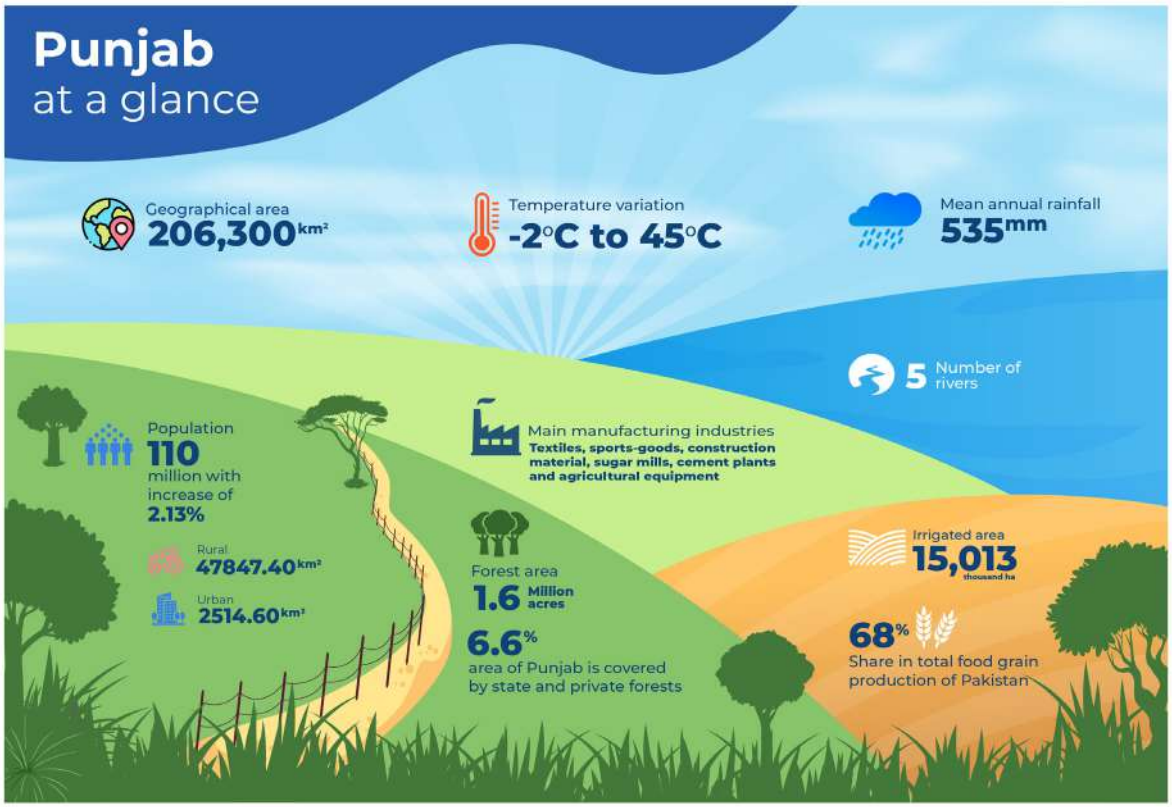


Figure 1-2: Ecosystem services for wellbeing of humans and other species

However, ecosystems' capacity to offer these essential services to all species is significantly hampered by the multiplicity of human activities. Increased pollution load in air and water ways (especially in the Indus tributaries), loss of biological diversity, land levelling and degradation to meet increasing housing and food demands, poor solid waste management and other anthropogenic activities in Punjab are resulting in disease burden, food insecurity, loss of recreation and aesthetic values and poor livability. The need to adopt sustainable and equitable practices for the wellbeing of both present and future generations is increasing with every passing day.

2.2 Punjab at a Glance



[2] The Living Indus Investing in Ecological Restoration, 2022 (UN & MoCC)

2.2.1 Geography and population

Geographically, Punjab is the second largest province after Baluchistan in terms of area (206,300 km)[23] roughly occupying 25.8% of the total land of Pakistan. Punjab is part of transnational Punjab region, divided among India and Pakistan. It has 09 divisions (Bahawalpur, Dera Ghazi Khan, Faisalabad, Gujranwala, Lahore, Multan, Rawalpindi, Sargodha and Sahiwal) and 36 districts. For each division, one district is entitled as 'divisional headquarter'. Punjab is the most populous state and is home to 109,989,655 population (about 110 million)[4] . Comparatively, Punjab has highest population growth rate than other provinces (Figure: 1-3)[5] . The population density of the province has increased from 183 persons/sq.km in 1972 to 536 persons/sq.km in 2017[6] .

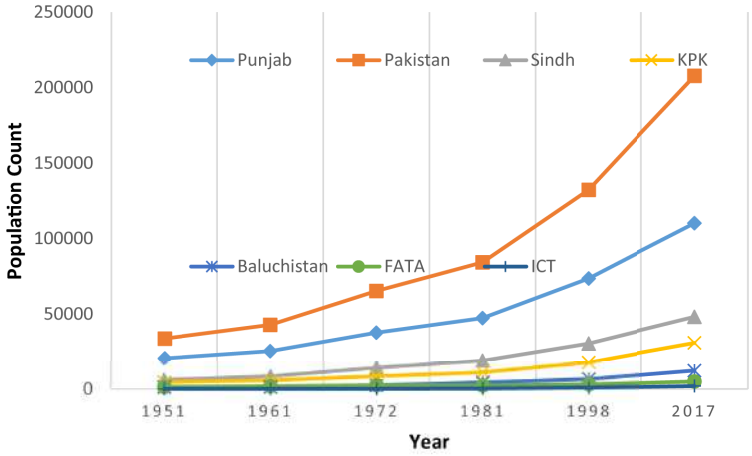


Figure 1-3: The trend of population growth in Pakistan

2.2.2 Topography and land use

The topography of Punjab is quite diverse and mostly consists of croplands as shown in Figure 1-4. The extreme South West and North West of Punjab have some hilly areas while in the South East it has a desert belt (i.e., Cholistan). Almost half of the area of the Punjab province is under agricultural land use. Water bodies comprise of 155.5 km^2, urban and built-up area comprises 3882.7 km^2, croplands comprise 115836.3 km^2 and barren land covers 34208.6 km^2 of total area of Punjab.

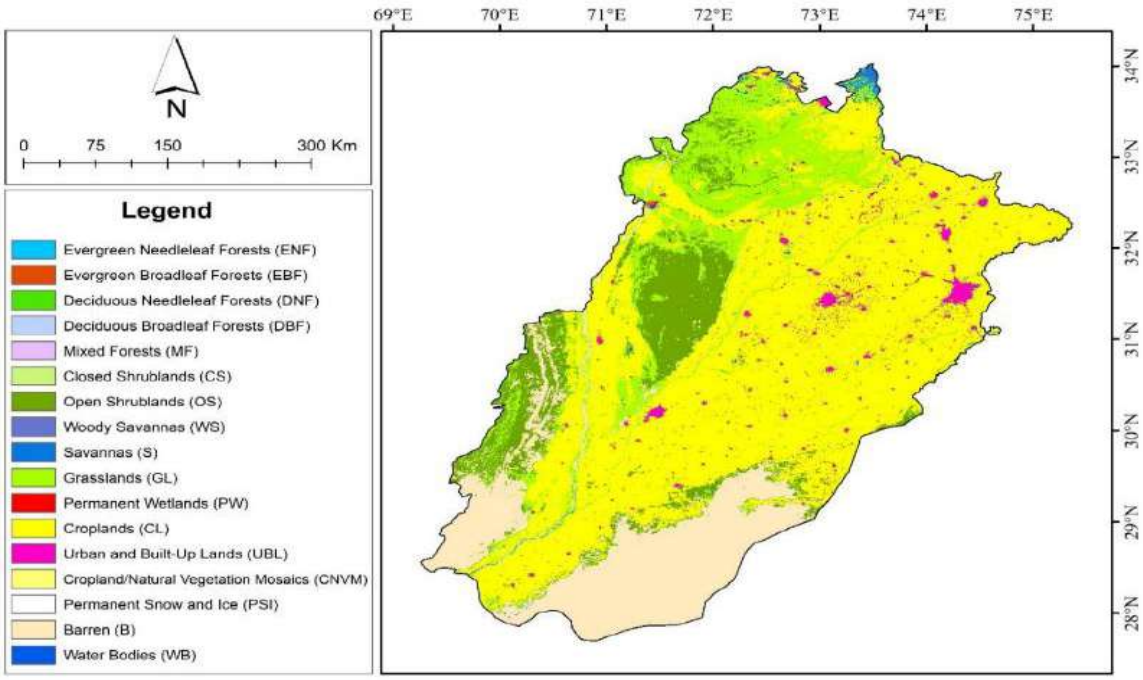


Figure 1-4: Land use Map of Punjab

(Source: Syed, A. et al., 2021.Assessment of Climate Variability among Seasonal Trends Using In-Situ Measurements: A Case Study of Punjab, Pakistan. Atmosphere 2021, 12(8), 939; https://doi.org/10.3390/atmos12080939)

[3] Statistical Pocket Book of the Punjab (2022), Punjab Bureau of Statistics (Page 51)
[4] Final Results of Punjab Population Census (2017), Punjab Bureau of Statistics
[5] Data Source: Statistical Pocket Book of the Punjab (2022), Punjab Bureau of Statistics (Page 313)
[6] Statistical Pocket Book of the Punjab (2022), Punjab Bureau of Statistics (Page 314-315)

The land use of Province has been divided into three categories; cropped area (total area cropped once or multiple times in a given year), cultivated area (the area sown with crops but only counted once) and non-cultivated area. The non-cultivated land area of the province is further classified into forest area, the land that cannot be used for agriculture and cultivable waste land. Punjab comprises around 0.49 mha of forest area, 2.97 mha area not available for cultivation, 1.52 mha cultivable waste land, 12.52 mha cultivated area, 10.63 mha net area sown (area that is sowl atleast once in a year) and 16.52 mha cropped area of the country[7] (Figure 1-5).

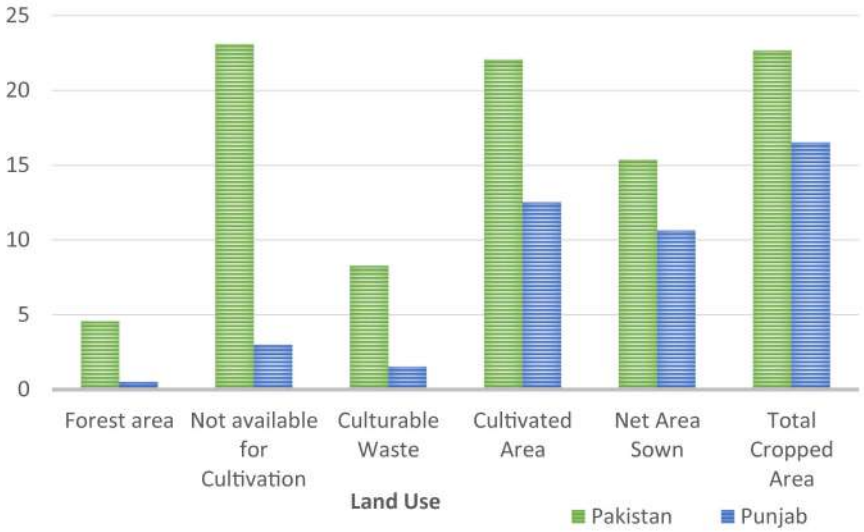


Figure 1-5: Land-use in Punjab in comparison with Pakistan (in million Hectares)

2.2.3 Irrigation system

With 15 million hectares of irrigated land, Punjab is endowed with greatest natural drainage system[8] . Its irrigation system is based on Indus Bain, consisting of several tributaries, seasonal streams and five permanent rivers (Ravie, Beas, Satlej, Chenab, Jhelum), meeting River Indus at Panjnad[9] . In every division, irrigated area outnumbers the non-irrigated land by a greater proportion (Figure 1-6).

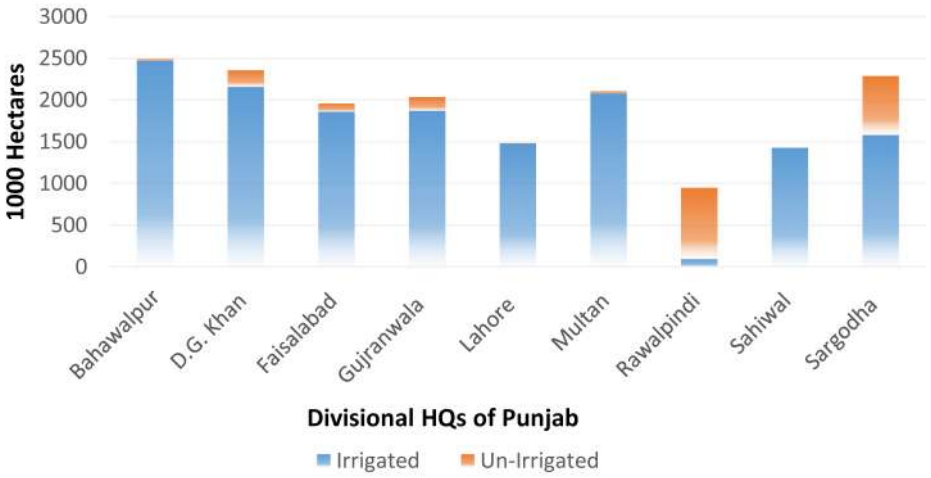


Figure 1-6: Irrigated and Un-irrigated Land in Punjab (Thousand Hectares)

However, the Indus Basin has undergone disturbances in its hydrological balance due to the induction of a vast irrigation system in an area of flat topography and limited drainage. With the continuous extension of the canal irrigation system, blocked drainage, water-recharge from unlined canals and seepage of water from irrigated fields, the water table in the vast irrigated plains of Punjab has raised up to 1.5 m of the soil surface causing the issues of waterlogging and soil salinity[10].

The Living Indus Report 2022 has revealed disappointing facts about degradation of Indus Basin, reporting that it has shrunk by 92% over past two centuries causing a loss of 4% to country's GDP on average. The cost of degradation of Indus River basin has estimated to be over 2.00 Billion USD per year, with 50% from agricultural losses due to waterlogging and soil salinity; and 50% from loss of ecological services of Delta[11].

[7] Land Utilization Statistics, Pakistan Bureau of Statistics

[8] Statistical Pocket Book of the Punjab (2022), Punjab Bureau of Statistics (Page 68)

[9] Landcover Atlas Of Pakistan_ The Punjab Province, A Joint Publication By FAO, SUPARCO And Crop Reporting Service, Government Of The Punjab

[10] Qureshi, A.S.;McCornick, P.G. and Qadir, M.; 2008, Managing salinity and waterlogging in the Indus Basin of Pakistan, Agricultural Water Management 95(1):1-10 DOI:10.1016/j.agwat.2007.09.014

2.2.4 Agriculture, forests and wildlife

Punjab, known as the 'breadbasket' of Pakistan is mainly agrarian providing 68% of the national annual yield of food grains [12]. The cash crops that make up a significant proportion of national income are cotton and rice. The Punjab, not only has agricultural land but also has a cover of green and dry forests. Protected forests, reserved forests, and unclassed forests are the main forest categories of Punjab. Among the reserved forests, 67% fall in the Rawalpindi division (Northern Punjab)[13] (Figure 1-7).

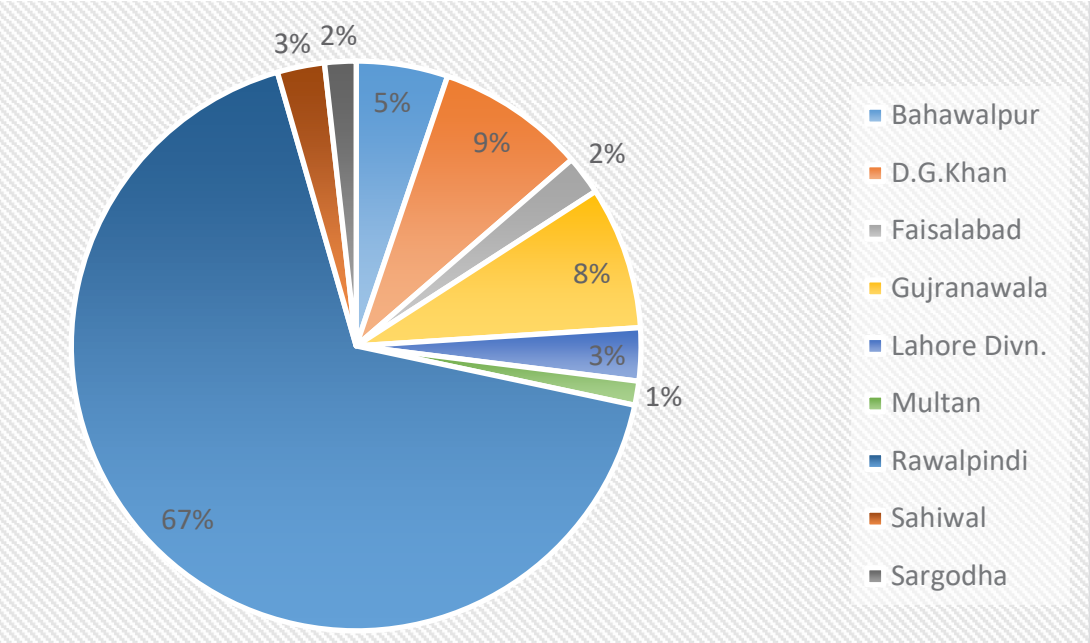


Figure 1-7 Division wise distribution of Reserved Forest area (%) in Punjab

The province has a wide variety of dryland forests, including Subtropical dry scrub forest (Olea cuspidata and Acacia modesta), Tropical dry thorn forest (flood plain and desert) dominated by Salvadora oleoides, Prosopis cineraria and Tamarix aphylla and Capparis decidua as sub-climax species, Tropical dry Broadleaved forest with a dominant cover of Butea monosperma and Subtropical Pine Forests dominated by chirpine (Pinus roxburghii). These forests are found in the Subtropical sub-Himalayan and temperate regions to the south of tropical Indus plains (Figure 1-8)[14].

It has been reported that during 2001 to 2021, Punjab has experienced a loss of 88ha of tree cover due to fires and 347ha from all other drivers of tree cover-loss. Maximum loss of tree cover resulting from fires (over 31 hectares of land) was reported in 2009[15]. Among other factors of loss in forest cover, conversion of forests into agricultural lands is also evident in Punjab. For instance, the tropical desert thorn forest located in Thal region of Punjab is rapidly being converted for agricultural purposes[16].

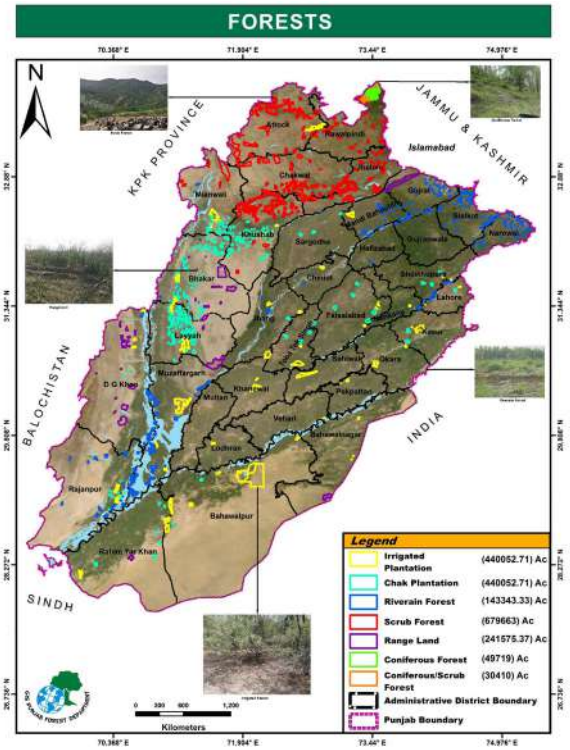


Figure 1-8: Map of forested areas in the Punjab province

[11] The Living Indus Investing in Ecological Restoration, 2022 (UN & MoCC)

[12] http://punjab.gov.pk/about_punjab_economy

[13] Statistical Pocket Book of the Punjab (2022), Punjab Bureau of Statistics (Page 216)

[14] Pakistan Climate Risk Country Profile, 2021, The World Bank.

[15] Global Forest Watch (https://www.globalforestwatch.org/dashboards/country/PAK/)

[16] Gratzfeld, J. and Khan, A. U. (2015). Dry Woodlands in Pakistan's Punjab Province – Piloting restoration of unique yet vanishing natural assets. Botanic Gardens Conservation International. Richmond, UK.

The diverse topography of Punjab, ranging from gigantic Himalayas to grazing pastures and deserts, provide habitats for a large diversity of flora and fauna. Over 80 species of mammals and reptiles and around 500 species of birds have been reported in the province. Mammalian species include jungle cat, jackal, Indian gerbil, fruit bat, palm squirrel, mongoose, white hare, wild boar and field mouse, whereas famous reptiles are including; viper, Varanus, Uromastic, krait, and cobra. It has been reported that 11 bird species and 6 mammal species have been nominated as vulnerable as per IUCN Red list, with habitat loss being the major cause of vulnerability[17].

In context of wildlife conservation, a network of institutions have been established throughout the Province (Figure 1 9).

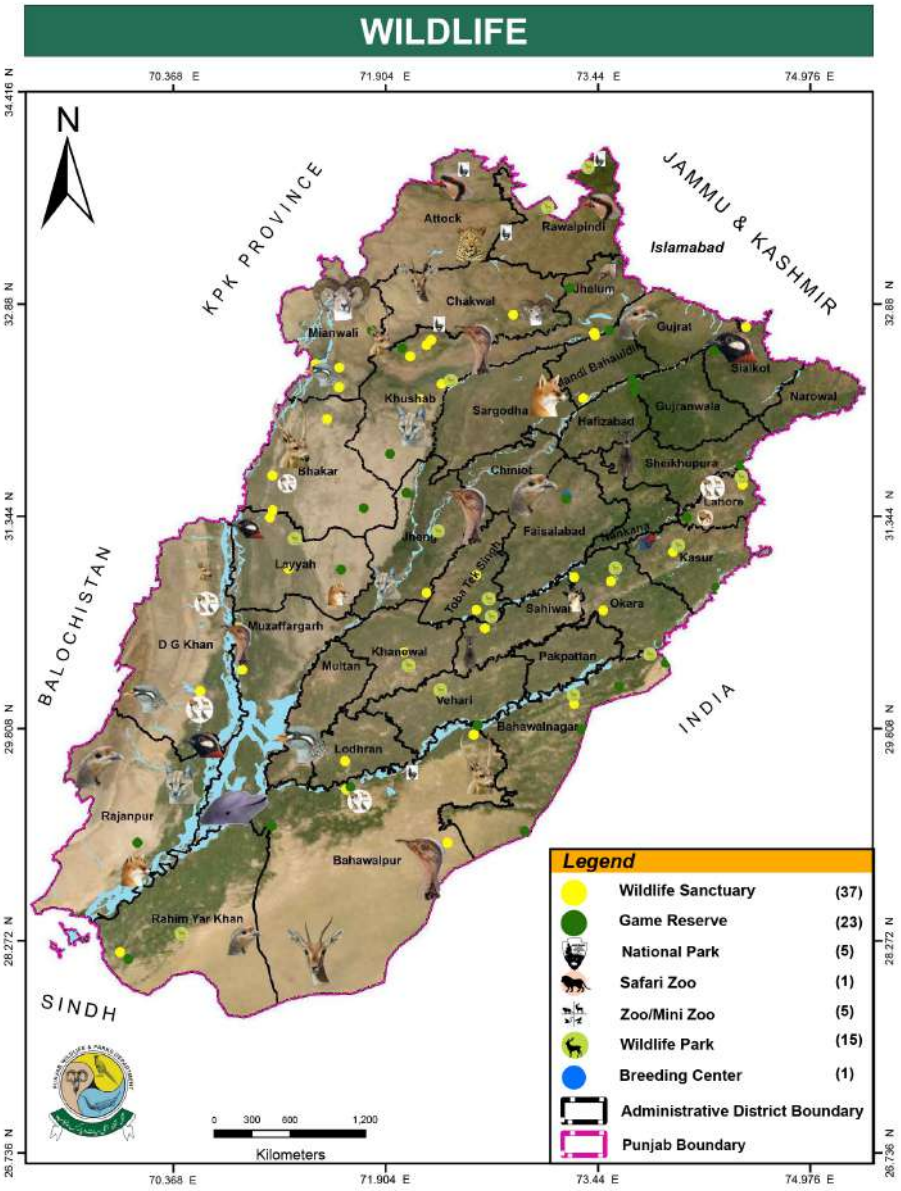


Figure 1-9 Wildlife Conservation Facilities in Punjab Pakistan

2.2.5 Industry and economic hubs

Punjab has diverse range of manufacturing industries including textiles, sports goods, heavy machinery, electrical appliances, surgical instruments, building materials, automobiles, metals and autoparts, sugar mills, cement plants, agricultural equipment, auto-rickshaws, floor coverings, processed foods, etc. The Urban Unit's System of Cities Model, which is a continuation of the Punjab Spatial Strategy (2017-2047), classifies economic hotspots in the province according to the population. One "Mega hub" (Lahore) and eight "divisional headquarter hubs" (sometimes called "hubs"), as well as eight "regional hubs," have been classified in Punjab. These hubs link to the neighbouring smaller cities to support a number of economic activities, including the transportation of goods, the provision of healthcare facilities and social services, and contributions to regional supply chains. Each hub forms a ‘cluster’ after connecting with the neigbouring cities[18] (Figure 1-10).

[17] Punjab Spatial Strategy (2017-2047)

[18] System Of Cities, The Urban Unit, Punjab.

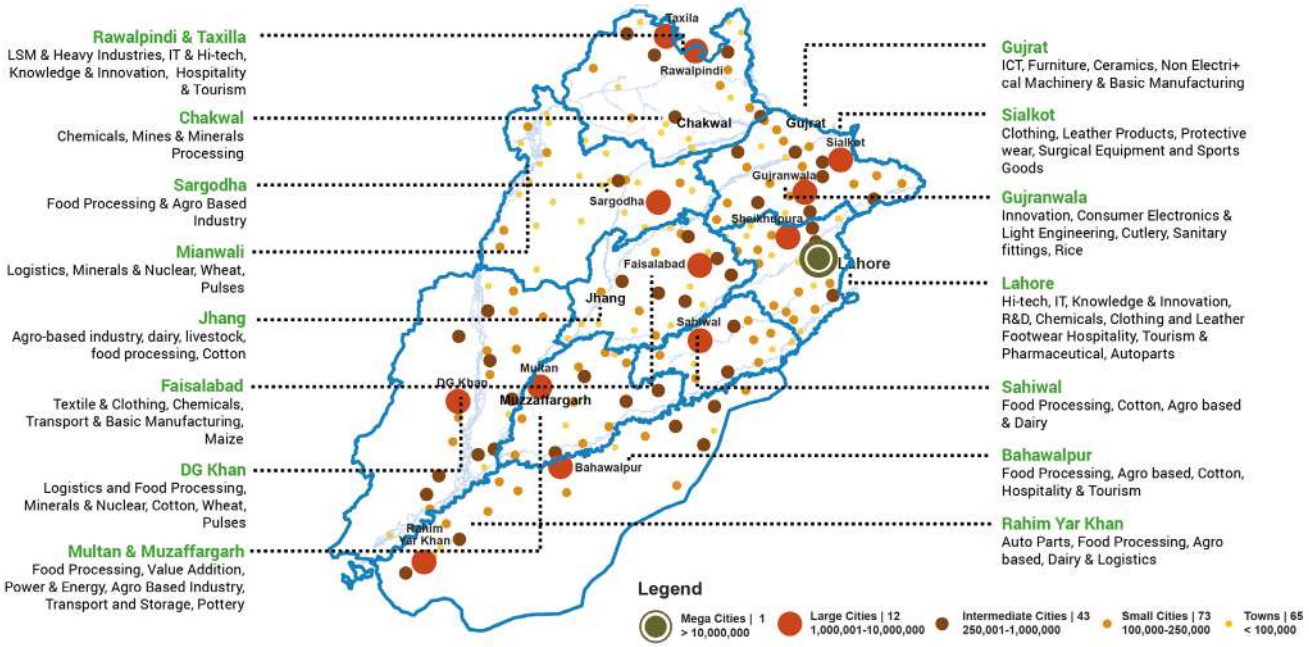


Figure 1-10: Industry and Economic Hubs of the province Punjab

The large-scale industries are clustered in mega urban centers in Punjab, particularly affecting the environmental quality in these cities, whereas the small-scale industry is scattered in the province evenly. Such spatial concentration of industries, coupled with unplanned land-use is aggravating the pollution, as well as the burden on local natural resources, especially on the water[19]. The major industries contributing to pollution are cement manufacturing plants, fertilizer plants, textile industries, sugar industries and power plants.[20]

2.2.6 Mineral profile

Punjab is known for rich mineral resource base comprising of argillaceous clay, bauxite, bentonite, construction aggregate, calcite, celestite, chalk, kaolin, coal, dolomite, refractory clay, fuller's earth, gypsum, iron ore, laterite, limestone, halite, and silica sand. The Salt Range harbors extensive reserves of sub-bituminous coal. The coal reserves are available in district Attock, Jhelum, Chakwal, Khushab, and Mianwali. The soil composition prevalent in the foothills is typically characterized by a mixture of sand and gravel. Pure deposits of sand enrich the banks of waterways (rivers and streams). Pure sand can be found at a depth of 4 to 5 feet (below crust) in the channels of old rivers. Punjab's fertile soil is rich in iron ores. The Kalabagh iron ore deposits are the largest known reserves in Pakistan, located in the District Mianwali within the Surghar Range and near the Sakesar, Salt Range[21]. No resource extraction is without its environmental implications in terms of air pollution, soil erosion and contamination of surface and groundwater resources. The mining activities also negatively affect the ecology of the area.[22]

2.2.7 Climate change

The climate of Punjab province exhibits a range of characteristics, from semi-arid to arid in the southern regions to cool and humid in the northern areas (north to the Salt Range). The topography of the province is predominantly characterized by low-lying terrain, minimum high-altitude regions are situated in the northernmost areas. This kind of topography makes the province warmer. The Province experiences temperature fluctuations ranging from minimum-2°C to maximum 45°C, occasionally reaching the extreme high of 50°C. Punjab is located at the western edge of the tropical monsoon zone, which is characterized by the influx of summer precipitation resulting from winds originating in the Bay of Bengal. Additionally, it marks the eastern boundary of western depressions, which are winter storm systems that originate over the Mediterranean Sea.

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[19] Sustainable Industrial Development in Punjab, The World Bank, 2019.
(https://openknowledge.worldbank.org/server/api/core/bitstreams/f8054741-7eaa-5983-a459 cf54083111b3/content)

[20] Punjab Spatial Strategy (2017-2047)Technical Paper 10 Environment Protection and Conservation, The Urban Unit

[21]Mines & Minerals Department, Government of the Punjab

[22] Jabbar Khan A, Akhter G, Gabriel HF, Shahid M. Anthropogenic Effects of Coal Mining on Ecological Resources of the Central Indus Basin, Pakistan. International Journal of Environmental Research and Public Health. 2020; 17(4):1255. https://doi.org/10.3390/ijerph17041255

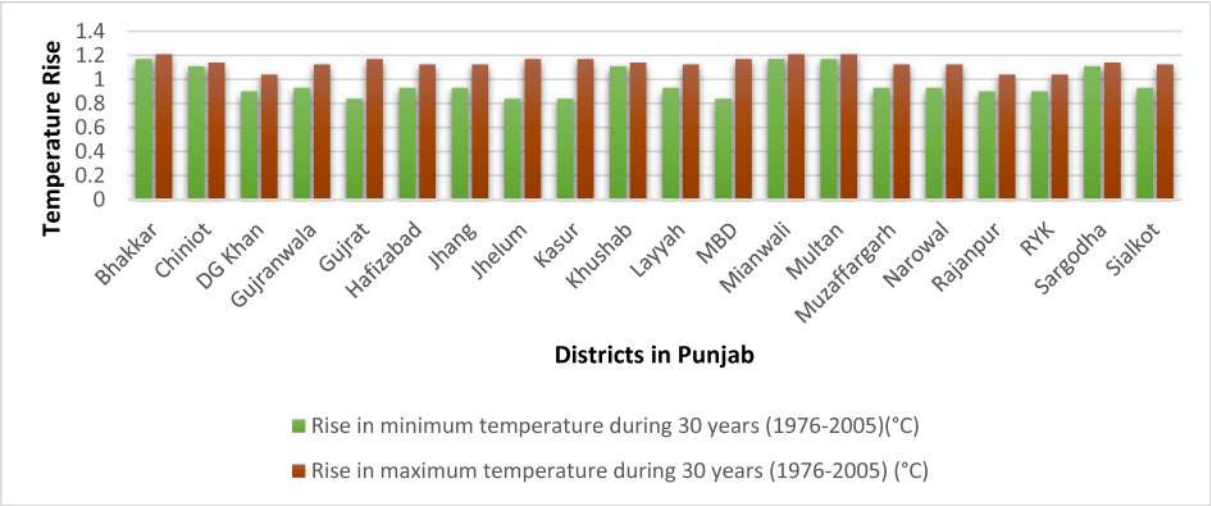


Figure 1-11: Average rise in minimum and maximum temperatures (1975-2005)

The Provincial Disaster Management Authority (PDMA) of Punjab reports that minimum temperature of Punjab has increased by 0.97°C and maximum temperatures by 1.14°C over the last 30 years (1975–2005) as indicated in Figure 1-11[23]. In 2022, an anomaly of 0.88°C in the annual area-averaged mean temperature has been reported in Punjab, making it the sixth warmest year for the province[24].

Punjab Bureau of Statistics confirms the rising trend of rainfall in many areas of the Province (Figure 1-12). As reported by Pakistan Meteorological Department, during the monsoon season of 2022, Punjab experienced a precipitation level that was significantly higher than the average, with an increase of 70%[25].

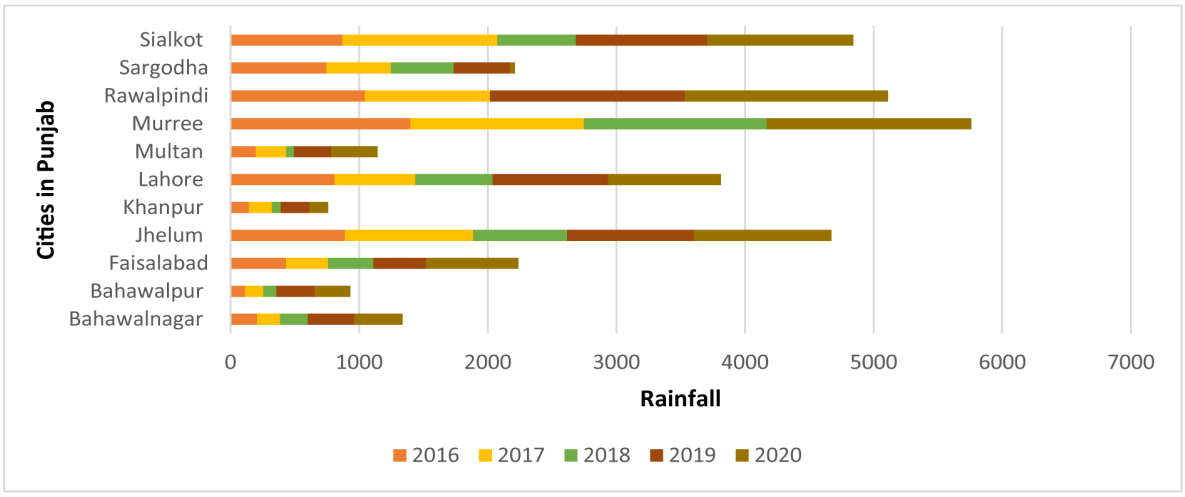


Figure 1-12: Rainfall Trends in Punjab (2016-2020)

In Punjab, climate change has its manifestations in the form of accelerated frequency and intensity of riverine, flash & urban flooding, droughts and heatwaves, with multiplex secondary impacts on all sensitive sectors, including, but not limited to the water resources, agriculture, health and ecosystems. District level climate risk and hazard assessment classification indicates that Rahim Yar Khan, Multan, Gujranwala, Muzaffargarh, Gujrat, Sialkot, Narowal, Jhang, Dera Ghazi Khan and Layyah are most vulnerable to the risks of flooding[26].

Southern region of the province has faced the catastrophic floods in 2010 causing the damages of 219 billion PKR[27], in 2014 affecting more than 10 million acres of agricultural land in Districts Jhang and Muzaffargarh[28] and in 2022 damaging over 438,000 acres of crops/orchards, 733,000 livestock and up to 50% of water systems[29]. Cost of loss and damages from 2022 floods in Southern Punjab was 566 and 515 Million USD respectively[30].

[23] Multi-Hazard and Vulnerability Assessment (MHVRA) Reports, PDMA, Punjab

[24] State of Pakistan Climate in 2022. Pakistan Meteorological Department (2022)

[25] Monsson Report (2022), Pakistan Meteorological Department

[26] Zaman, Q. 2017.Climate Change Profile of Pakistan. Asian Development Bank. Manila, Philippines.

[27] Pakistan Flood Impact Assessment, Economic Survey, 2010-11

[28] Ghani, R. et al (2017) , Socio-economic Damages caused by the 2014 Flood in Punjab Province, Pakistan Academy of Sciences

[29] Situation Report No. 4, 2022 (UN-OCHA)

[30] Pakistan Floods 2022, Post Disaster Needs Assessment, Ministry of planning and Special Initiatives, Government of Pakistan.

A list of major environmental events of Punjab is presented in Figure 1-13. Weather Trends in Punjab during 2022 are provided in Annexures II and III.

Figure 1-13 Timeline of major environmental events in Punjab province during 2022

3. MANAGEMENT

3.1 Strengthening institutional capacities and adopting an integrated approach to environmental management

Governments, businesses, communities and individuals should all show their commitment to social and environmental responsibility through the decisions they make. Policy development, regulation enforcement, strengthening institutional capacities, environmentally responsible investments, developing innovative solutions along with community involvement, education and awareness are the key actions required to be taken for environmental protection (Figure 1-14).

Six natural resource systems and the results we want to achieve for each of them may help us frame our responsibilities as people and members of our communities.

i. Air: Sustain clean and healthy air
ii. Ecosystems: Protect and restore ecosystems functions, goods, and services
iii. Energy: Generate clean energy and use it efficiently
iv. Land: Support ecologically sensitive land management and development

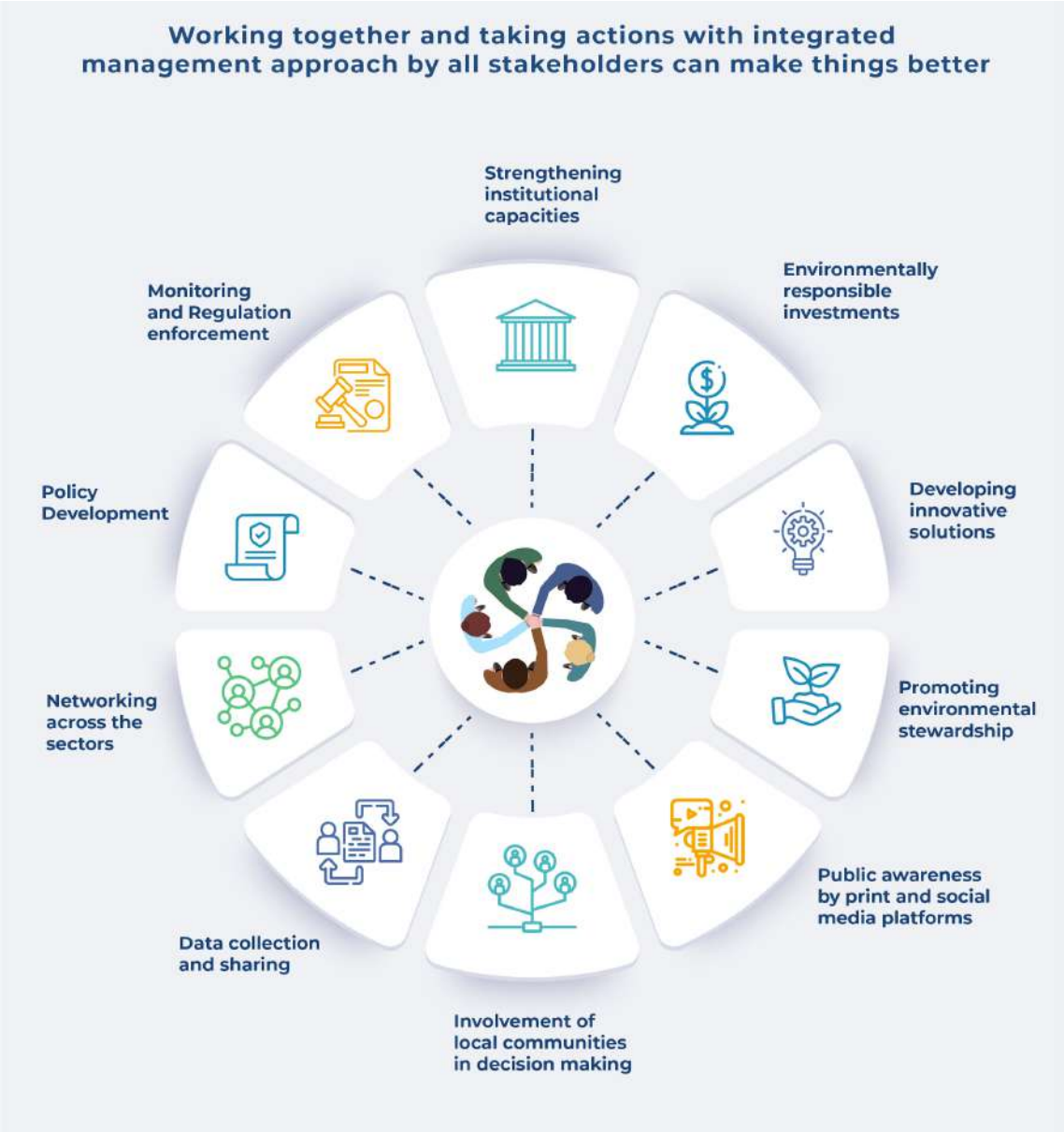


Figure 1-14: Need for adopting an integrated management approach to solve environmental issues

3.2 Context to protect Punjab's environment

On October 8, 2021, Resolution 48/13 was enacted by the Human Rights Council, guaranteeing everyone the right to live in healthy, clean and sustainable environment. Therefore, safeguarding this basic human right must be a top priority. Punjab is the most populated province in Pakistan; thus, it is especially important that it takes measures to preserve its natural environment and the natural resources upon which its economy depends. According to the Punjab Social Protection Policy for 2022, a large percentage of the population in the province is at or below the poverty line. The agricultural industry, which is responsible for providing jobs for 47% of the labor force[31], is vulnerable to environmental and climate change risks, including crop diseases, pollution, excessive rainfall, high air temperature, and other hazards[32]. To safeguard and conserve the environment, policymakers and communities from all walks of life must be kept abreast of environmental conditions and trends.

4. ENVIRONMENTAL QUALITY ASSESSMENT

The role of Environmental Monitoring and Assessment becomes crucial for taking action to improve the environment. It's the process of analyzing data from Environmental Quality Monitoring to determine what can be done to lessen pollution in the air, water, and soil. Figure 1-15 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.

[31] Punjab agriculture profile (https://www.agripunjab.gov.pk/system/files/Punjab%20Agriculture%20Profile.pdf)

[32] Ahmad, D., Afzal, M. Flood hazards and factors influencing household flood perception and mitigation strategies in Pakistan. Environ Sci Pollut Res 27, 15375–15387 (2020). https://doi.org/10.1007/s11356-020-08057-z

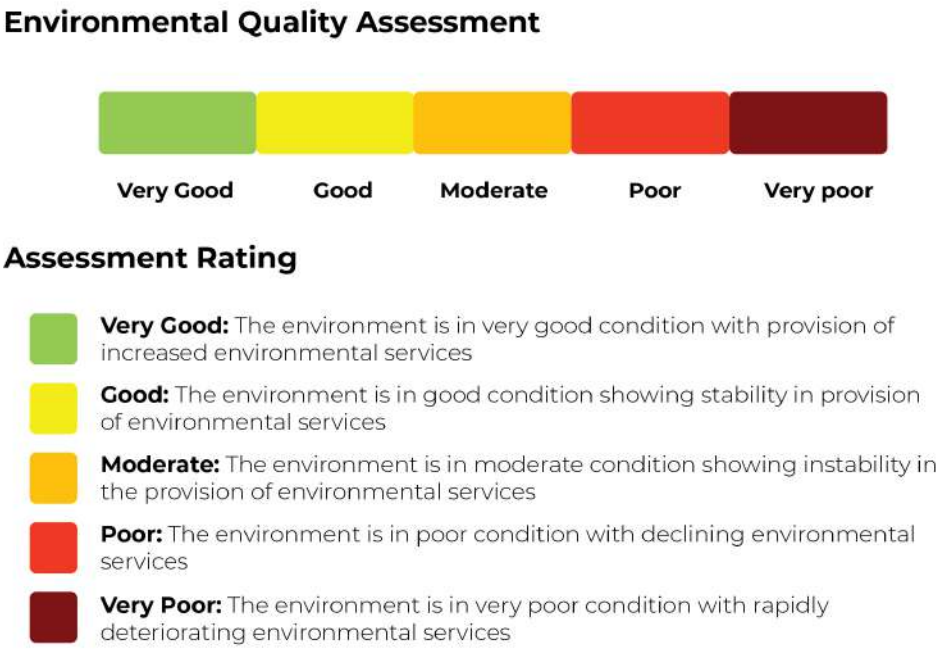


Figure 1-15: Environmental Quality Assessment Scale

This State of Environment Report is an important step forward and an indispensable resource for gathering data on the status of the environment in Punjab as of the present. The most recent scientific information is included in the study, which is likely to have a major influence on promoting environmental sustainability.

2 AIR QUALITY

CHAPTER 2 AIR QUALITY

1. OVERVIEW

Air – a primary constituent of the environment – is essential for life on Earth. Nitrogen and Oxygen gases make up about 99 percent of Earth's air. Air quality is deteriorating due to industrial emissions, vehicular pollution, rapid urbanization trends, use of fossil fuels, open burning, poor agricultural practices, and climate change, etc. EPD Punjab, with its limited capacity, is striving hard for taking appropriate actions for maintaining good air quality. It has a limited number of fixed ambient air quality monitoring stations (AQMS) and a mobile AQMS. The daily value of the Air Quality Index (AQI), is disseminated through the EPD's website[1] . Based on AQI, Meteorological Department issues the air quality forecast[2]. Furthermore, EPA is carrying out the monitoring of point and non-point pollution sources.

1.1 Air quality and society

The ambient air quality in Punjab is affected by multiple sources, including those within its borders and those from other regions beyond its boundaries. Air Pollution is one of the rapidly growing problems in Punjab Province. The presence of higher concentrations of air pollutants and variations of climatic conditions (like temperature inversion) may result in the occurrence of critical air pollution events like smog.

The Indo-Gangetic Plains, composed of the Indus (areas in Pakistan, and parts of Punjab and Haryana in India) and the Gangetic Plains (India, Nepal, and Bangladesh) have been identified as one of the most polluted regions due to high aerosol concentration. These plains have humid subtropical climates. The region is characterized by high pollutant levels, especially smog from October to April each year which contributes to poor health and causes severe illnesses[3]. The poor air quality directly means poor health of people. The report provides a description of ambient air quality as measured by the AQMS and an evaluation of pollution sources with regard to PEQS.

2. ENVIRONMENT

2.1 Ambient air quality and AQI

Maintaining good air quality is essential for protecting public health, preserving the environment, mitigating climate change, and promoting sustainable economic growth. The overall 7 categories of AQI (represented by a different color) vis-à-vis health advisory notes are as shown in Table 2-1[4]. Color coding is used to make it easier for people to understand whether the quality of air is healthy or unhealthy.

One of the critical challenges associated with the management of poor air quality faced in Punjab is the lack of air quality monitoring systems. There are different sets of air quality monitoring systems available with EPA Punjab. Three of these were received in a project[5] and the other six (compact ones) were purchased by EPA Punjab[6]. The ambient air quality monitoring stations require continuous repair and maintenance including replacing filters etc. for their proper functioning. The values of AQI[1] issued are mentioned in this report. AQI is calculated by using the formula given in BOX 1 with some specific breakpoints described in Annexure IV.

BOX -1

AQI is calculated by using the following formula with some specific breakpoints (Annexure --)

$$AQI = \frac{I_{Hi} - I_{LO}}{BP_{HI} - BP_{LO}} * (Cp - BP_{LO}) + I_{LO}$$

Where

AQI	=	the index for pollutant p or air quality index
Cp	=	the truncated concentration of pollutant p
BPHi	=	the concentration breakpoint that is greater than or equal to Cp
BPLo	=	the concentration breakpoint that is less than or equal to Cp
IHi	=	the AQI value corresponding to BPHi
ILo	=	the AQI value corresponding to BPLo

KEY FINDINGS

Poor air quality is the leading cause of premature deaths

- World Bank estimates Pakistan's annual burden of disease from outdoor air pollution to be responsible for around 22,000 premature adult deaths and 163,432 DALYs.
- WHO reported that the exceeding levels of air pollution have resulted in the loss of 5.3 and 4.8 years of life expectancy from 1998-2016 among populations of Lahore and Faisalabad, respectively.

Overall Air quality assessment of different cities in Punjab is from moderate-poor

- Ambient air quality monitoring of Lahore for the year 2022 shows poor air quality with only 17 good AQI ($PM_{2.5}$) days out of the total 309 monitored days.
- Snapshot of one-day monitoring of the other nine divisional headquarters during November and December shows moderate air quality with 5 out of 9 cities showing good/satisfactory AQI ($PM_{2.5}$) values.

Vehicular and Industrial emissions are the main cause of deteriorating air quality

Satellite data revealed that Lahore, Kasur, Sheikhupura, Nankana Sahib, Faisalabad, and Gujranwala are among the hotspots of CO, SO_2, and NO_2.

Different stakeholders are responsible to manage the quality of Air around us

- Punjab Province has notified the PEQs for Ambient Air and Industrial Gaseous Emissions.
- Improving the air quality is a continuous process and major changes are needed across different sectors in the existing system through advent of many initiatives.

[1]https://epd.punjab.gov.pk/aqi
[2]https://rmcpunjab.pmd.gov.pk/WWW/AirQualityUpdate.php
[3]https://epd.punjab.gov.pk/system/files/Smog%20commission%20report.pdf
[4]https://epd.punjab.gov.pk/system/files/Health%20Advisory%20Notification_0.pdf
[5]"Establishment of Environmental Monitoring System in Islamic Republic of Pakistan"
[6] "Establishment of Air Quality Monitoring System in Punjab" (1 No.) and "Installation of Ambient Air Quality Monitoring Station in 4 cities of Punjab" (5 Nos.).

Table 2-1: Colour illustration and information of AQI

AQI	AQI Category	Color Code	General Public	Vulnerable Groups
0-50	**Good**		In terms of performance assessment, exposure to this air results in Good to satisfactory.	
51-100	**Satisfactory**			
101-150	**Moderate**		Consider AQI to plan outdoor activities	• Keep a regular check on your health vitals e.g. oxygen levels, blood pressure etc. • In case of respiratory problem etc. consult your doctor/family physician. • Eat healthy diet to naturally boost your immunity. • Avoid smoking or any related activity. • Reduce prolonged or heavy outdoor exertion. • Make the emergency equipment such as nebulizers available at home as first aid measure.
151-200	**Unhealthy for sensitive groups**		Reduce prolonged or heavy outdoor exertion	• Check AQI level before outdoor workout/ exercise. • Wear face masks during outdoor activities. • Restrict children from playing outdoors. • Avoid unnecessary traveling, residing, and visits in the areas having unhealthy AQI. • Elderly people should minimize outdoor exposure. • Consider doors and windows closed to reduce outdoor air intake. • Avoid prolonged or heavy outdoor exertion. • Patients of COPD & CVD should select the face masks in consultation with their physician.
201-300	**Unhealthy**		• Wear face masks during outdoor activities. • Reduce prolonged or heavy outdoor exertion.	• Regularly check AQI and health vitals. • Spend maximum time at home. • Use N95 mask when going outside is unavoidable. • Restrict prolonged or heavy outdoor exertion. • Bar children from unnecessary outdoor visits/activities. • Patients of COPD & CVD should select the face masks in consultation with their physician.
301-400	**Very Unhealthy**		• Limit outdoor activities on days with air quality is poor. • Limit outdoor exercise activities and shift to indoor gyms or home-based workouts to protect your health	• Stay indoors. • Use N95 or equivalent mask and pollution protective glasses/ goggles when going outside is unavoidable. • Regularly check AQI and health vitals. • Patients of COPD & CVD should select the face masks in consultation with their physician.
401-500+	**Hazardous**		• Stay indoors. • Use N95 or equivalent mask and pollution protective glasses/goggles when going outside is unavoidable. • Regularly check AQI and health vitals.	• Stay at home. • Use air purifiers or equivalent. • Frequently check health vitals.

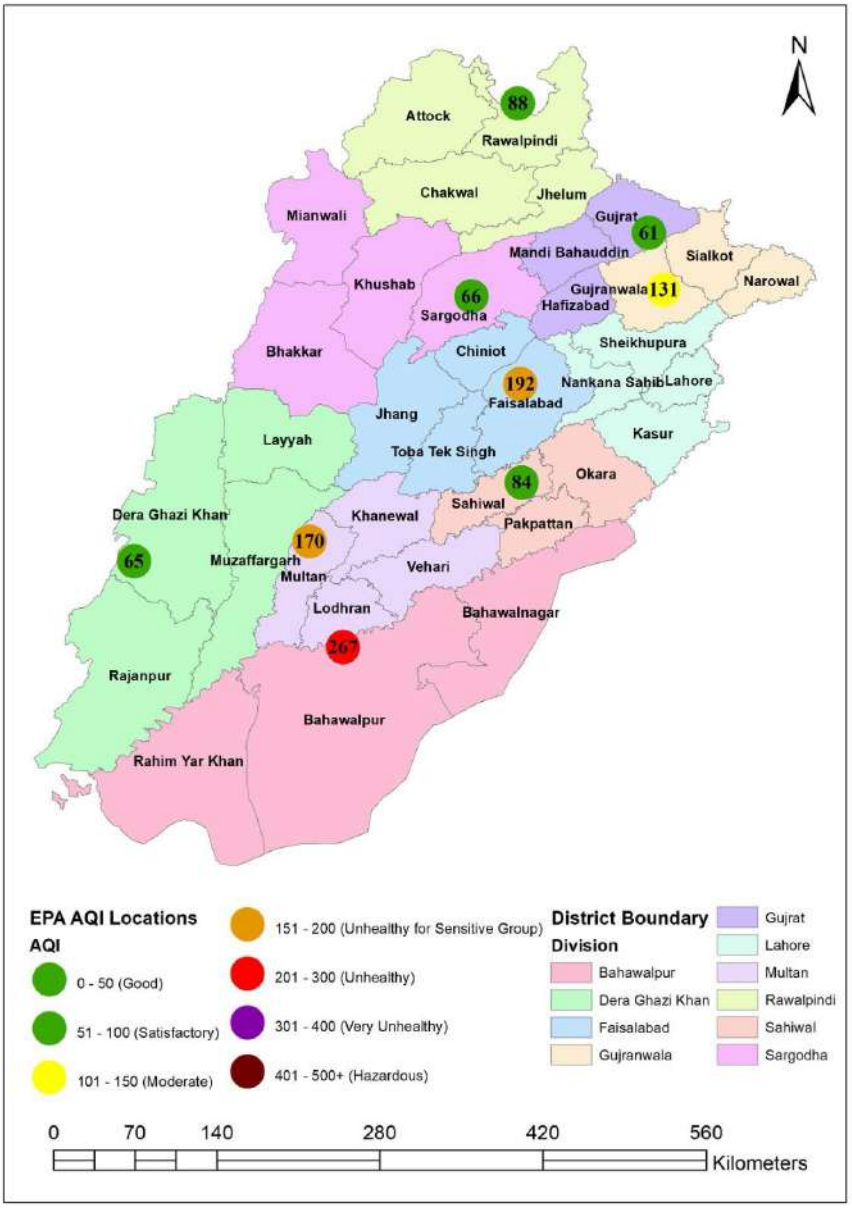


Figure 2-1: Monitoring locations and AQI values in nine cities of Punjab in 2022

2.2 Snapshot of air quality of nine divisional headquarters of Punjab (excluding Lahore)

This section covers information about the monitoring and measurement of air quality in nine major cities of the Punjab Province. Monitoring of the nine divisional headquarters i.e., Bahawalpur, DG Khan, Faisalabad, Gujrat, Gujranwala, Multan, Rawalpindi, Sahiwal, and Sargodha were conducted through mobile AQMS. With regards to the above monitoring, it is important to mention that this monitoring was carried out on a single day and is only a representative sample of the ambient air quality on that particular day. This data does not reflect the annual trend or the prevailing values of air quality in that particular region. The monitoring was carried out between 30th November to 11th December, 2022 and was carried out for criterion pollutants only at each location i.e., either for $PM_{2.5}$ or SO_2. The locations of the ambient air quality monitoring carried out in nine divisional headquarters along with their AQI values are shown in Figure 2-1.

AQI $PM_{2.5}$ was found to be within the PEQS limit (35 µg/m^3) for Sargodha and Gujrat, while it was "moderate", "unhealthy for sensitive groups", and "unhealthy" for Gujranwala, Faisalabad, and Bahawalpur, respectively. AQI (based on SO_2) was found to be within PEQS limits (120 µg/m^3) in all three cities i.e., Sahiwal, Rawalpindi, and DG Khan.

2.3 Air quality of Lahore

Lahore, once considered the city of the gardens, is facing alarming levels of air pollution for the last few years. In this report, two types of data are reported for Lahore. One was obtained through fixed AQMS (installed each at Town Hall and Township) the second from mobile AQMS. Figure 2-2 shows the monitoring locations and the average AQI values for Lahore that are higher than the safe limits at almost all of the sites (except one) with most of them falling into "unhealthy "and "very unhealthy" categories.

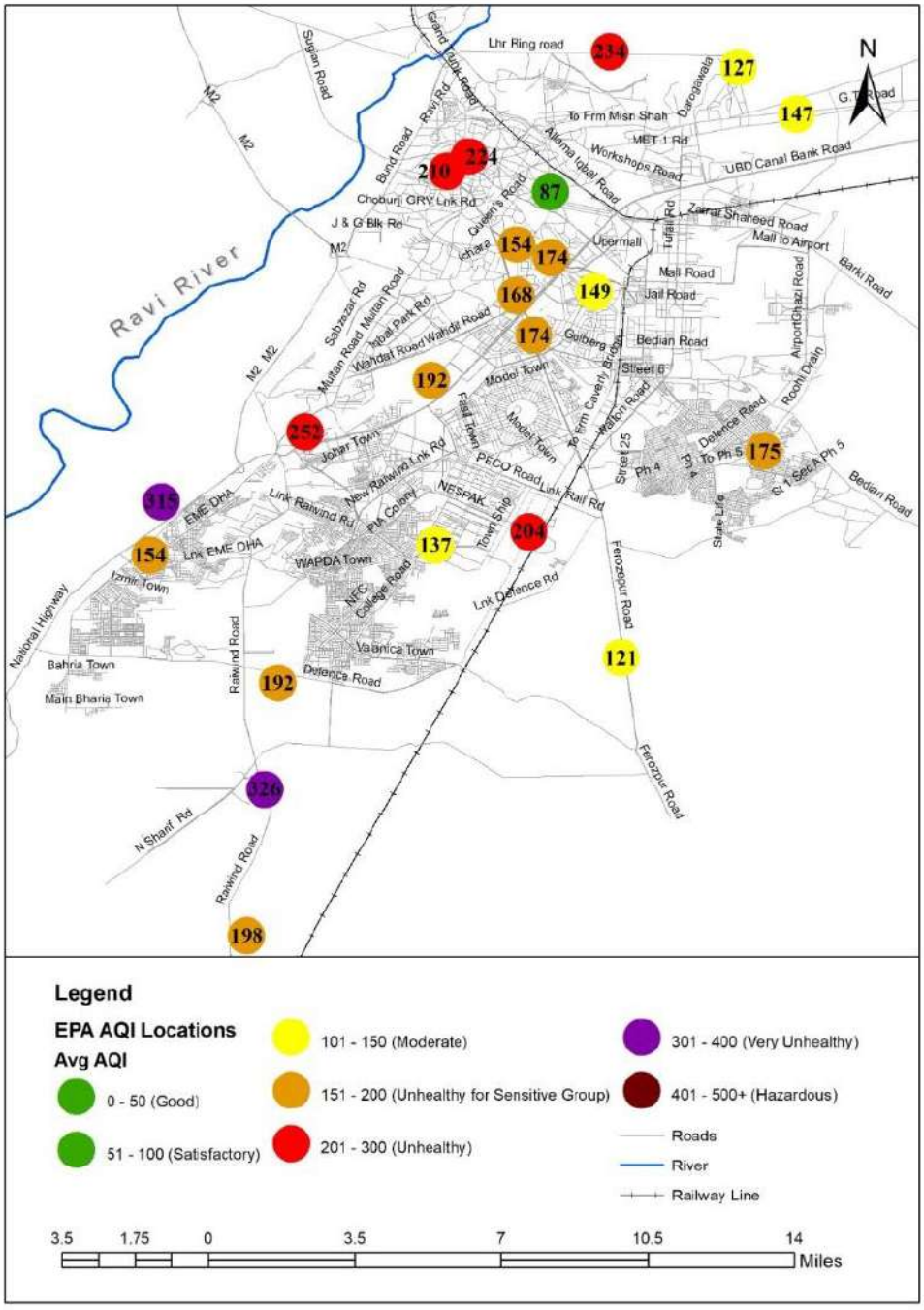


Figure 2-2: Monitoring locations and average AQI values in Lahore during 2022

Continuous monitoring for AQI (based on $PM_{2.5}$) shows that the values were above the safe limits almost the whole of the year with the highest values during winter months (November-January). The prevalent ambient air quality trend shows very poor air quality in Lahore peaking up to very unhealthy and hazardous levels during the winter season (Figure 2-3). Climate-induced changes in weather patterns such as reduced wind speed, fluctuations in relative humidity, and the occurrence of temperature inversion are some factors that may worsen the situation of ambient air quality of the province during the winter season.

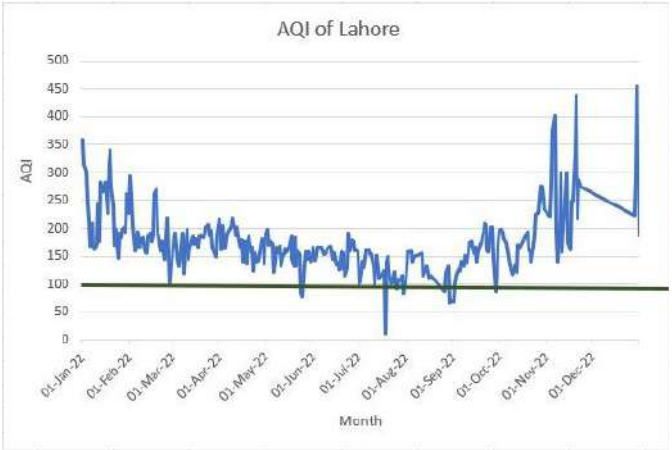


Figure 2-3: Continuous monitoring of AQI (PM2.5) in Lahore during 2022

Figure 2-4 shows that Lahore enjoyed only 17 days of good/satisfactory air quality with respect to AQI

($PM_{2.5}$) values in 2022. Urbanites experienced 78 days of moderate and 214 days of unhealthy-hazardous air quality in Lahore.

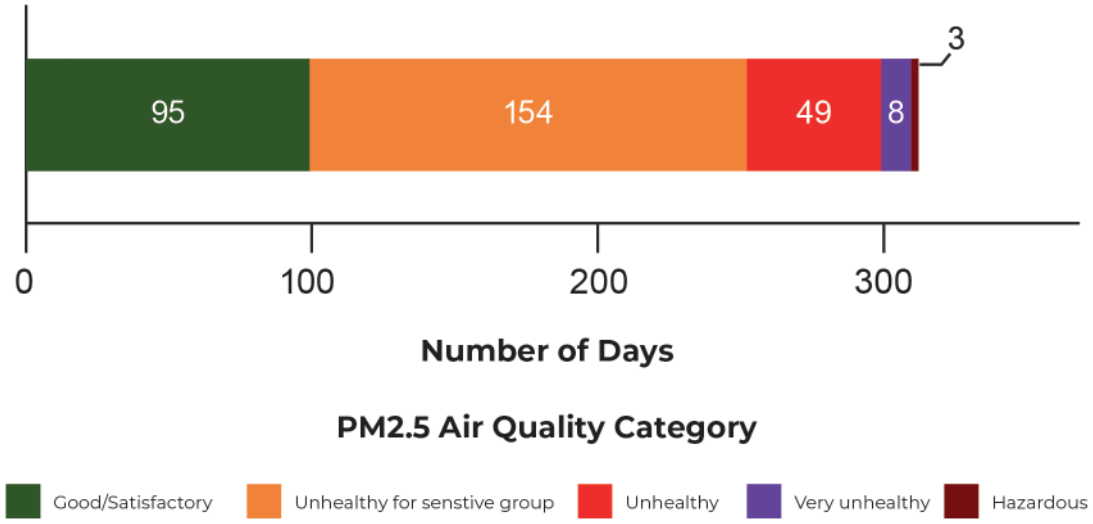


Figure 2-4: Number of days and AQI ($PM_{2.5}$) levels in Lahore for 2022

Between 2006 and 2012, source apportionment studies conducted in Pakistan, particularly in Lahore, revealed elevated concentrations of primary and secondary pollutants, specifically fine particulate matter. The average annual concentration of $PM_{2.5}$ was 194 ± 94 (µg/m^3). The contribution of secondary organic aerosols also peaked during the winter, potentially influenced by foggy conditions[7]. The trends of particulate matter concentration[8] in Lahore from 2019 to 2022 is shown in Figure 2-5.

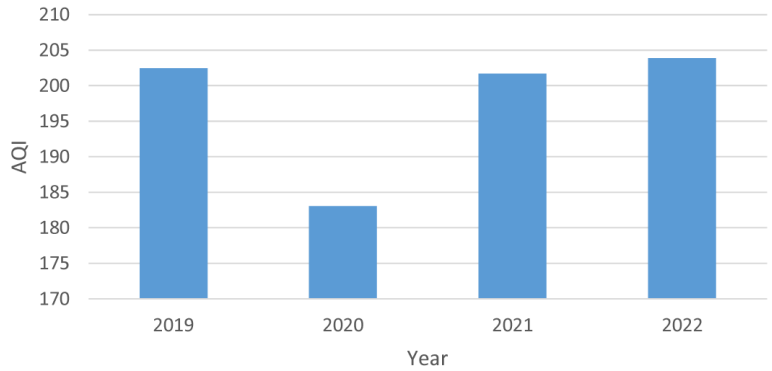


Figure 2-5: Trend of AQI-$PM_{2.5}$ between 2019 and 2022 in Lahore.

2.4 Satellite-based monitoring of atmospheric trace gases[9]

Annual averages of three major atmospheric trace gases viz. Carbon monoxide (CO) and Nitrogen dioxide (NO_2) were measured during 2022 in Punjab by using satellite-based observations. The annual average concentrations and details of hotspots in the districts of Punjab are given in Table 2-2 and Figure 2-6 and 2-7.

Table 2-2: Annual average concentration of trace gases measured by satellite-based sensors

Trace Gases	Annual Average Concentration	Hotspots
Carbon Monoxide	27 to 43 mmol/m^2	Lahore, Kasur, Sheikhupura, Nankana Sahib, Faisalabad, Gujranwala, and Muzaffargarh
Nitrogen Dioxide	17 to 183 µmol/m^2	Lahore, Kasur, Sheikhupura, Nankana Sahib, Faisalabad, Gujranwala, Dera Ghazi Khan and Rawalpindi

[7] Ernesto Sánchez-Triana, Santiago Enriquez, Javaid Afzal, Akiko Nakagawa, and Asif Shuja Khan, Cleaning Pakistan's Air, Policy Options to Address the Cost of Outdoor Air Pollution, World Bank, https://documents1.worldbank.org/curated/pt/701891468285328404/pdf/890650PUB0Clea00Box385269B00PUBLIC0.pdf

[8] https://www.airnow.gov/international/us-embassies-and-consulates/#Pakistan$Lahore

[9] As provided by the Pakistan Space and Upper Atmosphere Research Commission [10401-SPARC-LAHORE] for the Report by using TROPOMI on board Sentinel-5P satellite

The monthly averaged column concentrations of the trace gases remained low in the months of Jul and Aug, 2022 with significant decrease in urban hotspots. High concentrations of CO and NO_2 were seen in the months of winter, spring, and summer. Relatively lower concentrations and less hotspots for all the trace gases were observed in the southern part of the province.

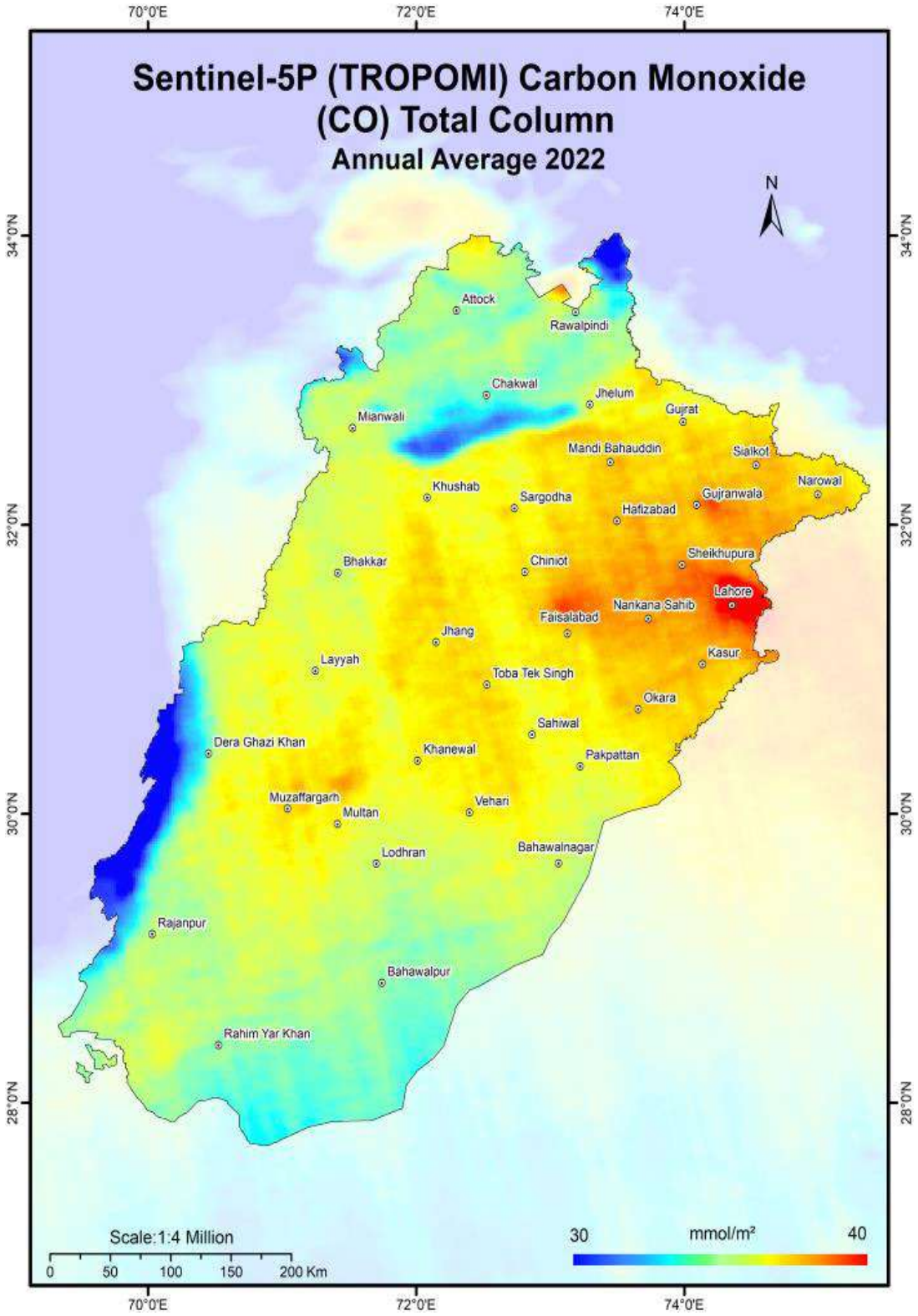


Figure 2-6: Annual average concentration of CO (mmol/m²)

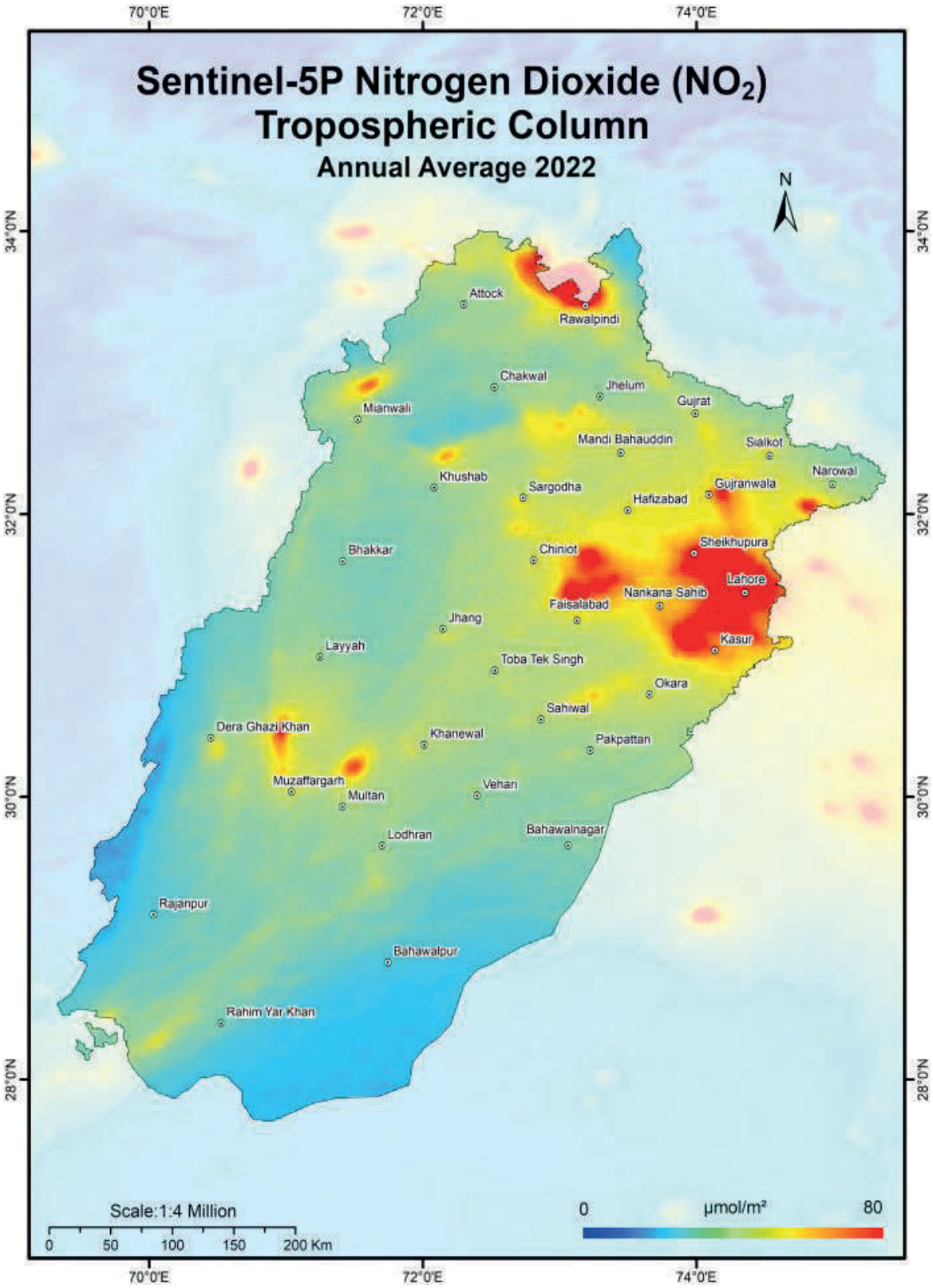
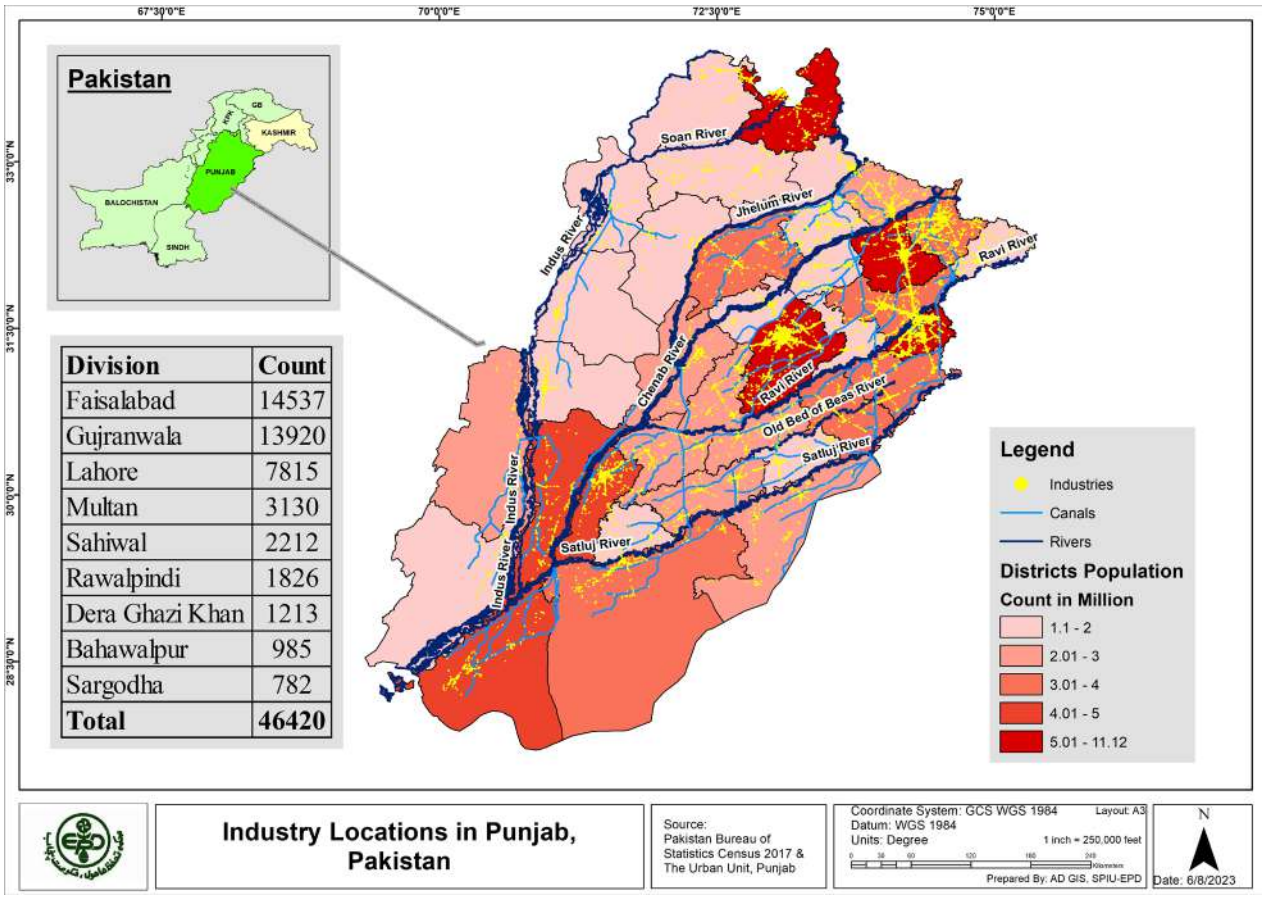


Figure 2-7: Annual average concentration of NO_2 (mmol/m²)

2.5 Monitoring of industrial emissions and vehicular registration

Baseline data was gathered regarding the industrial establishments, monitoring of industrial emissions, and vehicular registration, as detailed below.



Division	Count
Faisalabad	14537
Gujranwala	13920
Lahore	7815
Multan	3130
Sahiwal	2212
Rawalpindi	1826
Dera Ghazi Khan	1213
Bahawalpur	985
Sargodha	782
Total	**46420**

Figure 2-8: Location of the industries in Punjab

2.5.1 Industrial establishments

Three datasets have been reviewed in order to identify the number of pollution sources in Punjab. During 2013-14, EPA Punjab carried out geo-tagging of industrial units. Identified 18,271 establishments comprising 67 different types. The data of the Industries Department (2016-17) describes 18,540 industrial establishments comprising 194 different types. The data in the Map Book of Punjab, 2020 (spatial encyclopedia)[11] shows 46,420 industrial establishments belonging to 24 different sectors (Figure 2-8).

The division-wise comparison of these data sets is presented in Figure 2-9. The unavailability of updated datasets is a major bottleneck in understanding the quantum of pollution sources in the districts. This further complexes the matter of finding a solution with respect thereof or even understanding the summary inventory of pollutants, detailing the time and intensity thereof.

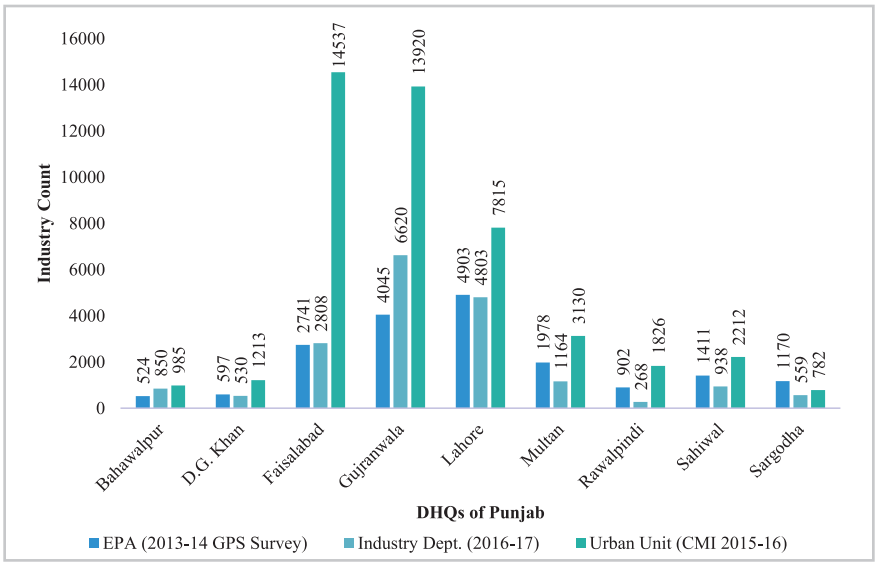


Figure 2-9: Division-wise count of the industries

[11] Map Book of the Punjab prepared by The Urban Unit

2.5.2 Industrial monitoring

There are 8 Environmental laboratories of EPA having specific "Area of Jurisdiction"[12] as mentioned in Table 2-3. A total of 334 inspections of stack emissions were carried out in the year 2022. Only EPA Laboratory Lahore has the capacity to measure the PM in the stack emissions.

Table 2-3: EPA laboratories with their area of jurisdiction

EPA laboratory City	Area of jurisdiction
Faisalabad	Faisalabad, Toba Tek Singh and Jhang
	District Chiniot, Sargodha, Bhakkar and Khushab
Gujranwala	District Gujranwala, Gujrat and Mandi Baha-ud-din
Lahore	District Lahore, Kasur and Okara
	All districts of Punjab for special Monitoring
Multan	Multan, Vehari and Khanewal,
	Dera Ghazi Khan, Muzaffargarh, Rajanpur and Layyah
	Sahiwal, Pakpattan and Okara District
Rawalpindi	Rawalpindi, Attock, Jhelum, Chakwal and Mianwali
Rahim Yar Khan	Bahawalpur Division (Bahawalpur, Bahawalnagar and Rahim Yar Khan)
Sialkot	District Sialkot and Narowal
Sheikhupura	District Sheikhupura, Nankana Sahib and Hafizabad

PM, NOx, and CO (mg/Nm^3) emissions were generally recorded from the stacks of the boilers. The comparison of monitoring results with the PEQS is given in Figures 2-10, 2-11 & 2-12. All the pollutant concentrations in the stack emissions were found to be higher than the PEQS values in all the industries with the highest levels shown by the Lubricant Reclamation Unit followed by the Chipboard manufacturing industries. CO (mg/Nm^3) concentrations were found to be highest in the Lubricant Reclamation unit, while NOx and PM concentrations were highest in the Poly packaging and Steel re-rolling mills, respectively.

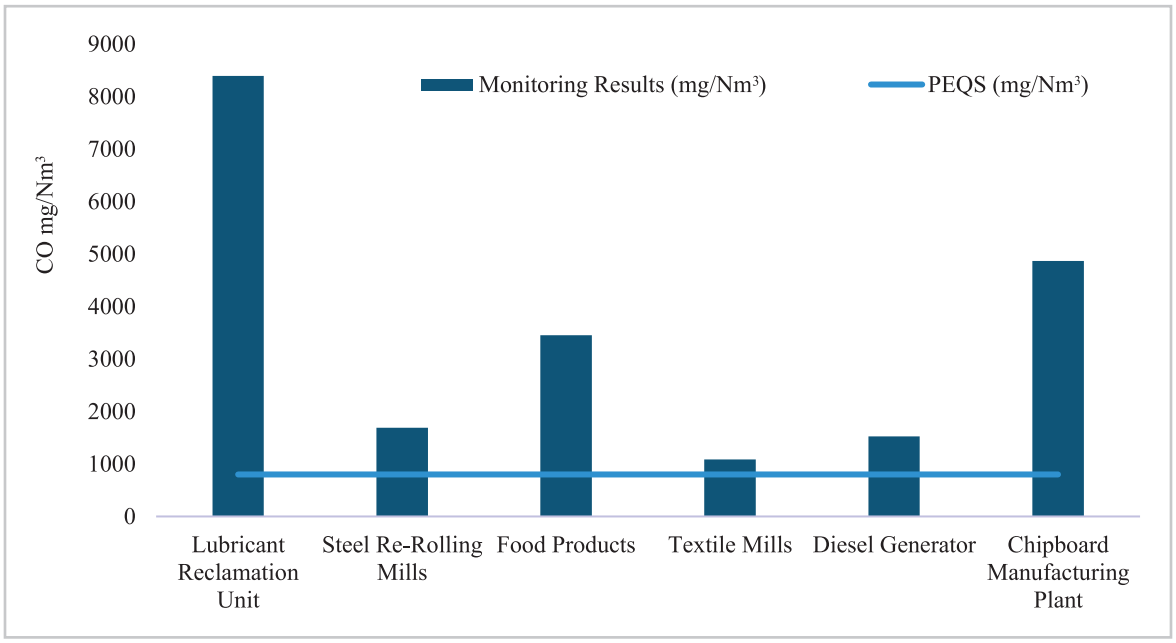


Figure 2-10: Monitoring of industrial emissions of CO (mg/Nm^3)

[12] Notification No 02/LS/EPA/Vol-II dated 17th April 2014

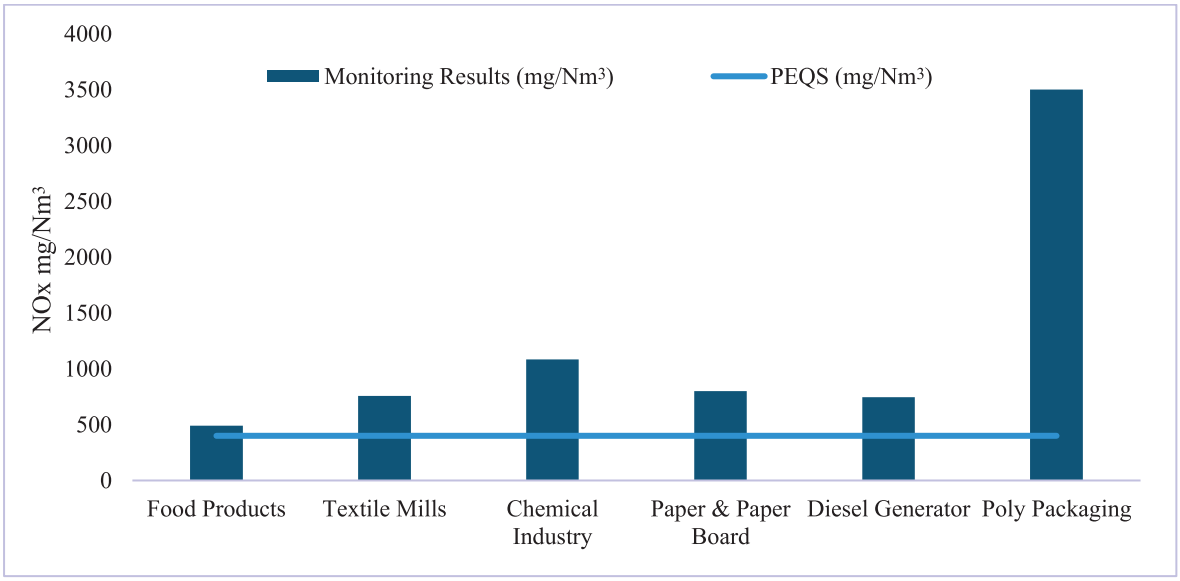


Figure 2-11: Monitoring of industrial emissions of NOx (mg/Nm³)

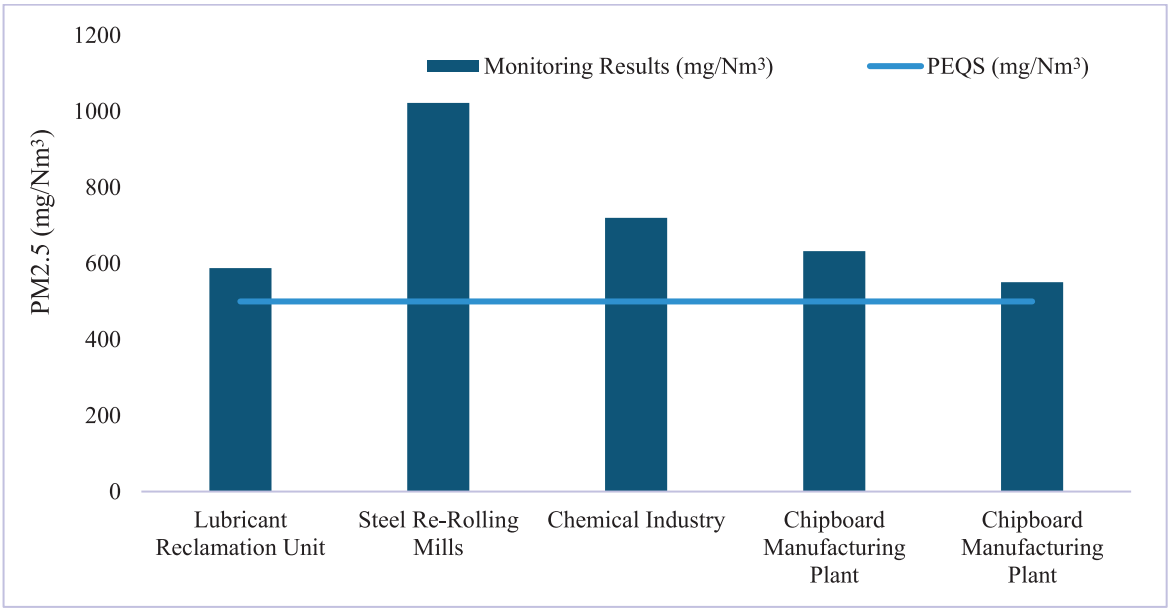


Figure 2-12 Monitoring of industrial emissions of PM (mg/Nm³)

Vehicular Registration Data and actions taken against vehicular pollution

The transport sector is one of the major emitters of air pollution. The Food and Agriculture Organization (FAO) during 2020 has reported that 43% of the air pollutants are emitted from the transport sector, 25% from the industrial, and 20% from the agriculture sector[13]. Global Change Impact Study Center (GCISC) reported that 12% of particulate matter ($PM_{2.5}$) was sourced from the soil dust, 11% from power plants and heavy industries, 18% from small industries, 21% from residential, 18% from mobile sources, 5% from municipal waste, 4% from agriculture residues burning, 11% from Livestock and fertilizers[14] . During the year 2022, a total of 1,327,730 vehicles were registered in Punjab. Registrations in Lahore comprised of over a quarter of the total registered vehicles in Punjab, followed by Faisalabad, Multan, Gujranwala, and Sialkot. In terms of body type, motorcycles constituted ~ 88% of the registered vehicles during the given period, followed by motor cars (~9%).

In Punjab, vehicular pollution has emerged as a significant policy matter and needed immediate attention. Foremost of them include; the unprecedented increase in the number of vehicles, a dire need for gradation of vehicular emissions standards, and poor fuel quality. The subject of petroleum standards as well as vehicular standards falls under the ambit of the Federal Government.

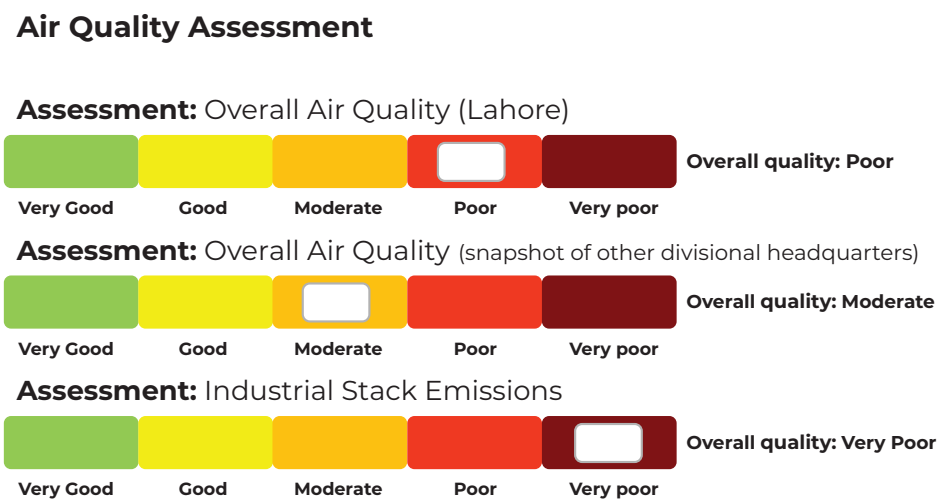
Throughout Punjab, an active regulatory as well as enforcement drive was carried out by the District Offices of the EPA

[13] https://www.fao.org/documents/card/en/c/ca6989en/
[14] An Unpublished study titled as "Application of the GAINS IGP-HF AQM Policy Planning Tool" By GCSIC

Punjab against vehicular pollution with the assistance of the Traffic Police. This campaign resulted in the issuance of challans, imposition of fines, impounding of vehicles as well as lodging of FIRs against the defaulters. A total of 112,661 number of vehicles were inspected by the Vehicle Inspection and Certification System. Details are provided in Chapter 6 of this Report.

3. OVERALL ASSESSMENT

Quality assessment of ambient air of Lahore, divisional headquarters and industrial stack emissions showed 'poor', 'moderate' and 'very poor' respectively.



4. MANAGEMENT

This section describes the efforts by the Punjab Government to encounter the major pollution sources affecting air quality in the Province.

4.1 Regulatory framework

The Punjab Environmental Protection Act, 1997 (XXXIV of 1997) is an Act to provide protection, conservation, rehabilitation, and improvement of the environment, for the prevention and control of pollution, and promotion of sustainable development[15]. The environment, pollution, and air pollutant are defined in § 2(x), § 2(xxxiii), and § 2 (iii) of the Act ibid respectively. In addition to the above, to gauge the pollution levels the Agency has to notify emission standards as defined § 2(ix) and § 2(xli) of the Act ibid. Furthermore, it is the function of the Agency to establish standards for the quality of the ambient air, water, and land under § 6(1) of the Act ibid. The PEQS for ambient air quality as well as industrial gas emissions have already been notified. The Act ibid § 11 imposes a prohibition of certain discharges or emissions including air pollutants in an amount, concentration, or level which is in excess of the Punjab Environmental Quality Standards. Regulation of motor vehicles regarding air pollutants is also carried out § 15 of the Act ibid. The Act ibid provides a mechanism against its violators through the issuance of Environmental Protection Order § 16. The penalties of the Act ibid are given § 17.

5. DPSIR framework

DPSIR framework is used to assess the air quality in Punjab for management purposes. This framework outlines the drivers exerting pressures with their prevalent state and their impacts, linking responses to understand the air quality management in Punjab (Figure 2-13). The details are as follows:

Drivers

Punjab has almost 54.2% economic contribution to the national GDP and employs approximately 37.6 million people[16] .

The drivers of air quality in Punjab are identified as

a. Population Growth: Punjab is the most populous province and its 110 million dwellers constitute an overall 52% population count of the country. Punjab has a population density of 536 persons per Square Kilometer with an annual percentage average growth rate (1998-2017) of 2.13%[17] .
b. Urbanization: Urbanization is one of the drivers of aggravating air quality in Punjab. The urban proportion in Punjab as recorded in 2017 was 36.86%[18] .
c. Industrialization: Punjab has a strong economic record and significantly contributes to the GDP. In Punjab,

[15] http://punjablaws.gov.pk/laws/2192a.html
[16] https://punjab.gov.pk/system/files/PGS_2023.pdf
[17] https://www.pbs.gov.pk/sites/default/files/population/2017/national.pdf
[18] https://www.pbs.gov.pk/sites/default/files/population/2017/national.pdf

industrialization is growing and impairing air quality either due to a lack of air pollution control devices or the inefficiency of the installed ones.

d. Agricultural Demand: 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, the number of vehicles on the roads in Punjab is increasing and is a major contributor to air pollution. 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 Effects: Stubble burning has been reported to be among the major contributors of air pollution especially in South Asia. Therefore, the ambient air quality of Punjab has a direct linkage with the practices in the neighboring countries.

Pressures

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

a. Higher Greenhouse Gas Emissions (GHG): Every driver exerts multiple pressure 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 insert 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: Agricultural practices in Punjab are putting tremendous pressure on the ambient air quality. The activities like stubble burning, fertilization, cattle farming, 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.
e. Dust Storms: The hot summer temperatures, ranging from 40-50°C, cause fine dust to rise into the atmosphere, forming dust clouds/storms, which have a negative impact on air quality in the cities.

State

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

a. Poor Air Quality: All the major cities in Punjab experience poor air quality showing higher AQI values. The Aerosol Optical Depth data reveals that particulate matter in the ambient air of Lahore remained high not only throughout the year 2022 but similar was the trend for the last many years[19]. The average concentration of Particulate Matter in Lahore is accounted as “unhealthy for sensitive groups”.
b. Climatic Changes: Pakistan has faced extreme climatic events in 2022 including both heat waves and torrential rains ending up in the worst flash floods during the months of August to October.
c. Higher values of industrial emissions: Particulate matter of industrial gaseous emissions of Cement Plants, Chemical Projects, Floor Mills, Furnaces, Lubricant Recycling Units, and Oil & fats, and Vegetable Ghee is not in compliance with PEQS.

Impacts

The impacts of the drivers and pressures on ambient air quality in Punjab are as follows:

a. Impacts on life: Estimates of World Bank report Pakistan’s annual burden of disease from outdoor air pollution to be responsible for around 22,000 premature adult deaths and 163,432 DALYs (disability-adjusted life years)[20] . According to the data from Global Burden of Disease (GBD), exposure to $PM_{2.5}$ had caused 103 deaths per 100,000 population in Pakistan in 2019[21] . The rate of deaths related to air pollution (including indoor pollution, $PM_{2.5}$ and ozone) in Pakistan is higher than the global average and is declining at a slower pace compared to other regions[22] . A WHO report shows that the exceeding levels of air pollution have resulted in the loss of 5.3 and 4.8 years of life expectancy from 1998-2016 among populations of Lahore and Faisalabad, respectively[23].

[19] https://epd.punjab.gov.pk/system/files/Smog%20commission%20report.pdf

[20] Anjum, M. S., Ali, S. M., Subhani, M. A., Anwar, M. N., Nizami, A. S., Ashraf, U., & Khokhar, M. F. (2021). An emerged challenge of air pollution and ever-increasing particulate matter in Pakistan; a critical review. Journal of Hazardous Materials, 402, 123943. DOI: 10.1016/j.jhazmat.2020.123943

[21] https://documents1.worldbank.org/curated/en/746031566833355389/pdf/Opportunities-for-a-Clean-and-Green-Pakistan-A-Country-Environmental-Analysis.pdf

[22] https://documents1.worldbank.org/curated/en/897001552661768639/pdf/135335-PN-P163618-PUBLIC-15-3-2019-16-1-53-PakEnvironmentalSustainabilityFinal.pdf

[23] https://apps.who.int/iris/bitstream/handle/10665/250141/9789241511353-eng.pdf?sequence=1&isAllowed=y.

b. Health Impacts: Extensive research has linked short-term, year-round and long-term exposure of particulate matter to various health impacts. The health impacts of air pollution range from respiratory infections to chronic diseases, and from serious discomfort to morbidity and premature mortality.[24] Even such exposure may result in death due to lung cancer and other respiratory illnesses[25]. A study in 2021 reported that elevated $PM_{2.5}$ levels are negatively affecting Pakistani population and the avoidable deaths attributed to ischemic heart disease and lung cancer account to over 2 million people (2,773 for every 100,000 people) and the total cost related to this mortality is estimated to be 1 billion USD[26] .
c. Social Impacts: Elevated levels of fine particulate matter and ozone have been linked to increased levels of violent crime, indicating a potential impact on aggressive behavior. Additionally, studies have identified a connection between long-term exposure (over six months) to fine particulate matter and depression. Short-term exposure to only nitrogen dioxide (excluding ozone, sulfur dioxide, or particulate matter) showed a positive association with depression, which includes symptoms such as social withdrawal and isolation[27].
d. Economic Impacts: A recent World Bank publication has reported that in individual countries, the economic burden of pollution associated with premature mortality and morbidity is also significant accounting for 5-14% of the countries' GDPs[28]. Each unit of PM2.5 results in a loss of 18.9 USD in GDP. Thus, the predicted economic cost of air pollution in Pakistan is 47.8 billion USD, or 5.88% of GDP[29]. In Pakistan, generating 1 unit of PM 2.5 requires a GDP per capita of US$18.9, while in China, it is associated with US$145. The economic growth of Pakistan continues to suffer from the health costs and reduced productivity caused by air pollution[30] .

Responses

Following is a glimpse of various management practices being carried out for the betterment of air quality in the province. These practices are mainly extracted from the Annual Development Program 2022-23[37] related to the respective Government Departments. The brief description is as follows:

a. Environment Protection Department is undertaking multiple initiatives regarding air quality management practices which have been discussed in detail in Chapter 6 of this report.
b. Forest Wildlife and Fisheries Department are undertaking the afforestation/tree plantation, establishment of a Forest Park, and establishment of an Endowment Fund for the development of allied infrastructures.
c. Industries, Commerce and Investment Department is undertaking the establishment of Industrial Estates, Cluster Development, and Pilot/Demonstration Resource Efficiency and Cleaner Production Investments in key industrial sectors.
d. Transport Department is undertaking the procurement of eco-friendly urban buses for major cities of Punjab; and the expansion of inspection and certification systems for motor vehicles.
e. Excise Taxation, and Narcotics Control Departments have started registration of electrical vehicles in Punjab.
f. Agriculture Department is undertaking the introduction of mechanized management of rice crop residues. Through the provision of 10,000 Pak seeders, 10,000 rice straw choppers, and 500 rice combine harvesters to farmers/ service providers at a subsidized rate (60:40).
g. PHA Lahore is undertaking the development of Miyawaki urban forests in the different areas of Lahore City, tree plantation campaigns, and tree-washing activities through water lorries.
h. Lahore Electric Supply Company is already expanding the smart grid system through the induction of (solar) electric energy into the system by providing net metering connections to consumers on a regular basis within the shortest possible time.
i. Lahore Waste Management Company (LWMC) is actively and effectively doing the activity of vacuum cleaning at selected locations along three major roads of Lahore (Canal Road, Jail Road, and Ferozepur Road). Moreover, LWMC through anti-smog squads is washing the main roads with mechanical washers.
j. Energy Department is undertaking the installation and provision of biogas plants/digesters, converting three Cities of Punjab into solar smart cities, installation of solar power plants, setting up solar tube wells in water-logged areas of Punjab, Improvement of energy efficiency in WASA systems, the establishment of waste to energy fund to meet financial viability gap for waste to energy projects in Punjab, and development of lift irrigation systems using solar energy. Furthermore, Energy Department is in the process of solarizing public sector buildings.
k. In addition to the above-mentioned initiatives, Energy Department is in the process of constructing an Energy Resource Center which will be a net zero emission building for the Project Management Unit (PMU) of the Energy Department. This building is going to be an energy-efficient building and will be Platinum LEED certified.

[24] The World Bank, 2022, Striving for Clean Air, Air Pollution and Public Health in South Asia, pp. 45
[25] https://www.lung.org/getmedia/338b0c3c-6bf8-480f-9e6e-b93868c6c476/SOTA-2023.pdf
[26] https://doi.org/10.1016/j.heliyon.2021.e05968
[27] https://ehjournal.biomedcentral.com/articles/10.1186/s12940-021-00761-8
[28] https://www.worldbank.org/en/topic/pollution#1
[29] https://documents1.worldbank.org/curated/en/746031566833355389/pdf/Opportunities-for-a-Clean-and-Green-Pakistan-A-Country-Environmental-Analysis.pdf
[30] https://documents1.worldbank.org/curated/en/897001552661768639/pdf/135335-PN-P163618-PUBLIC-15-3-2019-16-1-53-PakEnvironmentalSustainabilityFinal.pdf
[37] https://pnd.punjab.gov.pk/ADP202223

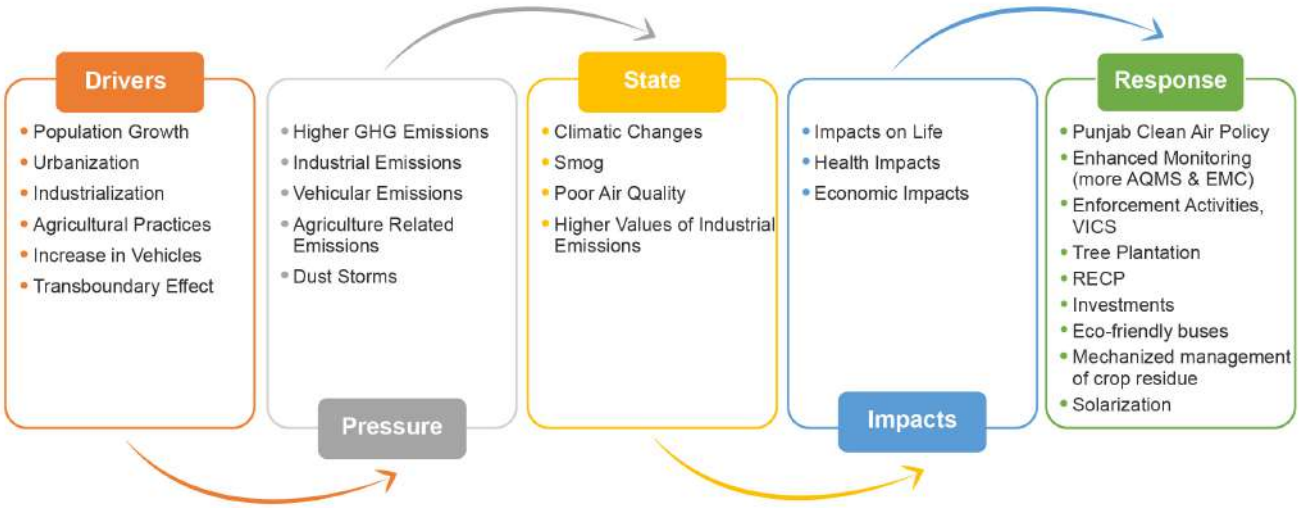


Figure 2-13 DPSIR of Air Quality in Punjab

6. The Way Forward

Strengthening of regulatory framework: The AQI level of ambient air quality in the Punjab requires strengthening of regulatory framework in the Province with introduction of Climate Change Policy, Clean Air Act, Punjab Clean Air Policy with Phased Action Plan, Anti-Smog Rules and pollutant release and transfer register, etc.

Enhanced Air Quality Monitoring with apportionment studies: More air quality monitoring stations are required along with carrying out source apportionment studies for identification of problems and for taking informed decisions.
Documentation of major air pollution sources: Documentation of major air pollution sources (with geo-tagging) and compilation of ancillary dataset is required.

Industrial interventions: For industrial establishments certain interventions need to be carried out such as implementation of resource efficiency and cleaner production technologies, introduction of carbon neutrality regime and financial assistance to green micro-enterprises.

Controlling Vehicular Emissions: Many actions including increase in public transportation, strengthening of vehicular inspection certification system, retiring excessively old vehicles and installation of catalytic converters/diesel particulate filter, adoption of latest Euro Standards for vehicular emissions and vehicle manufacturing are required for the betterment of air quality.

Certification, Labeling and Energy Conservation Standards: Energy Department may go for notification of certification and labeling system for green/energy saving products, energy conservation standards for newly built urban buildings and industrial establishments and energy saving renovation/retrofitting in existing buildings for improved energy efficiency.

Coordination for Air Shed Management: there is a need for better coordination at every tier to deal with the transboundary air pollution issues and air shed management in the South Asia Region.

3 WATER QUALITY

CHAPTER 3 WATER QUALITY

1. OVERVIEW

Water is an essential resource to sustain life on Earth. It plays a crucial role in maintaining health of communities, economy and ecosystems. The unique physicochemical characteristics of water render it indispensable for biological functions. Access to safe and clean water supplies is critical for the socio-economic wellbeing of society as is also called for under UN SDG 6 (ensure availability and sustainable management of water and sanitation for all).

Pakistan, once a water surplus country, is presently facing numerous challenges related to both water quantity and quality. The uneven distribution of water resources, climatic variability, population pressure, over-extraction of water for domestic, agricultural and industrial needs and their ensuing pollution loads have affected both water quality and quantity (Figure 3-1).

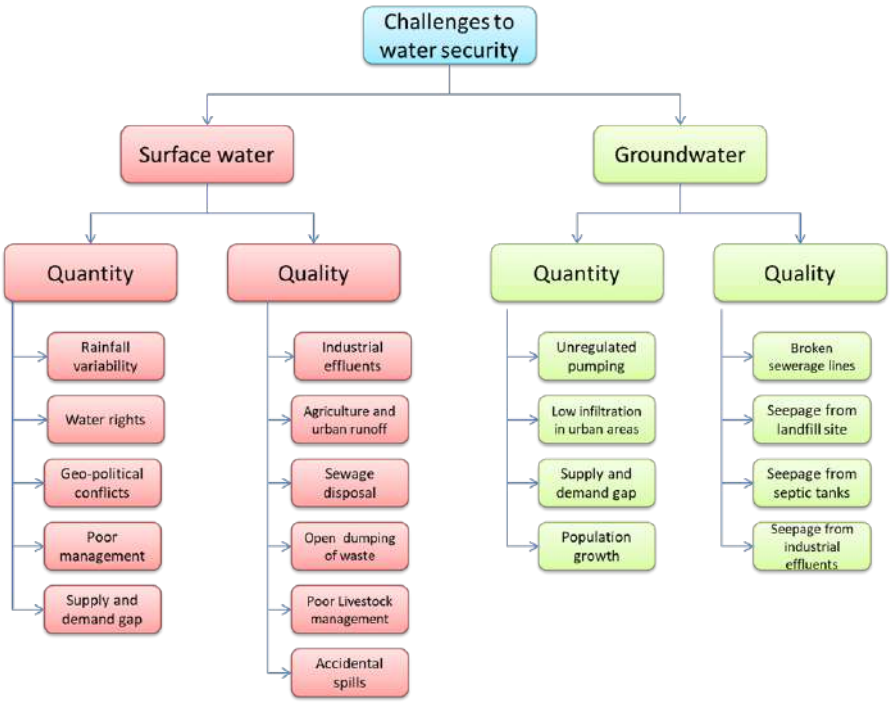


Figure 3-1: Challenges to water resources in Punjab

KEY FINDINGS

Punjab is facing numerous challenges to water resources

Population growth, rapid urbanization, unfettered industrialization, over-extraction/runoffs for agricultural purposes along with climatic variability are the key challenges putting pressure on water resources of Punjab.

Indus River has the highest flow rate in Punjab

- Average flow rate (2022): 4.69 MAF
- Maximum flow rate during a single month (2022): 14.75 MAF (August)

Access to water resources relates to both their quality and quantity

- Pakistan is fast transitioning to become a water scarce country. The water table in urban areas has drastically declined. Pakistan would soon approach water scarcity level (<1 million cubic meters per capita per annum).
- Drinking water quality at source in big cities of Punjab (Faisalabad, Gujranwala, Lahore and Rawalpindi) generally meets WHO standards except for Lahore and Gujranwala where E. Coli contamination was sporadically found (in a few samples).
- Most of the common illnesses reported in Pakistan are due to water-borne infections. PCRWR reported 69%, 38%, 21%, 20% and 12% bacteriological contamination in drinking water in Multan, Rawalpindi, Sargodha, Shiekhupura and Lahore, respectively.

Drains in Punjab have the poorest water quality

- The analysis revealed very poor water quality of drains, followed by poor quality of shallow groundwater and drinking water within the distribution network, whilst the quality was moderate for drinking water at source (WASA tube wells), deep groundwater and rivers in terms of tested parameters.
- Due to high Arsenic (As) and coliform contamination, the quality of shallow groundwater is poor in Punjab but is ranked moderate in case of deep groundwater. Drinking water quality at source is also ranked as moderate because of the potential hazard of Arsenic contamination (not tested by WASAs though in the reported samples). The presence of E. Coli is addressed by WASAs through chlorination at source.
- Sugar mills, leather tanneries and textile industries are among top polluters discharging untreated effluents in the surface water bodies with high levels of COD, BOD, TDS and pH beyond PEQS limits.

Different stakeholders are responsible for management of the quality and quantity of water resources

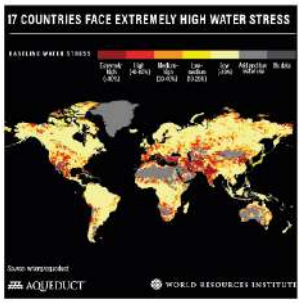
EPA Punjab, PCRWR, WASA, Irrigation Department, Local Government and Community Development Department and Agriculture Department are the key stakeholders engaged in water resource management in the province. These stakeholders are taking a number of initiatives to manage water quality and quantity in Punjab.

Despite identification of aforementioned challenges, by and large, little realization and understanding of underlying issues is rendered therein. Punjab, the most populous province of Pakistan (with 53% of country's population), has access to 41% of national water resources and has the highest water use in the country. However, the water availability in Punjab is constantly declining owing to its (largely) arid climate and unfettered use of freshwater resources. More than 80% of available water resources are already in use, with irrigation/agriculture (90%) leading in total water withdrawals[1]. Demand for water has drastically increased in recent times with growing population and declining groundwater resources. As a consequence of these immense pressures on water resources, the quality has also deteriorated and the province is facing serious water security challenges. Per capita freshwater availability, especially for drinking and domestic purposes, is already at an all-time low. It is estimated (ADB; The World Bank) that we are fast transitioning from a water stress level (<1.7 million cubic meters per capita per annum) to a water scarcity level (<1 million cubic meters per capita per annum).

World Resources Institute ranks Pakistan

14th out of 17 countries

with extremely high baseline water stress



Water table of freshwater/usable water in urban areas, especially in big cities, has drastically declined particularly in the last few years. Moreover, most of the currently available water resource is already highly polluted, and is further getting polluted due to multiple factors causing degradation of local/natural environment. The burgeoning population in the rapidly urbanizing cities is putting immense pressures on freshwater resources. Moreover, unregulated dumping of sewage, leachate contamination from poorly designed landfill sites, discharge of industrial effluents into the water ways and agricultural runoffs add tons of harmful chemicals into the fresh water bodies (Figure 3-2).

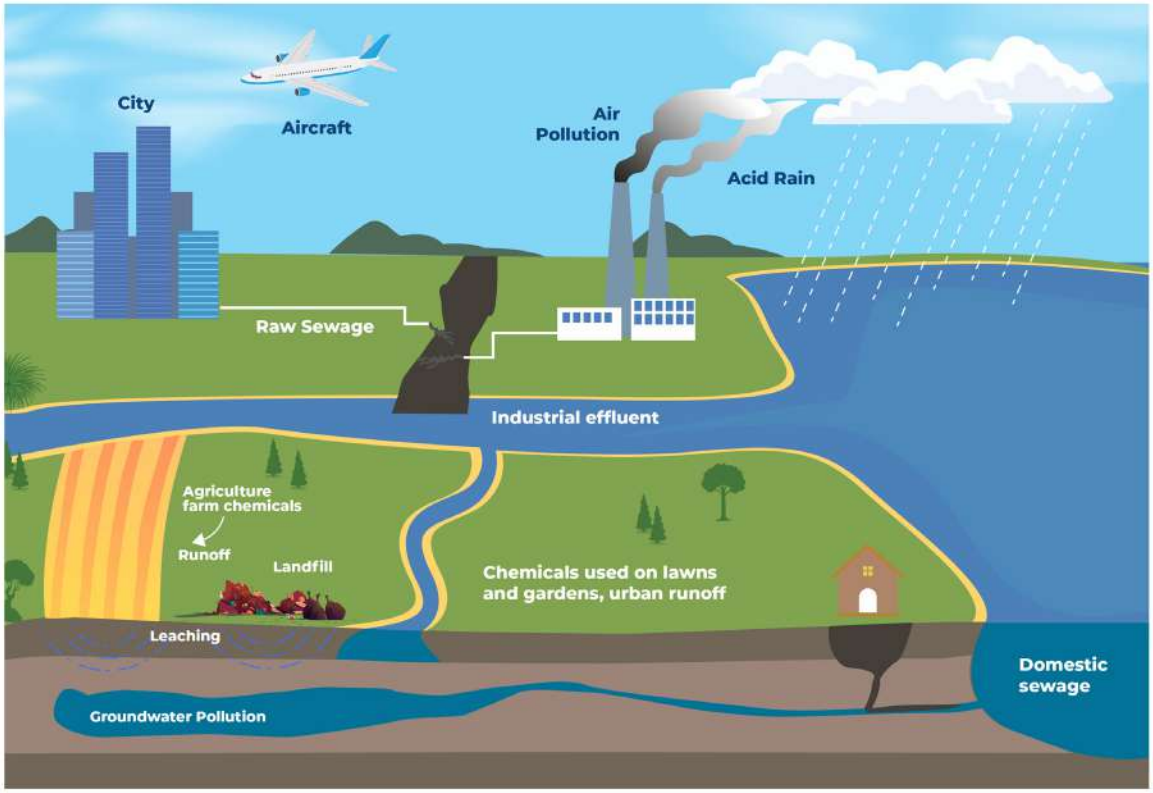


Figure 3-2: Sources of water pollution

Poor water quality and contaminants there in have been known for causing significant negative impacts on the nation's health. Most of the common diseases that affect public health at large result from consumption of contaminated drinking water as documented by Planning Commission, Government of Pakistan[2]. Access to safe and clean drinking water and

[1] FAO (2020) AQUASTAT. Pakistan: agricultural water withdrawal. Available at: http://www.fao.org/nr/water/aquastat/data/query/results.html

[2] Pakistan 2025 – One Nation-One Vision, Planning Commission, Ministry of Planning Development & Reforms, Government of Pakistan.

sanitation facilities is a basic human right, and is critical to promote public health as envisioned in the UN Sustainable Development Goals (SDGs 3 and 6). Multiple Indicator Cluster Survey (MICS) 2017-18 showed that most of the households in Punjab have access to improved drinking water sources in sufficient quantity at their premises.

The risk of E. Coli contamination in drinking water is high in Punjab[3]. With regards to water quality, PCRWR reported that 51% of the drinking water sources in Punjab are 'unsafe' (comparatively worse than during 2002-06 and 2010-15 studies)[4]. The incidence of bacterial contamination is high in major cities of Punjab (including Lahore, Multan, Rawalpindi, Sargodha and Sheikhupura), thereby indicating increase in disease burden resulting from waterborne infections. Although access to 'safe' water increased from 31% (2015) to 39% (2020) (based on samples tested), however, consumption of 'unsafe' water poses a significant health risk in the form of onset of diarrhea, dysentery, typhoid, hepatitis, skeletal and dental fluorosis, methemoglobinemia and even cancer[5]. Another study reported that agriculture water deprivation and use of wastewater for irrigation has led to malnutrition, loss of income and increase in water-related diseases in Punjab[6]. The rural-urban differences in the availability of clean water, sanitation and hygiene indicators are presented in Figure 3-3. A USAID study undertaken in Kasur district found that 87% of the health-related costs in the region were directly attributable towards water quality aspects. The total economic cost of water and sanitation, floods and droughts in the country is estimated to be 4% of the national GDP (US$ 12 billion/year). The Government of the Punjab, cognizant of the need for strategic investments in the WASH sector, allocated a budget of PKR 41,405 million for this sector during 2019-20 for its development.

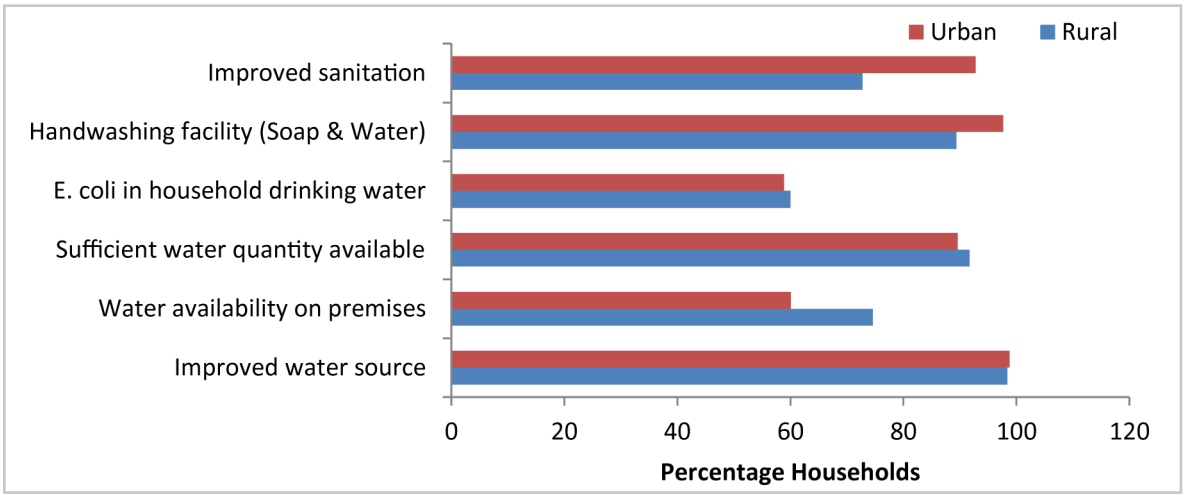
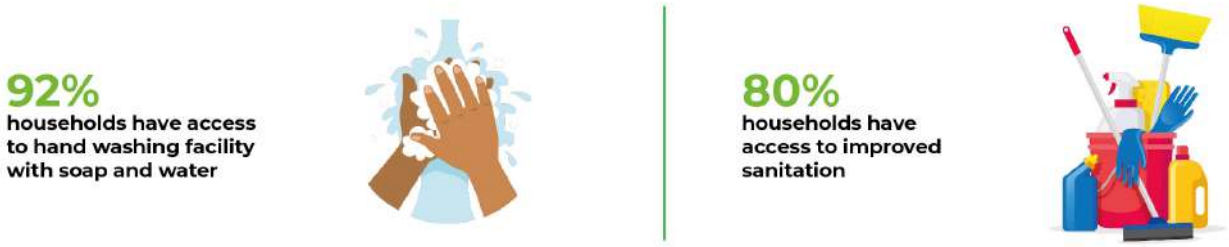


Figure 3-3: Rural-urban difference in the drinking water, sanitation and hygiene indicators of Punjab (Source: Government of the Punjab, 2019)



[3] Government of the Punjab (2019). Multiple Indicator Cluster Survey (MICS), Punjab 2017-2018. Punjab Bureau of Statistics Planning & Development Board Government of the Punjab, pp. 247, 253, 257 and 259

[4] Hifza, Fauzia, Kiran and Ashraf (2021). Drinking Water Quality in Pakistan: Current Status and Challenges. Pakistan Council of Research in Water Resources (PCRWR). Based on a sample study of 29 cities across Pakistan in 2020

[5] National Academies Press (US) 2009. Global Environmental Health: Research Gaps and Barriers for Providing Sustainable Water, Sanitation, and Hygiene Services: Workshop Summary. Institute of Medicine (US) Roundtable on Environmental Health Sciences, Research, and Medicine. <https://www.ncbi.nlm.nih.gov/books/NBK50774/>

[6] Mikosch, Berger, Huber &Finkbeiner (2021). Assessing local impacts of water use on human health: evaluation of water footprint models in the Province Punjab, Pakistan. International Journal of Life Cycle Assessment (26). Springer

2. ENVIRONMENT

2.1 Surface water resources

The surface water resources of Pakistan are primarily dependent on the flows of the Indus River and its various tributaries. The total length of the Indus River is 2,900 km draining an area of 966,000 km^2. Five major tributaries namely Chenab, Sutlej, Jhelum, Ravi and Beas join Indus from eastern side while minor tributaries such as Soan, Siran and Harow drain mountainous areas. Additionally, Indus is also joined by a number of small tributaries from its western side, the largest of which is Kabul River (Figure 3-4)[7].

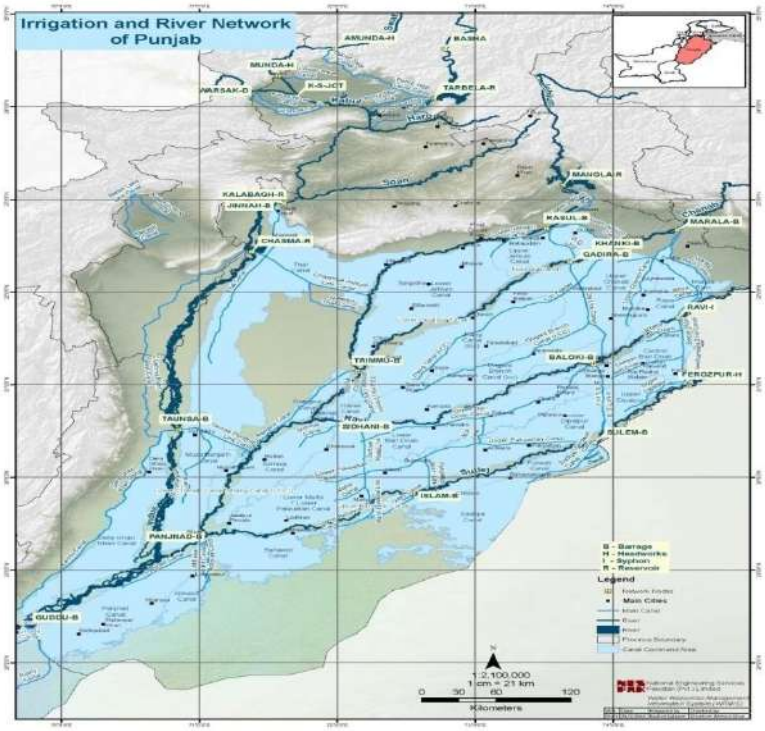


Figure 3-4: Irrigation and river network of Punjab

During year 2022, the Punjab Irrigation Department calculated flow of rivers Indus, Jhelum, Chenab and Kabul at Rim Stations. The maximum flow of Indus River was 14.75 MAF during the month of August. River Kabul recorded the lowest flow in February. The average flow of the rivers in 2022 was in the order of Indus > Chenab > Kabul > Jhelum with averages 4.69, 1.78, 1.58 and 1.35 MAF respectively (Figure 3-5).

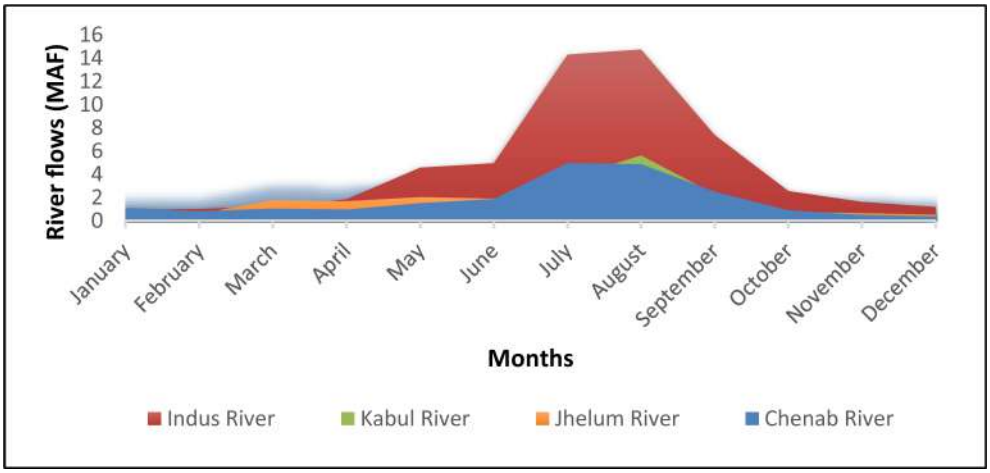


Figure 3-5: Average monthly flows of major river in Punjab (MAF)

2.2 Surface water quality

The Pakistan Council of Research in Water Resources (PCRWR) routinely monitors the quality of water channels throughout the country through investigations of biochemical and physical characteristics. This entails sample-based monitoring of rivers, drains and groundwater (for both shallow and deep sample extractions). The ensuing analysis is based on water quality data from their monitoring network in Punjab for the duration ranging from January to November, 2022.

[7] http://pakirsa.gov.pk/images/Punjab-IRSA.jpg

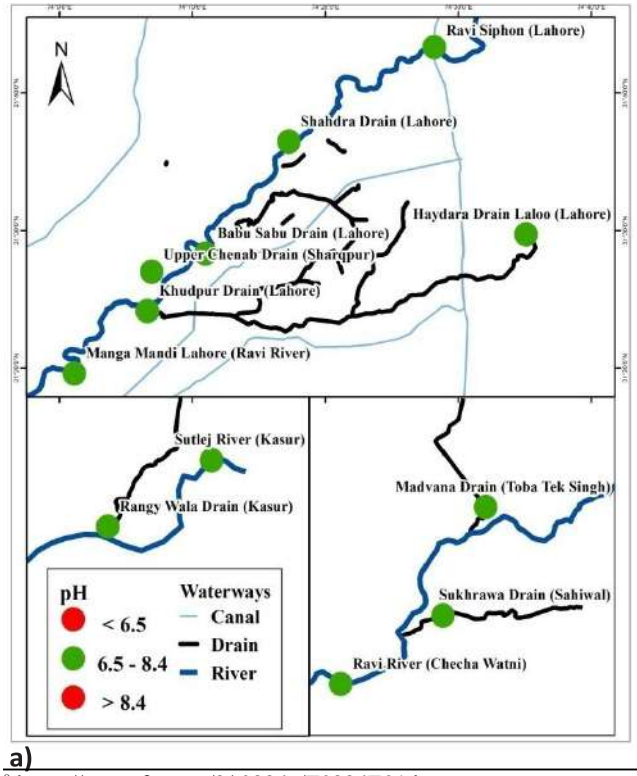
Assessment of surface water quality

There are no surface water quality monitoring stations installed within the EPD monitoring space, at the moment the, data was sourced from PCRWR for the purpose of this report. Similarly, limited standards for surface water quality are available for Punjab, therefore, international irrigation water quality standards (FAO, etc.) were used in their stead.

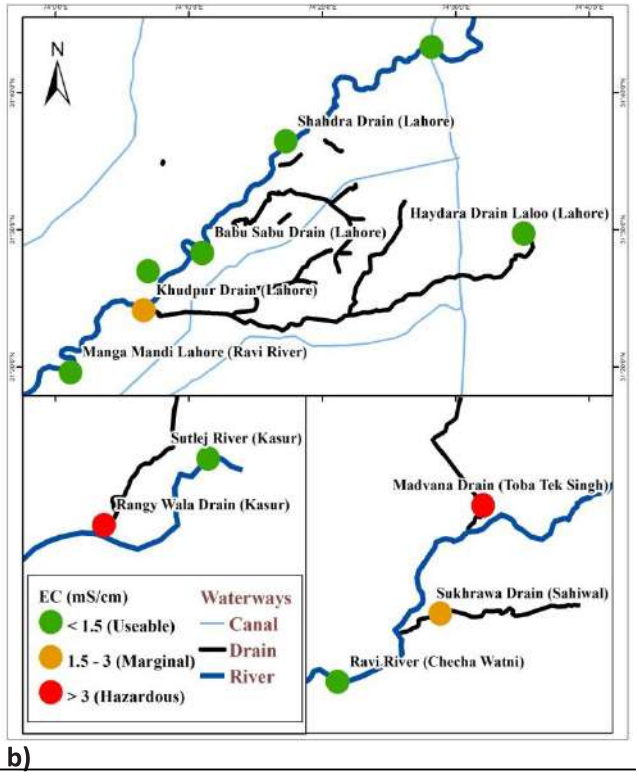
Rivers and Drains: PCRWR provided water quality data for the rivers Ravi and Sutlej, and 8 drains that flow into these two Eastern rivers. For the river Sutlej, samples were taken from one location, and for the river Ravi, samples were taken from three locations (Lahore Siphon, Manga Mandi and Checha Watni). To assess the water quality of rivers and drains for irrigation purposes (being the dominant use of surface water), the results of the water quality parameters were compared with FAO standards[8] (for pH, TDS, NO_3^--N and Cl^-), USEPA limits (for turbidity), and Water and Power Development Authority limits (for EC and SAR (Sodium Adsorption Ratio) (ICARDA manual)[9]).

The results showed that all drains and rivers samples reported pH levels that were within the acceptable ranges set forth by the FAO for irrigation water quality (Figure 3-6 a). Two drains (Rangy Wala and Madvana drains) had salinity levels that were hazardous, whereas all rivers and majority of the drains had salinity levels that were either useable or marginal (Figure 3-6 b). No sodicity threat was detected in the rivers and drains tested as evidenced by the SAR levels being within the useable range (Figure 3-6 c). While most of the drains and both rivers had low levels of TDS and NO_3^--N, indicating that they could be used for irrigation, Madvana, Rangy Wala, and Sukhrawa drains had relatively high levels, indicating severe restrictions on using such water for irrigation (Figures 3-6 d & e). Except for the Madvana, Sukhrawa and Rangy Wala drains, where moderate to severe restrictions in the use of water for irrigation are advised owing to high levels of chlorides therein (Figure 3-6 f), no restrictions in the use of surface water (both rivers and most drains) for irrigation purposes due to chlorides was advised. Madvana, Sukhrawa and Rangy Wala drains also reported significant levels of hardness, whereas the hardness quality of remaining drains and rivers was ascribed as intermediate and soft respectively (Figure 3-6 g). All drains had high levels of turbidity with a cloudy appearance, whereas rivers had relatively low levels of turbidity (with a light cloudy appearance) (Figure 3-6 h). Both rivers reported low BOD and COD values, but all drains had very high levels, indicating considerable pollution load inflows from multiple sources (Figure 3-6 i & j). In this context, secondary data sources/studies too narrate that excessive quantities of heavy metals, BOD, COD, NO_3^--N, and TDS have severely degraded the river water quality in Punjab[10,11]. Using both primary and secondary data, it was determined that the water quality of rivers in Punjab was 'moderate' for irrigation purposes but 'very poor' for drains.

It is significant to note that PCRWR conducts monthly assessments of surface water quality indicators for their reporting purposes. This report relates an (averaged) snapshot of water quality indicators in this regard. In addition, it is important to measure discharge flow rates as well since quality depends upon both pollutant concentrations and flow rates, allowing for a more thorough evaluation of the pollution load and its transportation (and reach) impact.

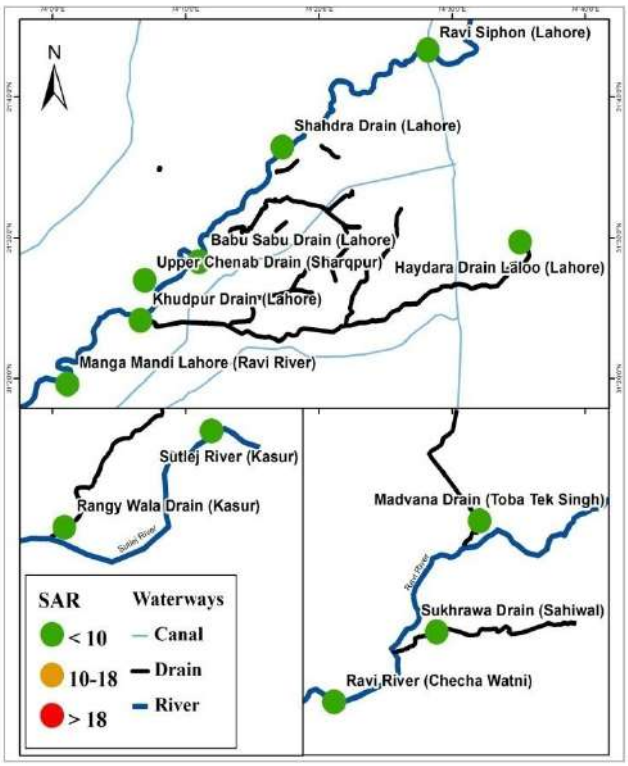


a)

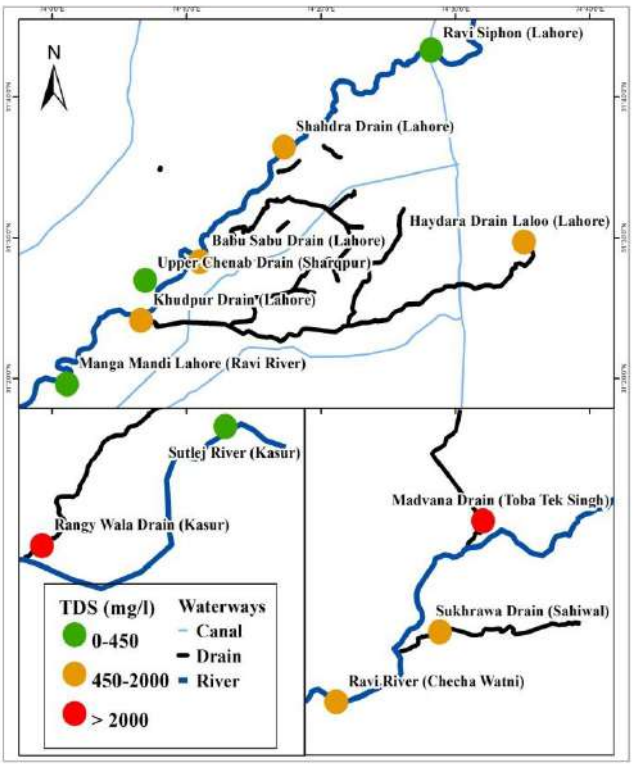


b)

[8] https://www.fao.org/3/t0234e/T0234E01.htm
[9] Rayan, J., Estefan, G., Rashid, A. Soil and Plant Analysis Manual. 2nd Edition. ICARDA, Syria & NARC, Pakistan
[10] Iqbal, Shoaib, Agwanda and Lee (2018). Modeling Approach for Water-Quality Management to Control Pollution Concentration: A Case Study of Ravi River, Punjab, Pakistan. Water, 10(8). MDPI. <https://doi.org/10.3390/w10081068>
[11] Naz et al (2022). Water quality and health risk assessment of trace elements in surface water at Punjnad Headworks, Punjab, Pakistan. Environmental Science and Pollution Research, v. 29. Springer. <https://doi.org/10.1007/s11356-022-20210-4>


N
Ravi Siphon (Lahore)
Shahdra Drain (Lahore)
Babu Sabu Drain (Lahore)
Upper Chenab Drain (Sharqpur)
Haydara Drain Laloo (Lahore)
Khudpur Drain (Lahore)
Manga Mandi Lahore (Ravi River)
Sutlej River (Kasur)
Rangy Wala Drain (Kasur)
Madvana Drain (Toba Tek Singh)
Sukhrawa Drain (Sahiwal)
Ravi River (Checha Watni)
SAR
< 10
10-18
> 18
Waterways
Canal
Drain
River

c)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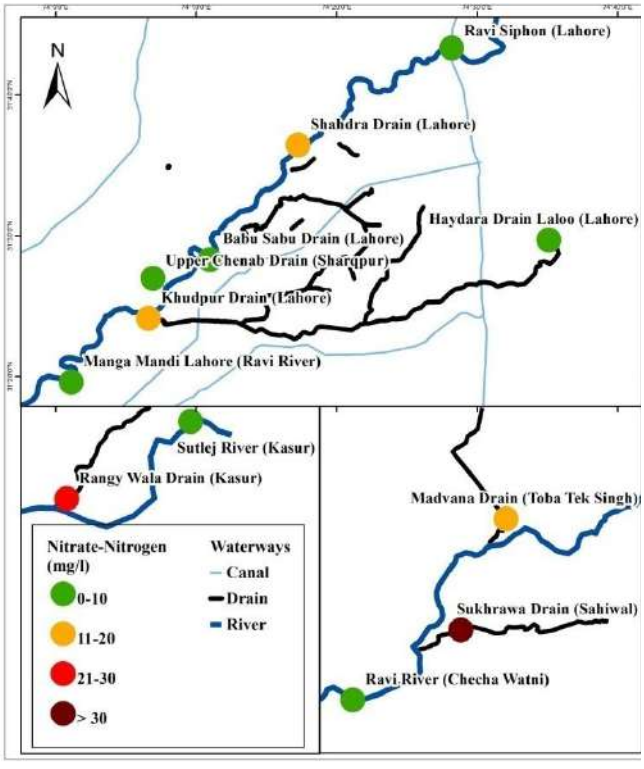
Babu Sabu Drain (Lahore)
Upper Chenab Drain (Sharqpur)
Khudpur Drain (Lahore)
Manga Mandi Lahore (Ravi River)
Sutlej River (Kasur)
Rangy Wala Drain (Kasur)
Madvana Drain (Toba Tek Singh)
Sukhrawa Drain (Sahiwal)
Ravi River (Checha Watni)
TDS (mg/l)
0-450
450-2000
> 2000
Waterways
Canal
Drain
River

d)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Shahdra Drain (Lahore)
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Babu Sabu Drain (Lahore)
Upper Chenab Drain (Sharqpur)
Khudpur Drain (Lahore)
Manga Mandi Lahore (Ravi River)
Sutlej River (Kasur)
Rangy Wala Drain (Kasur)
Madvana Drain (Toba Tek Singh)
Sukhrawa Drain (Sahiwal)
Ravi River (Checha Watni)
Nitrate-Nitrogen (mg/l)
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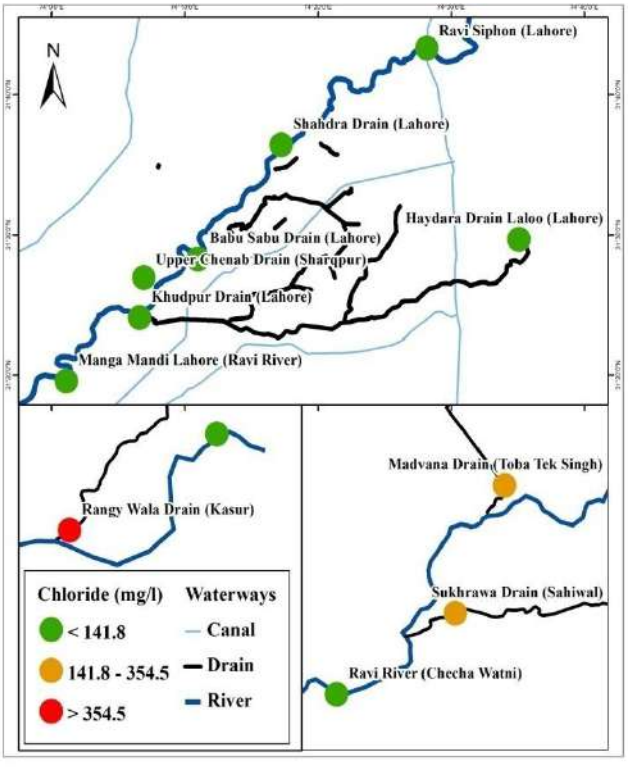
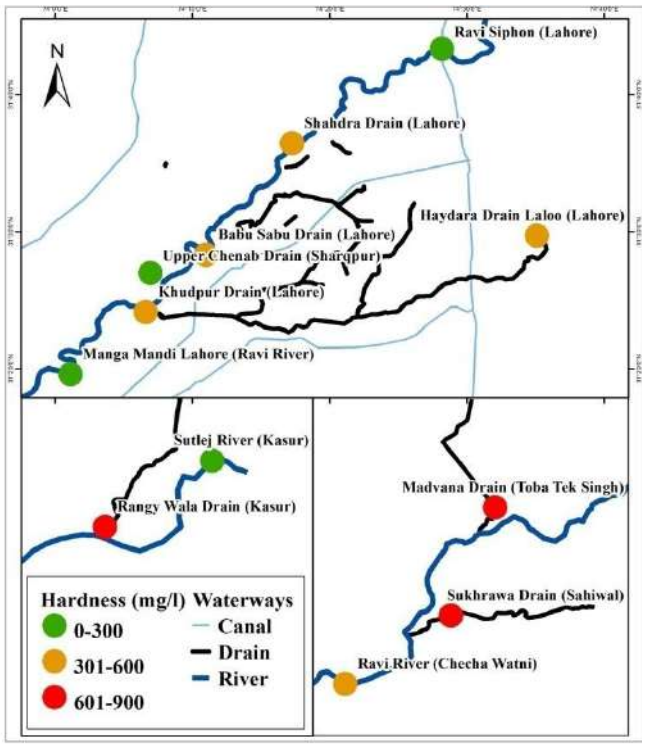
21-30
> 30
Waterways
Canal
Drain
River

e)


N
Ravi Siphon (Lahore)
Shahdra Drain (Lahore)
Haydara Drain Laloo (Lahore)
Babu Sabu Drain (Lahore)
Upper Chenab Drain (Sharqpur)
Khudpur Drain (Lahore)
Manga Mandi Lahore (Ravi River)
Rangy Wala Drain (Kasur)
Madvana Drain (Toba Tek Singh)
Sukhrawa Drain (Sahiwal)
Ravi River (Checha Watni)
Chloride (mg/l)
< 141.8
141.8 - 354.5
> 354.5
Waterways
Canal
Drain
River

f)



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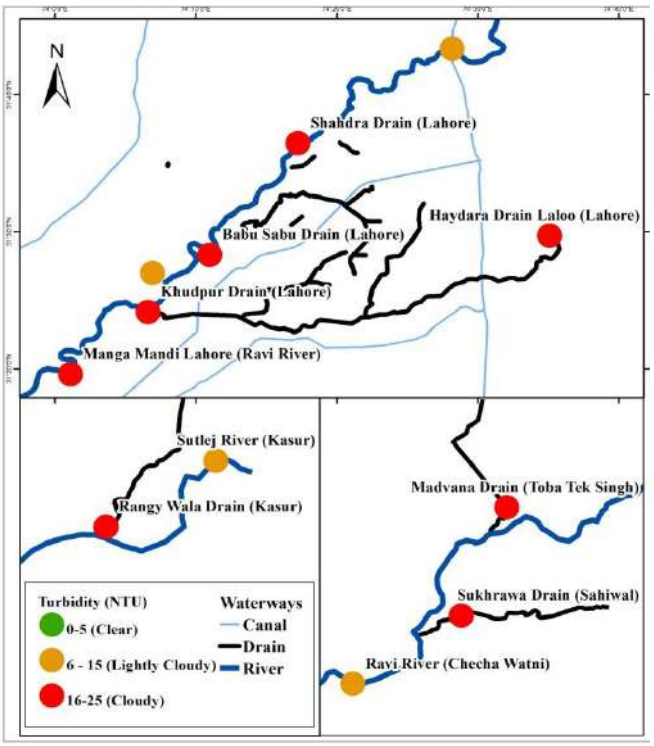

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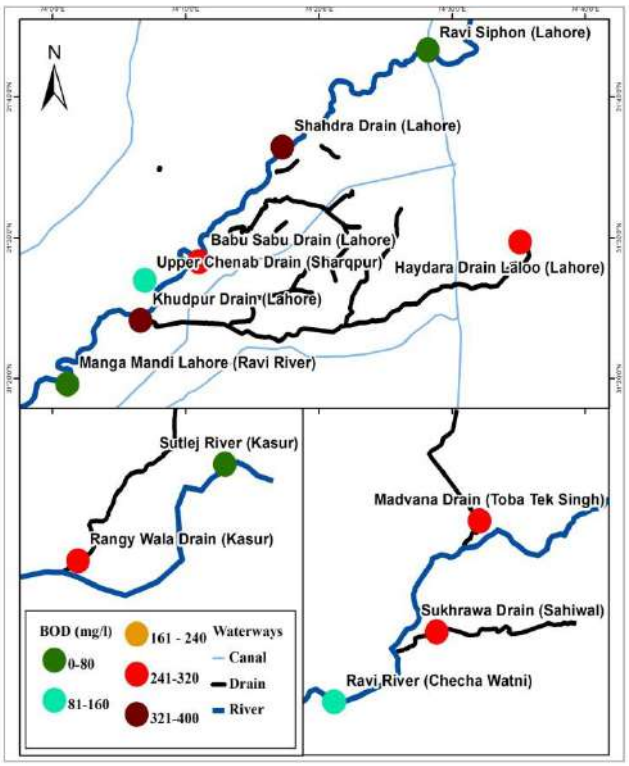

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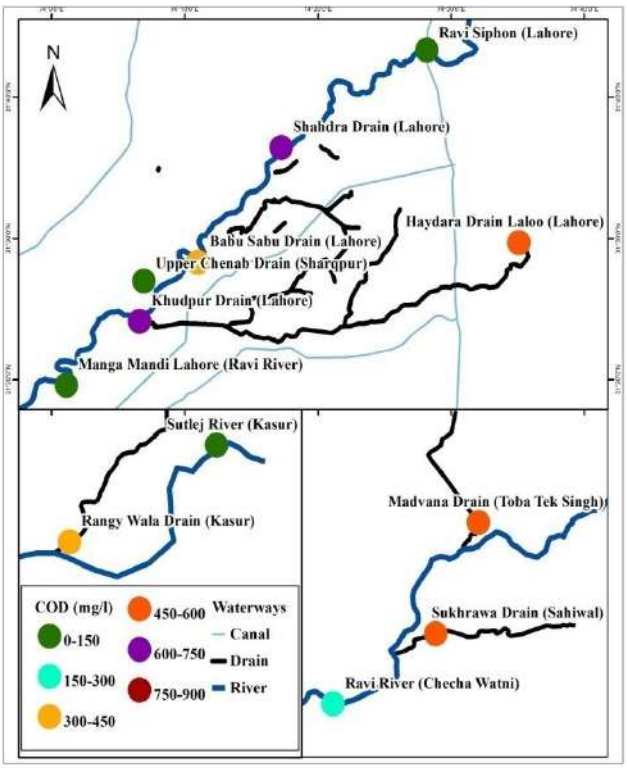


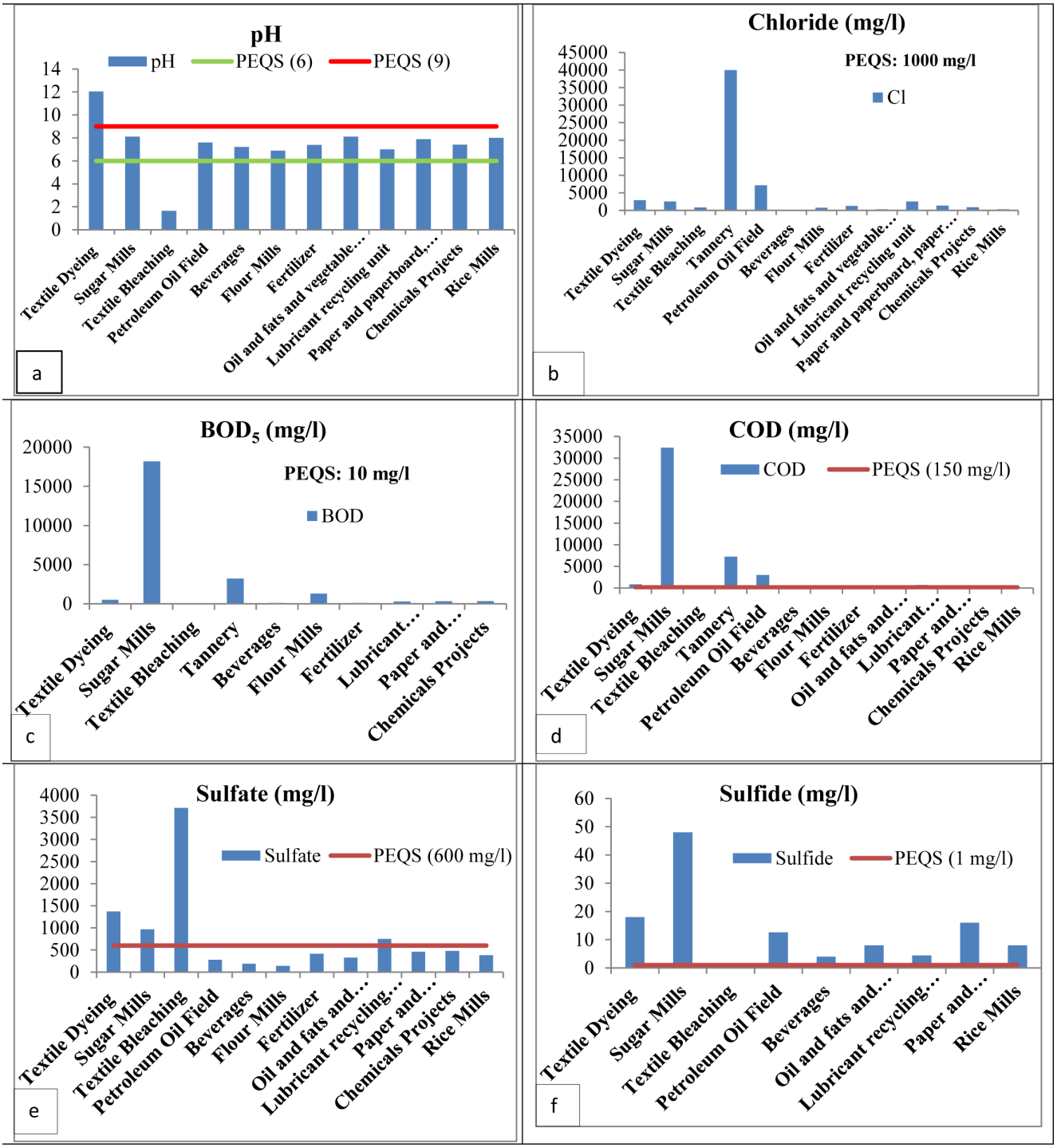
j)

Figure 3-6: Surface water quality of rivers and drains in Punjab.

Organic load
in rivers is resulting
in high BOD levels

Drains
in Punjab have
high pollution load

Effluent characteristics: During 2022, various EPA laboratories conducted monitoring of wastewater samples to assess pressures on water resources in Punjab. Most assessments were conducted by EPA laboratories in Lahore and Faisalabad. Industrial effluents were found to be a leading cause of water pollution in Punjab with a major contribution coming from textile factories, sugar mills and leather tanneries, etc. The monitoring results showed that effluents from textile factories had slightly higher pH values than PEQS (Figure 3-7 a). The level of chlorides was approximately 40 times higher in the case of tanneries, 7 times in case of petroleum oil fields and twice for textile dyeing and lubricant recycling units than the limits prescribed by PEQS (Figure 3-7 b). Higher values of BOD5, COD, and Total Dissolved Solids, Total Suspended Solids and Sulfide were recorded for the effluents from most of the industries; sugar mills reported the highest values therein. Textile effluents had 6 times higher values of sulphates than PEQS (Figures 3-7 c-h). Overall, sugar mills, tanneries and textile industries were discharging effluents in the surface water bodies with high levels of pollutants (COD, BOD, TDS and pH) beyond PEQS limits.



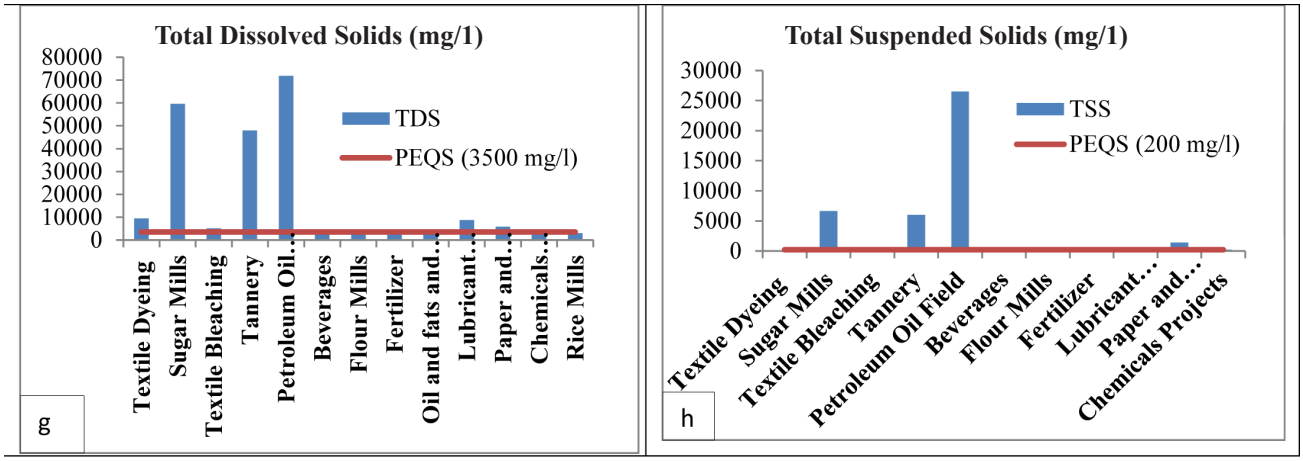


Figure 3-7: Effluent characteristics of various industries operating in Punjab

2.3 Groundwater Resources

Groundwater supplies 70% of the domestic and 50% of the agriculture water in Pakistan. It is a life sustaining resource, but unregulated pumping is resulting in drying up of wells and depletion of aquifers in Punjab. Other threats such as seepage of industrial wastewater and domestic sewage into groundwater are two of the leading causes of contamination thereof.[12]

2.4 Groundwater quality

Groundwater sampling and testing thereof was carried out by PCRWR near each of the above 8 drains. In total 16 venues of groundwater were selected for monthly sampling, 8 each from shallow (up to 150 ft. deep, usually via hand pumps) and deep groundwater (beyond 350 ft. deep, usually via tube wells) (Figure 3-8).

Punjab has poor quality shallow groundwater

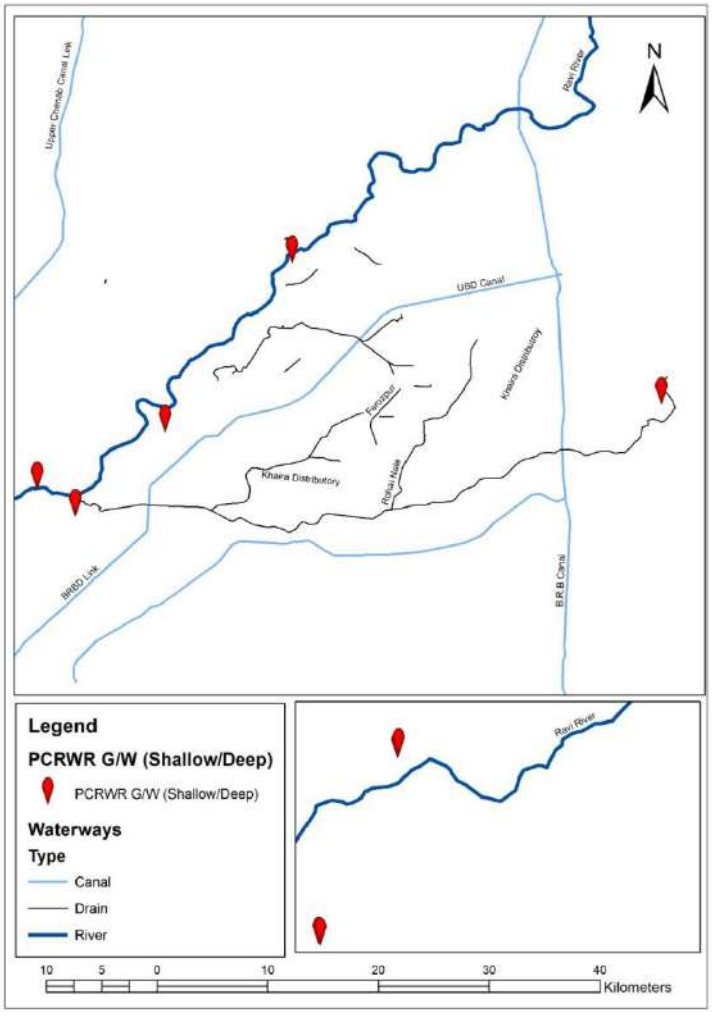


Figure 3-8: Sampling locations of shallow and deep groundwater in Punjab

At various locations sampled across Punjab in year 2022, the quality of shallow groundwater was poor compared to the deep groundwater with a larger number of parameters exceeding the prescribed limits. Higher values of alkalinity, turbidity and arsenic were found for both shallow and groundwater. The level of turbidity remained high in 5 out of 8 shallow groundwater samples. The level of arsenic was critically high in all samples with up to 734 times high in shallow groundwater at Shahdara drain (Figure 3-9). Coliforms (total, fecal and E. Coli) were also detected in the groundwater samples (Figure 3-10). The level of EC at Madvana drain was slightly higher than the limits set by WHO, while it was low for all other samples. Hardness, pH, Nitrates and TDS at all locations remained well below the limits (Figures 3-11 & 3-12).

[12] The World Bank (2021). Managing Groundwater Resources in Pakistan's Indus Basin. https://www.worldbank.org/en/news/feature/2021/03/25/managing-groundwater-resources-in-pakistan-indus-basin

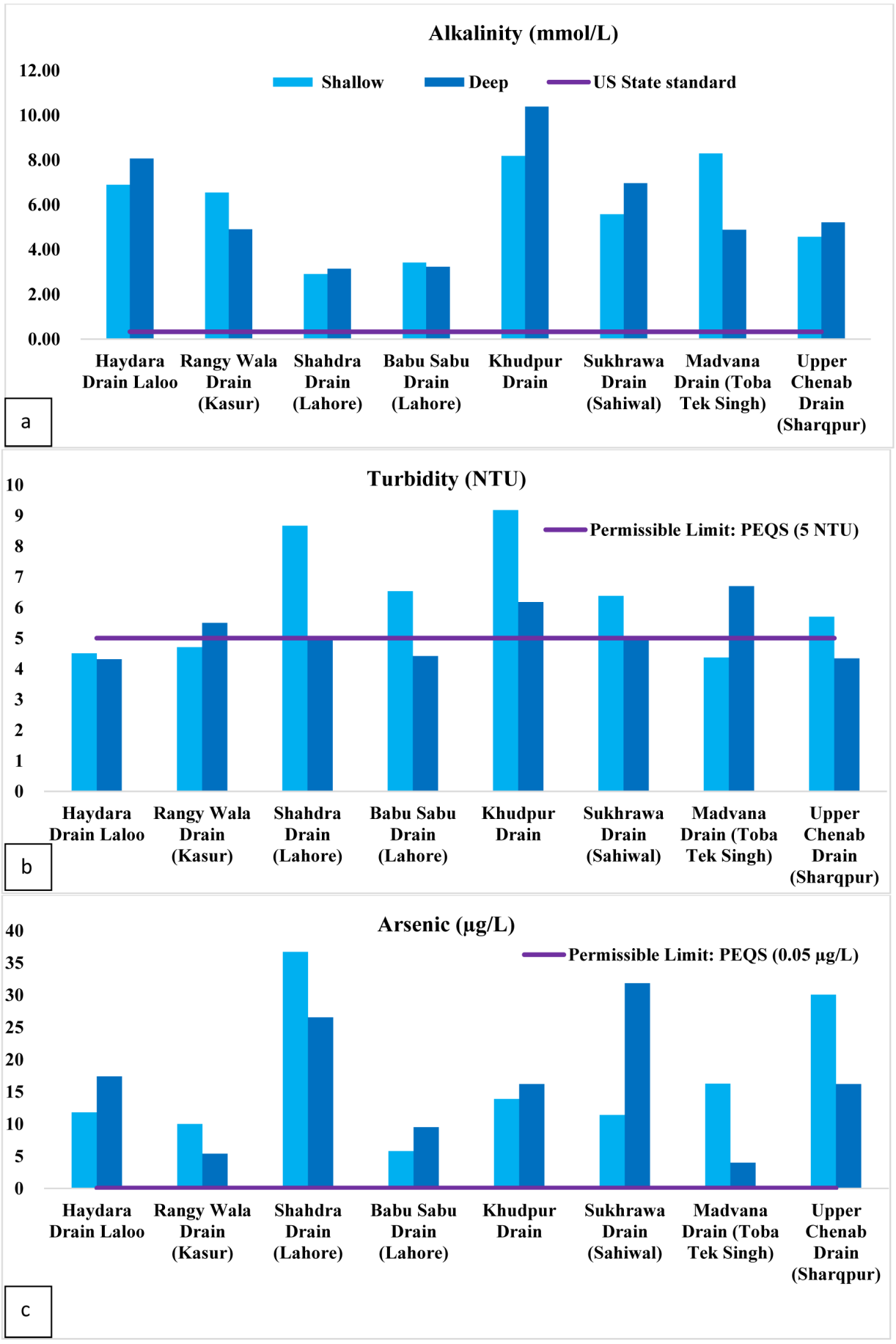


Figure 3-9: Level of (a) alkalinity, (b) Turbidity and (c) Arsenic in the groundwater samples

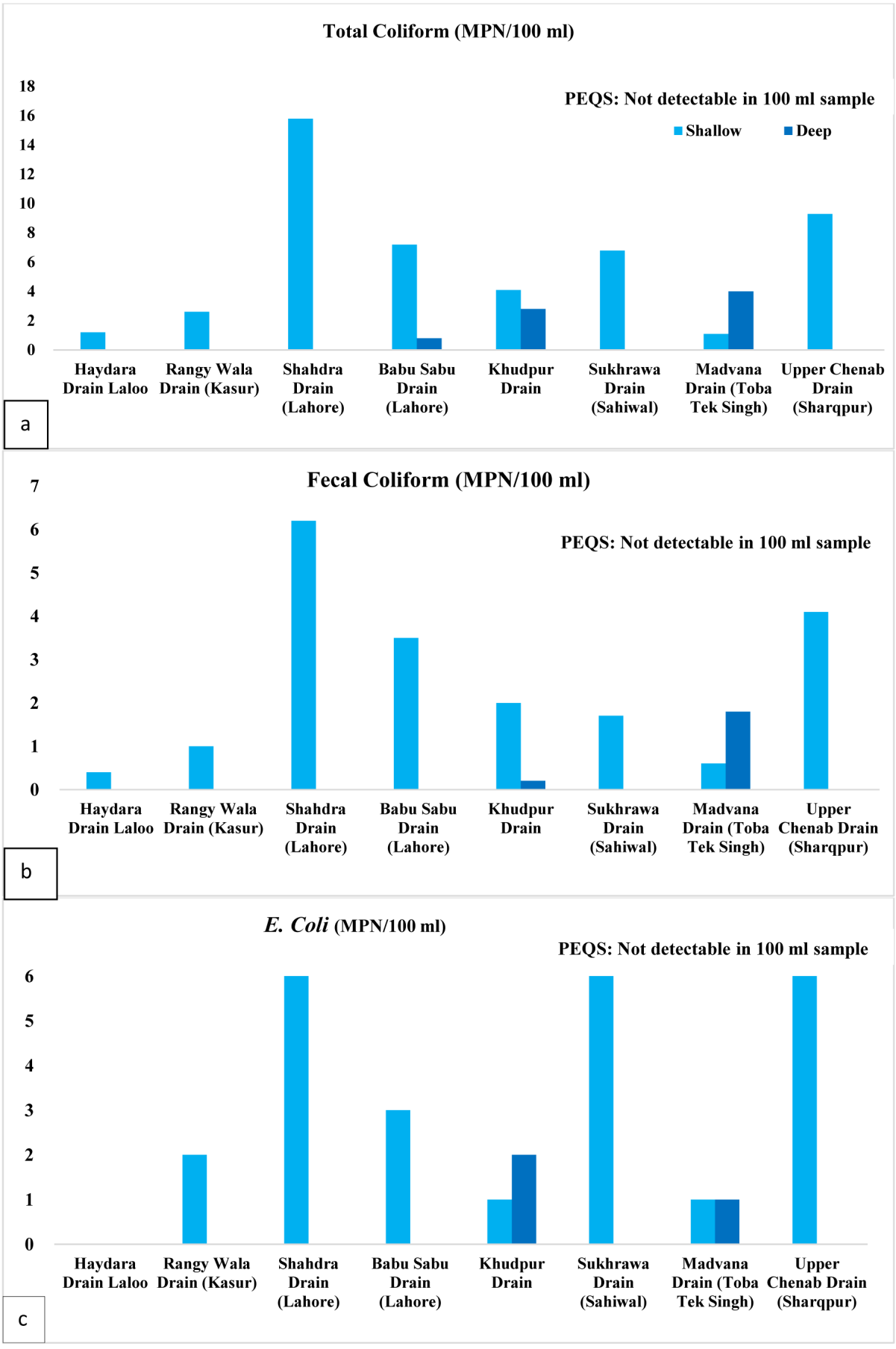


Figure 3-10: Microbial quality of shallow and deep groundwater in Punjab

Average values of alkalinity, HCO3, EC, Ca, SO4, Cl-, Hardness, Mg, As, pH, K, Na, TDS, Turbidity, NO3-N, BOD, COD, TC, FC. and E. Coli for rivers, drains and groundwater samples are given in Annexure V.

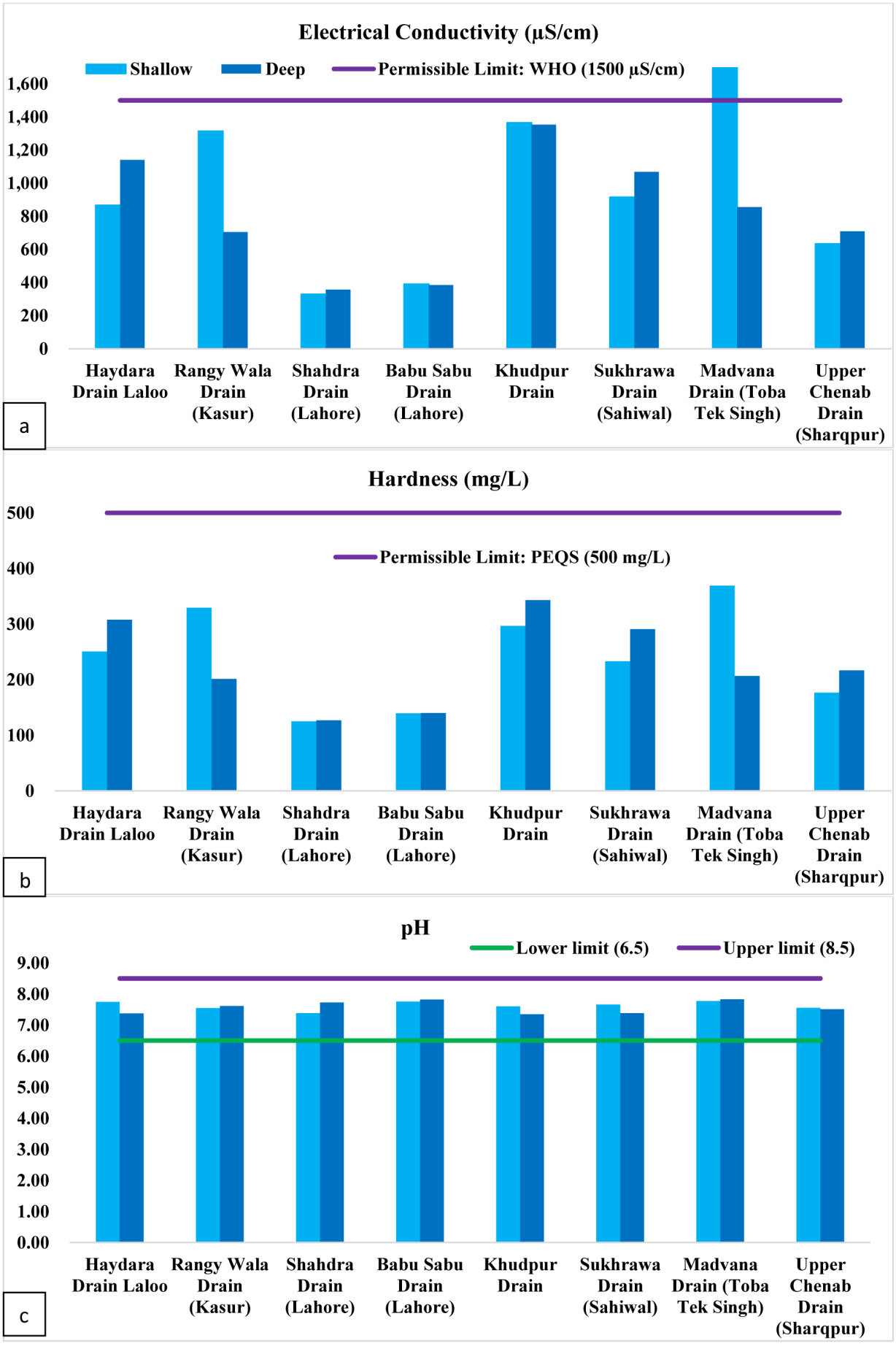


Figure 3-11: Water quality of the shallow and deep groundwater in Punjab

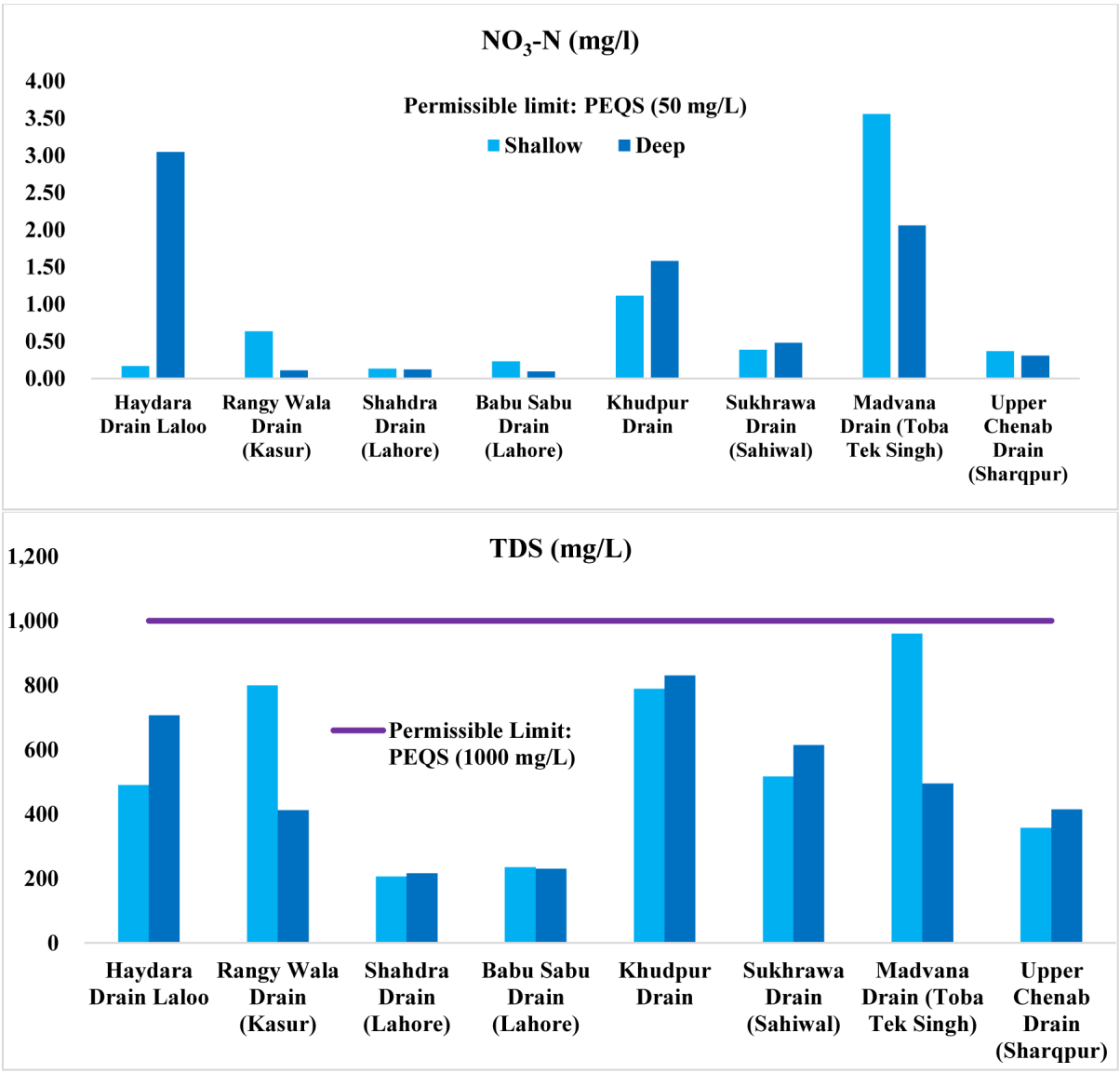
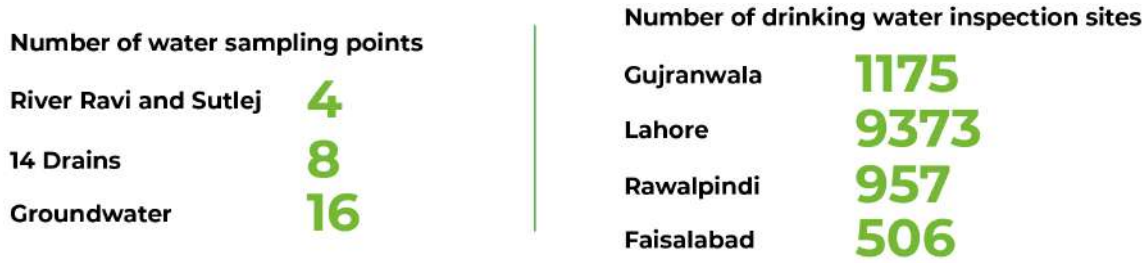


Figure 3-12: Level of NO_3-N and TDS in the groundwater of Punjab

Secondary data sources also reported higher concentrations of arsenic and fluoride in shallow groundwater of Lahore but free from fluoride in deep water. Similarly, in Rawalpindi, around 50% of the samples were found contaminated with bacteria. Overall, in Punjab, around 11% and 96% of the groundwater samples were found unsafe for drinking in Sialkot and Bahawalpur cities respectively.



2.5 Drinking water quality of Punjab

In Punjab, around 69.4% of the population has access to improved water sources within their premises. This percentage is higher in rural areas (74.6%) compared to urban areas (60.1%). On the other hand, the availability of piped water supply in Punjab stands at 19.3%. Piped water supply is more prevalent in urban areas (29.3%), while its accessibility is lower in rural areas (13.1%) . A recent drinking water quality assessment carried out by WASAs in four big cities of Punjab – Gujranwala, Lahore, Rawalpindi and Faisalabad – reported on service delivery of WASAs within these cities. The assessment therein is presented in Table 3-1.

[13] Groundwater in Pakistan's Indus Basin: Present and Future Prospects. https://openknowledge.worldbank.org/entities/publication/6aaa5fb6-f7ce-5bc6-9e36-edafb15fbbc9

[14] https://hudphed.punjab.gov.pk/system/files/3%20Punjab%20Water%2C%20Sanitation%20%26%20Hygiene%20%28Sector%20Status%20Report%202019%29.pdf

Table 3-1: Water and sanitation service indicators of WASA in four major cities of Punjab[15],[16],[17]

Service indicators of WASA	Gujranwala	Lahore	Rawalpindi	Faisalabad
Number of Tube-wells	67	584	4000	62
Water supply pipeline length (3" – 24")	-	4550 km	-	-
Population served	70%	90%	85%	60%
Water production	-	540 MGD	56 MGD	88.5 MGD
Water connections	-	≈8 million	125,008	147,684
Sewage production	-	-	-	280 MGD
Coverage of sewerage/drainage system	70%	-	35%	-
Length of sewerage network	-	4006 km	-	-
Disposal stations	35	16	-	-
Lift stations	-	112	-	-
Major drains and drain length	-	6 – total length 74.98 km	-	-
Secondary drains and length	-	30 – total length 69.12 km	-	-
Tertiary drains length	-	213 km	-	-
Pumping capacity of disposal/lift stations	-	6699.25 cusec	-	-

Table 3-2 presents the source spread of drinking water service supplies within housing units[18] in Punjab[19].

Table 3-2: Housing units by source of drinking water
(17 million households as per 2017 Housing Census)

Source of Drinking Water	Inside	Outside
Tap	25.98%	2.51%
Electric/Hand Pump	59.82%	3.51%
Protected Well	0.58%	0.24%
Un-Protected Well	0.21%	0.13%
Spring	-	0.18%
Canal/River/Pond	-	0.47%
Others	3.00%	3.37%

Graphical representation of physical, chemical and biological analyses of drinking water samples carried out by WASA during 2022 in three major cities of Punjab is presented in Figure 3-13. In District Gujranwala, drinking water samples were collected at source (tube-wells) and from consumers. With regards to color, taste, odor, physical and chemical parameters, 94% of samples were found fit (within the permissible limits of PEQS and WHO) for consumption while only 6% samples had E. Coli contamination. The incidence of E. Coli might have resulted from seepage of sewage into the deteriorated water pipelines. The samples from Lahore district were colorless, tasteless and odorless and were fit for consumption while only 3% were contaminated with E. Coli. This shows that at source drinking water quality was good but deteriorated at consumer due to pipeline leakage. The water quality parameters from District Rawalpindi and Faisalabad were within the permissible limits.

[15] https://www.wasag.org.pk/content/wasag/about.html
[16] https://wasa.punjab.gov.pk/infodesk_watersupply
[17] http://wasafaisalabad.gop.pk/Home/WaterService
[18] A housing unit consisted of approximately 6.4 persons. Data is also classified on the basis of whether the service is located within the household premises or outside.
[19] Pakistan Bureau of Statistics (2017). Population Census 2017. Available at <https://www.pbs.gov.pk/content/brief-census-2017>

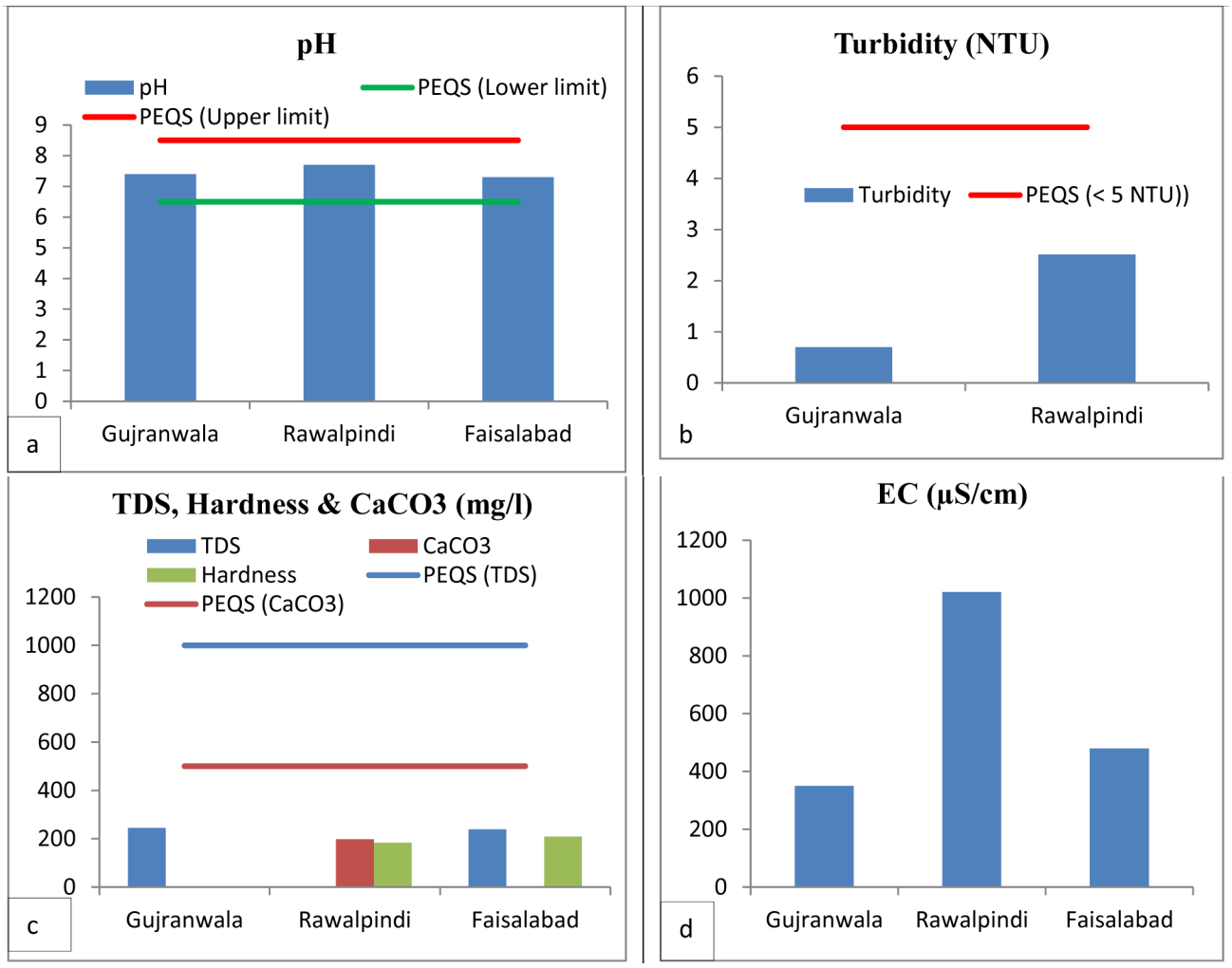


Figure 3-13: Drinking water quality of the major cities of Punjab

Secondary data sources also indicated higher bacteriological contamination and arsenic in major cities of Punjab (Table 3-3) [20].The incidence of bacterial and arsenic contamination was the highest in the case of Multan while drinking water of Sialkot city was found free of these contaminants.

Table 3-3: Characteristics of drinking water sources for consumption (PCRWR, 2020)

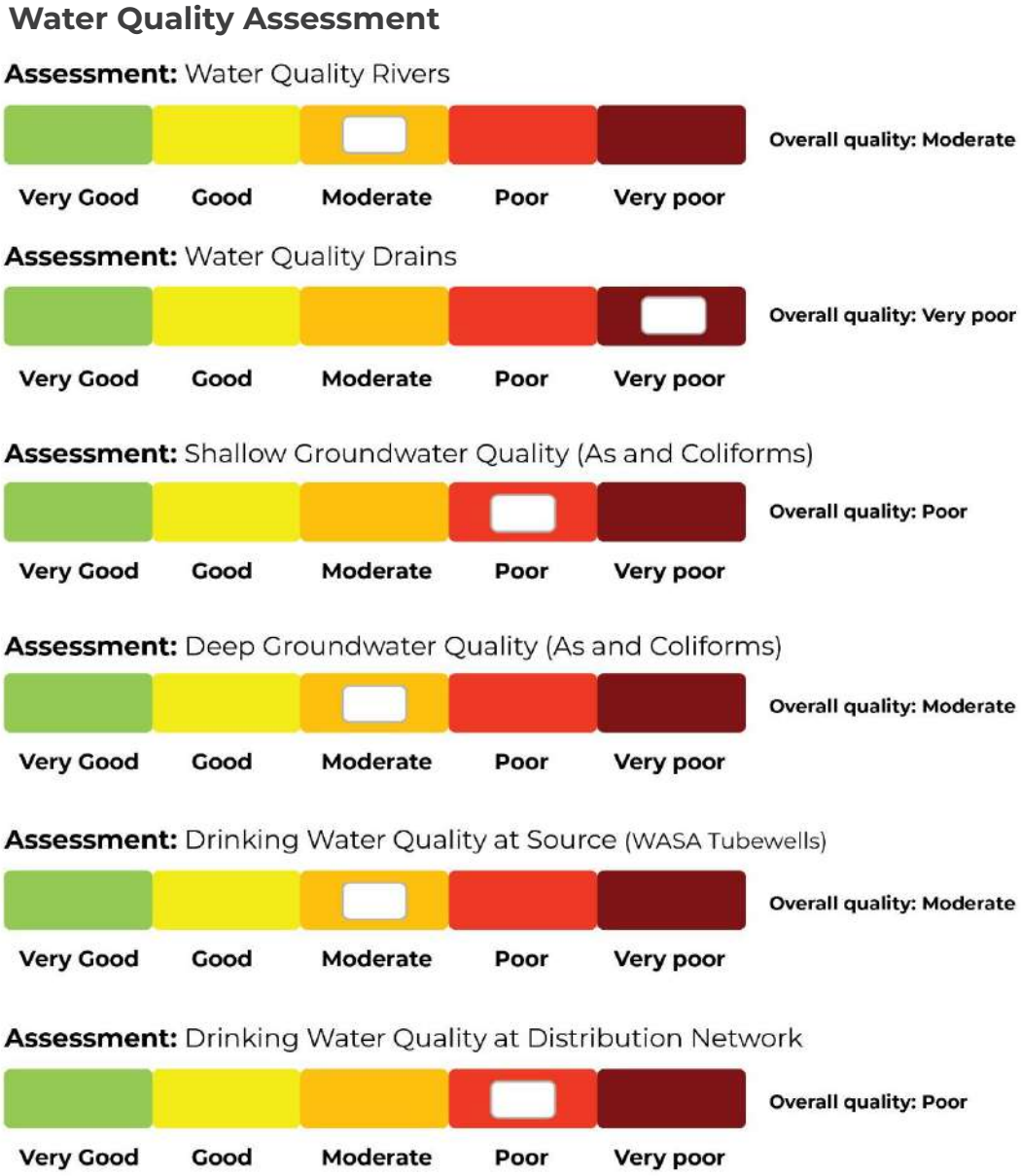
Cities	Lahore	Multan	Rawalpindi	Sargodha	Sheikhupura	Sialkot
Bacteriological Contamination	12%	69%	38%	21%	20%	All monitored sources provided safe water to the public
Arsenic	6%	63%	-	-	10%	

3. OVERALL ASSESSMENT

Summarily, the overall quality of water in rivers is rated as 'moderate' (for irrigation purposes as the dominant use thereof) while it is rated as 'Very Poor' for drains due to the high pollution load. Quality of shallow and deep groundwater in Punjab is rated as 'Poor' and 'Moderate' respectively for drinking purposes. The drinking water quality at source is rated as 'Moderate' whilst it is rated as 'Poor' for the distribution network due to presence of Arsenic and E. Coli; the rest of the parameters meet the permissible limits set by PEQS.

[20] Hifza, R., Fauzia. A., Kiran, A., and M. Ashraf (2021). Drinking Water Quality in Pakistan: Current Status and Challenges. Pakistan Council of Research in Water Resources (PCRWR), Islamabad <http://pcrwr.gov.pk/wp-content/uploads/2021/10/Drinking-Water-Quality-in-Pakistan-2021.pdf>

[21] Water quality at 'source' means quality of water at WASA Tube-wells/Canals before it is pumped into the supply lines/distribution network.



4. MANAGEMENT

The government can address water quality issues through enactment and promulgation of appropriate, requisite legal acts and policies related to water safeguards, conservation and sustainability. Laws including PEPA, 1997 and environmental quality standards need to be updated in line with modern requirements from governance and regulatory standpoints. A further aspect in this regard is enforcement of the promulgated laws, whereby appropriate legal actions can be taken against environmental polluters/violators therein. Both the public and private sector can play a proactive role through adoption of best water management practices, relating to both treatment and conservation. Appropriate implementation of these, especially the latter, can significantly help in assuring better water quality in the province.

4.1. Regulatory framework

A regulatory framework regarding water is available in the Punjab Environmental Protection Act, 1997 (XXXIV of 1997). In addition to "environment" and "pollution", the keyword "effluent" has also been defined § 2(viiii) of the Act ibid. Environmental quality standards for the municipal and industrial effluents and drinking water have already been notified by EPA, Punjab. However, the agency has to establish standards for specific effluents under this regulatory framework; this includes for both general/universal standards and those that are intended for specific industries.

4.2. Water Quality Management Practices

Government departments, through their Annual Development Programs, undertake various projects for the management and conservation of water resources. Some of the key projects included in ADP-2022-23 regarding water management are summarized in Table 3-4.

Table 3-4: Initiatives taken by government departments in Punjab for water quality management

Relevant Departments	Initiatives taken in Punjab
Irrigation Department	1. Construction of • Mini Reservoirs in D.G Khan • Dams (Mohata, Papin, Dadhocha, Mujahid, MohraShera, Dhrabi, Minwal, Ghabir, Sorra and Tamman Dam) • Small dams in District Attock and Chakwal 2. Aquifer Recharge for Groundwater Managementin Punjab
Urban Development Department	Construction of • Wastewater Treatment Plant in Faisalabad (45 MGD - Phase I) • Lahore Water &Wastewater Management Project (surface water treatment plant in BRBD Canal Lahore) • Rainwater Management (Drainage arrangement for sore point SheranwalaGate Lahore) • Upgradation of Disposal Stations (Chungi No. 09, Multan) • Storm Water Drainage and Temporary Storage (Dijkot road, Faisalabad)
Agriculture Department	1. National Program for improvement of watercourses across Pakistan (Phase II) 2. Development of groundwater resources with 3d-ERM & Geo-Logging Technology 3. Initiative targeting climate change mitigation 4. National Program for Enhancing Command Area in Barani Areas of Pakistan (Punjab Component) 5. Command area development of Jalalpurirrigation project 6. Improving irrigation water quality through foreign and local funded project • Punjab Resilient and Inclusive Agricultur Transformation (PRIAT) (2022-23 to 2026-27) • Promotion of High Value Agriculture through Solarizationof Drip & Sprinkler Irrigation System (2019-20 to 2022-23)
LG & CD Department	1. Solid waste management to prevent surface water contamination in Sahiwal and Sargodha districts 2. Formulation of Solid Waste Management Framework in Punjab 3. Master plans/Land Use Zoning Plans for Local Governments in Punjab.

5. DPSIR FRAMEWORK

The DPSIR Framework for water resource management system in Punjab (Figure 3-14) identifies the challenges and requisite responses as follows

Drivers

The rapid urbanization with recent proliferation of housing schemes, especially in the big cities, unplanned industrialization (resulting in excessive water usage) and conventional agricultural practices have placed immense pressure on the availability of water resources. The burgeoning population in our cities and poor agricultural practices on the rural side has caused decline in the water table.

Pressures

Inappropriate agricultural and industrial practices lead to resource wastage thereby affecting per capita water availability. Polluting factors, in particular those owing to untreated sewage from municipal sources, untreated effluents from industries and agricultural runoffs also place pressure on availability of freshwater resources. Industries discharge huge volume of effluents into the nearby water bodies thus affecting their overall quality.

State

Coupled with the water scarcity challenges, Punjab is also dealing with poor quality of the drains and aquifers. All of these factors have deteriorated the overall quality of life (human and natural ecosystems). Release of heavy metals (such as Arsenic) can travel through food chain and pose health impacts. The freshwater resources are also subject to degradation due to deforestation, runoff and water logging leading to ecological ramifications.

Impacts

Per capita availability of water in Punjab is declining and soon the province will touch water 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.

Response

Proactive measures on the legal and policy making side are the need of the hour for appropriate management of the water resources in Punjab. Enactment of the appropriate legal frameworks (laws and policies) can help in safeguarding water resources. A requisite legal framework against polluters/violators can further help in protecting the quantity and quality of the resource. Better water management practices related to conservation and treatment of effluents before disposal can reduce the pollution load and associated environmental costs.

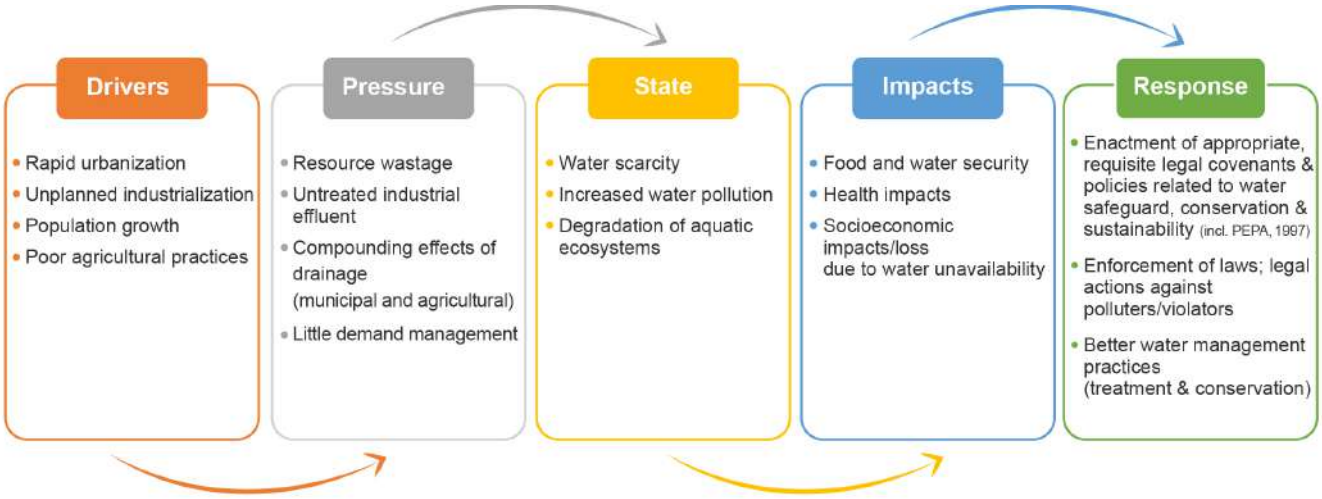


Figure 3-14: DPSIR framework of water quality in Punjab

6. THE WAY FORWARD

The progress of government in providing or assuring access to safe water supplies is slow due to multiple factors including lack of real time monitoring data, institutional capacity and adequate mechanism, research, awareness and transparency in use of resources22. Therefore, following interventions can help in ensuring sustainability of water resources in the province:

Water Monitoring System: A well-coordinated, evidence-based monitoring system is needed at provincial level to provide real-time spatiotemporal trends of water quality for rivers, drains, groundwater and effluent discharges. This will help in problem identification and to make informed decisions regarding their resolution and enhancing quality thereof. Currently, drinking water quality monitoring at the end of EPA Punjab is scanty and needs to be strengthened.

Environmental Legislation: Promulgation and enforcement of water and related environmental legislations is required including development of comprehensive water quality standards for drinking, irrigation, wastewater (municipal, industrial and agriculture) and recreational water.

Sustainable Institutional Mechanism: Sustainable institutional mechanisms to be developed for watershed management and strengthening pollution control system at inter-provincial and trans-boundary levels focusing on water security, conservation and treatment before discharge ('Zero Liquid Discharge' policy). Geo-tagging and compilation of the ancillary dataset regarding water pollution sources is also required.

Improving the Water Quality: Additionally, prioritize the treatment of water and wastewater, as well as the reclamation of waterlogged areas. Installing wastewater treatment plants in the industrial establishments shall further help in reducing pollution loads. For betterment of the water quality, every municipality must install a wastewater treatment plant whenever a new disposal station is going to be built.

Construction of Water Infrastructure: Construction of more water infrastructure in Punjab and maintain existing one to safeguard water security, avoid flooding and enhancing electricity generation.

Safe Drinking Water: Initiatives to be taken to ensure access to adequate and safe drinking water in the province and promoting aquifer recharge. There is a dire need to construct underground storm/rain water recharge galleries in public as well as private establishments. Further, relevant authorities (like WASAs, municipal authorities) shall go for water metering for every (domestic and industrial) connections.

Revision of PEQS: There is a need to revise PEQS for municipal and industrial effluents by incorporating 'requisite missing indicators' into the standards and delineating industry-specific environmental quality standards for key polluting industries.

[22] Hifza, Fauzia, Kiran and Ashraf (2021). Drinking Water Quality in Pakistan: Current Status and Challenges. Pakistan Council of Research in Water Resources (PCRWR)

4
SOIL QUALITY

CHAPTER 4 SOIL QUALITY

1. OVERVIEW

The term 'Soil' has a Latin origin 'Solum' meaning 'floor'. It's a unique non-renewable natural resource necessary to sustain life on this planet. In agroecosystems, good quality soil refers to its ability to sustain the growth of crops while at the same time maintaining environmental quality[1].

Good quality soil provides plants with all the required essential minerals, organic matter, and microbial communities and facilitates better aeration and infiltration. The essential minerals are classified into macronutrients and micronutrients based on the quantities required by plants. The macronutrients include Nitrogen (N), Potassium (K), Phosphorus (P), Sulfur (S), Calcium (Ca), and Magnesium (Mg) which plants require in large quantities. Micronutrients include Iron (Fe), Chlorine (Cl), Zinc (Zn), Manganese (Mn), Boron (B), Nickle (Ni), and Molybdenum (Mo) which are required in trace amounts to carry various plant processes[2]. The physical and chemical characteristics of soil such as pH, temperature, organic content, minerals, water holding capacity, and soil aggregation are the essential parameters determining soil processes including fertility, drainage, erosion, and salinity[3]. 56% of total geographical area is cultivated in Punjab[4], which is mainly attributed to its rich, fertile alluvial soils and diverse irrigation system.

KEY FINDINGS

Punjab has fertile alluvial soils

In Punjab 56% of total geographical area is cultivated, which is mainly attributed to its rich, fertile alluvial soils and diverse irrigation system.

Soil salinity is high at some places in Punjab

All the tested soil samples exhibited high values of sodium. The higher values of EC (>15 mS/cm) were predominantly found in industrial areas of the selected districts.

The soils of Punjab have low organic matter content

- Salinity induced land degradation has resulted in an annual loss of over 2326 million USD in selected regions of Punjab in the cropping year 2012-2013.
- The soils of Punjab are low in organic matter (0-1% in most areas), mainly due to extreme summer temperatures, use of inorganic fertilizers, and intensive tillage, and is subject to a further decline, if not managed adequately, in wake of climate change and conventional farm practices.

The physical and hydraulic properties of soil are related to topography

The soils of Doabs (plains) have low infiltration rates and uniform moisture retention than soils of Potwar Plateau which is related to site topography and disturbance (erosion).

Stakeholder involvement in managing soil resources of Punjab

Agriculture Department, Forest Department and Soil Survey authorities are major stakeholders active in soil and land management practices across Punjab.

In Punjab, there is paucity of data regarding the sources of soil pollution. However, a number of factors have been recognized to be responsible for deteriorating soil quality such as sewage and industrial discharges, leachate contamination from landfill sites, deposition of air pollutants in soil and unsustainable agricultural practices (Figure 4-2 and 4-3). Over the time, human activities and the geological factors, such as the extensive canal irrigation system along Indus Basin, irrigation of land with saline underground water, etc., have led to soil contamination and land degradation (water logging and salinity), respectively. The issues have further been discussed in detail in upcoming sections. The deteriorated soil quality has also resulted in adverse environmental and economic impacts.

[1] https://aari.punjab.gov.pk/iso_rsfri
[2] Shahid, M., Awan, M., &Hussain, K. (2013). Mineralogy of major soils of Punjab (Pakistan) by X-ray diffraction. Int J AgricSci, 2, 265-272.
[3] Rogers et al, Important Agricultural Soil Properties, Irrigation Management Series
[4] Land Utilization Statistics, Pakistan Bureau of Statistics

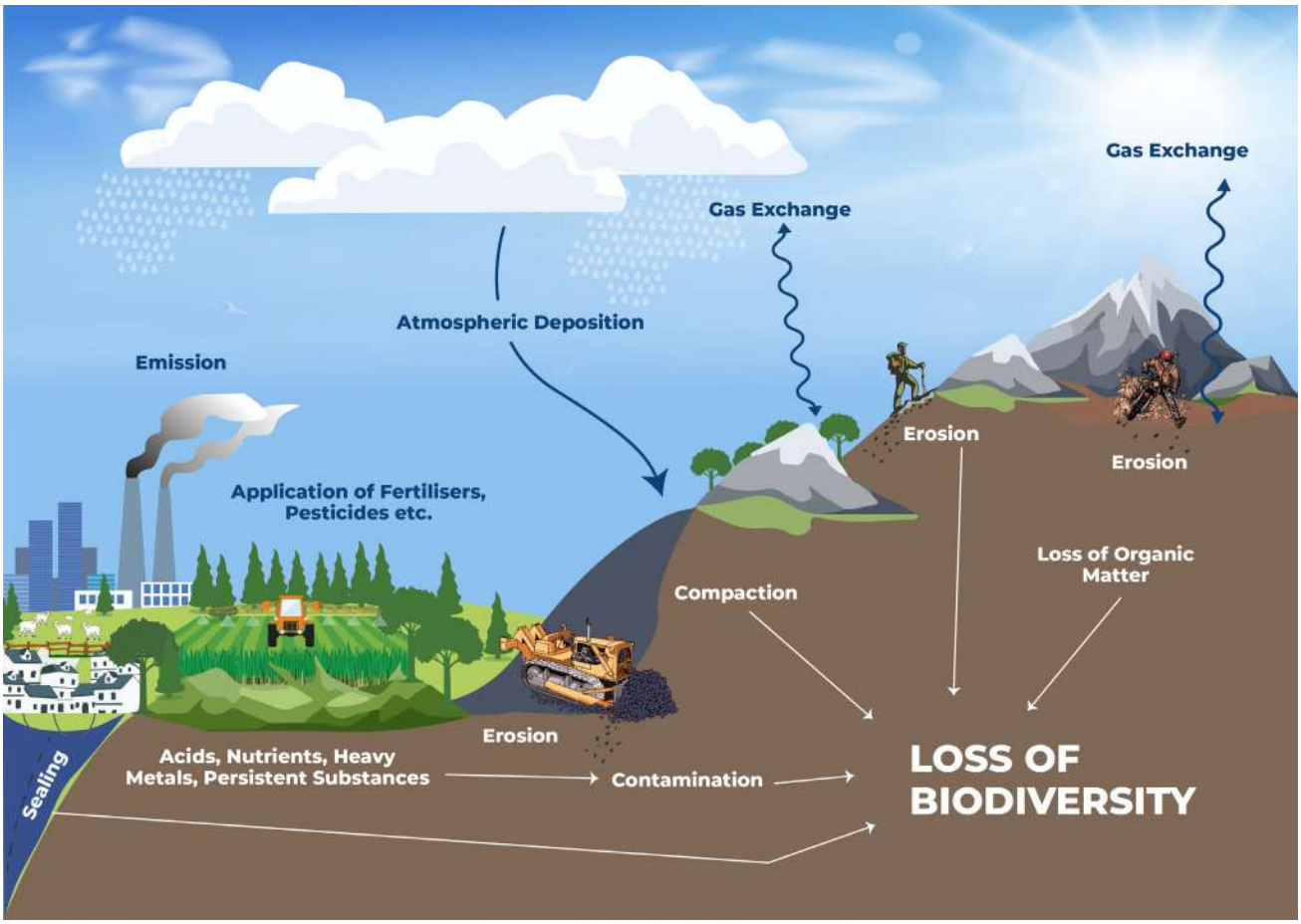


Figure 4-2 Sources of contaminants in soil

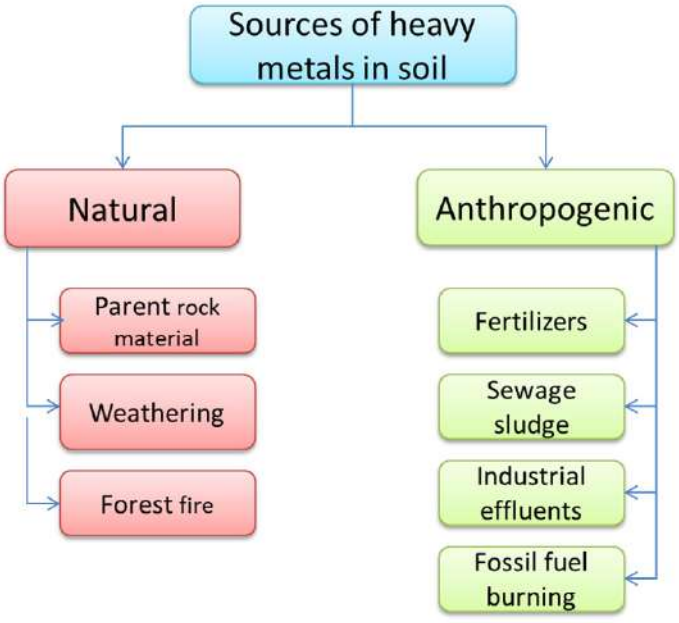


Figure 4-3 Sources of heavy metals contamination in soil

2. ENVIRONMENT

2.1 Assessment of soil quality

Soil quality is assessed on the basis of multiple parameters such as its organic content, heavy metal contamination, water holding capacity, porosity and alkalinity. Similarly, multiple phenomena are taken into consideration to assess land degradation resulting from water logging and salinity, erosion and heavy metals contamination. For the purpose of this report, soil quality of some representative locations in Punjab was assessed using primary and secondary data sources. Measurement of heavy metals, salinity and fertility parameters was done by an EPA certified laboratory. Data on soil organic content and physical and hydraulic properties was collected from secondary data sources.

2.1.1 Salinity, fertility parameters and heavy metals

Soil samples from urban, industrial and agriculture soils of 9 districts of Punjab were tested for pH, Electrical Conductivity (EC), heavy metals (Chromium, Copper, Lead and Nickel) and soil fertility parameters (Zinc, Iron, Manganese and Sodium). There are no environmental quality standards or limits available / developed in Punjab to assess the soil quality parameters except the classification developed by Water and Power Development Authority for salinity and sodicity (1981). Figures 4-4 to 4-6 show the quality of agriculture, urban and industrial soils in the selected districts of Punjab. It is pertinent to mention that the agricultural soils selected for assessment were not irrigated with industrial wastewater. The pH range of all soil types across the selected districts was around neutral. Electrical Conductivity (EC) (mS/cm) of was assessed on the basis of WAPDA's classes of soil salinity. EC of the agricultural soils was found as non-saline (< 4) for most of the districts while slightly saline (4 – 8) in case of Khushab, Mianwali and Rawalpindi districts. Lahore, Faisalabad and Kasur districts had strongly saline (>15 mS/cm) industrial soils while EC of all other districts in this soil type was found to be slightly saline. The urban soils of Bahawalpur, Rahim Yar Khan and Multan districts were moderately saline (8-15 mS/cm) while slight soil salinity was recorded for Khushab, Mianwali and Rawalpindi districts.

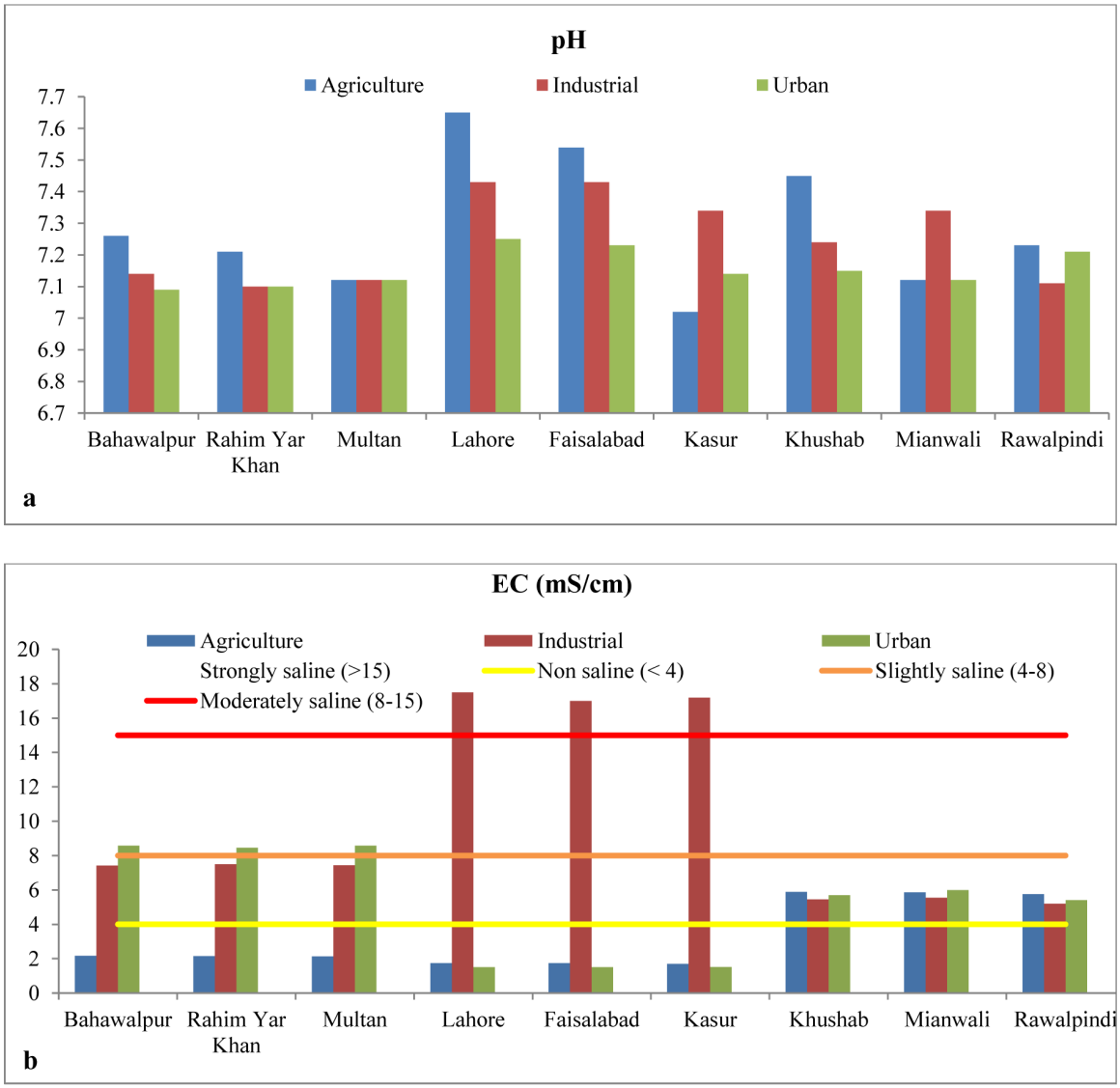


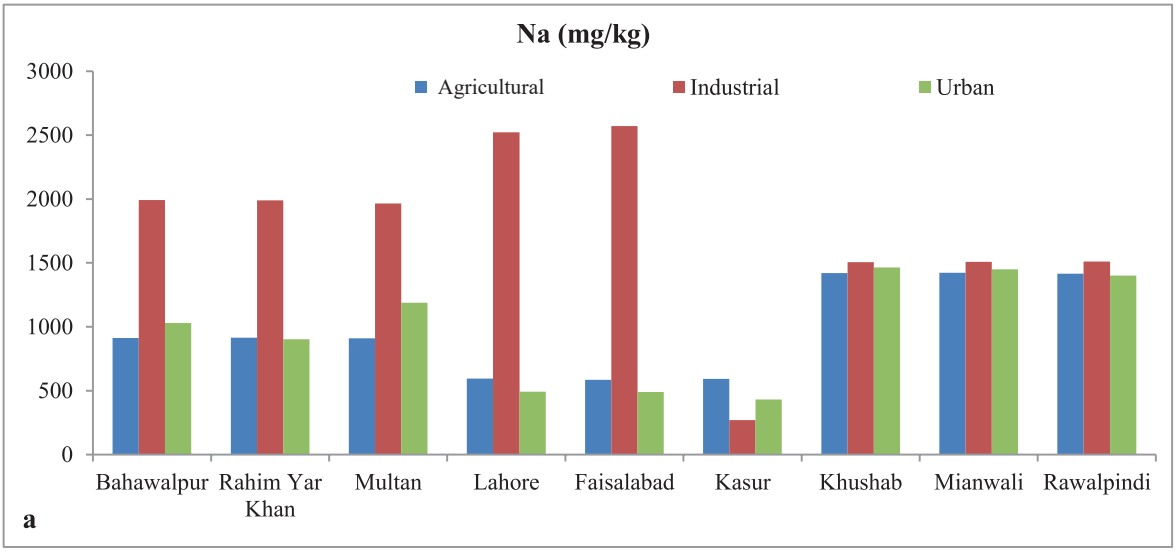
Figure 4-4 pH (a) and EC (b) in three soil types of selected districts in Punjab

Though the soil salinity has become a trend all over the country (on about 6.3 million hectares[5]), the issue has become graver in Punjab, where 75% of irrigation is based on groundwater, with 50% of the pumped water being saline and unfit for irrigation purposes[6]. The groundwater has lost its purity over time and most of it has now become saline and turbid due to multiple factors, The irrigation of agricultural soils with alkaline groundwater is adversely affecting the soil quality and threatening the sustainability of irrigated lands. A study conducted on economic impacts of such land degradation indicates an annual loss of over 2326 million USD in selected areas of Punjab i.e., Cotton-Wheat, Rice-Wheat and Mixed crops regions during the cropping year 2012-2013[7]. The results from primary data collected on soil quality for the purposes of this report also confirm the high electrical conductivity values in the soil samples indicating the presence of higher concentrations of soluble salts in them.

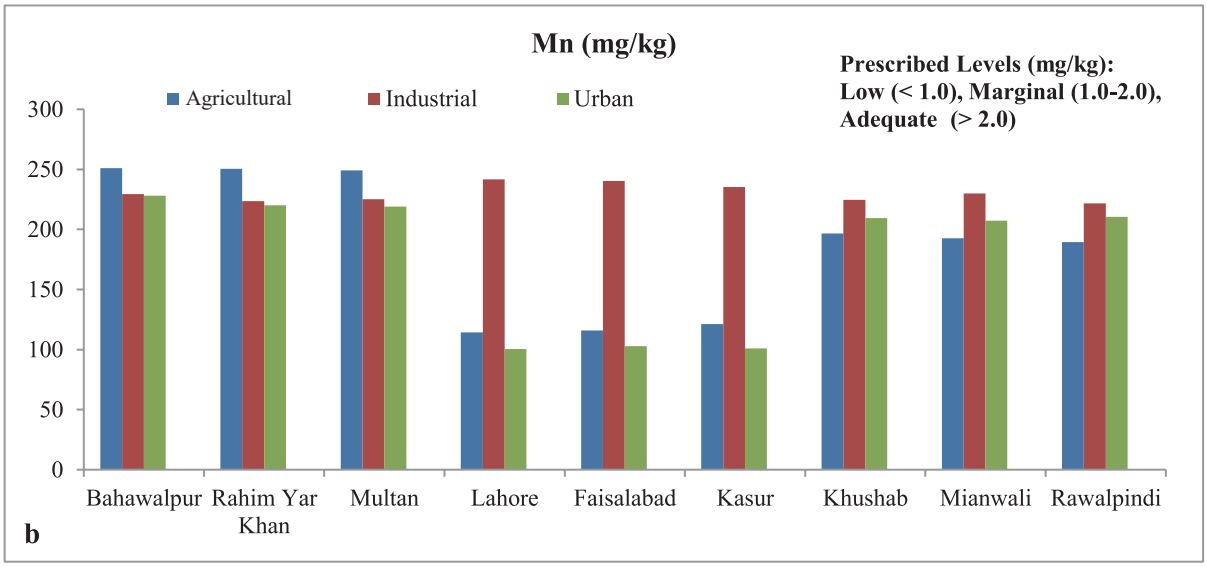
The salinity in Punjab has mostly been caused by the development of canal irrigation system in the Indus plains. The Indus River and its tributaries serve as Punjab's main water supply for canal irrigation. The salts brought in by the rivers and their tributaries are estimated at 23 million tons (Mt) annually causing salts to build up in the soil over time, raising salinity levels[8]. The cost of inaction in underperforming degraded lands, such as salt-affected soils, is estimated to be a 15–69% loss in revenue, depending on factors like the crops planted, the severity of land degradation, and the degree of water quality deterioration, among others[9].

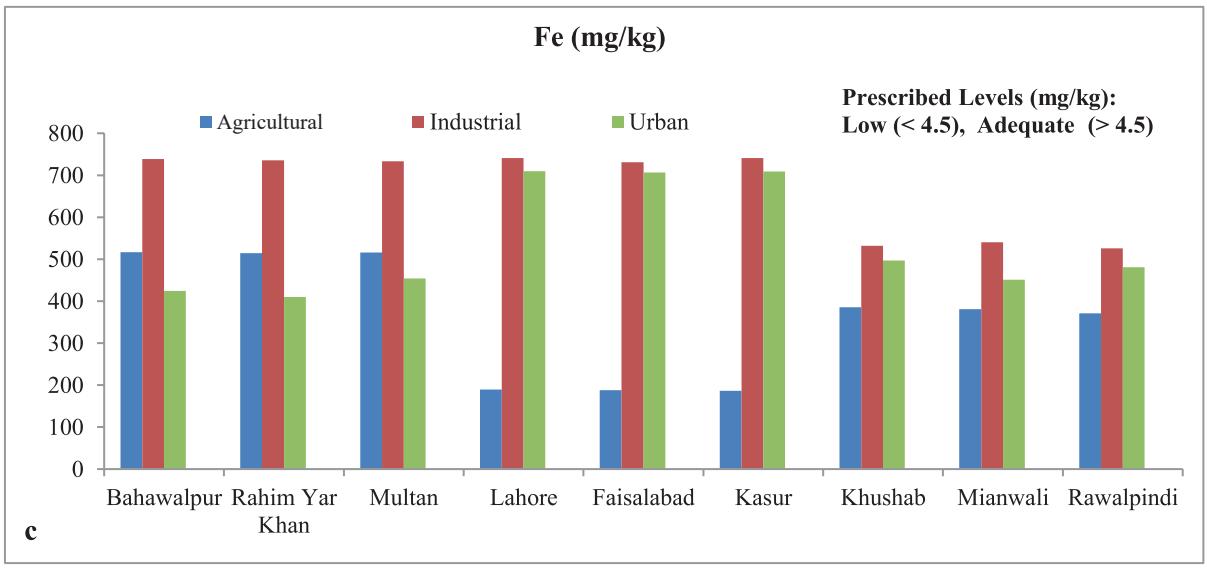
In addition, the excessive use of irrigation water by the farmers also leads to secondary salinity. High water table due to side seepage from extensive, unlined canals and poor drainage have led to waterlogging issues in the irrigated lands of Indus plains. Such challenges faced by irrigated lands in the province have resulted in economic losses due to lower yields and inefficient use of water. However, the government and farmer community, being gradually more and more aware of the negative consequences of land degradation, are adopting multiple engineering, reclamation and bio-chemical management interventions to combat salinity and waterlogging issues across Pakistan[10].

The level of sodium (Na) in all soil types were in the range of 430-2571 mg/kg except for industrial soils of District Kasur where Na levels were comparatively low (269 mg/kg). Most of the soils have adequate levels of Mn and Fe (following ICARDA Manual)[11](Figure 4-5).



[5] Ishfaq, M. 2017. Perspectives of Salt-Affected Soils in Pakistan. Rizing Nation.1.
[6] Punjab Economic Research Institute, 2016
[7] Punjab Economic Research Institute, 2016 (https://peri.punjab.gov.pk/system/files/Economimcs%20of%20Land%20Degrdation.pdf)
[8] https://www.sciencedirect.com/science/article/abs/pii/S0378377407002429
[9] https://doi.org/10.1111/j.1439-037X.2008.00350.x
[10] Qureshi, A.S.; Perry, C. Managing Water and Salt for Sustainable Agriculture in the Indus Basin of Pakistan. Sustainability 2021, 13, 5303. https://doi.org/10.3390/su13095303
[11] Rayan, J., Estefan, G., Rashid, A. Soil and Plant Analysis Manual. 2nd Edition. ICARDA, Syria & NARC, Pakistan.





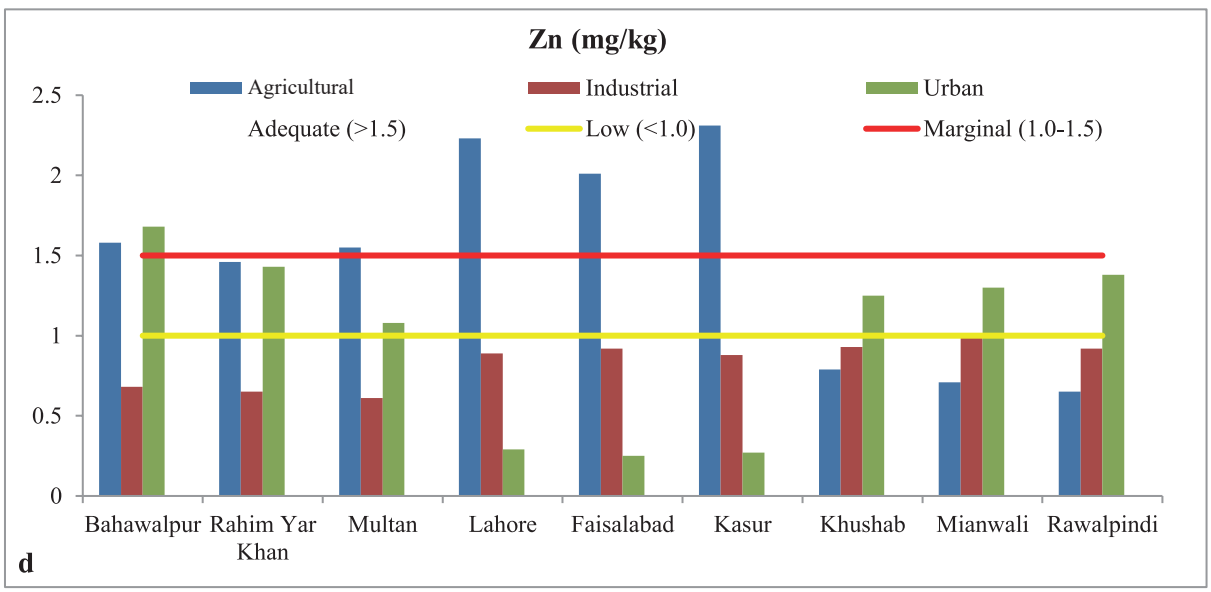
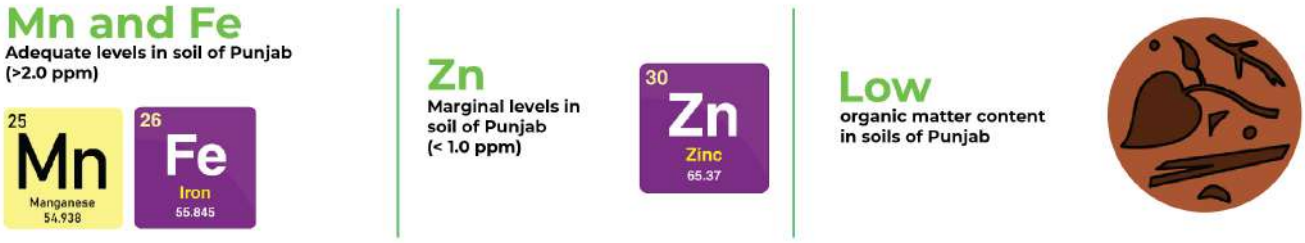


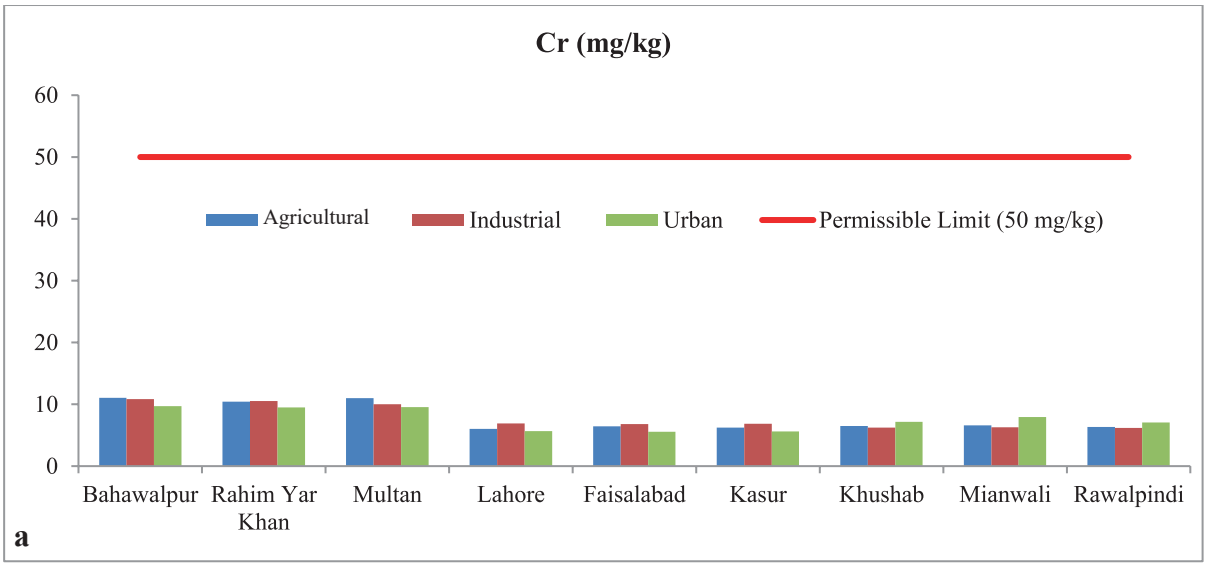
Figure 4-5 Soil fertility status of different soil types in Punjab



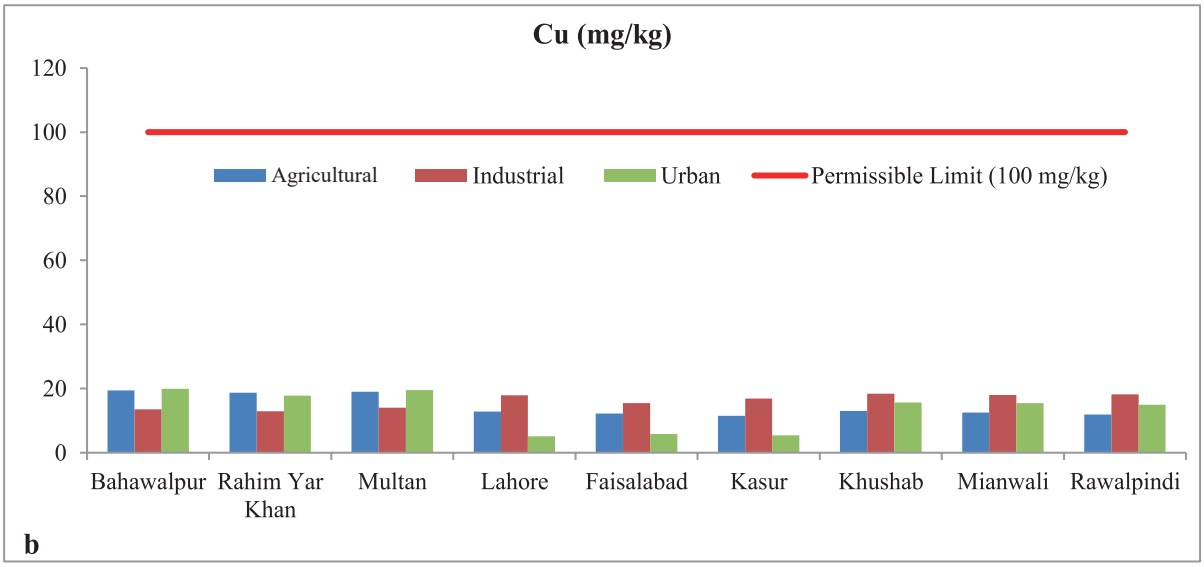
Heavy metals concentration was compared with Australian standards[12]. Heavy metal concentrations in all soil types from the selected districts were within the limits (Figure 4-6).

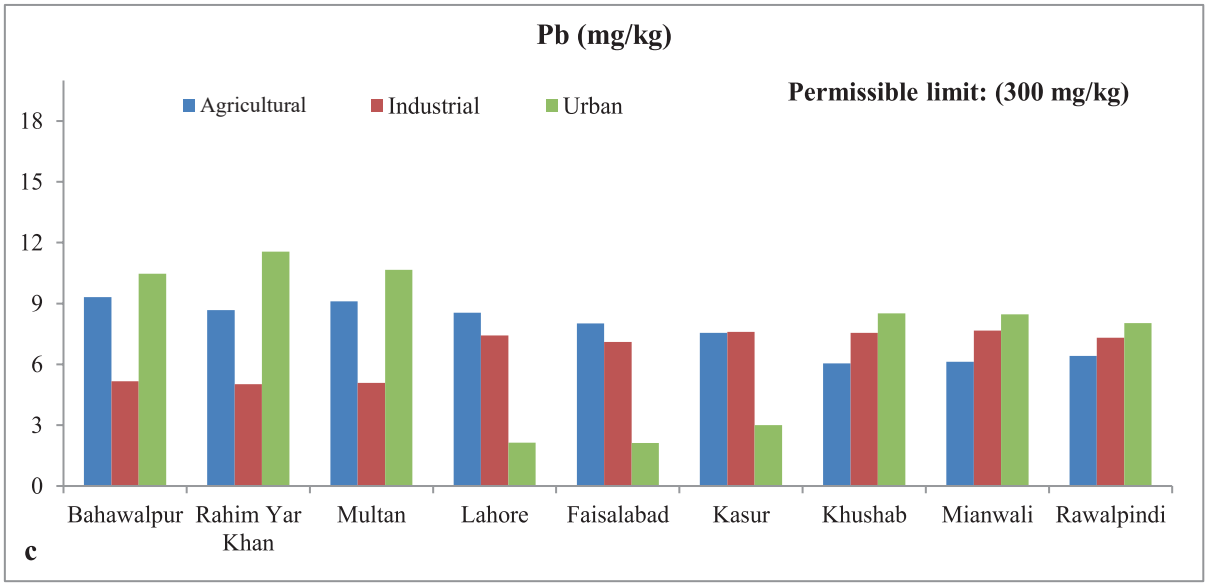
The soils in agricultural land irrigated with industrial wastewater may contain significant levels of heavy metals that bio-accumulate in plants and travel in the food chain posing serious health threats to the consumers. A study was conducted on the soils irrigated with industrial wastewater and plants grown on such soils in Southern Punjab, which indicates that although the average value of heavy metals such as aluminum, arsenic, chromium, iron, etc. in soil were within permissible limits set by WHO or FAO, however, the transfer of these metals from soil to the plants was significantly evident and the concentrations of chromium, nickel, manganese and lead were beyond the standards in the plant samples due to biological magnification[13].

In a study conducted in District Faisalabad, 79 samples from ornamental, flowering and tree plant form landscape and green belt areas were collected during year 2021 and analyzed for cadmium (Cd), lead (Pb) and nickel (Ni). It was observed that 96% of ornamental plants sampled in the areas irrigated with industrial wastewater were found contaminated with cadmium, 56% were contaminated with lead and Nickle was found in 41% of the samples when compared with permissible limits[14]. Another study conducted in District Kasur illustrated that the concentrations of Arsenic, Cadmium, Copper and Lead were 22.65 mg/kg, 4.375 mg/kg, 22.8 mg/kg and 32.80 mg/kg respectively, all being beyond the permissible limits of World Health Organization (WHO)[15].



[12] He, Z., Shentu, J., Yang, X., Baligar, V. C., Zhang, T., &Stoffella, P. J. (2015). Heavy metal contamination of soils: sources, indicators and assessment.
[13] Atta, M. I. et al., 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., 16 January 2023 Sec. Plant Nutrition. Volume 13 – 2022 https://doi.org/10.3389/fpls.2022.1080635
[14] Annual Abridged Report 2021-2022, Institute of Soil Chemistry and Environmental Sciences, Ayub Agricultural Research Institute, Faisalabad.
[15] Ashraf, I., Ahmad, F., Sharif, A. et al. Heavy metals assessment in water, soil, vegetables and their associated health risks via consumption of vegetables, District Kasur, Pakistan. SN Appl. Sci. 3, 552 (2021). https://doi.org/10.1007/s42452-021-04547-y





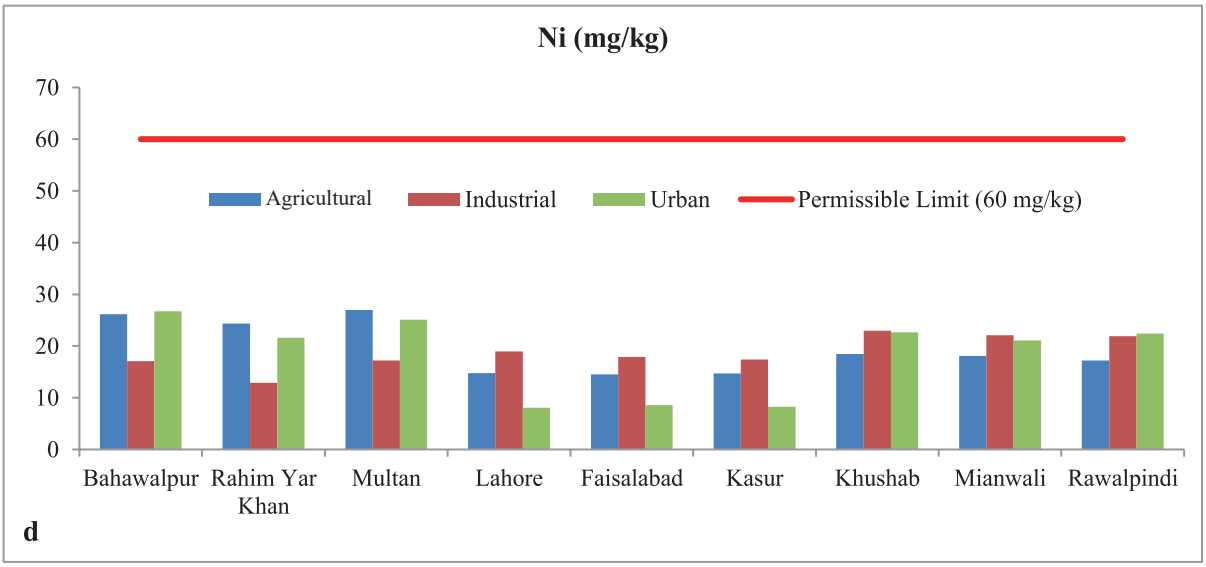


Figure 4-6 Heavy metal concentration in different soil types in Punjab

2.1.2 Total organic matter

Organic matter is a critical factor for soil fertility, water-holding capacity, and improving soil structure. It provides plants with essential nutrients, increases porosity, is a substrate for soil microbes (decomposers), and is significant with reference to nutrient cycling. Based on secondary data sources, the soils of Punjab are generally deficient in organic matter, with only 0-1% found in most of the areas[16]. The reasons for low soil organic matter content relates to high summer temperature that favors the growth of microorganisms converting organic nutrients into inorganic forms. The use of inorganic/synthetic fertilizers and poor agricultural practices such as intensive tillage also reduce soil organic matter.

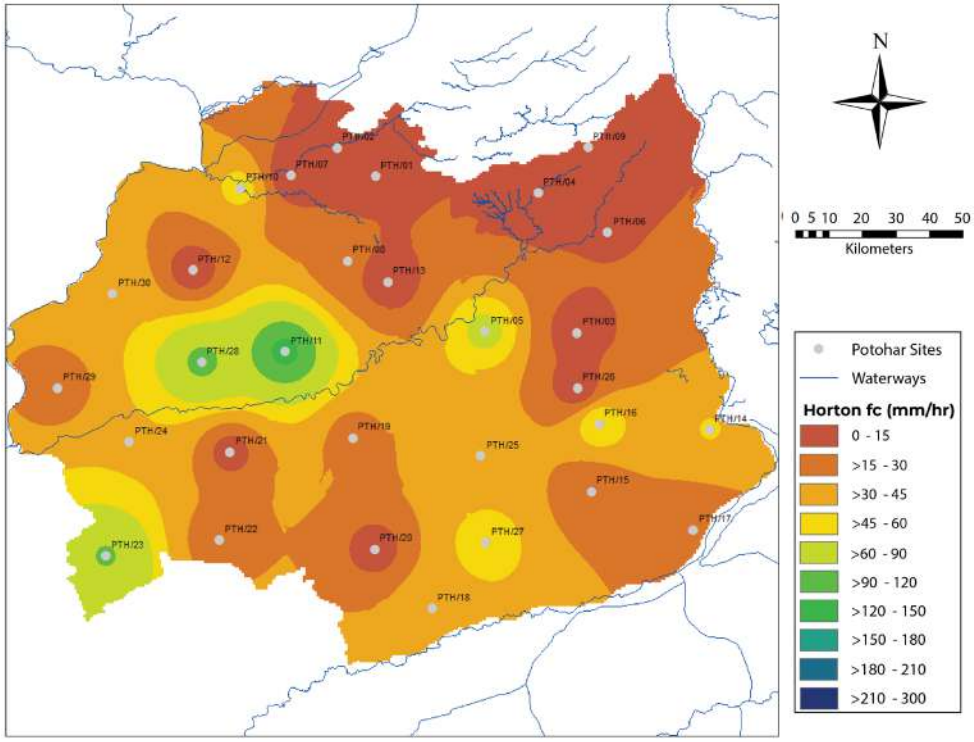
Secondary data depicts that the organic content of soil is declining especially in the dry land regions of Punjab. In these areas the farmers use intense farming practices due to limitations related to rainfall, soil stability and fertility. Furthermore, more tillage practices and lack of crop rotation practices decrease the soil organic content in drylands of Punjab[17]. Moreover, a further decrease in soil organic matter content is implicit, pertaining to the elevating temperatures and heavy rains resulting from climate change.[18,19]

2.1.3 Physical and hydraulic properties

Soil physical and hydraulic properties play considerable role in determining fertility and quality of soil. PCRWR conducted a study n 2019, wherein, two representative sites from Punjab (Doabs and Potwar Plateau) were selected for the assessment of soil organic matter, texture, moisture retention and infiltration rate. Major districts that encompass the Doabs region and Potwar Plateau include Chakwal, Jhelum, Attock, Rawalpindi, Layyah, Khushab, Bhakkar, Mianwali, Mandi-Bahauddin, Gujrat, Muzaffargarh, Sargodha, Faisalabad, Gujranwala, Khanewal, Narowal, Sialkot, Nankana Sahib, Okara, Toba Tek Singh, Multan, Sheikhupura, Sahiwal, Lahore and Kasur.[20]

2.1.4 Infiltration rates

Soils of Doabs region in Punjab show up to 30 mm/hr infiltration rate which is lower than Potwar region (15-45 mm/hr). Doabs are intensively ploughed for agriculture resulting in compaction of clay layer below the ploughed soil. The surface pores are blocked hence erosion is also less in these areas. Topography also plays an important role in determining the erosion rates and Doabs having less degree of slope are comparatively less prone to erosion (Figure 4-7).



[16] Annual Detailed Report, Annual Detailed Report 2019-20 Institute of Soil Chemistry & Environmental Sciences, Ayub Agricultural Research Institute Faisalabad; and Syed, R.M.A.; Shahida, H.; Muhammad, M.W.; and Farkhanda, J. Distribution of Soil Texture, Organic Matter, Nitrogen and Phosphorous Under Farm Plantations in Various Agro- Ecological Zones of Punjab, Pakistan, The Pakistan Journal of Forestry, 2009, 59(2)

[17] Naz, I.; Ijaz, S.S.; Mussie, Y.; Habteselessie, M.; Ansar, M and Khan, K.S. Impact of Conservation Tillage on Organic Matter Dynamics in Loess Dryland Soil, Punjab, Pakistan, Journal of Animal & Plant Sciences, 2022, 32(5) https://doi.org/10.36899/JAPS.2022.5.0534

[18] https://doi.org/10.3389/fenvs.2020.579904

[19] https://doi.org/10.1186/s13021-021-00187-2

[20] Soil Physical and Hydraulic Properties of the Upper Indus Plain of Pakistan, Pakistan Council of Research in Water Resources (2019)

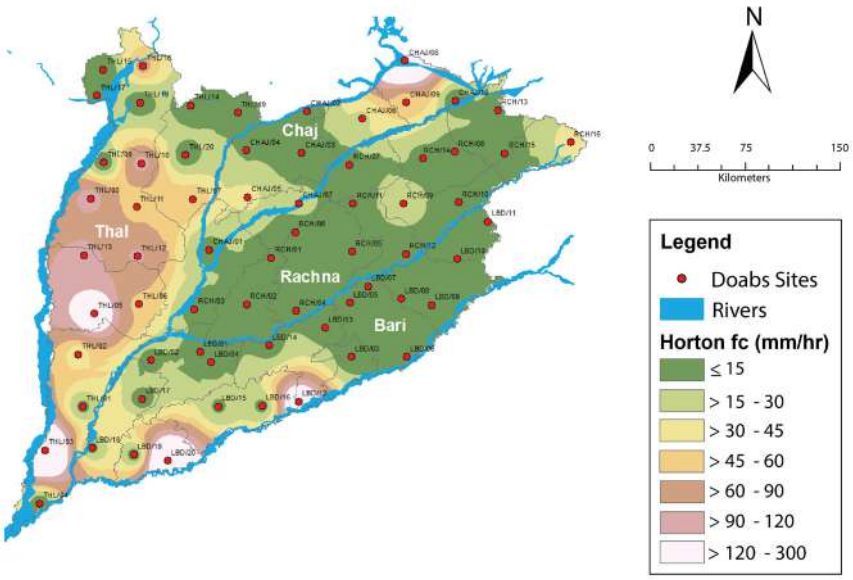


Figure 4-7 Infiltration rates in the surface layers of Potwar (a); and Doabs region (b)

2.1.5 Moisture retention

Soil moisture retention is comparatively uniform in Doabs but highly variable in the Potwar region (Figure 4-8). The most apparent cause for the high variability in Potwar region seems to be high erosion levels in this area, leading to high segregation of particles.

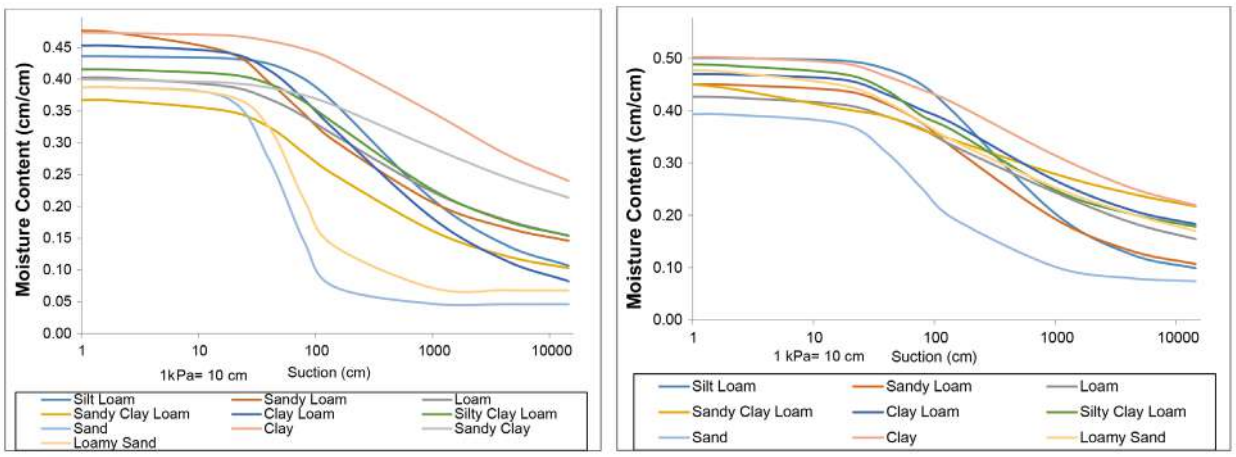


Figure 4-8 Variation of soil moisture in Potwar (left) and Doabs (right) region.

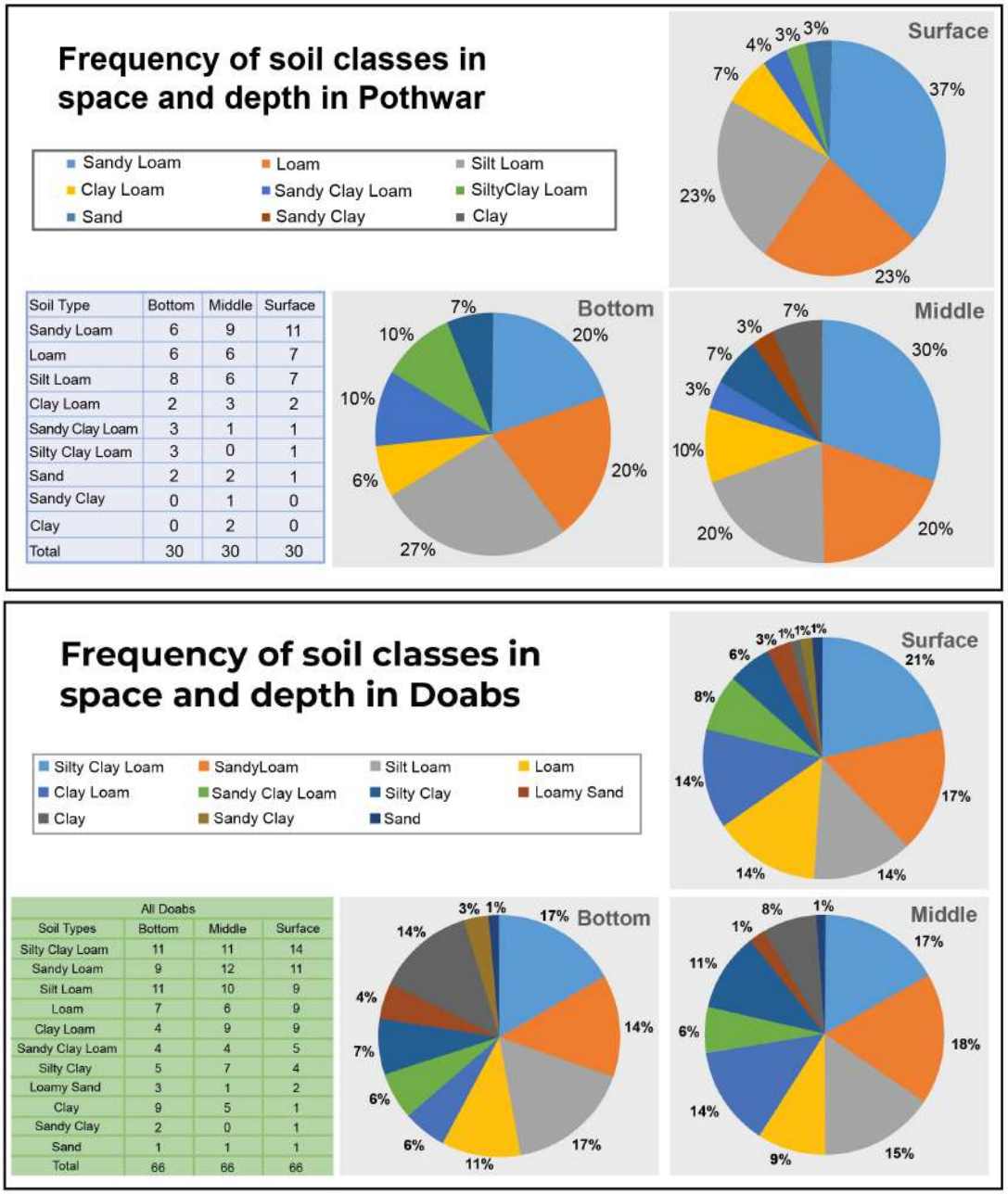
2.1.6 Soil texture

Soil texture is the major determinant of other soil properties i.e., soil moisture retention, porosity, infiltration rates, nutrient content, organic content and erodibility, and hence, is an important parameter to be considered for agricultural purposes[21]. The texture of soil and related physio-chemical properties, such as the nutrient holding capacity and organic matter play a significant role in nutrient availability and plant growth. Usually, the loamy textured soils, comprising almost equal proportions of sand, silt and clay are considered ideal for agriculture use, mainly because these are convenient to be cultivated and have good crop productivity. The well-balanced texture with good proportion of both fine and coarse textured particles offers a desired soil structure that permits efficient water drainage and aeration while maintaining adequate moisture for plant growth. Coarse particles in soil produce pore spaces that support root penetration while fine particles (clay) are helpful in retaining moisture due to their colloidal properties and forming water stable aggregates that bind the soil and reduce soil erosion.

The soil texture of the Potwar region is mainly loam, sandy loam and silt loam. While that of the Doabs is mainly silty clay loam, sandy loam and silt loam. Clay content increases in the deeper layers of both regions (Figure 4-9). Hence, most of the soils in Punjab are loamy in nature.

[21] Chakrabortay, K and Mistri, B. 2015. Importance of Soil Texture in Sustenance of Agriculture: A Study in Burdwan-I C.D. Block; Eastern Geographer;21(1).

The soil properties, including its texture, vary with varying seasons, top vegetation cover and topography, naturally.[22] Climate change also has both the direct and indirect implications on soil properties and subsequently, upon its fertility and productivity. The floods and torrential rains result in plant damage, water logging, loss of soil biota (due to declined oxygen levels and light absorption) and altered chemical proportions[23]. The land sliding and subsequent erosion occurring during floods 2022 have led to 29% of total damages to the environment[24].



Soil Type	Bottom	Middle	Surface
Sandy Loam	6	9	11
Loam	6	6	7
Silt Loam	8	6	7
Clay Loam	2	3	2
Sandy Clay Loam	3	1	1
Silty Clay Loam	3	0	1
Sand	2	2	1
Sandy Clay	0	1	0
Clay	0	2	0
Total	30	30	30

All Doabs			
Soil Types	Bottom	Middle	Surface
Silty Clay Loam	11	11	14
Sandy Loam	9	12	11
Silt Loam	11	10	9
Loam	7	6	9
Clay Loam	4	9	9
Sandy Clay Loam	4	4	5
Silty Clay	5	7	4
Loamy Sand	3	1	2
Clay	9	5	1
Sandy Clay	2	0	1
Sand	1	1	1
Total	66	66	66

Figure 4-9 Soil texture classes in Potwar (top) and Doab region (bottom)

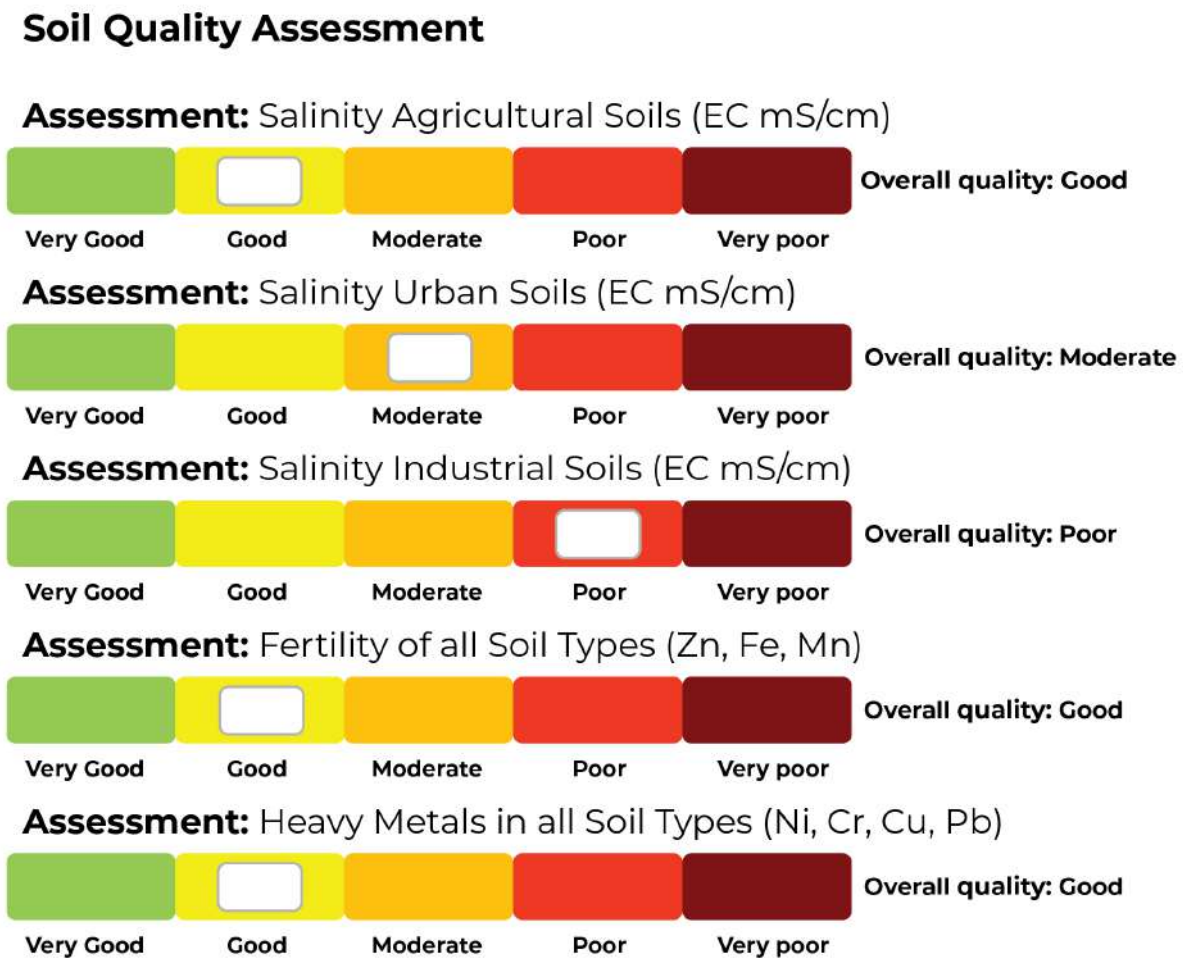
[22] Ahmad, I.; AHMAD, M.S.A.;Hussain, M.; Ashraf, M., and Ashraf, M.Y.; 2011. Spatio-Temporal Variations in Soil Characteristics and Nutrient Availability of An Open Scrub Type Rangeland in the Sub-Mountainous Himalayan Tract of Pakistan. Pakistan Journal of Botany. 43(1).

[23] Qamer, F.M., Abbas, S., Ahmad, B. et al. A framework for multi-sensor satellite data to evaluate crop production losses: the case study of 2022 Pakistan floods. Sci Rep 13, 4240 (2023). https://doi.org/10.1038/s41598-023-30347-y

[24] Pakistan Floods 2022 Post Disaster Needs Assessment (October 2022). Government of Pakistan, Asian Development Bank, European Union, United Nations Development Programme and World Bank

3. OVERALL ASSESSMENT

The overall quality of various types of soils in Punjab in terms of salinity is rated as 'Good' (agriculture), 'Moderate' (urban), and 'Poor' (industrial). While the fertility status and heavy metal content of all soil types are rated as 'Good' based on the prescribed limits available for each of the indicator parameters.



4. MANAGEMENT

Soil plays a crucial role in maintaining ecosystem health which is essential for the survival of flora and fauna. In regions like Punjab, where agriculture is the backbone of economy, collaborative efforts must be taken by public and private sectors to regulate and maintain soil quality. At present, no government department in Punjab is keeping a regular record of soil quality data of the districts. Therefore, the relevant organizations (public and private) need to be mobilized to carryout studies concerning soil quality of the province. Appropriate soil management practices and pollution control measures can be an effective way to reduce effluent discharge into soil. In addition, there is need to develop a comprehensive framework to establish the environmental quality standards or threshold limits for soil and define monitoring mechanisms for its sustainable management.

Table 4-1 Initiatives taken by the government departments in Punjab for soil management

Relevant department	Initiatives taken
Agriculture Department	1. Farmers education about best crop and soil management practices 2. Research on soil quality assessment and mitigation of pesticide residues in vegetables at different locations in the province.
Soil Survey Department (Govt. of Punjab)	Strengthening GIS laboratories to spatially evaluate impacts on soil quality
Forest Department	1. Plantation projects and regular afforestation campaigns across the province (protection of soil) 2. Maintenance and restoration of national parks and reserve forests

5. DPSIR FRAMEWORK

The DPSIR framework is described below:

Drivers

Number of factors affects the physicochemical characteristics of soil driven by atmospheric, topographic and anthropogenic drivers. These include:

a. Increase in food demand: Punjab is the most densely populated province of Pakistan. Higher population leads to higher demands for food and agricultural products, resulting in increased burdens on soil resources.

b. Urbanization: Punjab is recognized as one of the most urbanized regions of South Asia, undergoing a continuous, long-term population shift to urban centers, with around 36% of the people residing in urban Punjab. The expansion of cities leads to generation of more waste and its improper disposal from houses and industries put pressure on soil resources.

c. Industrialization: Escalating industrialization in the province is also the major driving factor affecting the soil quality, with more industrial discharges and waste management issues especially in the areas surrounding the industrial clusters.

d. Poor agricultural practices: Improper use of fertilizers and pesticides along with irrigation of crops with poor quality water containing sewage or industrial effluents leads to the degradation of soil quality.

e. Topography: Topography is a major determinant of soil of an area. In Punjab, the soils of Potwar and Doab regions vary in their physio-chemical properties. For instance, the soil erosion levels are far higher in the sloppy lands of Potwar region than the plains of Doabs.

Pressures

a. Land Use Change: In Punjab, most of the land area comprises of agricultural land. The available data of land use change in Punjab is heterogeneous with limited geographical scope. For example, it is reported that the vegetation area of district Okara has decreased from 91.6% in 2002 to 89.3% in 2020 with 4.5% increase in the built-up area. A study conducted on Land-use change in Southern Punjab from 2000 to 2001 demonstrated a change in water, cropland, forest, settlement and barren land as 1.02%. 2.63%, 31.03%. 14.52% and 12.87%, respectively .

b. Livestock grazing: The Forest Department, Government of the Punjab manages over 6 million rangelands. Range management circle Lahore is engaged in managing these rangelands in 12 districts of four range management Divisions including Chakwal, Bhakkar, DG Khan and Bahawalpur for the benefit of local community. The rangelands are mostly located in Potwar, Thal and Cholistan regions. About 0.4 million farmers /grazers living in the vicinity of these rangelands are directly advantaged by grazing about 1.2 million animals. However, rotational grazing is practiced throughout the year for managing the pressure on these pastures .

c. Biomass Use: A technical and theoretical assessment of the biomass-based energy production potential of Punjab depicted that the use of agricultural biomass as non-commercial/household energy source has reduced the technical potential of generating ethanol from this biofuel has reduced significantly . Other secondary data sources also confirm the use of biomass by rural households for burning purposes. The agriculture biomass, such as crop residues, in addition to increasing the soil moisture retention, reduces the water losses from evapotranspiration, and hence improves the soil quality . Hence its uncalculated loss may lead to undermined quality of soil.

d. Overuse of Pesticides and Fertilizers: Since most of the area is cultivated, the soils of Punjab receive higher quantities of fertilizers, pesticides, insecticides and fungicides. A study conducted to determine the overuse of pesticides in cotton fields of Punjab reported that 70% more use of pesticides by the farmers in the area as compared to other provinces to achieve higher cotton yields[30].

e. It was also reported that most of the active ingredients of the pesticides being used were classified as moderately

[25] Hussain et al, 2022. Landuse landcover (LULC) change using TM, ETM+ and OLI Landsat images in district of Okara Punjab Pakistan. DOI: 1016/j.pce.2022.103117
[26] https://doi.org/10.3390/su15043572
[27] https://fwf.punjab.gov.pk/rangelands
[28] Zulfiqar, M. et al. 2021. Prospects of bioenergy potential in Punjab (Pakistan) under different scenarios of agriculture growth. International Conference on Advances in Mechanical Engineering, Pakistan, 21.
[29] Saleem, M; 2022. Possibility of utilizing agriculture biomass as a renewable and sustainable future energy source. Heliyon. 8(2) (https://doi.org/10.1016/j.heliyon.2022.e08905)
[30]10.1016/j.cropro.2014.10.013

hazardous (54.7%) or highly hazardous (23.3%) as per WHO pesticide hazard classification[31]. The phosphate-based fertilizers are a major cause of fluoride contamination in soils[32] .

f. Unsound irrigation practices: Continuous use of contaminated water for irrigation purposes may result in increase in soil salinity and addition of heavy metals. Flood irrigation, overuse of fertilizers and extensive tillage also render land unfit for cultivation.

g. Heavy metals and other soil Contamination: High rates of industrialization in the province with limited use of environmentally sound management of industrial effluents and waste are leading to increased levels of soil contamination, especially with the heavy metals[33].

h. Climate change: Punjab lies in arid and semi-arid climate with high summer temperatures and very low atmospheric humidity. This is why the agriculture in the province is dependent on heavy irrigation system to ensure the availability of water for the crops.

i. The southern Punjab is especially prone to harsh climate and droughts. The arid climate results in evapotranspiration from soils, greatly reducing the moisture and water content. The other climate-extreme i.e., unprecedented torrential rains and flooding have also been a major cause of soil erosion and instability in agricultural areas of province.

j. Erosion: Erosion reduces the fertility and productivity of the soil by removing top soil that is rich in organic matter. The eroded soil ends up in water ways leading to sedimentation that prevents rivers and streams from smoothly flowing and increases the chances of floods. It increases turbidity of water thus negatively aquatic life.

State

a. Soil Pollution: Heavy metals enter soil through natural routes. However, there are number of anthropogenic sources as well such as those related to improper waste disposal. Secondary data sources reveal high levels of heavy metals in the industrial soils of district Punjab.

b. Salinity and sodicity: High evapotranspiration rates in the arid areas leave salts behind resulting in increasing soil salinity. Other factors such as irrigation using industrial wastewater also leads to accumulation of salts in soil.

c. Desertification: The chances of desertification are high in the soils degraded with multiple pollution sources and with high rates of erosion. In the agricultural zones desertification can have far reaching impacts on food security.

d. Variable physio-hydraulic properties: Human activities such as an increase in built up area, cultivation on slopes, and activities promoting erosion lead to the degradation of soil.

Impacts

a. Impacts on agricultural yields: Soil contamination has been evidently reported in the soils irrigated by industrial effluents in major metropolises of Punjab. The soil contaminated with high concentrations of heavy metals and alkalis is subject to degradation and infertility, ultimately negatively affecting the crop yields.

b. Impacts on groundwater: The contaminant mixtures in soil also percolate in the groundwater and subsequently degrade the quality of aquifers. Groundwater is the major drinking water source in Punjab. Hence the soil quality affected by industrial and agricultural contaminants may have potential impacts on the drinking water quality in the province. Groundwater in Lahore and its surroundings is contaminated with Cadmium, Chromium and Arsenic.[34]

c. Health Impacts: Contaminants in soil also travel in food chain and accumulate in tissues of plants and animals reaching up to humans showing serious health consequences. Most of the soils in Lahore and its suburbs are reported to be contaminated with cadmium, nickel, copper, and lead, with significant impacts on the population's health[35]. The toxic metals in food chain cause damage to DNA and proteins, posing carcinogenic effect in humans. These also result in skin and lung diseases, especially in vulnerable group of population including the infants and pregnant women. The food and fodder grown in the soils contaminated with heavy metals is also deleterious for livestock health[36].

[31] https://doi.org/10.1016/j.cropro.2014.10.013
[32] Farooqi A, Masuda H, Siddiqui R, Naseem M. Sources of arsenic and fluoride in highly contaminated soils causing groundwater contamination in Punjab, Pakistan. Arch Environ Contam Toxicol. 2009 May;56(4):693-706. Doi: 10.1007/s00244-008-9239-x. Epub 2008 Oct 21. PMID: 18937006
[33] http://doi.org/10.3390/air1010004
[34] https://doi.org/10.1155/2014/813206
[35] https://doi.org/10.1016/S0160-4120(98)00068-3
[36] Atta, M. I. et al., 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., 16 January 2023 Sec. Plant Nutrition. Volume 13 – 2022 https://doi.org/10.3389/fpls.2022.1080635

Response

a. Integrated management practices: Considering the multiple drivers and pressures to the soil resources, there is a need to adopt integrated management practices in Punjab to safeguard the quality and productivity of the soil.

b. Sensitizing farmers: Reforms in agriculture sector along with farmers' education targeting appropriate and sensible use of fertilizers and pesticides, switching to organic farming and shift from conventional tillage to no till farming can lead to improved soil quality. Sensitizing farmers about best soil and crop management practices, use of farmyard and green manure, crop residues and other organic amendments can increase soil organic content crucial for improving soil structure and nutrient load.

c. Plantation: Tree plantations at the degraded lands can restore the soil quality. It will also improve soil nutrient status by the addition of organic matter and will also enhance water holding capacity of the soils.

d. Research and development: Further research and development for integrated management of soil resources in required in Pakistan. In this connection, relevant departments such as Soil Survey Department, Irrigation and Agriculture Departments are taking initiatives to protect soil resources.

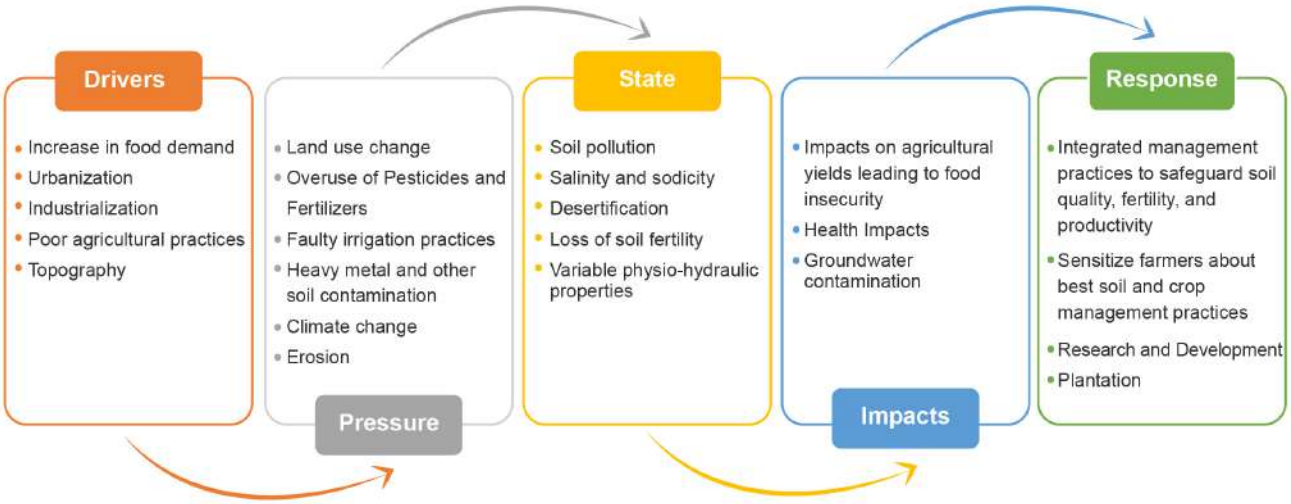


Figure 4-10: DPSIR framework of soil quality in Punjab

6. THE WAY FORWARD

Soil quality monitoring and reporting regime: Establishment of a continuous soil quality monitoring and reporting regime may be established to keep the farmer community abreast of soil conditions subsequently assisting them through informed decision making.

Research and development for salt-tolerant crop varieties: Research and development need to be strengthened for enhancing the success and efficacy of available reclamation techniques and breeding of salt tolerant varieties. Farmers may be encouraged to shift towards planting salt-tolerant crop varieties to mitigate the economic losses arising from reduced productivity of lands already affected by high salinity and sodicity.

Sustainable Agricultural practices: Policy development and investment in the adoption of sustainable agriculture practices especially organic farming, reduced tillage, crop rotation and use of sprinkler and drip irrigation systems are highly recommended.

Prevention from soil pollution: Discharge of untreated industrial and municipal wastewater in agricultural lands may be discouraged to avoid soil contamination.

Regular soil-reclamation programs: Regular soil-reclamation programs may be launched for maximum restoration of degraded and water-logged soils.

5

WASTEWATER TREATMENT AND SOLID WASTE MANAGEMNT FACILITIES

CHAPTER 5 WASTEWATER TREATMENT & SOLID WASTE MANAGEMNT FACILITIES

1. OVERVIEW

This chapter deals with the assessments of industrial wastewater treatment plants as well as solid waste management facilities (municipal and hospital disposal facilities). For the purpose of this report, the assessment of wastewater treatment facilities is limited to the industrial wastewater treatment plants only. Approximately 6.24% industries in Faisalabad, 3.30% in Sheikhpura and 2.78% in Lahore have industrial wastewater treatment plants. The effluent treated from wastewater treatment plants did not comply fully with PEQS.

1.1 Industrial wastewater treatment facilities

In Punjab, wastewater comprises both domestic and industrial effluents. Industrial units release industrial wastewater, and its volume and characteristics vary based on each industry's type and number of industries, operational hours, and water consumption. The discharge of industrial effluents into the ecosystem presents a substantial risk, leading to various environmental problems as well as concerns for public health and safety. Industries such as tanning, leather production, petrochemicals, pharmaceuticals, and textiles generate effluents that pose significant threats to the aquatic ecosystem. These effluents contribute to high toxicity levels, cause endocrine disruptions, and negatively impact reproductive functions. Domestic water supplies are generally unsafe, with contamination by sewage effluent, industrial effluent, and geogenic Arsenic common but poorly assessed, especially in rural areas. Effluents from marble, steel, and aluminum factories are the main sources of cadmium, and effluents from leather tanneries are the main source of chromium. Moreover, elevated levels of total solids can make drinking water unappealing and unpalatable.

In order to protect the environment from the detrimental effects of pollutants released from municipal and industrial effluent, Wastewater treatment plants needs to be installed to treat

KEY FINDINGS

During 2022, EPA identified, 392 industrial wastewater treatment plants (primary, secondary, and tertiary) in Punjab.

Performance efficiency of wastewater treatment facilities installed in various industrial sectors is very low with 'very poor' performance for sugar and paper mills. Whereas, 'poor' performance is for leather and tanning, power looms, foods, oil, fats and ghee and animal feed industries.

Punjab generates approximately 47,300 tons of municipal solid waste daily.

Municipal solid waste management companies are operating in seven districts of Punjab, namely Lahore, Faisalabad, Multan, Rawalpindi, Gujranwala, Sialkot and Bahawalpur, carrying out the municipal solid waste management in respective districts.

There is a single environmentally approved landfill site in Punjab, based in Lakhodair area, District Lahore. In rest of the districts, the municipal collected is dumped at open sites, without proper landfill.

The overall quality of solid waste management in Punjab, as assessed from primary and secondary data, is poor and has been categorized as 'Red' on color coding scheme being followed in the report.

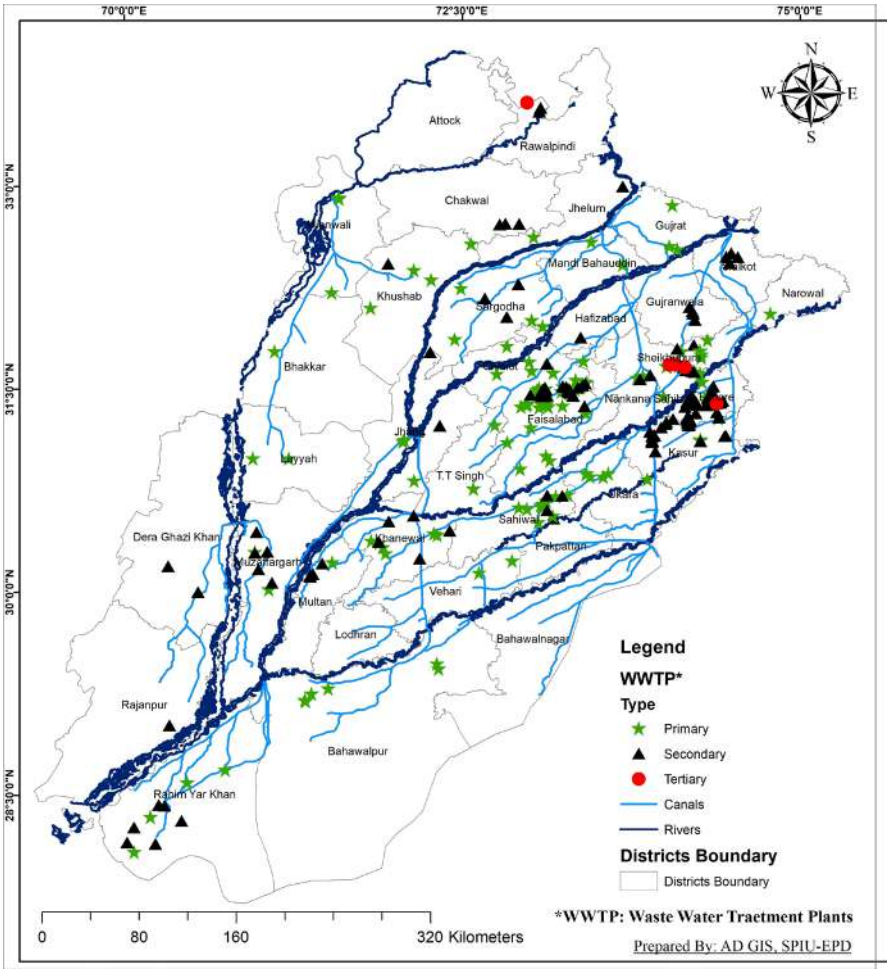


Figure 5-1 Wastewater Treatment Plants in Punjab, Pakistan

both municipal and industrial wastewater. EPA carried out a survey of the industrial wastewater treatment plants installed in various industries in different districts of Punjab. A total of 392 industrial wastewater treatment plants (WWTPs) are installed in various industrial sectors in Punjab as shown in Figure 5-1. Of these WWTPs, 206 are primary plants, 180 are secondary treatment plants, and 6 belong to the tertiary treatment plant category. There are 23 different industries that have these plants installed, with the textile industry having the greatest number of wastewater treatment plants followed by other sectors, where fertilizer industry stands at the lowest position in terms of having WWTPs count.

In terms of the number of industrial WWTPs installed in the Punjab district wise, Faisalabad stands first, followed by Lahore, Sheikhupura, Kasur, Sahiwal, Khanewal, Muzaffargarh, and Rahim Yar Khan. Figure 5-2 shows the distribution of primary, secondary, and tertiary treatment plants in various districts of Punjab. The districts which show industrial WWTPs count less than 5 are Jhang, Khushab, and Multan (5), 4 in Chiniot and Gujranwala, 3 in Attock, Chakwal, and Layyah, 2 in Jehlum and D G Khan, 1 in Hafizabad, Bhakkar, Nankana Sahib and Narowal while no industrial WWTP is in Bahawalnagar.

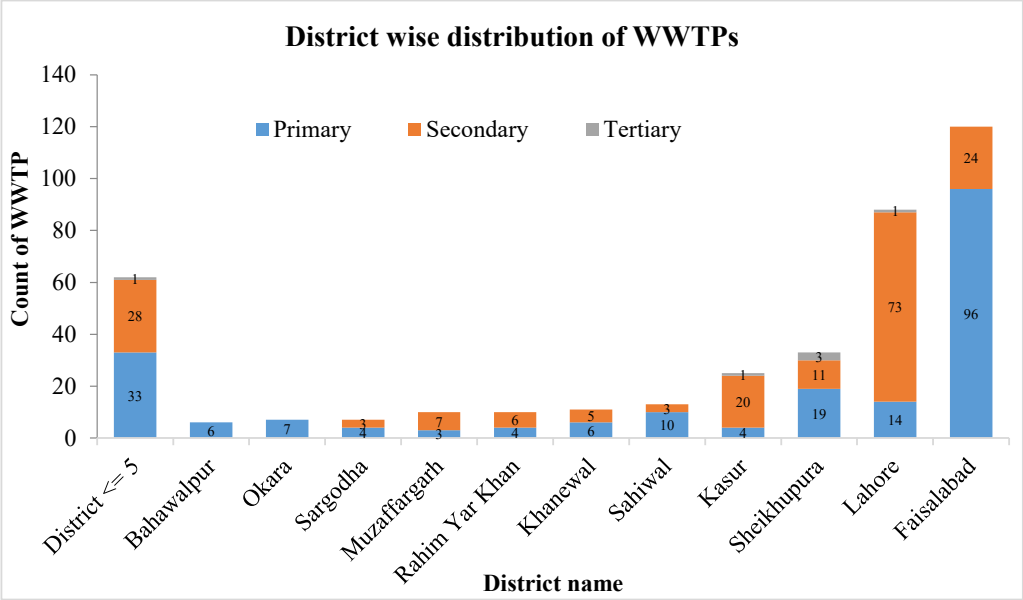


Figure 5-2: District-wise distribution of WWTPs in Punjab

In order to evaluate the environmental performance of these 392 WWTPs installed in the industries, the wastewater of 35 such plants was compared with the PEQS, both before and after treatment. The influent and effluent of 21, 10, and 1, industrial WWTPs were analysed by the EPA Laboratories in Multan, Faisalabad, and Lahore, respectively. Figure 5-3 shows the number of three categories of WWTPs installed in various sectors of industries in Punjab.

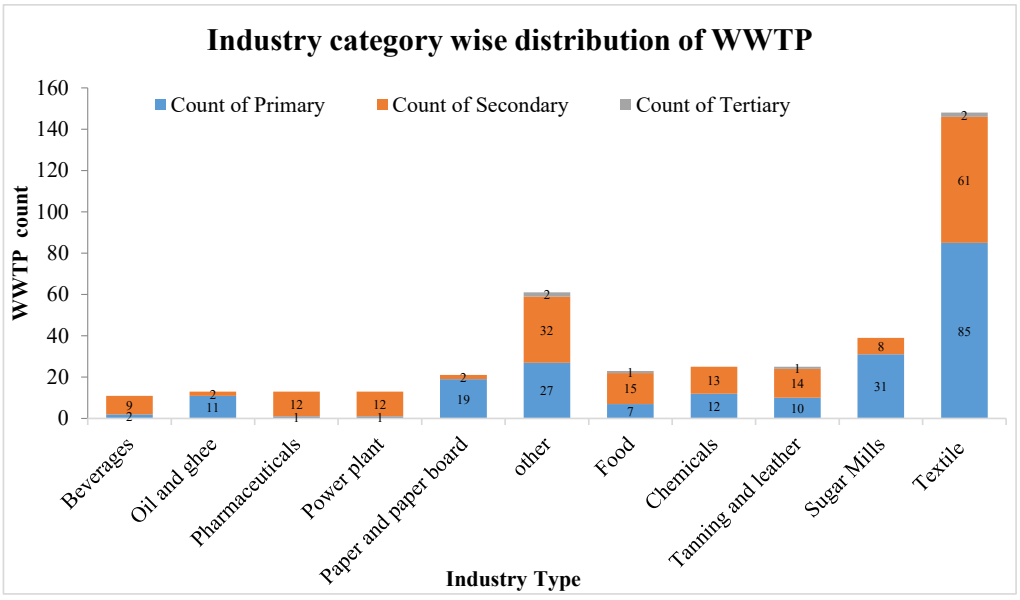


Figure 5-3: Industry Wise Distribution of WWTP in Punjab

1.2 Solid waste management in Punjab

1.2.1 Municipal Solid Waste (MSW)

Currently, no concrete figures for total waste being generated in Punjab are available, however when calculated on the basis of the average quantity of waste generated in Pakistan i.e. 0.43 kg/capita//day[1], it may be estimated that Punjab produces around 47,300 tons of municipal waste on daily basis. It is well-established that the amount of waste generated increases with a rise in population and urbanization in an area. So is the case in Punjab. The materials that make up municipal solid waste include food, glass, textiles, metals, and plastics. Lahore contributes most in waste generation (29%) followed by Rawalpindi, Multan, Kasur, Faisalabad, Gujranwala, Sheikhupura, and Sialkot. Whereas rest of the 28 districts produce 21% of Punjab's overall debris (Figure 5-4).

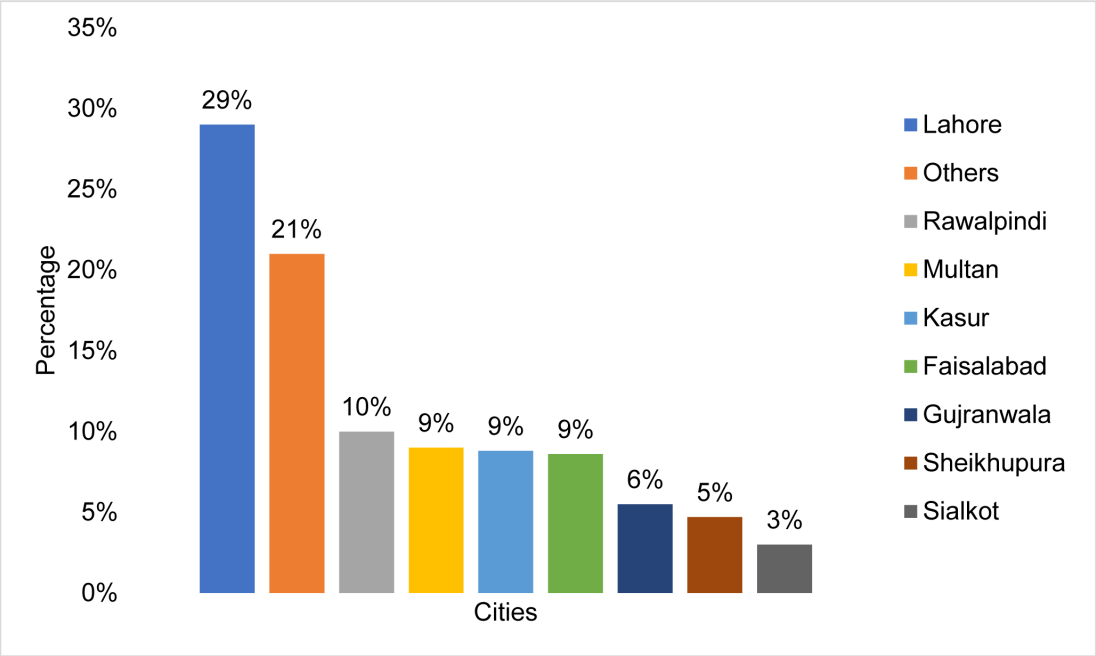


Figure 5-4 Comparison of percentage of MSW generation contributed by 36 districts in Punjab

Local Government and Community Development Department, Government of the Punjab is mandated with the solid waste management at provincial level, whereas at local level, local authorities and municipalities are primarily responsible for providing services regarding solid waste management. Currently, waste management companies, LWMC, RWMC, BWMC, FWMC, MWMC, GWMC and SWMC are functioning in Punjab's seven major cities, i.e. Lahore, Rawalpindi, Bahawalpur, Faisalabad, Multan, Gujranwala, and Sialkot, respectively LWMC covers 150 UCs of Lahore through outsourced companies and its own resources collectively[2] MWMC covers 68 UCs of district Multan[3] GWMC collects municipal solid waste covering 64 UCs in Gujranwala[4] Bahawalpur covers 18 UCs, SWMC covers 16 UCs of district Sialkot and RWMC covers 63 UCs of district Rawalpindi for waste management services. Major services include waste collection and transportation, manual and mechanical sweeping, and other ancillary services related to solid waste management.

The province hosts a single organic waste composting facility at the Mehmood Booti Landfill site (a central unit for managing organic waste from Lahore that makes a significant portion of the province's total waste generation) and a single environmentally approved landfill at Lakhodair site, both located in provincial capital i.e. Lahore.

The current practices in Punjab regarding waste disposal is open dumping at landfills/dumpsites designated at different locations in different cities. Other methods in practice are open waste burning, informal recycling, and illegal dumping. As reported by several sources, the disposal methods are far from the requirements of a controlled landfill. Resource recovery does not appear to be a major focus in the province so far.

[1] Solid Waste Management Sector in Pakistan; A Reform Road Map For Policy Makers, Asian Development Bank (2022)
[2] Iqbal A, Yasar A, Nizami A.S,. Sharif, F., Tabinda, A.B., Sultan IA, Batool SA, Haider R, Shahid A, Chaudhary MM, Ahmad M. Evolution of Solid Waste Management System in Lahore: A Step towards Sustainability of the Sector in Pakistan. Applied Sciences. 2023; 13(2):983. https://doi.org/10.3390/app13020983
[3] Multan Waste Management Company (MWMC) official website (https://mwmc.com.pk/)
[4] Gujranwala Waste Management Company (GWMC) official website (https://mwmc.com.pk/)

Despite a major percentage of the solid waste budget being spent on the physical components of the solid waste management system, i.e., collection and transportation, many areas in the province still lack proper collection and transportation to the designated dump sites. Source separation practices are rare, and public awareness regarding integrated sustainable waste management is poor.

The inadequate solid waste management and disposal system prevailing in the province pose significant environmental and health risks arising from release of harmful pollutants during waste burning, seepage of leachate into the soil and underground water and vectors breeding at the unmanaged dumpsites, in addition to the odour and other aesthetic issues. In addition, inadequate waste collection and transportation systems exacerbate the problem, accumulating waste in public places.

1.2.2 Hospital waste

Regarding healthcare hazardous waste, it is predominantly handled at individual hospital sites using on-site incineration facilities. Although this practice is crucial in maintaining biosecurity, it is noteworthy that these incinerators currently operate without an energy recovery system, missing an opportunity for efficient energy use. Rapid urbanization, unchecked population growth, institutional flaws, a lack of resources, and low awareness among the public all play a role in Punjab province's inappropriate solid waste management.

According to a survey conducted by EPA Punjab in 2021, Punjab's hospitals (with more than 20 beds) produce about 2.8 tonnes of infectious waste per day. However, it is noteworthy that as the survey did not cover all healthcare facilities of the province, comprehensive data on the total generation of infectious waste within Punjab remains unavailable, so far. In 2022, EPA Field offices gathered some estimates on hospital waste collection from relevant local authorities, according to which, district Kasur has the maximum collection rate (27%), followed by Sargodha, Faisalabad, Gujranwala, Rawalpindi, Sheikhupura, Sahiwal, Okara, Muzaffargarh, Lahore, and Bhakkar, with the remaining districts having a collection rate of 22.1% (Figure 55).

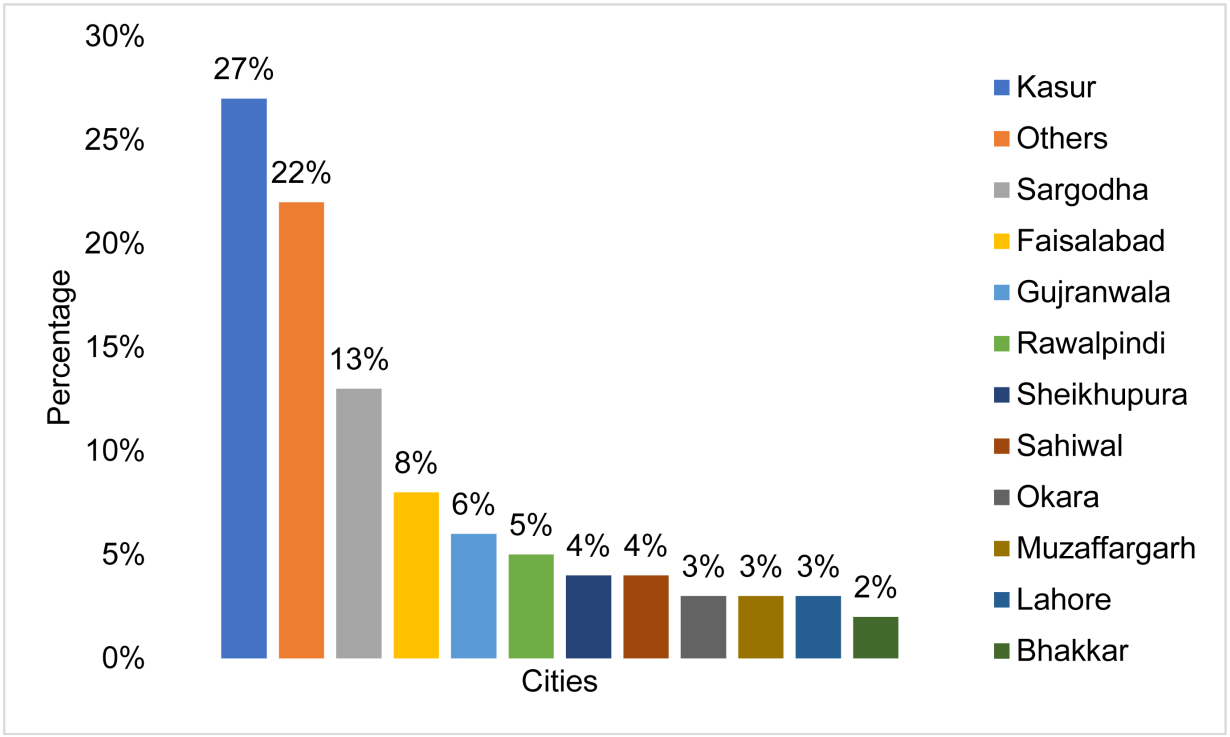


Figure 5-5: District wise comparison of hospital waste collection in Punjab (%)

Both the legitimate (incineration, autoclaving, burial pits) and illegitimate (open dumping at municipal waste dumping sites and burning) ways are being followed in Punjab for disposal of hospital waste. Throughout province, there are 47 private and 40 public incinerators with installed capacity ranging from 100-500 and 50-200 respectively. However, not all the incinerators are functional. Most of these incinerators have obtained environmental approval from EPA Punjab for installation. As per survey, Kasur has the largest incineration capacity (30.2%), followed by Lahore, Faisalabad, Khanewal, Attock, Rawalpindi, Sargodha, Sheikhupura, Gujranwala, Multan, and Sahiwal. Other districts have an incineration capacity of 19.2% (Figure 56).

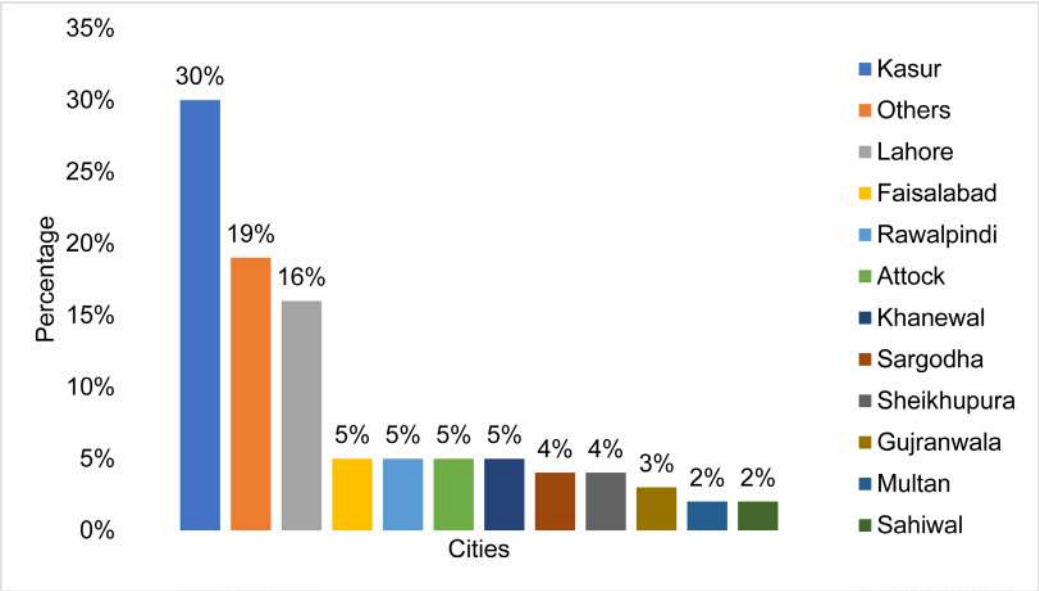


Figure 5-6: District wise comparison of incineration capacity in Punjab (%)

2. ENVIRONMENTAL PERFORMANCE OF WWTP

EPA performed an analysis of wastewater treatment plants installed in various industries in order to check their efficiency by measuring and analyzing some parameters and comparing them with PEQS. For this purpose, the analysis was done for 27 of primary, 12 secondary, and 1 tertiary treatment plants. Average values of various parameters from various industries are documented in Table 5-2 which shows a comparison of values of parameters before and after treatment. Analysis of treatment plants in various sectors of industries is as follows:

- **Animal feed industry** Results showed that the average values of chlorides, pH, and sulfates were within the limits of PEQS after treatment. On the other hand, sulfide, TSS, and COD showed higher average values even after treatment in WWTPs.
- **Beverage industry** In the beverage industry, values of sulfate, chloride, TSS, TDS, COD, and pH were observed to be the same before and after the passage of effluent from WWTPs which were evaluated to be under the limits of PEQS. While WWTP failed to lower the value of Sulphide in the liquid effluent.
- **Fertilizer plants** Prior to treatment, the average value of TSS was discovered to be within PEQS guidelines. The non-compliance values for TDS, Sulphate, chloride, and COD were changed to the compliance levels. However, even after the liquid effluent was treated in the WWTP, the Sulphide level remained over the allowable limit.
- **Food industry** In the untreated effluent, the values of Chloride, Sulphate, and pH were observed to be within PEQS limits. After treatment, the average value of TSS was lower than the compliance limits, while the average values of TDS, COD, BOD5, and Sulphide were greater than the allowable limits.
- **Man-made fiber industry** In the untreated liquid effluent, the average values of TDS, Sulfate, and pH were assessed to be within PEQS compliance limits. After the treatment, the level of COD got reduced to meet the allowable range of PEQS, on the other hand, the level of Sulphide remained higher than the PEQS range.
- **Oil & fats and vegetable ghee projects** Values of sulfate, chloride, TDS, and pH were observed to be the same before and after the passage of effluent from WWTPs which were evaluated to be under the limits of PEQS. After treatment, the average value of TSS got reduced while COD and Sulphide values remained higher than the PEQS limits.
- **Paper and paperboard, paper pulping** in the liquid effluent, sulfate, Chloride, and pH values remain under the PEQS range while TDS, COD, BOD5, and Sulphide values remain higher than PEQS limits.
- **Power looms** Values of sulfate, chloride, TDS, and pH were observed to be the same before and after the passage of effluent from WWTPs which were evaluated to be under the limits of PEQS. TSS was observed to be reduced to the compliance limit of PEQS after treatment whereas COD, BOD5, and Sulphide remained higher than the PEQS limits.
- **Sugar mills** In the untreated effluent, the values of Chloride and pH were observed to be within PEQS limits, but the values of BOD5 and COD were much higher. TDS was observed to be reduced to the compliance limit of PEQS after treatment whereas COD, BOD5, Sulfate and Sulphide remained higher than the PEQS limits.
- **Tanning and leather finishing projects** In untreated liquid effluent, the value of pH remained within PEQS limits. After treatment, values of TDS, Sulfates, and Chlorides got reduced to the allowable range of PEQS. On the other hand, BOD5, COD, and Sulphide values remained higher than the PEQS allowable limits.
- **Textiles** In untreated liquid effluent, the value of pH remained within PEQS limits. After treatment, values of TSS, TDS, and Chlorides got reduced to the allowable range of PEQS. On the other hand, BOD5, COD, and Sulphide values remained higher than the PEQS allowable limits.

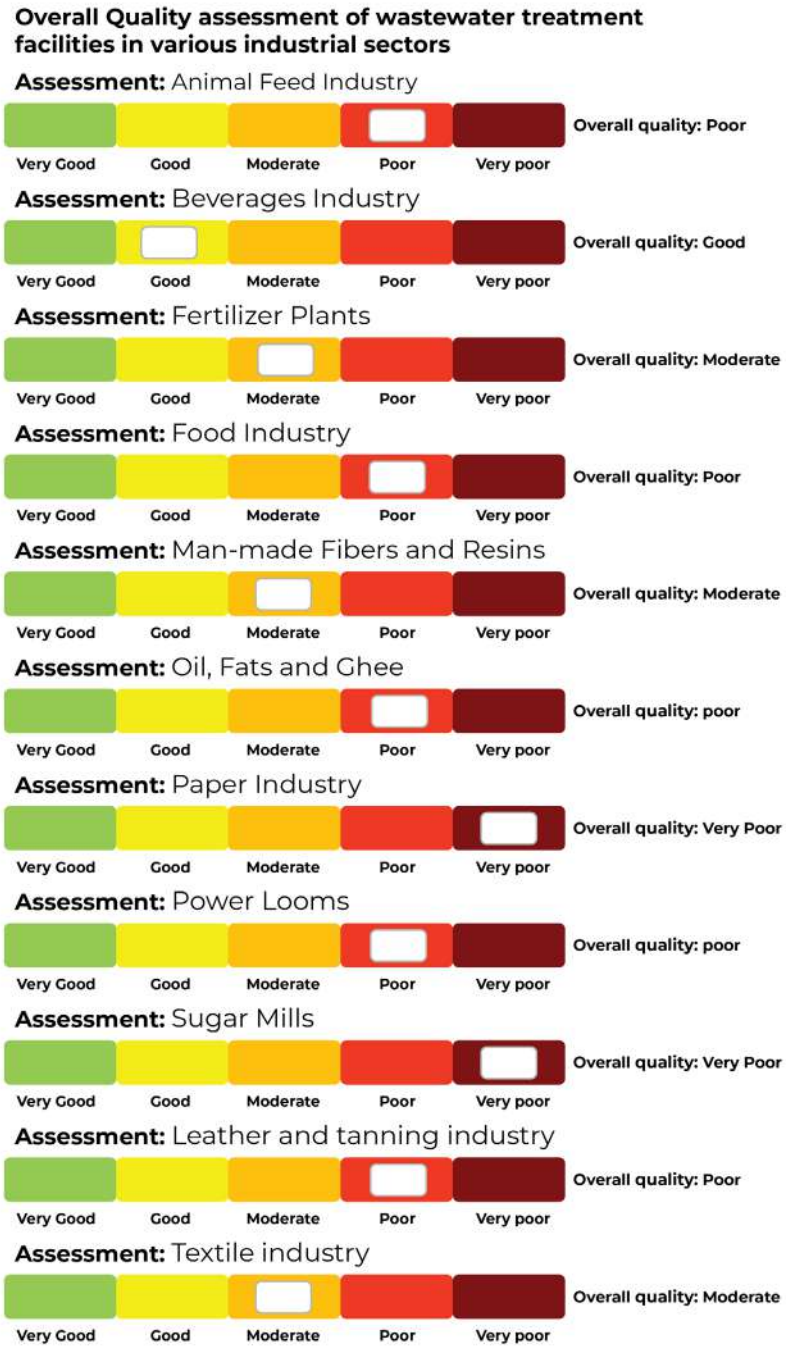
Table 5-2 Comparison of average values of various parameters of liquid effluent before and after treatment in WWTPs

Type of Industry	Sulfide (S^{2-}) mg/l		Temperature ˚C		pH		BOD5 (mg/l)		COD (mg/l)		TDS (mg/l)		TSS (mg/l)		Chloride (mg/l)		Sulfate (mg/l)	
	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*	B*	A*
Animal feed	20.0	16.0	19.2	17.9	7.2	7.5	N/A	N/A	416	336	3,742	3,356	302	256	946	852	418	392
Beverages	9.0	5.0	-	-	7.5	7.3	24.0	N/A	192	108	1,916	1,437	82.0	47.0	177	88.5	316	125
Fertilizer plants	20.0	8.0	27.0	26.2	8.9	8.6	N/A	N/A	1,040	164	5,674	2,186	150	27.0	1,166	506	672	344
Food industry	12.0	5.4	24.3	24.0	8.3	7.5	6,060	3,050	1,766	1,146	3,371	2,343	295	171	654	335	358	268
Man-made fibers and resin	8.0	N/A	24.0	21.0	8.3	7.2	N/A	N/A	164	102	3,224	2,134	N/A	N/A	318	212	302	218
Oils, fats and vegetable ghee	8.0	4.0	24.0	22.1	8.2	7.6	N/A	N/A	256	166	2,254	1,842	218	196	816	798	412	386
Paper industry	52.1	28.4	22.4	24.4	8.4	8.0	1,288	820	971	375	3,852	3,429	402	243	990	617	406	334
Power looms	10.0	6.0	21.6	20.7	7.3	6.7	N/A	N/A	196	160	2,205	1,643	242	191	528	364	335	283
Sugar mills	6.7	4.5	24.5	20.3	6.5	6.2	2,727	1,763	3,786	2,476	3,895	2,777	360	211	917	594	478	280
Tanning and leather finishing	12.0	4.0	26.3	26.1	8.9	7.6	N/A	N/A	920	182	6,326	3,230	846	218	1,096	810	716	292
Textile industry	10.9	6.4	23.8	20.3	8.5	8.4	822	273	1,211	522	5,365	3,140	320	189	1,454	859	362	291
PEQS values	**1.0**		**≤ 3**		**6.0 to 9.0**		**80**		**150**		**3,500**		**200**		**1,000**		**1.0**	

B*= Before Treatment, **A***= After treatment, **N/A**= Data not available, **Green color** = Within PEQS limits, **Red color** = Beyond PEQS limits

2.1 Overall Assessment

An overall assessment of the performance of wastewater treatment facilities was done for various sectors of industry in the province.



3. ENVIRONMENTAL PERFORMANCE OF SWMFS

In order to estimate the environmental performance of solid waste management facilities, a one-time study comprising selected disposal facilities (landfills/dumpsites for municipal waste and incinerators for hospital waste), located in four districts i.e. Multan, Rawalpindi, Faisalabad, and Lahore was conducted in last quarter of CY 2022. Table 5-1 shows the basic solid waste management information in the study area.

Table 5-1 Features of Study Area

Attributes		Multan[5]	Rawalpindi[6]	Lahore[7]	Faisalabad[8]
Population(million)		22	.1	11.1	Above3 .5
Area (km²)		3721	479	1772	1330
MSW Generation	**Total (tons/day)**	1,000	1280	6000-6500	1600
	Perc apita(kg/day)	0.48	0.61	0.54	0.45

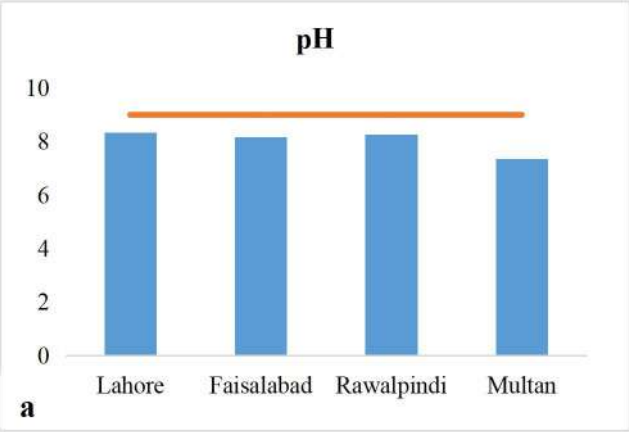
The environmental performance of selected facilities was assessed on basis of five parameters, including the quality of leachate, ambient air, soil (for landfills/dumpsites), stack emissions and ash (for incinerators), in comparison with available standards. Testing was carried out through EPA certified laboratories. The results are as follows:

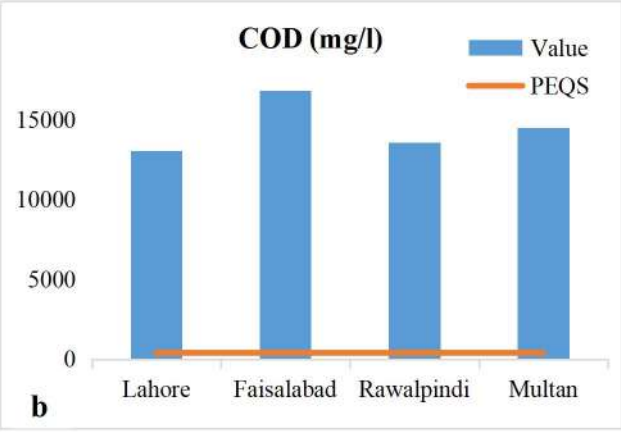
3.1 Landfills/Dumpsites

a. Leachate

Leachate from open MSW dumpsites was examined for Cadmium, Ammonia, Arsenic, Zinc, pH, COD, BOD, TDS and TSS. The findings show that, except for pH, all of the investigated parameters for municipal and liquid industrial wastewater exceeded the PEQS (Figure 5-7). The comparison with PEQS of wastewater has been done to better understand the overall landfill/dumpsites situation due to the absence of specific standards for landfill leachate.

The reported values of several parameters like COD, and Arsenic in landfill leachate are higher than the standard values established for wastewater in the PEQS. The high levels of heavy metals like arsenic in the non-sanitary landfills is alarming, as this contamination does not remain restricted to its origin. The organic and inorganic contaminants present in the leachate percolate to the groundwater, contaminating both the soil and the underlying aquifers. It is need of the hour to establish sanitary landfill sites equipped with leachate treatment/management system in accordance with effluent characteristics and best international practices.





[5] Arshad, R et al 2021. Solid Waste Management - An Integrated Approach towards Sustainability in Multan. European Journal of Applied Science and Technology-Novus (EJAST), pp. 44-70.
[6] Ilmas et al 2021. Characterization and energy potential evaluation of urban municipal solid waste of Pakistan. Carbon Management, 12(6), 581-591. https://doi.org/10.1080/17583004.2021.1976675.
[7] LWMC, "Municipal waste characterization study," Lahore Waste Management Company, Lahore, 2022.
[8] Aslam, B et al, 2022. Identifying and Ranking Landfill Sites for Municipal Solid Waste Management: An Integrated Remote Sensing and GIS Approach. Buildings, 12(5), 605. https://doi.org/10.3390/buildings12050605.

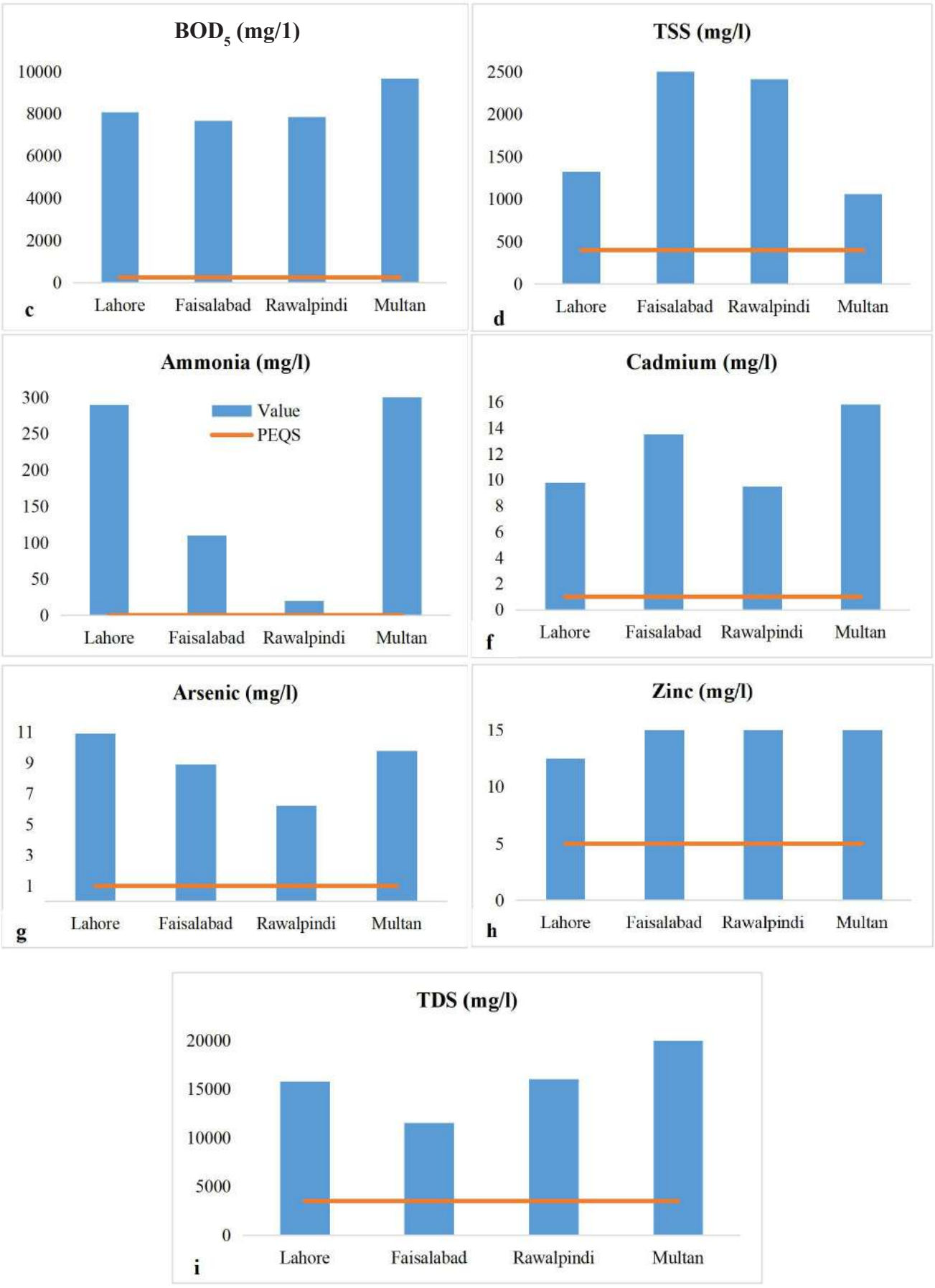
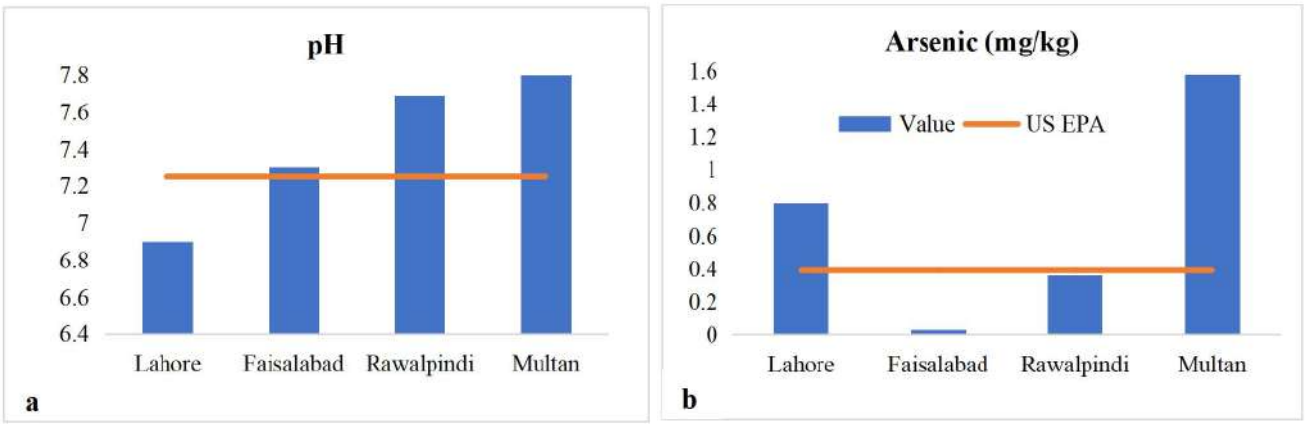


Figure 5-7: Results of Leachate Analyses in study area

B. Soil

Sampling of soil from landfill or open waste dumping sites was carried out in order to examine the Arsenic, Cadmium, and pH. The results were compared with US EPA's standard values, which show that Arsenic and pH levels were beyond the compliance limits (Figure 5-8).



C. Ambient air

Landfill sites or open dump sites have various sources of emission of harmful gases in the air deteriorating the ambient air quality. The ambient air quality assessment parameters under consideration were ozone, SPM, NO, NO_2, SO_2, PM_{10}, CH_4, $PM_{2.5}$, NOx, CO (Figure 59). The results were compared with standard values of PEQS, which shows that NOx was compared with OSHA standard & found beyond the compliance limits in all the sampling locations while methane was beyond limits only in Multan.

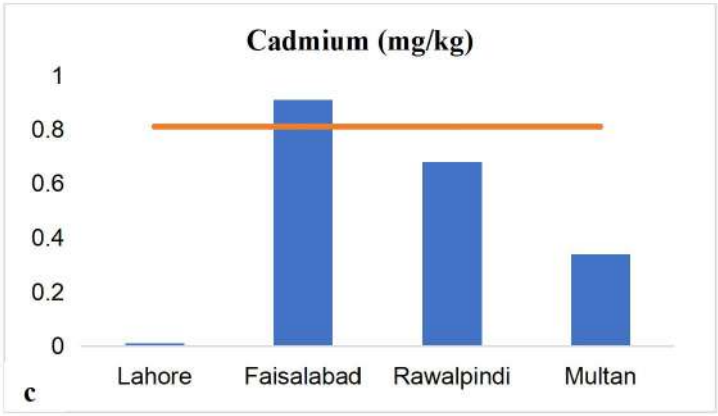
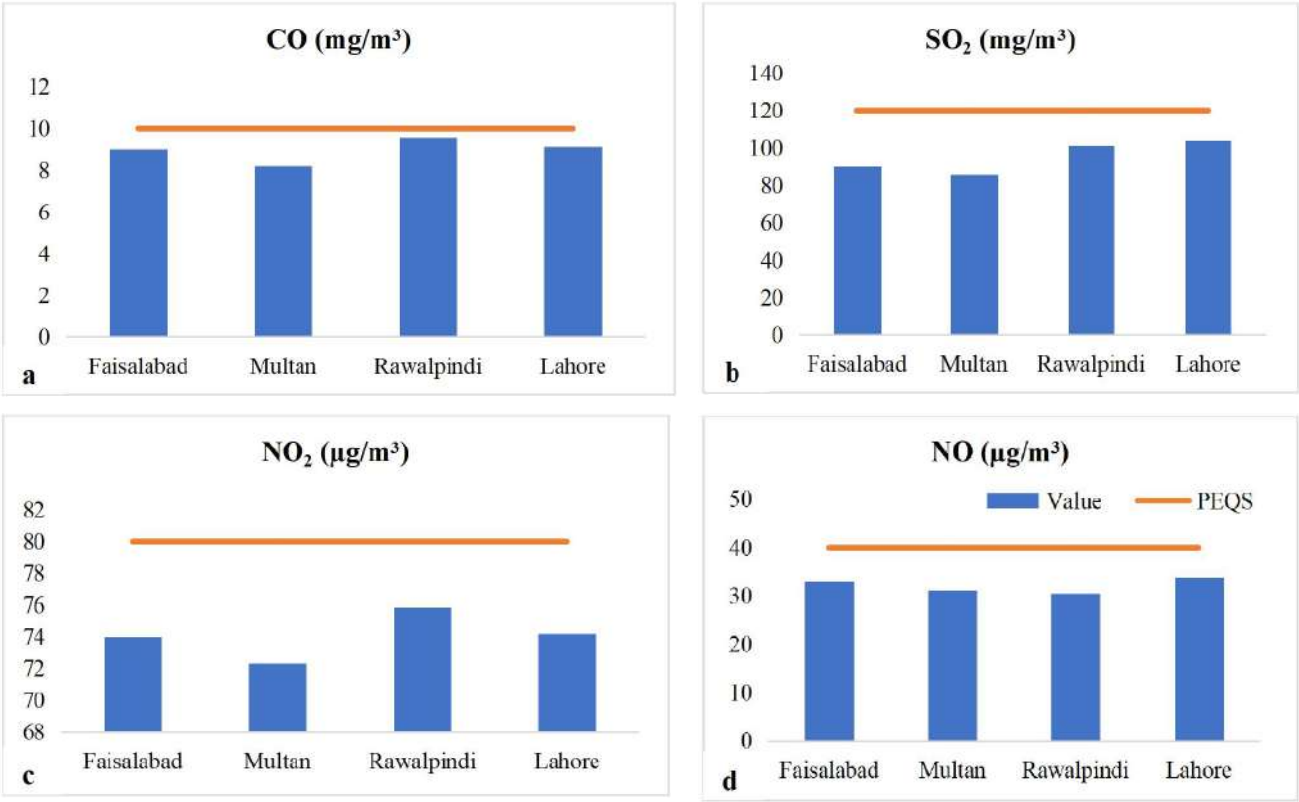


Figure 5-8: Results of Soil Analyses in study area (values compared with USEPA Standards for soil quality)



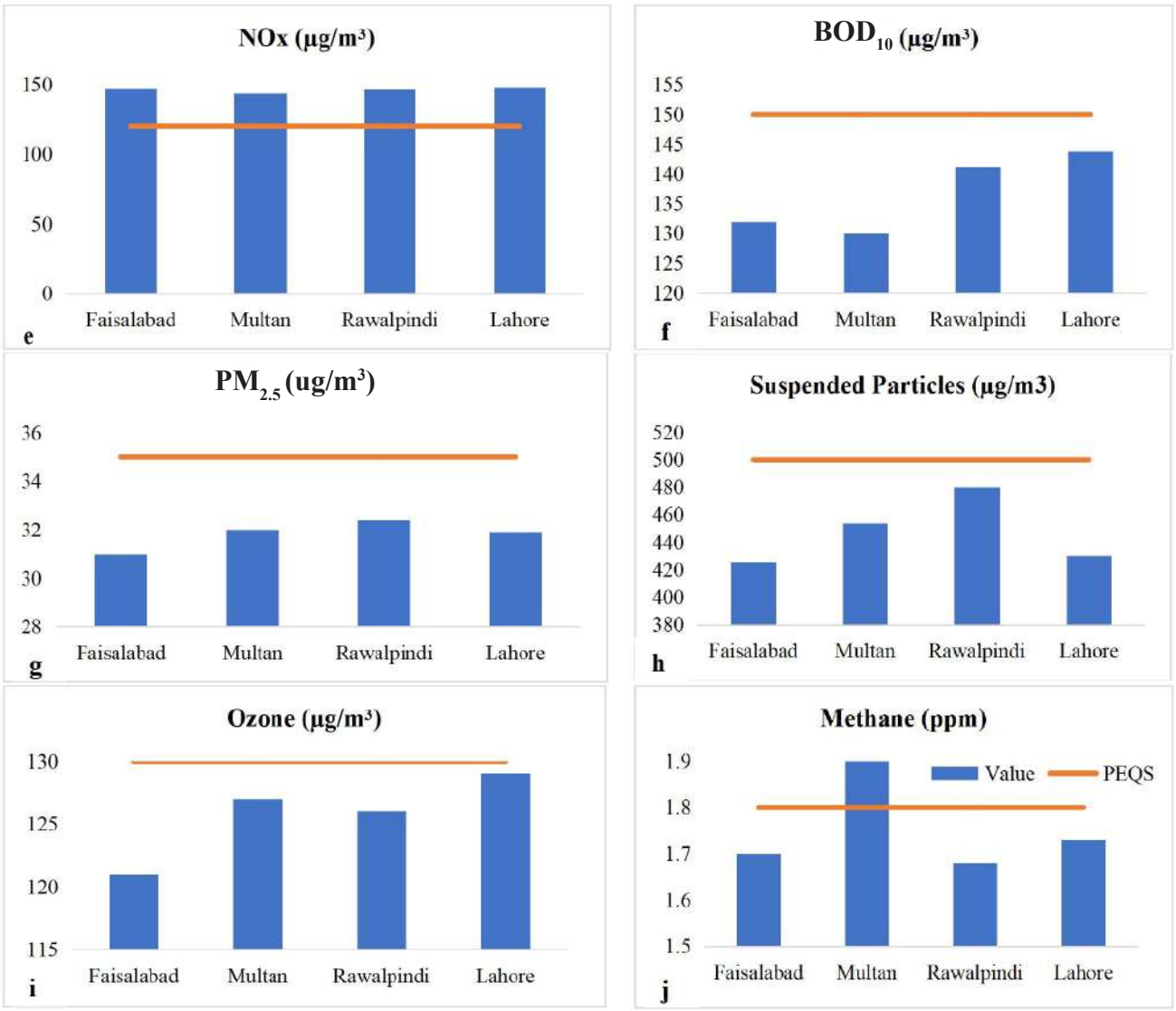


Figure 5-9: Results of Ambient Air Quality Analyses at landfill sites located in study area

It is noteworthy that where dumpsites are located within periphery of residential areas and along roadside the residents face the issues of odors, flying insects, etc. Whereas in the areas where such sites are at considerable distance from the population center and residential areas, the effects of issues like odour and vector breeding remain relatively limited.

3.2 Incineration facilities

A. Stack emissions

Stack emissions were evaluated from selected incineration facilities to compare the values of NO, SO_2, CO, smoke, HCl, NOx, and PM with PEQS. All the parameters had values within the compliance range in all the locations under study. The reported low emission from incinerators is attributable to the utilization of advanced technology integrated into these incinerators, which are mostly imported from Europe. These state-of-the-art techniques efficiently treat and mitigate hazardous emissions before release from the stack, considerably reducing emission levels.

B. Ash analysis

Ash was analyzed as it may contain environmentally hazardous constituents. However, due to limited available monitoring facilities, only the unburnt (UC) carbon and moisture content were added in scope of current study. It was observed that the level of UC is present in all samples from all the locations under consideration.

3.3 Solid waste management index

The Solid Waste Management Index for the four districts, Lahore, Faisalabad, Rawalpindi, and Multan, was calculated based on five indicators of environmental quality monitoring i.e. ambient air, leachate and soil (for landfill sites) and stack emissions and bottom ash (for incineration facilities) using following equations.

K - X = Y……(i)
Y x 100/K = Z……(ii)
K= PEQS value of parameter
X= Observed value of parameter
Y= +/– variation from PEQ
Z= +/– %

All the Z values were added and divided by a common denominator to Normalize the value as a single score between 0 to 100. A scoring scale of 0 to 100 was formulated with 0 being worst and 100 being best, which was then further categorized into 7 categorical ranges along with the assignment of following color scheme: (table 5-3)

Table 5-3: Color Coding

Score	Color Code
0-14 or below	
15-28	
29-42	
43-56	
57-70	
71-84	
85-100	

These categories are based on the solid waste management index for each assessed indicator (leachate, ambient air, soil, stack emissions and ash).

Solid waste management index developed during this study is a preliminary attempt to establish a basic solid waste index system for major districts in Punjab. This endeavor, inspired by various solid waste indices presented in scientific literature, aims to provide a comparative basis for solid waste management facilities (SWMFs). While in its nascent stage, this index system represents a crucial first step towards quantifying solid waste management performance. However, constructing a comparable index for SWMFs in Punjab would necessitate continuous data monitoring over several years, as in the case of Environmental Performance Index (EPI) or Global Waste Index.

Landfill/Dumping Site

A. Leachate

Results of leachate scoring show that the tested parameters for all the studied landfills/dumpsites had values higher than PEQS, with those located in Multan being the worst, followed by Lahore, Faisalabad, and Rawalpindi (Figure 5-10)

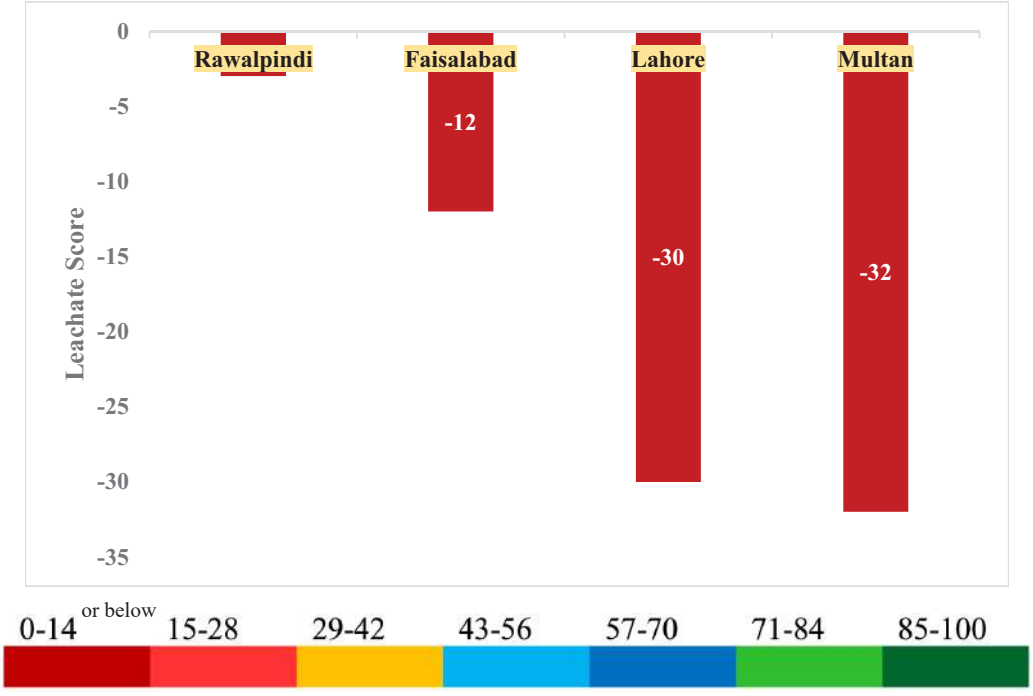


Figure 5-10: Leachate analysis score of SWMFs located in four cities

B. Ambient air quality

Scoring of ambient air quality show positive results in all of the study locations, implying that all of the tested parameters were within the compliance limits in accordance with PEQS. Score of Faisalabad and Multan were observed to be the same (Figure 5-11).

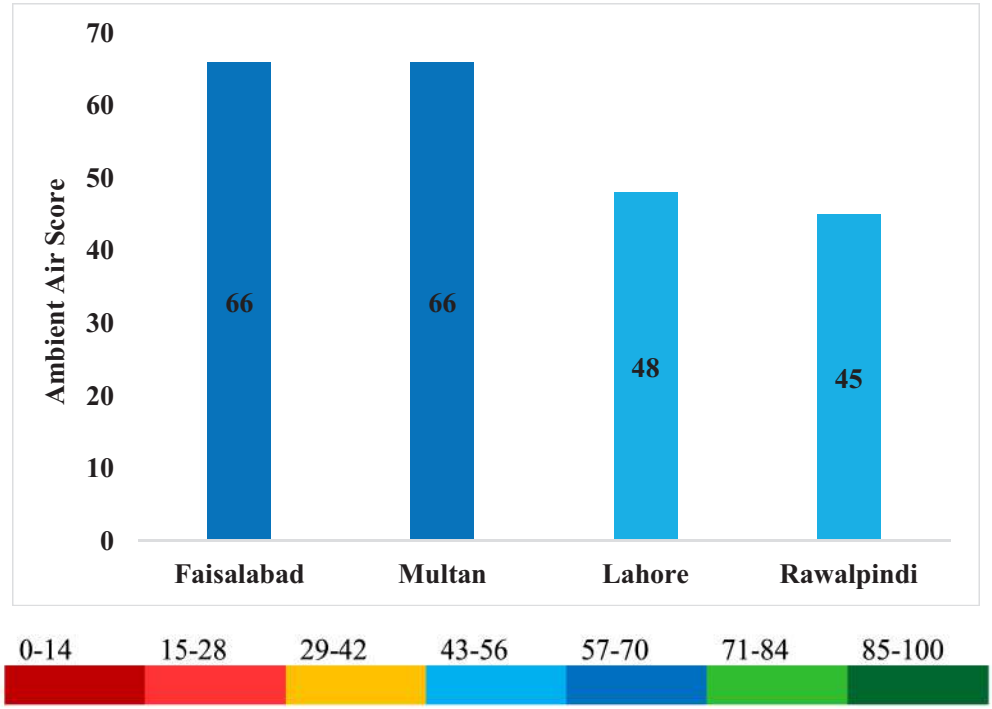


Figure 5-11: Ambient Air analysis score of SWMFs located in four cities

C. Soil analysis

The results showed scattered results for soil quality in all of the four selected districts, where Multan showed the lowest score, and Faisalabad was the best in terms of condition of soil at selected dumpsites (Figure 5-12).

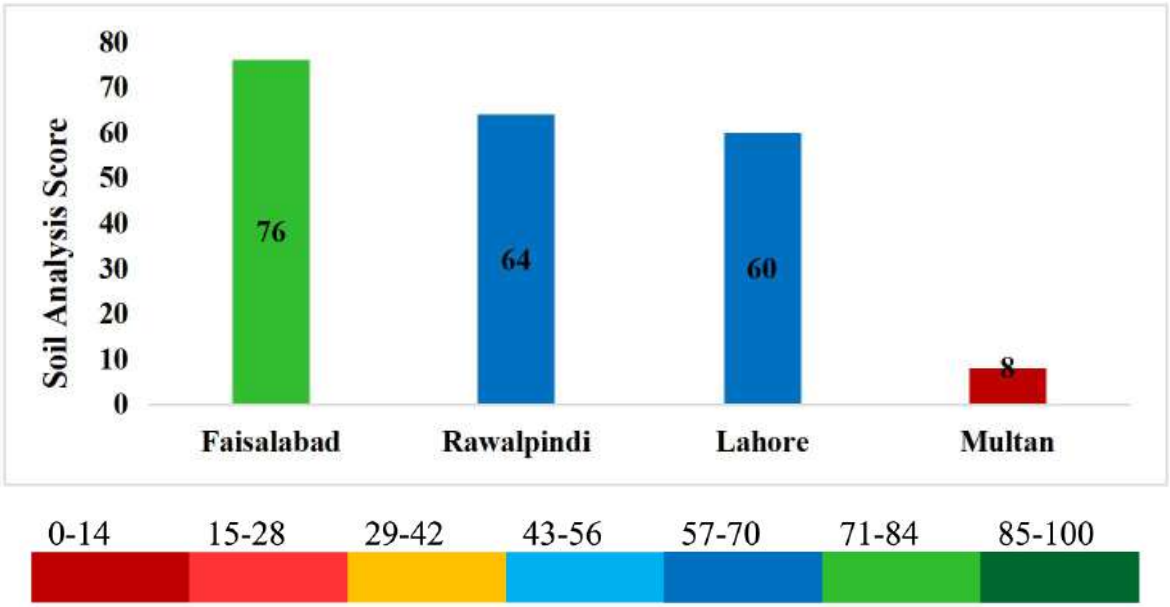


Figure 5-12: Soil Analysis score of SWMFs located in four cities

Incineration Facility

A. Stack emissions

Scoring analysis of stack emissions showed positive results in all of the study locations, which implies that all of the tested parameters were within the compliance limits in accordance with PEQS (Figure 5-13).

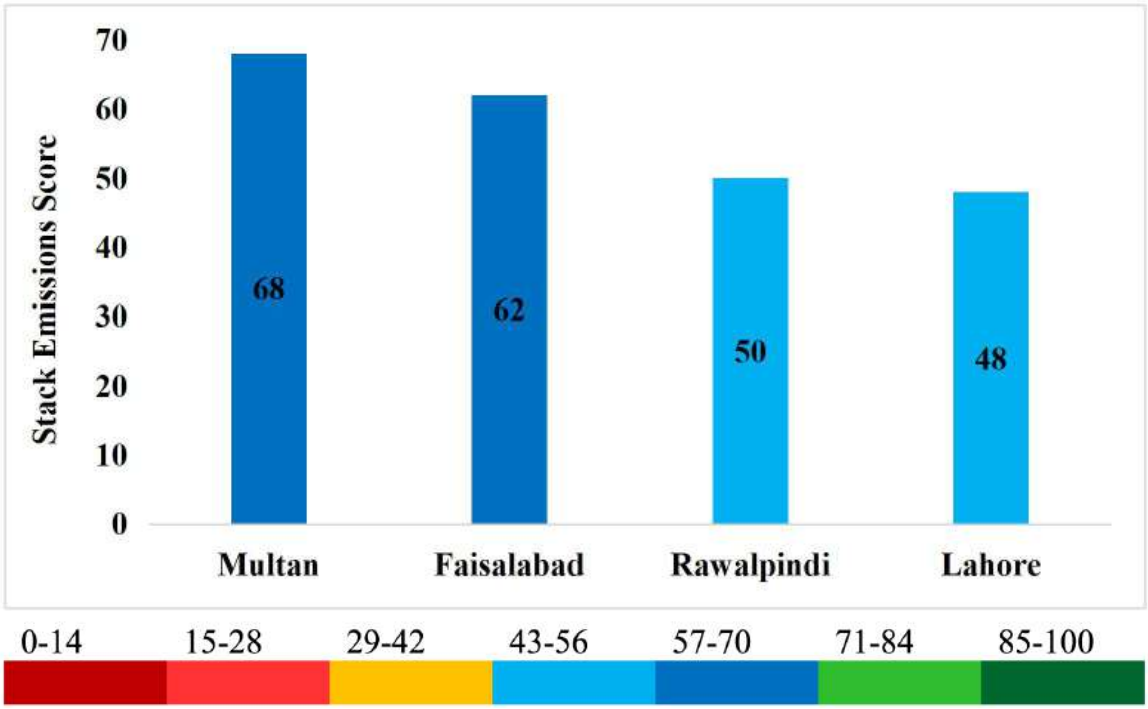


Figure 5-13: Stack emissions score of four cities

B. Ash analysis

For the analysis of ash, there are no PEQS, so in order to evaluate the ash, the average value for all the districts was considered the standard and was compared with each of the districts. The overall score remained positive, with Multan standing topmost, with maximum UC in the tested samples compared to the facilites tested in other districts (Figure 5-14).

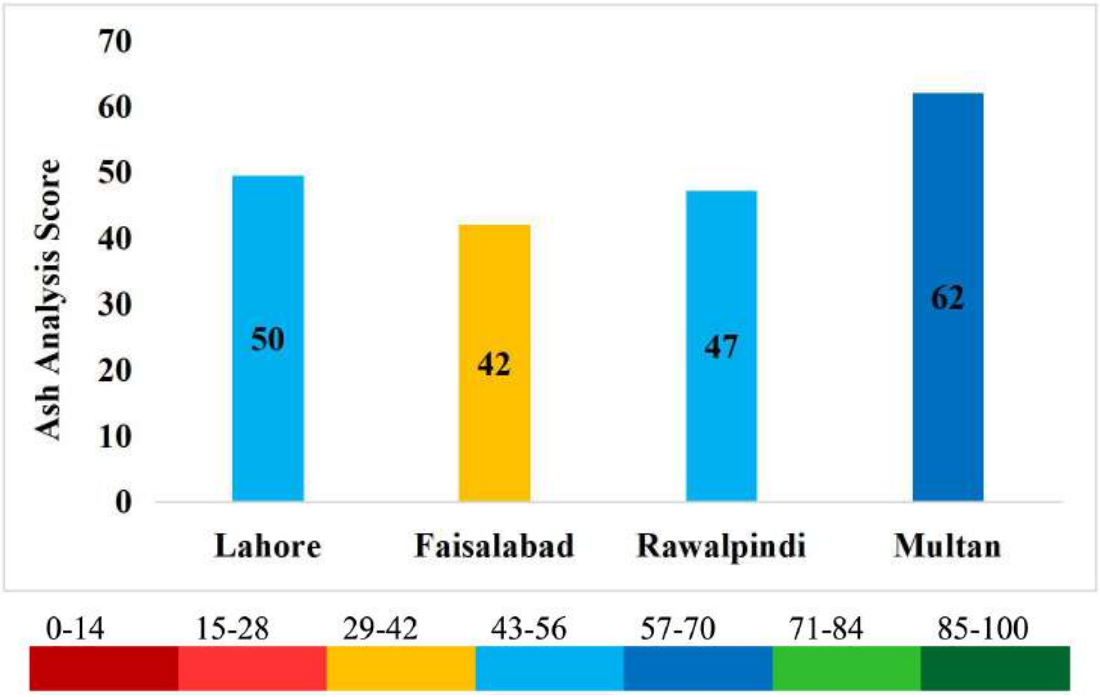


Figure 5-14: Ash Analysis score of four cities

Solid waste management index

Each district (study area) was deputed an overall score for the environmental performance of its tested solid waste management facilities (in terms of ambient air, leachate, soil, stack emission and ash monitoring), considering the individual scores for all tested parameters (Figure 5-15). Although all districts scored 50-80, it needs to be kept in mind that this collective score is a result of statistical analyses, whereas, the individual results of all tested parameters have already discussed in above sections.

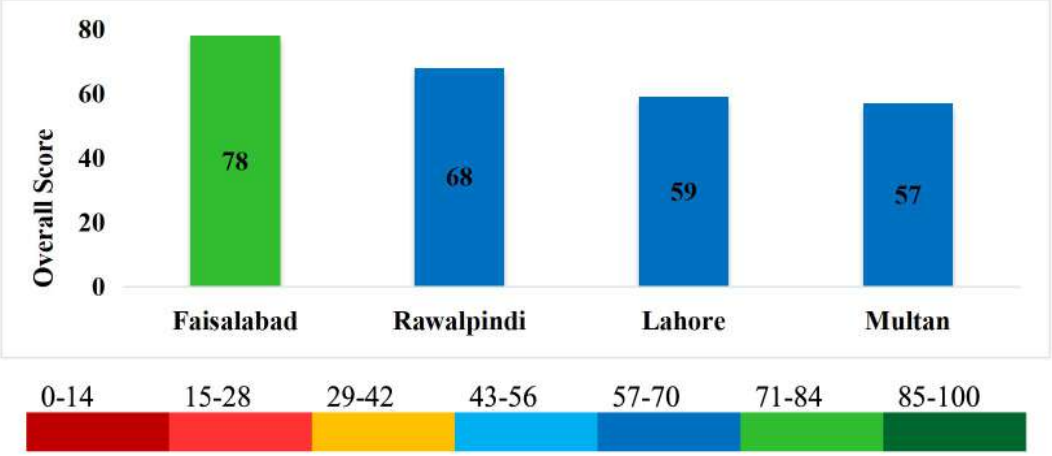
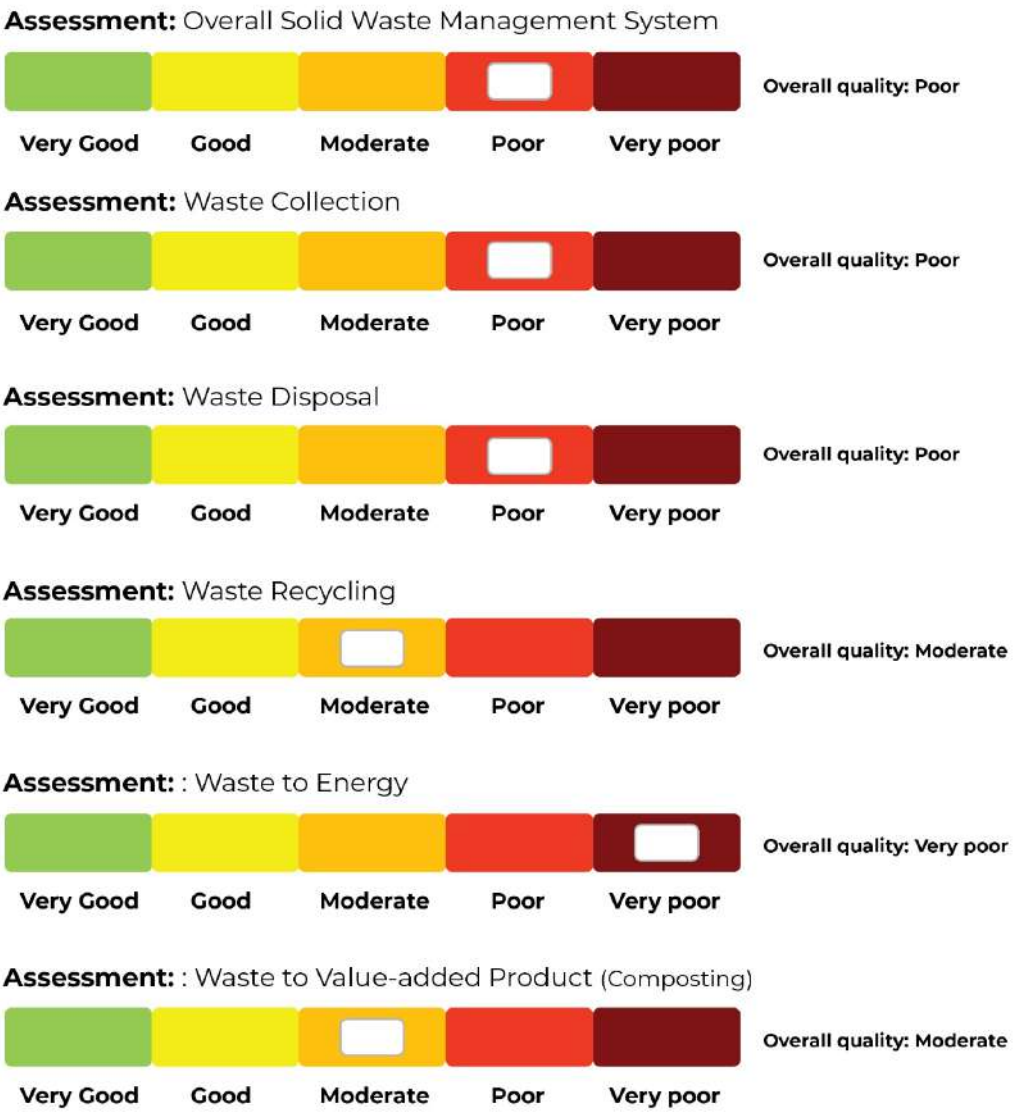


Figure 5-15: Total Score of four cities

3.4 Overall assessment

An overall assessment of solid waste management system in the province is depicted below:



4. DPSIR FRAMEWORK

DPSIR framework of solid waste facilities for Punjab is as follows:

Drivers

The rapidly growing population and urbanization in Punjab, Pakistan, exert immense pressure on its solid waste management facilities. As cities swell, the strain on existing facilities rises, necessitating an immediate need for more efficient solid waste management strategies. Institutional weaknesses, such as lack of control and monitoring of waste generation and inadequate financial and technical resources for waste management, compound the problem. Additionally, the lack of public awareness and education on proper waste disposal practices exacerbates the region's waste management infrastructure challenges.

Pressures

The increasing population of the province has caused increased consumption of utilities, hence the production of more waste. Moreover, the increased number of healthcare facilities contributes significantly to waste generation, especially hazardous medical waste. Further pressure is brought by the inadequate waste collection and segregation system, which cannot handle the growing waste volumes efficiently. Also, the limited formal recycling facilities and sanitary landfills, combined with increased waste generation, cause additional strain. The limited number of operational incinerators compounds the problem, making hosptial waste disposal a significant challenge in the province.

State

Punjab currently faces considerable challenges in context of solid waste management. The insufficient collection and treatment of hospital waste, coupled with the rampant open dumping of municipal waste, underscore the gravity of the situation. These practices pollute the environment and pose risks of contaminating nearby ecosystems. The state of solid waste management in Punjab is indeed concerning, given its significant potential impact on the environment and public health.

Impacts

The implications of inadequate solid waste management are multilayered, directly influencing health, environment, and socioeconomic conditions. Increased diseases and epidemics linked to waste mishandling highlight the pressing health issues. Furthermore, increased vector breeding sites, aesthetic view of the area, and odor problems pose societal challenges. Finally, the environmental impacts, such as the degradation of ambient air, soil, and water quality further demonstrate the urgent need for action.

Response

To address the waste management challenges, an integrated approach focusing on properly constructing and operating landfills, specifically sanitary or engineered ones, and establishing a robust municipal tax base is imperative. Constructing and managing landfills responsibly are essential steps to prevent potential environmental and public health threats. Concurrently, a solid tax base is crucial for financing waste management services, from regular waste collection to larger-scale initiatives. Through stable funding, regulatory enforcement can be strengthened, public education on appropriate waste disposal can be bolstered, and innovative solutions such as waste-to-energy conversion and organic composting can be explored. These measures can reduce the volume of waste directed to our landfills and facilitate the transition toward sustainable waste management practices in Punjab

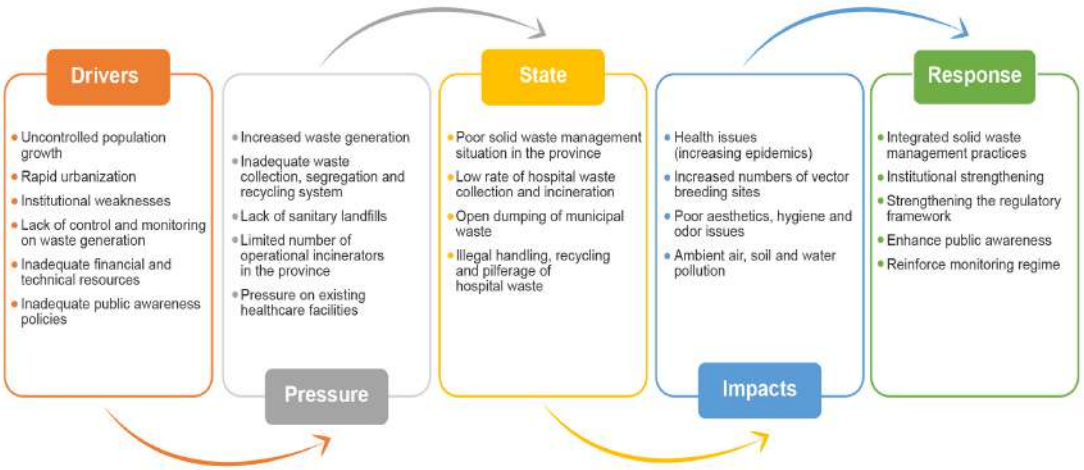


Figure 5-16 DPSIR framework

5. THE WAY FORWARD

Strengthening Monitoring and Control Frameworks: For wastewater, there is a need for continuous effluent monitoring systems, starting from large industrial establishments, to regularly monitor the quality of effluents. Establish a robust collection schedule for solid waste to prevent unauthorized dumping and waste accumulation. Implement monitoring and control systems to regularly assess the performance of the treatment plants, ensure compliance with PEQS, and promptly address any operational issues or deviations. Data on solid waste generation, collection, transportation, recycling, composting, treatment and disposal rates in province must be calculated and updated periodically.

Guidelines and Legal Framework: Devise guidelines for gauging and improving the environmental performance of wastewater treatement and solid waste management facilities for uniform assessment and improvement.Develop a comprehensive legal framework and national guidelines for wastewater and municipal solid waste management to enforce proper practices, implement penalties for non-compliance, and streamline operations across Punjab and Pakistan.

Technological and Methodological Improvements: Identify and implement the latest treatment techniques for wastewater or couple more than one technology for compliance with PEQS. For solid waste, segregation at source will ensure that different types of waste are properly sorted, making waste management more efficient and reducing the burden on waste processing facilities.

Periodic Evaluation, Optimization, and Collection Efficiency: Continuously monitor and evaluate the performance of wastewater and solid waste treatment plants, considering advancements in technology and regulatory requirements. Implement necessary upgrades or optimizations to enhance efficiency, reduce environmental impact, and improve overall effectiveness. Leverage technological advancements to monitor waste collection, ensuring timely and efficient pickup.

Formalize Recycling and Promote the 5R's: Transition the informal waste recycling sector to a formal one for better regulation, worker safety, higher efficiency, and quality. Promote the principles of Refusing, Reducing, Recycling, Reusing and Repurposing (5Rs) across Punjab through awareness programs, policy incentives for 5R practices, and integrating these principles into industrial design and lifestyle choices.

Private Sector Involvement and Innovation: Engage the private sector in waste collection, recycling, and treatment to bring expertise, innovation, and efficiency. This would also create new jobs and contribute to the economy.

Sustainable Waste-to-Energy Solutions and Sanitary Landfills: Develop the waste-to-energy sector for sustainable waste management and renewable energy production, thereby reducing reliance on fossil fuels. Establish sanitary landfills according to international standards to prevent the adverse environmental and health impacts caused by unregulated dumping sites.

Raising Public Awareness: Raise awareness about the consequences of wastewater and solid waste pollution among the general public, politicians, policymakers, and administrators. This will foster a sense of responsibility toward waste management and garner support for sustainable practices.

6 MEASURES TAKEN TO CONTROL POLLUTION

CHAPTER 6 MEASURES TAKEN TO CONTROL POLLUTION

1. OVERVIEW

Pakistan Environment Protection Act 1997 empowers Environment Protection Agency (EPA) Punjab to exercise numerous powers and functions under Section 6 of the Act ibid, which results in improved environmental quality. These powers include, in addition to the implementation of the Act through regulatory and enforcement activities, taking measures to promote research and development in various sectors of environment, need assessment for environmental legislations in the province and providing advice and assistance to local councils, authorities and the general public on environmental matters. EPA Punjab may also recommend environmental literature for inclusion in educational institutions' curricula and syllabi.

EPA Punjab has commenced several initiatives to help the environment and combat climate change (Figure 6-1).

Figure 6 1: Timeline of actions taken by EPD during the year 2022

2. MEASURES TAKEN TO CONTROL POLLUTION

Major activities that result in high air pollution levels are presented in Figure 6-2. Keeping in view the multi-faceted nature of issue, a multi-stakeholder approach was adopted to curtail the air pollution.

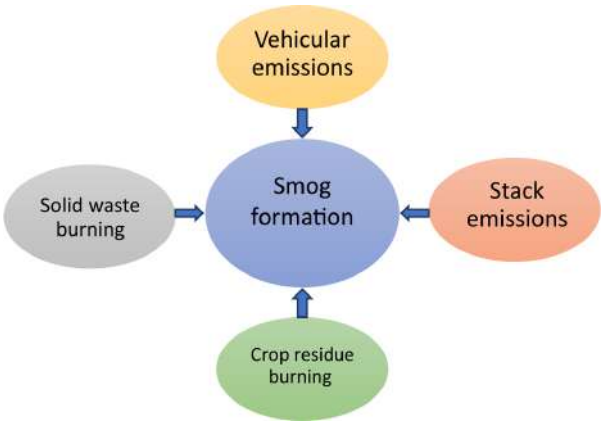


Figure 6-2: Anthropogenic factors mainly contributing to smog formation

2.1. Anti-smog campaign

In order to prevent the high air pollution levels experienced on seasonal basis in the province, EPA Punjab started anti-smog measures and launched an anti-smog campaign well before the arrival of the winter season in CY 2022.

KEY FINDINGS

EPD is taking measures to control pollution
EPD Punjab launched an anti-smog campaign in 2022 as a preemptive measure to control the seasonal high air pollution levels. The campaign included many institutional arrangements, enforcement and monitoring based anti-smog activities.

EPA Punjab inspected 2169 public and private hospitals to check the implementation of Punjab Hospital Waste Management Rules (2014) and action was taken against the non-compliant hospitals.

Greening of the Punjab
A total of 705,650 trees were planted under the supervision of EPA field offices across Punjab in collaboration with multiple stakeholders. Spring Tree Plantation was carried in the 3rd week of February in collaboration with Punjab Forest Department.

EPD envisions installation of environmental quality monitoring stations in Punjab
- A total of 30 AQMS stations will be installed in the 10 districts of Punjab.
- At least 15 WQMS will be installed along surface water bodies in Punjab.

Health Advisory System in Punjab
EPD Punjab established a Health Advisory System for Critical Air Pollution Events targeting vulnerable population groups.

Regulatory and Institutional Reforms in Punjab
major reforms for strengthening environmental governance in the province, accomplished or in pipeline in EPD Punjab, during 2022, 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.

2.1.1. Regulatory and enforcement actions taken during anti-smog campaign

The principal sources of smog (stone crushers, Bull's Trench Kiln technology - BTKs, pyrolysis plants and vehicles that emit smoke) were investigated by the anti-smog teams. A total of 16770 industries, including 168 pyrolysis plants, 63979 brick kilns and stone crushers were inspected. Figure 6-3 and Table 6-1 both present data on monthly inspections of industrial units, BTKs, and vehicles as well as actions taken against them.

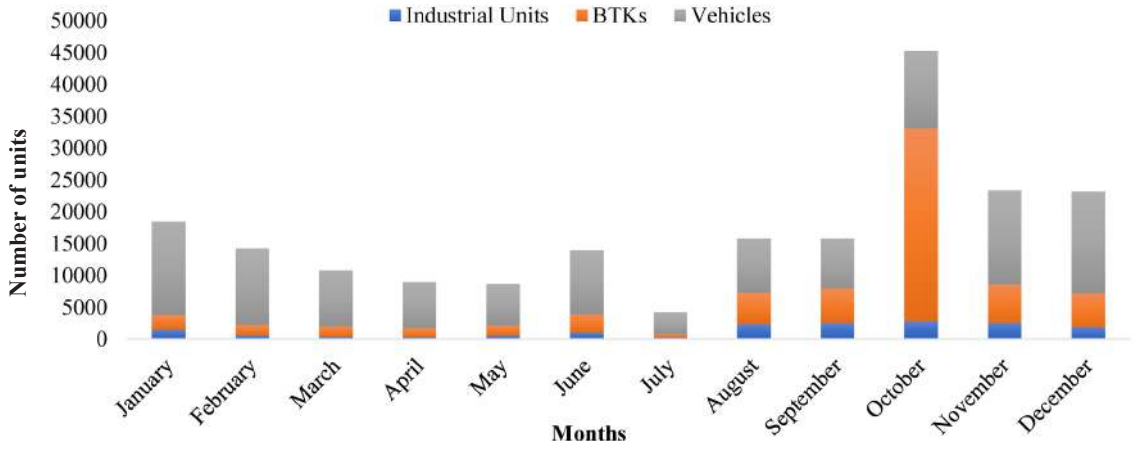


Figure 6-3: Number of inspections of smoke emitting sources in Punjab during CY 2022

Table 6-1: Actions taken by EPD Punjab against smoke emitting facilities during 2022

Month	Industrial Units including the stone crushers			Stone Crushers operating without wet scrubbers			Non-Compliant Brick Kilns (BTK)			Pyrolysis Plants				
	Units Inspected	FIRs Lodged	Units Sealed	Units Inspected	FIRs Lodged	Units Sealed	Units Inspected	Fine imposed	FIRs Lodged	Units Sealed	Plants inspected	Violating plants	Units sealed/operation stopped	FIRs lodged
January	1000	11	32	466	9	24	2348	2193271	75	47	0	0	0	0
February	569	10	15	0	0	0	1684	1915003	42	32	0	0	0	0
March	378	0	4	12	0	0	1629	2625001	59	8	0	0	0	0
April	323	0	15	18	0	0	1349	1400000	24	12	0	0	0	0
May	458	1	3	105	0	14	1609	2015014	120	25	0	0	0	0
June	898	39	29	128	9	9	2896	6857019	233	76	0	0	0	0
July	247	0	5	40	0	0	473	510004	33	12	0	0	0	0
August	2039	57	128	351	43	5	4877	5910001	248	336	69	17	7	10
September	2216	45	78	303	4	40	5491	9825011	170	511	58	17	7	7
October	2187	124	135	643	32	105	30260	74258027	1580	204	21	8	5	4
November	1863	67	100012	682	30	47	6042	22255010	405	267	13	8	15	1
December	1603	45	53	241	5	18	5321	7868000	234	80	7	2	2	0
Total	13781	399	100509	2989	132	262	63979	137631361	3223	1610	168	52	36	22

With the help of traffic police, a vigorous regulatory and enforcement campaign was launched against smoke-emitting automobiles (Table 6-2).

Table 6-2: Actions taken by EPD Punjab against Smoke Emitting Vehicles during 2022

Month	Vehicles Checked	Vehicles Challaned	Fine Imposed	Vehicles Impounded	FIRs Lodged
January	14654	4860	3178750	503	11
February	12008	8830	2078655	2709	0
March	8747	2290	1137950	57	0
April	7268	1902	774055	12937	7550
May	6484	1653	762700	54	1
June	10070	2999	1220351	787	0
July	3486	762	908500	102	0
August	8486	1551	1126800	219	0
September	7742	1972	2043500	300	0
October	12138	2750	4497900	681	0
November	14749	3527	5134600	687	0
December	15982	3604	5089400	662	0
Total	**121814**	**36700**	**27953161**	**19698**	**7562**

To further limit smog-emitting sources, the Punjab government issued an order under section 144 of CrPC on October 25, 2022, to completely restrict the production, transportation, and use of pyro-carbon powder as well as the use of thrift apparel/clothes for burning purposes in the industries.

2.1.2 Actions taken by other departments

In order to further curtail the sources of smog in the province, EPD Punjab coordinated with the relevant stakeholders and other departments to play their key role in anti-smog campaign. The relevant departments took initiatives to control smog and their focal persons reported EPD control room about the measures taken. Following are some of the significant actions taken by multi-stakeholders to curb smog in the province (Figure 6-4).

Figure 6-4: Actions taken by other departments to curb smog in Punjab

2.2 Anti-smog squads

In the major cities of Punjab including Lahore, Multan, Gujranwala, Sheikhupura and Faisalabad the anti-smog squads were established alongside the regular monitoring staff of EPA Punjab. The squads were assigned tasks to take action against polluting units, and report to the departmental representative on daily basis about their progress via District and Divisional anti-smog committees. Representatives from the EPA field offices and laboratories, the concerned Assistant Commissioner's office and Municipal Corporations/Town Committees (MCs) and Punjab Police were members in these squads. The administrative secretaries of Local Government and Community Development, Industries, Agriculture and Transport Departments were requested to establish smog cells in their departments to curb the likely activities resulting in the formation of smog. Additionally, special squads comprising of members from the traffic police, EPA Punjab, Vehicular Inspection and Certification System (VICS), and vehicle examiners were notified to check for vehicular pollution.

2.3 Establishment of Control Room

In August 2022, EPD Punjab established a Control Room to gather data on anti-smog activities for the purpose of continuous smog monitoring. Eight LEDs have been installed in the control room to track the movement of squads across the province and to monitor the overall condition of the air quality. During CAPEs, relevant dedicated staff deputed in the Control Room work in day and night shifts to ensure continuous monitoring of the operations.

In the control room, NASA's real-time geo-tagged imagery is taken to track thermal anomalies resulting from open/crop burning in the province. The latest information on temperature anomalies in the province is also shared by SUPARCO with the EPD Control Room. The concerned Deputy Commissioner and the Agriculture Department are then informed to take measures against violators. The control room also display the weather forecast and wind direction data to monitor potential smog related activities and intensities. Furthermore, the control room continuously monitors real-time Air Quality Index (AQI) developed on the basis of low-cost sensors installed in highly polluted areas of District Lahore (at Karol Ghatti along the Ring Road). This data enables prompt decision-making regarding the deployment of anti-smog squads in the pollution hotspots.

2.4 Android-based complaint line

An Android application with a dashboard was developed by EPD Punjab in collaboration with the Punjab Information Technology Board (PITB). The application is helpful to the anti-smog squads to upload and geo-tag smog monitoring

datasets to the dashboard including the number of inspections they carried out. The control room monitors and keeps track of the movement of the squads. In addition to the already installed telephone line, a WhatsApp complaint number has been introduced to make it easier for the public to report pollution sources from across the province. Every squad was instructed to respond to citizen concerns within 24 hours.

2.5 Hospital waste management

Through the Punjab Hospital Waste Management Rules (2014), which were notified under Section 31 of the Act, EPA Punjab regulates the management of infectious waste of hospitals, carried out by respective hospitals, from its generation to disposal. Under these rules, all hospitals in the province are required to make sure that infectious hospital waste is appropriately and safely disposed-off throughout the process from its collection, transport, treatment and to final disposal stage. For making sure that the rules are being followed, Deputy/Assistant Directors (Environment) randomly inspect hospitals in their area of jurisdiction and report to EPA headquarter to ensure compliance to the rules. Any contraventions are dealt through proper channel under section 16 of the Act ibid (Rule 23). In instances of continuous violation and non-compliance with the Orders, the Complaints are regularly placed before the Punjab Environmental Tribunal under Section 21 of the Act, ibid.

EPA Punjab visited about 2169 public and private hospitals in 2022. Following these inspections, the non-compliant hospitals were issued 123 Environmental Protection Orders and around 832 hearing notices.

3. MEASURES TAKEN TO IMPROVE ENVIRONMENTAL QUALITY

3.1 Tree plantation

In wake of improving environmental quality, EPA Punjab promotes tree plantation by issuing environmental approvals to industrial projects with one of the conditions to plant certain number of trees in project premises or other places under intimation to EPA Field Officer.

Under the supervision of EPA Field offices and in coordination with numerous stakeholders, 705,650 trees were planted across Punjab (Figure 6-5).

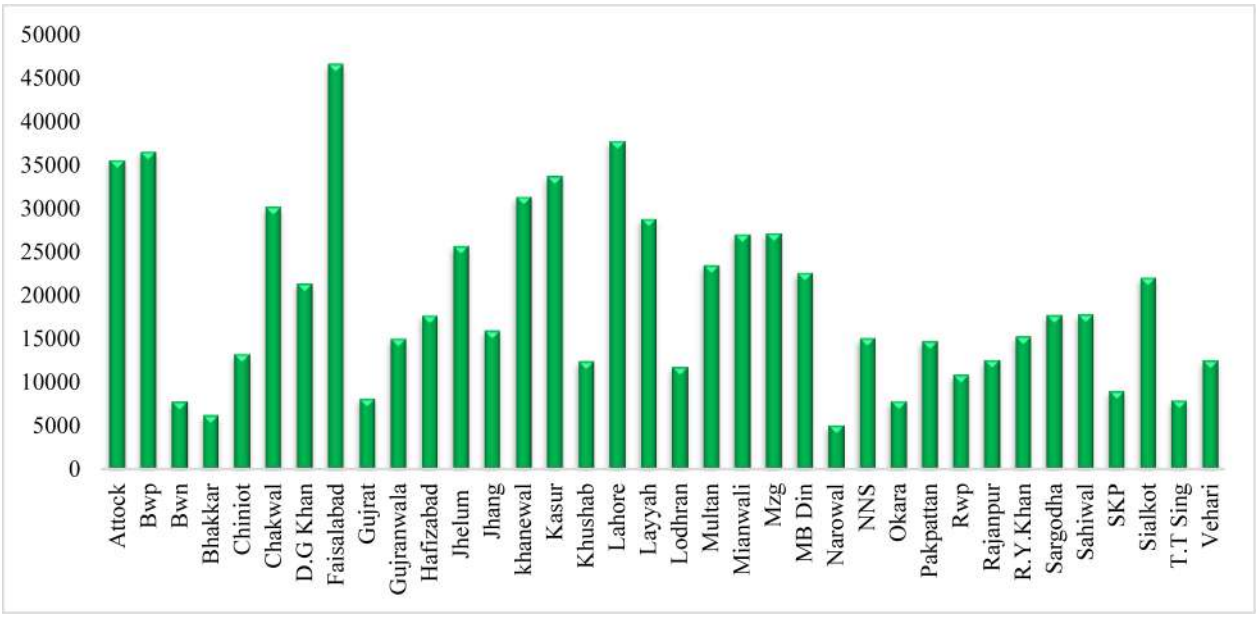


Figure: 6-5 District wise Number of tree planted during 2022

The Agency advocates the plantation of eco-friendly tree species that can contribute significantly towards environmental improvement in terms of capturing carbon, stabilizing soil, recharging aquifers, providing habitat, releasing plenty of oxygen and having capacity to absorb particulate matter. EPA HQ has directed EPA Field formation to stop the plantation of Conocarpus (Buttonwood) and to replace already existing plantation with some other tree species wherever possible. The reason for prohibiting plantation of this tree was the production of allergic pollens and its wide and deep root network that compete for available resources (water) with other tree species.

EPA Punjab also participated in the following plantation activities organized by Punjab Forest Department:

3.1.1 Spring tree plantation campaign

In the third week of February 2022, the Punjab Forest Department launched spring tree-plantation campaign. The action plan/strategy to run this campaign was shared with relevant key provincial departments, including the EPD, Punjab. The

action plan listed sector specific plantation targets, reporting mechanism and plantation festivals to be celebrated under this campaign.

EPA Punjab enthusiastically supported this remarkable event through rigorous campaigns of planting trees in the province and other co-activities, such as:

i. Tree Plantation Targets: Plantation of about 10,000 to 15,000 trees was planned in each district. Under the directions of EPA Field Formation, 362,181 trees were planted during the spring campaign in total. In districts Chakwal, Faisalabad, DG Khan, Bahawalpur, Gujrat, Sardgodha and Rajanpur, trees were planted more than the set target.

ii. Plant for Pakistan Day: The said day was also celebrated in each district.

iii. Media Campaign: A mass media campaign was initiated with the following objectives: (table 6-3)

Table 6-3: Activities of Tree Plantation

	Activities	Frequency
a.	Inauguration Ceremonies: (Deputy Commissioner/Assistant Commissioner as Chief Guest)	1 per district
b.	Shajarkari Walks	1 per district
c.	Display of awareness material (Banners/Streamers)	At-least 100 per district
d.	Media coverage/News Clipping/social media awareness activities	at least 20 per district

3.1.2 Green week

In Punjab, a 'Green Week' was celebrated from 14-20 August, 2022 and about 99,570 trees were planted during this week. (Figure 6-6)

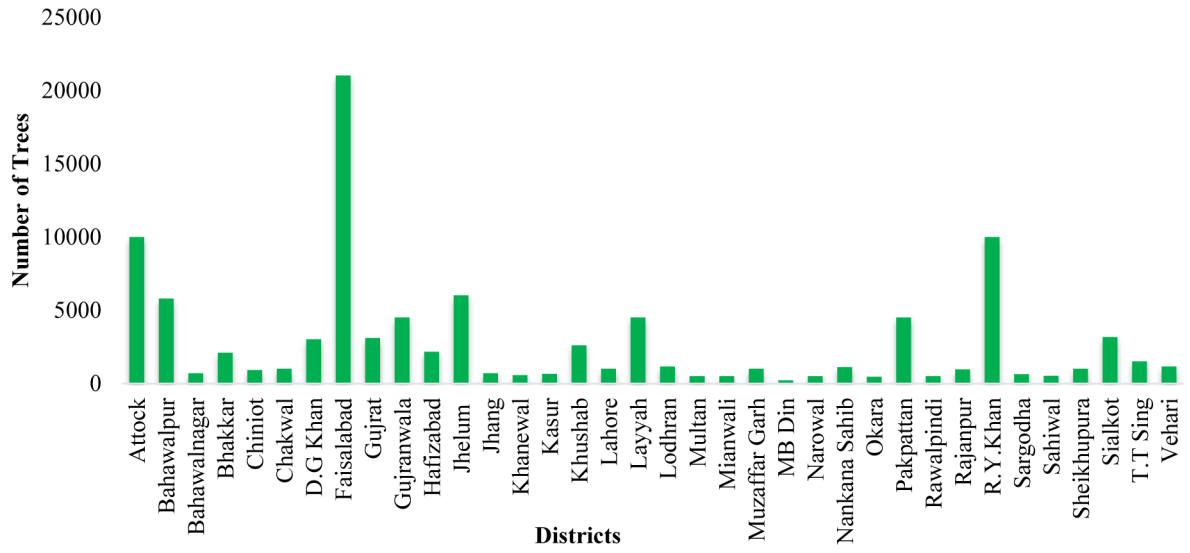


Figure 6-6 Number of trees planted during Green Week

3.2 Punjab green development program

Government of the Punjab launched a World Bank funded, Program for Results (PforR) namely "Punjab Green Development Program" in 2018, which aimed at strengthening environmental governance and promoting green investments in Punjab. The Program has eight Disbursement Linked Indicators (DLIs). The Program has enabled EPD Punjab in initiating multiple initiatives to strengthen environmental governance in the province.

3.3 Regulatory and institutional reforms

3.3.1 Restructuring of the Environment Protection Department

Under PGDP, EPD is improving its organizational structure, reforming its regulatory regime, and modernizing its administrative procedures and systems. The restructuring plan of EPD Punjab has been finalized and got approved from the Provincial Cabinet. The plan provides provisions for establishing the Environmental Technology Centre (ETC), Environmental Policy Centre (EPC), and Environmental Monitoring Centre (EMC) under the Environment Protection Department. EMC will establish a network of air and water quality monitoring equipment and a reference laboratory; EPC will support sound environmental policymaking for example, pollution management, resource uses, and climate mitigation/ adaptation; and ETC will identify, pilot, and demonstrate RECP and pollution control technologies for priority sectors and

GHG sources. EPD initiated the key steps required for the effective implementation of the restructuring plan during the year 2022, amendments in the EPD's Rules of Business and got around 280 regular positions sanctioned by the Finance Department.

To address the lack of facilities, which drastically limits the EPD's capacity to perform its functions, EPD Punjab also envisions the construction of a green building in Lahore to host the EPD and its operational wings. The department has commenced work for establishment of Green Building to house EPD and its operational wings. In addition, approval of project proposals for establishment of EPA Complexes in six divisions of Punjab has also remained a remarkable achievement during 2022.

3.3.2 Notification of health advisory system for critical air pollution events

In December 2022, the EPD Punjab Gazette notified the 'Health Advisory System for Critical Air Pollution Events (HAS-CAPEs) targeting vulnerable demographic groups. The key characteristics or HAS-CAPEs components are listed below:

I. Establishing institutional arrangements by creating a Steering Committee (an Apex Body), a Provincial CAPEs Committee (for monitoring and assessing CAPEs), and District Critical Air Pollution Events Committees (DCC) in districts for effective HAS-CAPEs implementation.
II. Development of an action plan and the steps that the District Critical Air Pollution Events Committees (DCC) and related Departments will take to tackle significant instances of air pollution.
III. Issuing health advisory notes for vulnerable populations and the general public.

3.3.3 Updated IEE and EIA review regulations

Under Section 12 of the Punjab Environment Protection Act (1997), EPA Punjab has notified in gazette the 'Punjab Review of IEE and EIA Regulations (2022)'. The IEE and EIA Regulations (2000) of the PAK-EPA were previously followed for the issues of environmental approvals. It is a noteworthy effort on the part of EPA Punjab to create its own provincial regulations to assess and categorize the development projects that can have an impact on the environment through IEE or EIA.

These regulations have been framed to operate under the Government of Punjab's vision of 'Ease of Doing Business (EoDB)'. The process of issuance of environmental approvals has been simplified and shortened through execution of these regulations. For instance, the duration between advertisement of Public Hearing Notice and date of public hearing required for EIA approvals has been reduced to 7 days from 30 days. The list of Schedule I and Schedule II projects have also been updated, keeping in view the diversity of industrial projects in the province.

3.3.4 Plastic waste management strategy and regulations on single-use plastics

The demand for the single-use plastics and other plastic products is very high in Punjab (~ 1.3 million tons/year) especially for PET bottles and LDPE bags. The majority of this plastic, except PET bottles, ends up in landfills or litters the streets. In year 2022, EPD through SPIU under DLI 4 of the PGDP (Punjab Green Development Program) hired a consultant to prepare 'Plastic Management Strategy and Regulations on the production and consumption of single-use plastics'. The strategy is being developed after reviewing the best practices to manage plastics (at international and regional level). Field trips and key informant interviews were carried out to gather information on the producers, recyclers, collectors and consumers of plastics. Furthermore, three consultative sessions were held to evolve the strategy and regulations. Representatives from the academic community, related government agencies, NGOs, plastic manufacturing association, plastic producers, recyclers, retailers and consumers attended these sessions. In December 2022, the draft strategy was completed and submitted for approval to the Punjab Environmental Protection Council.

3.3.5 Revision of existing PEQS and development of industry-specific environmental quality standards (EQS)

A project titled 'Establishment of Missing Environmental Quality Standards and Revision of Existing Standards' was started to develop industry-specific standards in addition to rationalizing the current PEQS for their effective enforcement. In 2022, the project execution was commenced. The industries of paper and pulp, pesticides, ceramics, paint, brick kilns, cement plants, stone crushing units, pharmaceutical industry, thermal power plants, ethanol and distilleries, tanneries and leather, integrated textile units of cotton, woolen and polyester units with printing, dyeing, bleaching process, or manufacturing and garment units, foundries and smelting industries were selected for which the development of EQS has been initiated.

3.3.6 Clean air policy and action plan

The Environment Protection Department Punjab revised and updated 'Policy on Controlling Smog' (2017) to 'Punjab Clean Air Policy'. Under this policy, a Clean Air Action Plan was also devised to implement the policy in true letter and spirit.

3.3.7 Punjab climate change policy

EPD has taken lead to formulate an inclusive 'Punjab Climate Change Policy' as affirmation of the national and international mitigation and adaptation commitments and to strengthen the resilience of the Province against the anticipated and current effects of climate change.
Additionally, EPA Punjab is making the following contributions for climate action at the provincial level:

i. Through environmental approvals, regulate the industries to prevent/minimize pollution load resulting from development
ii. Encourage plantations to generate carbon sinks
iii. Promoting rainwater harvesting and water conservation techniques through environmental approvals

4. OTHER MEASURES

4.1 Installation of air and water quality monitoring stations

EPD Punjab has started a project called 'Enhancing the air quality monitoring system in Punjab' and is moving forward rapidly in this direction. Following the plan, 30 Air Quality Monitoring Stations (AQMS) would be installed in the ten districts of the Province i.e. Gujranwala, Lahore, Multan, Sheikhupura, DG Khan, Sialkot, Sargodha, Bahawalpur, Rawalpindi and Faisalabad. Six criteria air pollutants and other meteorological data related to ambient air pollution will be monitored by the AQMS. In 2022, pre-qualification of the contractor to install AQMSs started after the locations for these installations were chosen. Additionally, the efforts were taken to repair the existing AQMS.

Similar to this, 15 water quality monitoring stations would be installed under another project 'Enhanced Water Quality Monitoring System in Punjab' in the various districts of Punjab. Each station will be equipped with a variety of pollutant analyzers/probes, a real-time flow information system and a data logger. Environmental Monitoring Centre (EMC) of EPD Punjab will house an integrated data-collection system that will connect the stations.

4.2 Pilot of low-cost wastewater treatment plants

EPD Punjab plans to identify, construct and test low-cost decentralized solutions to treat the domestic wastewater for villages, housing schemes and towns etc. A feasibility study for piloting such wastewater treatment plants has been placed in ADP 2022-23.

4.3 Establishment of Environment Endowment Fund (EEF)

In order to bring sustainability to environmental interventions in future, Punjab Government has established an "Environment Endowment Fund" of USD 50 million under DLI-8 of the PGDP. The government is going to establish a legal and institutional structure for execution of this fund. Endowment fund investment returns will be used to finance eligible environmental projects/activities for the protection, conservation, rehabilitation and improvement of the environment, the prevention and control of pollution, the sustainable development of resources and for research in any specified aspect of environment.

4.4 Automation regime of EPD

A project titled 'Automation Regime of Environment Protection Department' was approved in ADP 2022-2023 to improve the EPA/EPD for better service delivery by digitizing current manual processes and fostering E-Governance. The main objectives of the project are to design and develop new applications which integrate and synchronize information with existing applications, build an IT infrastructure to implement the systems (linking to the dashboard) in EPD and upgrade the current EPD website.

5. THE WAY FORWARD

Expeditious implementation of restructuring plan: Restructuring and strengthening of EPD Punjab is targeted to be achieved through establishment of EEF, EMC and EPC till December, 2023. Whereas, establishment of the ETC is targeted to be established till December 2024, for achieving visible results in the form of improved environmental governance.

Legislative Reforms: There is need to legislate upon the environmental sub-areas still to be regulated by the department, such as solid waste, soil quality, e-waste, climate change, etc. to communize the agenda of sustainable development.

Implementation of Health Advisory: Implementation of health advisory system can dramatically increase the system's ability to respond to CAPEs and other environmental issues in the province and assist protect vulnerable communities.

Citizen Engagement: The environmental governance may be strengthened through augmentation of the citizen engagement activities such as the establishment of hotlines, interactive data portals, etc. Employing e-governance and data democratization may assist EPA Punjab in filling up the gaps in Punjab's current regulatory framework.

Public Communication Campaigns: Maximum public communication campaigns on significant environmental issues e.g., negative environmental and health impacts of single use plastics may be organized.

7 ENVIRONMENTAL COMPLAINTS

CHAPTER 7 ENVIRONMENTAL COMPLAINT REDRESSAL

1. OVERVIEW

EPA Punjab has been working proactively in order to resolve the environmental related grievances receiving through different channels of preliminary examination defining various steps of complaints investigations. Through a formally established grievance redressal procedure, the Punjab Environment Protection Act 1997 offers a special set of provisions for the prompt resolution of environmental grievances throughout Punjab. Additionally, the Agency may conduct inquiries or investigations into environmental issues under Section 6 sub-section 2 (a) of the ibid Act, either on its own initiative or in response to complaints from any individual or organization. There are numerous channels available for filing grievances or complaints related to the environment by the complainants who may show serious concerns about rapidly deteriorating environmental quality.

At present, complaints cannot be filed electronically through official website of EPD Punjab. However, the main channels through which a complainant can lodge an environmental complaint are as follows:

a. By mail or post, by submitting a printed copy of the complaint to the relevant office.
b. Electronically through the Chief Secretary complaint cell, Prime Minister Delivery Unit, or by sending an email to the relevant quarters.
c. Manually in any of the offices of Secretary Environment, Deputy Commissioner, Chief Secretary, Chief Minister, Director General of EPA, Environmental field officer of the concerned district.

Once a complaint is received, it is properly documented, filed, and investigated through site inspections and personal hearings before being processed for resolution. Depending on the nature of the complaint, the length of the grievance resolution process may change.

2. Grievance Redressal Mechanism

Grievance Redressal Mechanism is providing an institutional framework to resolve the public grievances through the filing of complaints on environmental issues. In compliance with PEPA, 1997, it is an instrument providing methods and processes regarding effective redressal of environmental complaints for the early detection, evaluation, and prompt resolution of environmental hazards.

If a complaint regarding the environment is received by EPA HQs that falls under the purview of a district in-charge or Field Officer of the environment, it is sent to that district in-charge for review and resolution. Each Field Officer Environment has been given authority to handle environmental concerns in a timely manner at the district level. The district in-charge or members of its staff visit the site after receiving the complaint to determine its details. The district in-charge may ask the environmental laboratory to collect site samples and provide monitoring reports in order to prove the infringement under Section 11 of the Act ibid.

No person or entity may in accordance with Section 11 of the aforementioned Act, is allowed to 'discharge or emit or allow the discharge or emission of any effluent or waste or air pollutant or noise in an amount, concentration or level which is in excess of the PEQS or, where applicable, the standards established under clause (g) of Sub-section (1) of section 6 of the Act ibid' A site inspection report is generated after the visit which is then referred to Directorate of Planning and Coordination in the EPA, Punjab or environment offices of district for further action. A hearing notice is then issued to the accused to defend the case. An Environmental Protection Order is issued in accordance with section 16 of the aforementioned Act, if no response is received or if the response is deemed

KEY FINDINGS

- EPA regulates the quality of environmental parameters in compliance with Punjab Environment Quality Standards followed by regular procedures to keep a continue check on air, water, soil, noise, wastewater and solid waste management to protect the environment and human health.
- The Punjab Environment Protection Act, 1997 provides a unique set of arrangements for the redressal of environmental complaints proactively across Punjab through a formalized established Grievance Redressal mechanism.
- EPA receives complaints of different natures regarding various environmental issues and addresses them by taking corrective measures, lodging FIRs or by sealing polluting source units.
- EPA has received a total of 1091 complaints from 36 districts across Punjab in the year 2022, of which 63% complaints were resolved.
- Faisalabad district remained at top receiving highest number of complaints (116), while Lahore remained second with 99 registered complaints.
- Almost 47% of the complaints were related to air pollution showing public concerns towards clean air.
- Other complaints received in EPA were related to hazardous/ Hospitals/Municipal Solid waste, noise, cancellation of environmental approval/operation without Environmental Approval, untreated wastewater, sub-standard fuel used for combustion and soil pollution/ land degradation.
- There is dire need to introduce automated digital system in EPA Punjab for not only instant complaint lodging by the community but also to track the progress of the complaints redressal and their timely closure. This automated system shall be secure, transparent and free from any sort of data loss for efficient record keeping.
- Effective monitoring of this resolution mechanism for its efficacy will increase the trust of public regarding addressing of their complaints.

inadequate. Section 16(1) of the Act states, 'the Provincial Agency may, after giving the person responsible for such acts an opportunity of being heard, by order, direct such person to take such measures as the Provincial Agency may consider necessary within such period as may be specified in the order for any violation'.

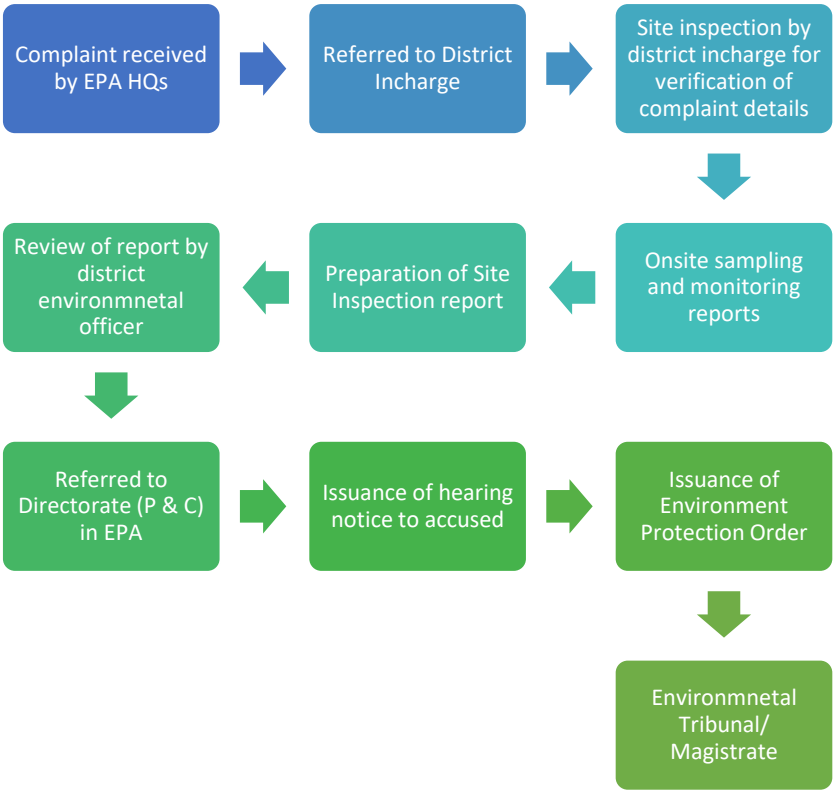


Figure 7-1 Legal framework for the processing of complaint through grievance redressal mechanism

In addition to the above-mentioned mechanism Lahore High Court is also authorized through certain orders to impose fines on violators. These legal frameworks define the contours of an appropriate and accessible grievance redressal mechanism for affected entities to lodge/pursue their complaints related to environmental issues.

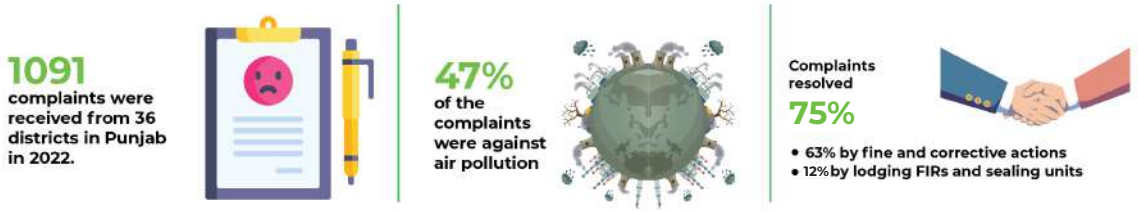
3. Nature of complaints

During the year 2022, complaints received by the EPA were related to the following environmental issues

- Air Pollution (means contamination of environment by any substance in undesirable quantity)
- Untreated industrial and municipal wastewater
- Noise Pollution (means the intensity, duration, and character of sounds from all sources, including vibration)
- Hazardous/Hospital (refers to the waste that contains any hazardous substance or which may be classified as hazardous waste under certain conditions, including nuclear waste and hospital waste)
- Sub-standard Fuel used for combustion
- Cancellation of Environmental Approval/Operation without Environmental Approval
- Soil Pollution/Land Degradation (means the presence of toxic chemicals and pollutants or contaminants in the soil high concentrations to pose risks to human and ecosystem health)
- Others (Poly-ethylene bags, dust, spray polish, crop residue burning, odor and traffic management etc.)

4. REGULATORY MEASURES

EPA received a total of 1091 complaints related to environmental pollution from 36 districts across Punjab in 2022. Almost half of those complaints (512) were related to air pollution. Other pollution complaints included were about hazardous waste, noise, untreated wastewater, sub-standard fuel and municipal waste. Figure 7-2 shows the total number of complaints received by different districts in Punjab.



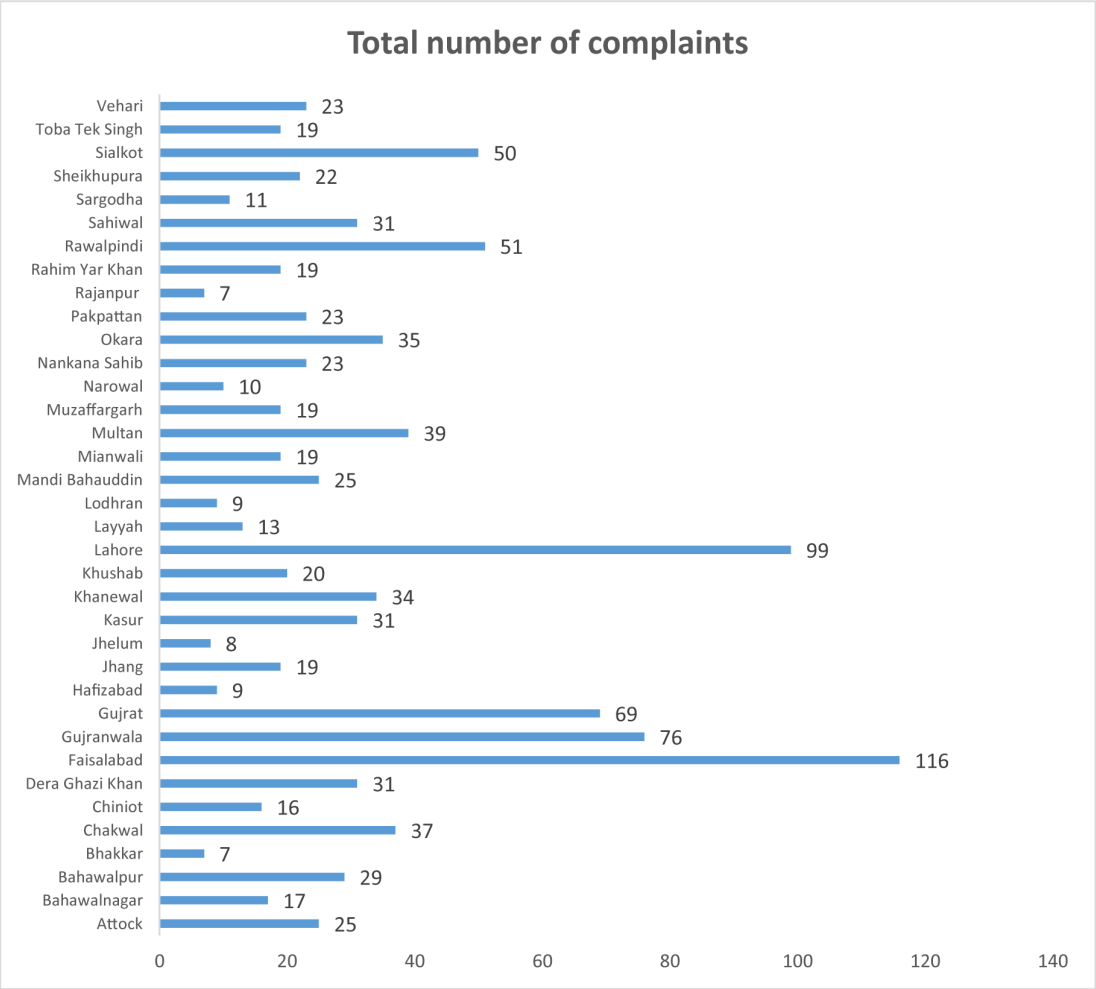


Figure 7-2 Total number of complaints registered in 36 districts of Punjab

Faisalabad District received highest number of complaints (116) followed by Lahore, Gujranwala, and Gujrat (99, 76, and 69, respectively). Maximum number of air pollution related complaints were (75) registered in Lahore. Figure 7-3 displays the geographic distribution, sources and categorization of registered environmental complaints.

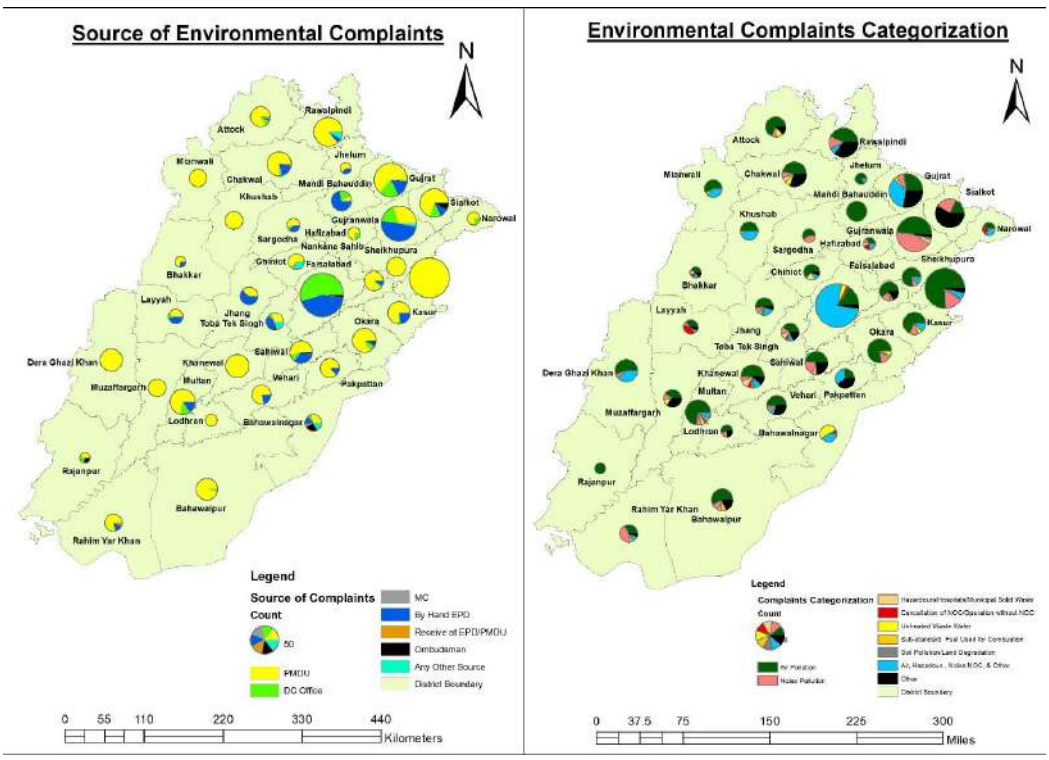


Figure 7-3 District Wise Environmetal Complaints (Sources & Categorization)

Some of the districts in Punjab received frequent complaints regarding noise, cancellation of environmental approvals, hazardous waste and air pollution. Figure 7-4 shows number of complaints received for various categories of environmental pollution.

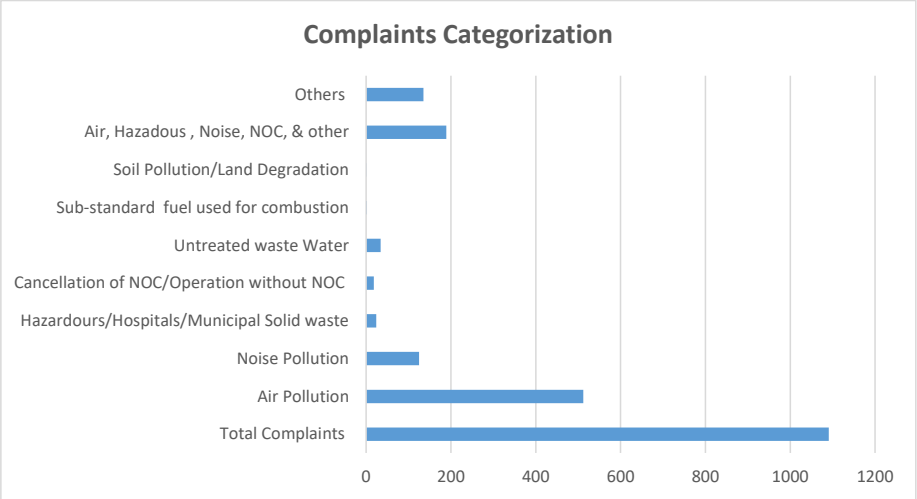


Figure 7-4 Complaints received in different categories

The majority of complaints were lodged in Gujranwala and Faisalabad districts against the foundries, brick kilns, woolen looms, steel mills, welding plants, dying units, generators, power looms, metal works, ceramics and textile industries. After filing and specifying the category of the complaint, a proactive strategy is adopted to swiftly process it through various preliminary examination channels. These channels define different steps of complaint investigations and facilitate in an easy resolution process.

The standard process to address the complaints is as follows:

- File and receive complaints
- An initial assessment (to determine whether the complaint relates to an environmental problem or not). Site inspections and investigations are conducted to address the complaint. If the complaint is related to another department, it is referred there for appropriate action as needed in accordance with their area of control and jurisdiction.
- Sending the complaint and Site Inspection Report to EPA Headquarters;
- Issuing a district-level hearing notice or Environmental Protection Order.

When a fact is established that complaint is genuine, the measures for their redressal include an array of actions including filing the complaint in the Punjab Environmental Tribunal (PET), Sealing of the Units, Decision of Environment Magistrate, Imposition of fine or Filing of FIRs with Police Stations and asking the pollution causing units to take corrective measures to improve the environment. Out of the total 1091 registered complaints, 63% were resolved, 6%----FIRs were issued and units were sealed for 9% of the complaints, rest are being processed through various modes of actions to resolve them effectively as shown in (Figure 7-5).

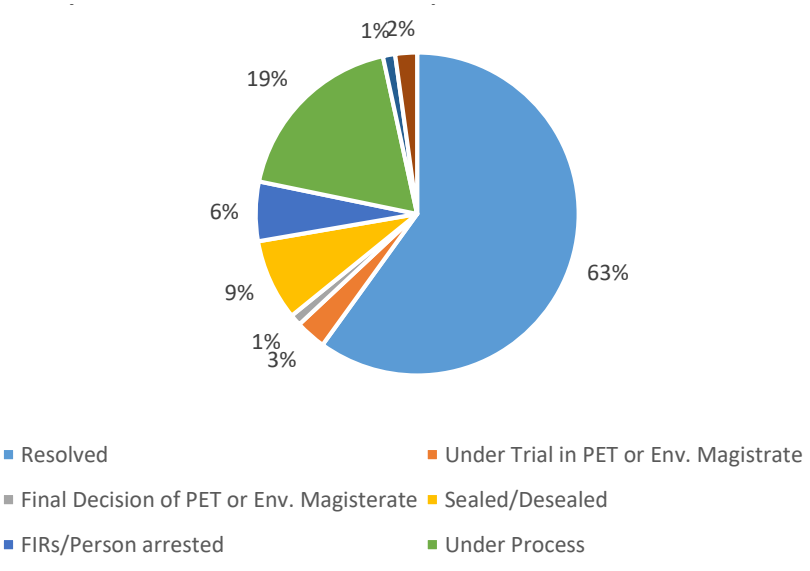
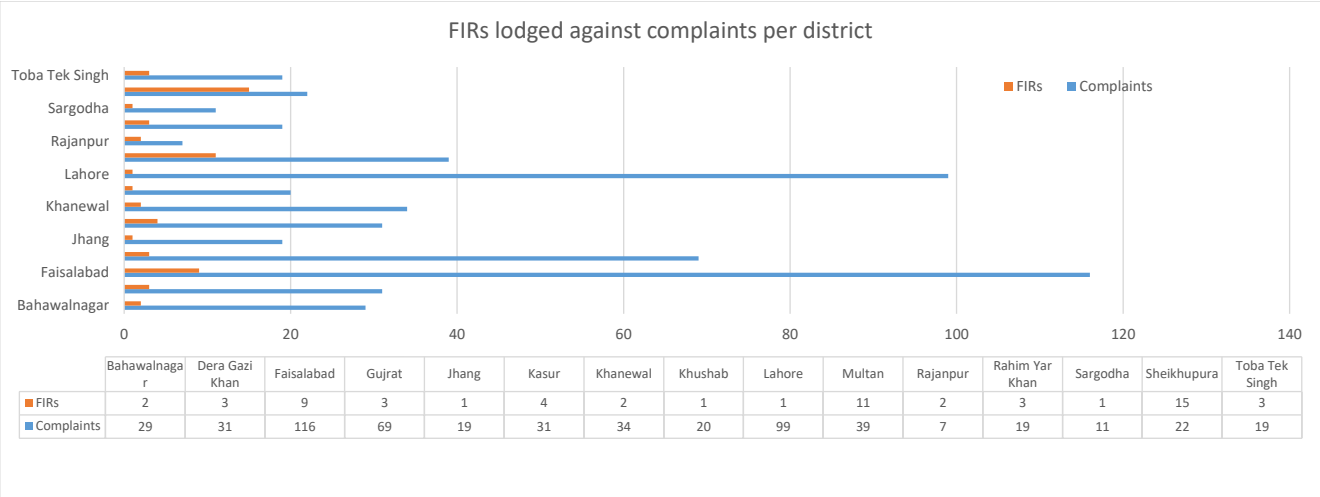


Figure 7-5 Action taken against complaints (January-December, 2022)

4.1 Details of FIRs

A total of 68 FIRs were filed in response to the 1091 total registered complaints. Out of that maximum number of FIRs were filed in Multan (11). Figure 7-6 shows the total number of FIRs lodged against complaints in various districts of Punjab.

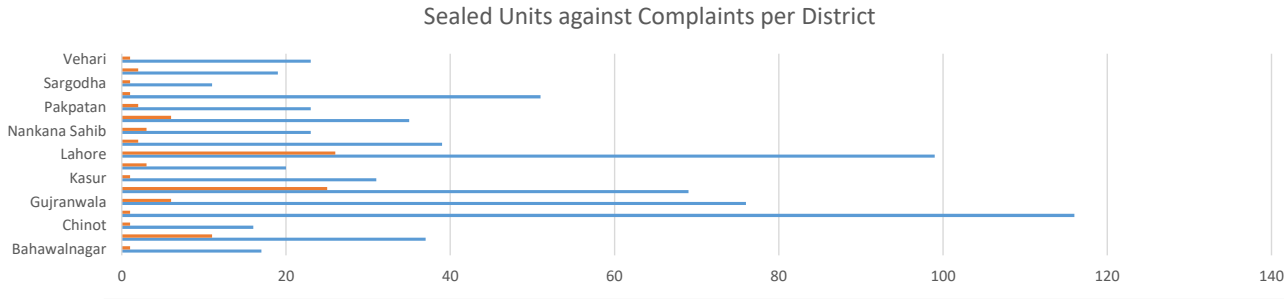


	Bahawalnagar	Dera Gazi Khan	Faisalabad	Gujrat	Jhang	Kasur	Khanewal	Khushab	Lahore	Multan	Rajanpur	Rahim Yar Khan	Sargodha	Sheikhupura	Toba Tek Singh
FIRs	2	3	9	3	1	4	2	1	1	11	2	3	1	15	3
Complaints	29	31	116	69	19	31	34	20	99	39	7	19	11	22	19

Figure 7-6: Detail of FIRs lodged in Punjab against environmental issues

4.2 Details of Units Sealed

Total 93 units were sealed from which 26 units were sealed in Lahore against 99 received complaints. In Gujrat 25 units were sealed against 69 complaints. The sealed units mostly foundries, brick kilns, pottery kilns, soap manufacturing units, and Atta chakis. However, these complaints were ultimately settled (Figure 7-7).



	Bahawalnagar	Chakwal	Chinot	Faisalabad	Gujranwala	Gujrat	Kasur	Khushab	Lahore	Multan	Nankana Sahib	Okara	Pakpatan	Rawalpindi	Sargodha	Toba Tek Singh	Vehari
Sealed	1	11	1	1	6	25	1	3	26	2	3	6	2	1	1	2	1
Complaints	17	37	16	116	76	69	31	20	99	39	23	35	23	51	11	19	23

Figure 7-7 Detail of Units sealed upon complaints in Punjab

4.3 Details of Fine Imposed

Sixteen out of 36 districts in Punjab reported imposition of fine subjecting to different amounts starting from PKR 5,000 and maximum fine imposed was in District Narowal that amounted to PKR 4,750,000 (Figure 7-9).

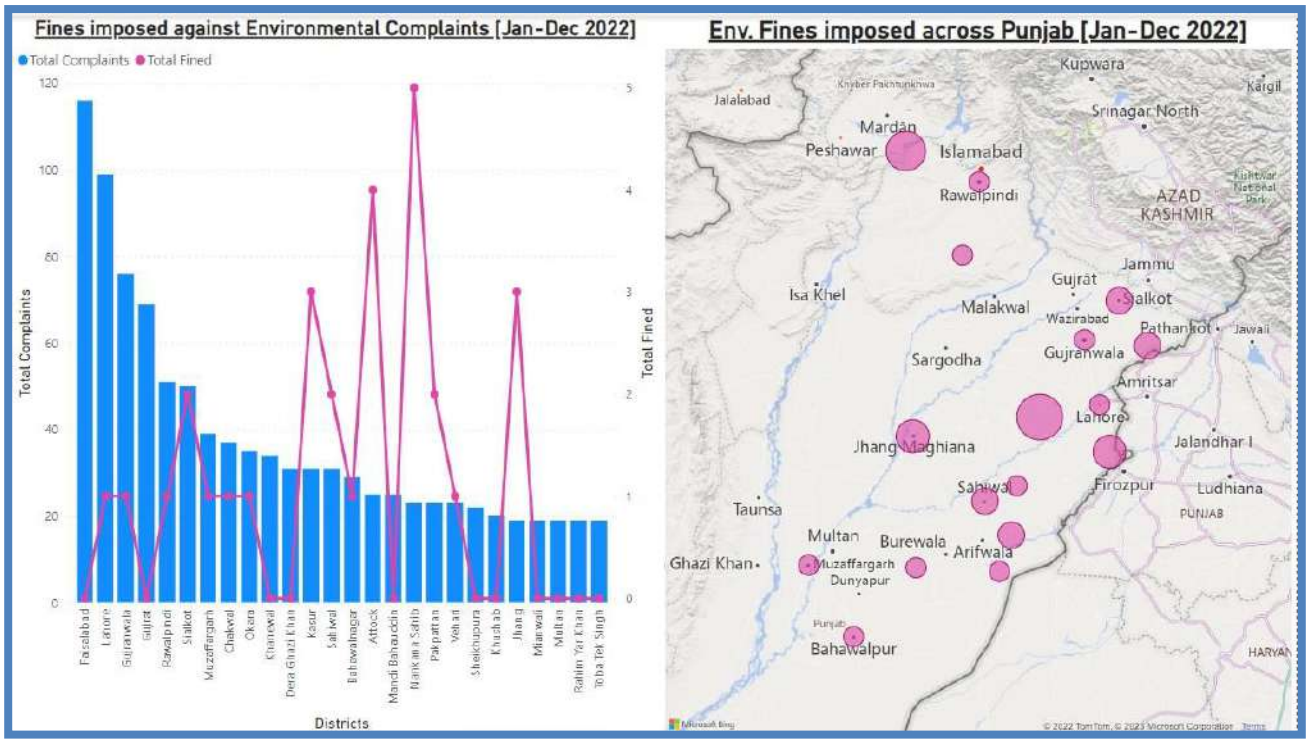


Figure 7-8 Fine imposed against complaints (January-December, 2022)

5. THE WAY FORWARD

Proactive Approach: A Grievance Redressal Mechanism should have a clear structure that explicitly spells out how to functions effectively, defining the roles and responsibilities for each tier. The resolution of environmental complaints requires proactive approach to manage the data and review the progress in terms of their redressal.

Complaint Management System: The unavailability of on-line complaint management system results in difficulty to track and monitor the complaints effectively. There is need to introduce an online complaint management system.

Capacity Building Programs: Needs to introduce capacity building programs to strengthen the capacity for effective handling, assessment, resolution, coordination and monitoring different types of complaints.

Notification of Grievance Redressal Committee: Dedicated GRC should be notified at department level looking vigorously at progress ensuring compliance with environmental regulatory framework for redressal of complaints on monthly basis.

Public Disclosure: Publication of GRM reports on monthly basis to monitor the progress regarding efficient and effective redressal of complaints. This report will define the district wise mapping of complaints from where complaints are generated at the most pertaining to environment and social issues. This will also explain the information regarding community concerns with environment for better service delivery.

8 STAKEHOLDERS CONSULTATION & PUBLIC FEEDBACK

CHAPTER 8 STAKEHOLDERS CONSULTATION & PUBLIC FEEDBACK

"Stakeholder consultations" were carried out through two rounds of public hearings, one on the proposed content of the report and another on the draft report, through formal hearings and online public comments on the Environment Protection Department's website. Concerned Government departments, chambers of commerce, industrial associations, civil society organizations, media, academia and donors were invited through formal letters to attend the sessions.

1. FIRST ROUND – ON PROPOSED CONTENTS

Advertisement was given in the newspaper on 5th October, 2022 to start the first round in the form of public hearing. It was conducted on 7th November, 2022 (Figure 8-1 to 8-2). Along with advertisement, written letters were also sent to stakeholders to get their feedback on the proposed contents. Response from different departments as Irrigation Department, Sialkot Chamber of Industry, Agriculture Department, Punjab Healthcare Commission, and The Urban Unit was received via letters/emails.

1.1 Keys findings on Proposed Contents (07.11.2022)

Followings are the highlights of proceedings including response received via letters/emails:

- Inclusion of climate change; overview of water resources in Punjab and its quantity and quality status; mapping of pollution sources with trend analysis and challenges in water quality; implementation mechanism for best management practices and separate heading for water quality monitoring.
- Solid waste, its collection, re-utilization for recycling, training for reduction of plastic waste, hospital waste, industrial waste as well as awareness seminars along with a small documentaries on environment friendly practices should be incorporated in report.
- Map for air, water and soil quality, geo locations of hazard sites, reclamation plan of polluted sites and legal framework for banning crop cultivation over polluted sites may be added.
- Inclusion of summary of various environmental factors and pollutants impacting the health status of the people in Punjab. Summary should also include an account of any baseline study, basic data on prevalence of such factors, impact of measures taken so far on the overall health status of populations exposed to such risks, and projected magnitude of the risk associated and measure to control such pollutants.
- Addition of data to find hotspots, portray historic, current, and future trends, foresee future states (predictions/ forecasting) and draw concrete conclusions (specifically policy and regulatory reforms). Components of biodiversity, forestry/green cover, solid waste, urban sprawl, and environmental health related issues, GIS[1] and RS[2] mapping and environmental modelling and the correlation between multiple drivers, pressures and states are also recommended to include in report.
- Need to include information of United Nation declaration for environment as a fundamental right, proper sanitation practices and ground water depletion verses water recharge rates.
- Importance of environmental awareness for children, trans boundary effects of air pollution as well as water pollution, strengthening feedback loop and introduced effective citizen engagement must be highlighted in report.
- Defining the mechanism for greening the brown patches of land, and enhancing the building sense of ownership through community engagement at UC[3] level.
- Certain issues to address water scarcity, development of zero carbon emissions, tree plantation, introducing public transport mechanism as well as promoting initiatives for electricity generation from municipal solid waste are needed to highlight.
- Inclusion of information related to effective community ownership for stoppage of water wastage in our daily life, water metering, water recharge galleries and installation of waste water treatment plants.
- issuance of environmental permits for the operational phase should address the environmental concerns, introduction of sanitary products for the water conservations and ensuring compliance with the environmental standards. Poultry industry is strictly required to adopt the sustainable mechanism.
- Highlighting that children are facing immense air pollution levels due to smog and got sick during winter season. Transport policy as well as fuel policy are the federal subjects which need to address to curb 80% of sectorial emissions. Shutting down of schools are not a solution to face these challenges. It is just the passing the buck of federal government to schools.
- Information on water conservation and water consumption patterns along with proposing Action Plans should be inculded accordingly.

[1] Geographical Information System
[2] Remote Sensing
[3] Union council

- Nature base solutions for soil, water, and air as well as measures for soil desertification control may be provided in report.
- Report highlighted the importance of hospital waste along with municipal solid waste as well as need to draw the linkages for burden of diseases with water/ air quality.

Figure 8-1: Public Hearing on 7.11.2022

Figure 8-2: Public Hearing on 7.11.2022

2. SECOND ROUND – ON DRAFT REPORT

The second round of public hearing on draft report was initiated with the posting of draft report on the website[4] (3rd April 2023). Afterwards, an advertisement was also made in the newspaper (19th April 2023) for inviting stakeholders in the public hearing event which was carried out on 27th April, 2023. In addition to it, individual letters were also written to stakeholder for attending the event. Stakeholders belonging to different sectors including the public sector (Livestock Department, The Urban Unit, P&D[5] Board Office, Industry Department, Transport Planning Department, Irrigation Department Mines & Minerals Department, WASA[6] Rawalpindi and Faisalabad),industrial sector (associations of different industries and Chambers of Commerce & Industry), academia (Government College University, Lahore, University of Engineering & Technology, Lahore, University of the Punjab) and non-governmental organizations (UNICEF[7] , WWF[8] , LCS) participated in the event (Figure 8-3 to 8-6).

[4] https://epd.punjab.gov.pk/system/files/SOE%20Report.pdf
[5] Planning & Development Board
[6] Water and Sanitation Agency
[7] United Nations International Children's Emergency Fund
[8] World Wide Fund

2.1 Keys findings on Draft Report (27th April, 2023)

- Pertaining to the constraints in primary data availability regarding climate change, heat wave and Punjab forest policy, secondary data could be used precisely to address these environment issues.
- Needs to classify city with respect to smog, and water related issues across Punjab. Polluter's pay principle & people's willingness to pay may be added appropriately for environment betterment and requested to update report accordingly. Awareness raising on smog and environmental issues are needed to enhanced.
- Catalytic converter requires DE carbonization.
- In addition to information on Air, Water and Soil, there is also need to include detail regarding forestry and impacts of floods on the quality of surface water either to reduce the pollution load or by adding new pollutants and GHG[9] emissions.
- Over use of Nitrogen fertilizers is common. Wheat, cotton crop residues are used to burnt. But, their impacts in temperature rising is needed to cover.
- Need to identify champions in every department and to strengthen the coordination mechanism among them.
- Mines and Mineral is very important sector; but limited information is provided in report regarding development sector to address environment and social issues.
- Ambient Air Quality - health effects and impacts are required to quantity and efforts to calculate DALYs[10] and economic cost of environmental pollution on individuals and communities so affected.
- Capacity building of local organizations for water quality monitoring and treatment is mandatory. It is prerequisite to engage public, private and civil sectors in the development of joint policy framework to address water quality challenges.
- Industrial and agricultural sectors need to be obliged to process their waste before being discharged particularly following the "Zero Liquid Discharge" policy.
- Rain water harvesting should be introduced for water recharge. In first phase it may be used in all government offices and new developed housing societies (green belts/ parks and industries).
- The industry and academia linkages may be involved in research for water conservations in industry and agriculture sector.

Figure 8-3: Public Hearing on 27.04.2023 (Registration Desk)

Figure 8-4: Public Hearing on 27.04.2023(Interactive session)

Figure 8-5: Public Hearing on 27.04.2023 (Interactive session)

Figure 8-6: Public Hearing on 27.04.2023(Group Photo

[9] Greenhouse Gase
[10] Disability-adjusted life years

2.2 Response of Environment Protection Department

Environment Protection Department acknowledged all comments and feedback given by the honorable stakeholders. Secretary EPD, Director General EPA, Project Director SPIU, Additional Secretary, EPD and Director (EPP), SPIU responded every question during the both sessions of public hearings pertaining to the first round on contents and second on draft report. Every possible effort was made to prepare the report in accordance with comments raised during these sessions. However, if there is any limitation the same have been incorporated in the action plan appropriately. The comments have also been appropriately addressed in the relevant chapters of the report.

9 ENVIRONMENTAL ACTION PLAN

CHAPTER 9 ENVIRONMENTAL ACTION PLAN

1. Overview

Environment Protection Department and Environmental Protection Agency are enforcing laws, rules and regulations relevant to environmental issues. This has become possible after strenuous efforts and striving commitment. But more efforts are required to keep pace with rapid urbanization, industrialization, and increasing complexity of environmental problems. Environmental governance should be strengthened in order to accomplish goals of sustainable development. The interventions and sub-interventions of the Environmental Action Plan are given in Table 9-1. It is pertinent to mention here that implementation of action plan is contingent upon the availability/confirmation of resources.

Table 9-1: Interventions and sub-interventions of the Environmental Action Plan

Interventions	Sub interventions
Legislative	15 sub interventions including; Notification of rules and regulations under PEPA 1997 (like Hazardous Substance Rules and implementation of MEAs given in the Schedule e.g. Green House Gases/ UNFCCC, Biodiversity etc.), Punjab Climate Change Policy, Punjab Clean Air Act, Punjab Clean Air Policy and Action Plan, Plastic Management Strategy, Formulating missing Environmental Quality Standards, Certification & Labeling System for energy-saving products, E-waste Management Rules and Energy-saving retrofitting
Citizen Engagement	07 sub interventions including; Establishment of hotline, interactive data portal, public communication campaigns on water, issuance of health advisory, air and water web-based data portal, engagement of public, private and civil sectors in the development of joint policy framework
Industries	07 sub interventions including; Geo tagging of industries, implementation of resource efficiency and cleaner production technologies, implementation of zero water discharge, introduction of carbon neutrality regime, financial assistance to green micro-enterprises, evaluation of impacts of pollution sources on the soil quality and installation of continuous emission monitoring systems
Vehicular	07 sub interventions including; Devising mechanism for retiring old vehicles/installation of catalytic converters/diesel particulate filter, enhancing the area of jurisdiction, mandatory vehicle inspection, promote mass transport, green transportation and removing traffic congestion
Monitoring	07 sub interventions including; Installation of 30 ambient air quality monitoring stations, installation of 15 water quality monitoring stations, establishment of reference laboratory, establishment of GIS lab at EPD, establishment of noise monitoring networks, environmental monitoring of industrial effluents at Ravi, and investigation of sources of particulate matter
Water and wastewater	07 sub interventions including; Construction of storm water drains, water metering domestic and industrial connections, rehabilitation of dams, rivers, drains and canals, conservation of natural habitats, installation of municipal and industrial wastewater treatment plants
Solid/ Hospital/Industrial waste	06 sub interventions including; Establishment of integrated solid waste management facilities, cleanup of the heaps of garbage, Establishment of hospital waste management facilities by large private hospitals, cleanup of the waste heaps, waste minimization (reduce, recycle, and reuses of municipal solid waste), installation of waste to energy projects, Provision of hospital and industrial waste management facilities
Punjab Sustainable Development Fund	02 sub interventions including; Operationalization of environment endowment fund management unit, devising operational guidelines for disbursement of this fund
Fugitive Dust	03 sub interventions including; Dust control/urban dust management, devising
Control	standards for controlling construction dust from road shoulders and construction sites and implementation of zero sand spillage regime regarding sand moving trolleys

Remodeling Environmental Governance	05 sub interventions including: Automation regime to expedite the public service delivery, establishment of environmental policy center and environmental technology transfer center, incentivizing the environmentally compliant industries
Others	05 sub interventions including; Construction of green buildings, research and development for adoption of indigenous technologies for pollution abatement, establishment of woodlands, establishment of noise-free zones and land-use classification of each district

The implementation of these interventions and sub-interventions have been distributed among the following agencies i.e., Energy Department, Transport Department, LG&CD, C&W Department, WASAs, municipal authorities, Irrigation Department, Mines and Minerals, Traffic Police, Forest Department and Industry Department. Private organizations are also assigned other tasks.

In this Environmental Action Plan, there are a total of 71 sub-interventions under the given 11 interventions. These have been set on a specific time scale i.e., Short Term (CY-23), Medium Term (CY-24) and Long Term (CY-25). Every intervention with reference to the time lines is shown in Figure 9-1.

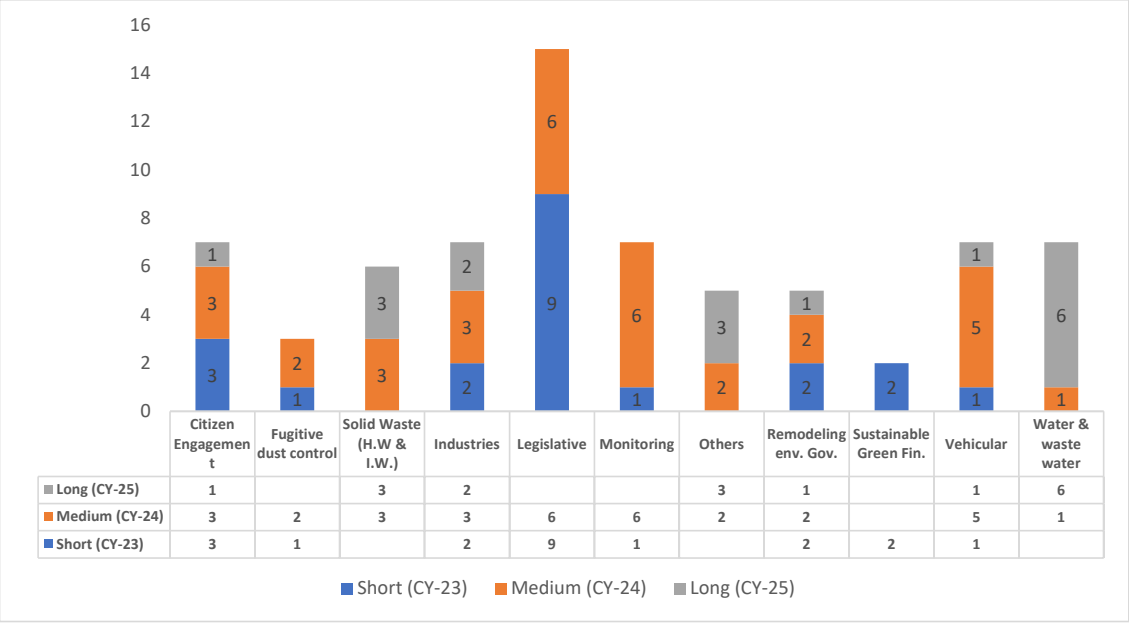


Figure 9-1: Role of organizations/departments in Environmental Action Plan

In these 71 sub-interventions, 21 Short-Term goals, 17 Long-Term goals and 33 Medium-Term goals are present in Figure 9-2.

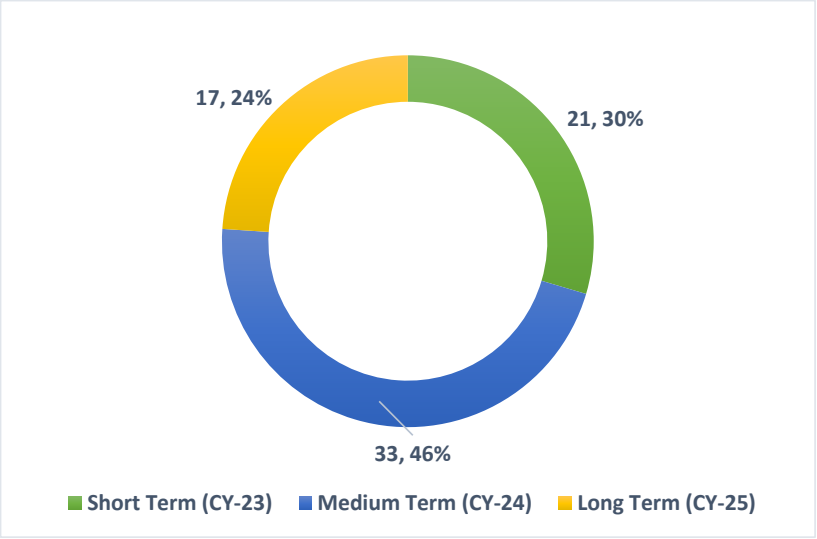


Figure 9-2: Distribution of Environmental Action Plan in Short-Term, Medium-Term and Long-Term goals

2. RESPONSIBILITIES

It is crucial to know that Environmental Action Plan can only be implemented given the availability of resources. For the successful implementation of this plan, each agency/department has to nominate a focal person. Further, every department/ organization has to continuously monitor, gauge and improve the implementation of this plan. A mandatory reporting protocol shall also be evolved for successful achievement of the plan. Every organization, whether public or private, should understand its role in environmental management and prepare policies as well as action plans, accordingly. It is mandatory that we take significant steps to preserve and protect our environment as it is crucial for our well-being, survival and for next generations to come. The timelines of these interventions are explained in Table 9-2 and Environmental Action Plan is given in Table 9-3.

Table 9-2: Timeline to complete/initiate sub-interventions of Environmental Action Plan

Short Term (CY-23)	The targets under Short-Term category include immediate interventions. These sub-interventions are to be completed/initiated in calendar year (CY) 2023.
Medium Term (CY-24)	The targets under Medium-Term category require implementation of modern strategies and policy support. These sub-interventions are to be completed /initiated in CY 2024.
Long Term (CY-25)	Long Term category targets are to be completed/initiated till 2025. These sub-interventions require sustained policy measures.

Table 9-3: Environmental Action Plan

Area of Interventionstions		
1- Legislative		
Term	**Sub-interventions**	**Responsibility**
Medium 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.)	EPD
Short Term (CY-23)	1-2 The Punjab Climate Change Policy	EPD
Medium Term (CY-24)	1-3 The Punjab Clean Air Act	EPD
Short Term (CY-23)	1-4 The Punjab Clean Air Policy & Action Plan	EPD
	1-5 The Punjab Environmental Protection (Anti-SMOG) Rules	EPD
	1-6 Plastic Management Strategy	EPD
	1-7 Regulations on production and consumption of single use plastic	EPD
	1-8 Missing Environmental Quality Standards and revision of existing standards	EPD
Medium Term (CY-24)	1-9 Certification and labeling system for green, energy-saving products	Energy Department
	1-10 Energy conservation standards for newly built urban buildings and industrial establishments.	Energy Department
	1-11 Energy saving renovations/retrofitting in existing buildings and improved energy efficiency guidelines/ regulations/rules	Energy Department
	1-12 E-Waste Management Rules	EPD
Short Term (CY-23)	1-13 Hazardous Substance/ Waste Management policy and rules (including but not limited to forever chemicals, polychlorinated biphenyls etc.)	EPD
	1-14 Green Financing Strategy	FD
	1-15 Establishment of pollution release and transfer register	EPD

2- Citizen Engagement

Term	Sub-interventions	Responsibility
Short Term (CY-23)	2-1 Establishment of hotline	EPD
	2-2 Establishment of interactive data portal for getting public input on environmental management	EPD
Medium Term (CY-24)	2-3 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.	EPD
	2-4 Public communication campaigns on negative environmental and health impacts of single use plastic focusing on the child health.	EPD
Short Term (CY-23)	2-5 Disclosure of environmental information through electronic means	EPD
Long Term (CY-25)	2-6 Public communication campaigns on water conservation, rain water harvesting, and environment conservation etc. focusing on the children.	EPD
Medium Term (CY-24)	2-7 Implementation of health advisory in the wake of critical air pollution events	EPD

3- Industries

Short Term (CY-23)	3-1 Geo tagging of industries (as well as others establishments having environmental concerns)	EPD
Medium Term (CY-24)	3-2 Implementation of resource efficiency and cleaner production technologies	Industry Department
Long Term (CY-25)	3-3 Implementation of zero water discharge/water conservations schemes in the water intensive industries like textiles, sugar etc.	Industry Department/ EPD
Medium Term (CY-24)	3-4 Introduction of carbon neutrality regime	EPD
Short Term (CY-23)	3-5 Financial assistance to green micro-enterprises	Industry Department
Medium Term (CY-24)	3-6 Evaluation of impacts of pollution sources on the soil quality	EPD
Long Term (CY-25)	3-7 Comprehensive control of industrial establishments & reduced emission of multi pollutants, end of pipe particular matter remover, installation of continuous emission monitoring systems etc.	EPD

4- Vehicular

Short (CY-23)	4-1 Devising mechanism for retiring excessively old vehicles and installation of catalytic converters/diesel particulate filter in the vehicles	Transport Department
Medium Term (CY-24)	4-2 Enhancing the area of jurisdiction of vehicles inspection and certification regime to the private vehicles	Transport Department
	4-3 Mandatory vehicle inspection certificate prior to sale and purchase of any vehicle regarding emission compliance	Transport Department/ Excise Department
	4-4 Promote mass transport facilities in the major urban centers of the province	Transport Department
	4-5 Devising mechanism to increase road denials of excessively old/ pollution causing vehicles during high air pollution levels	Transport Department/ EPD

Term	Sub-interventions	Responsibility
Long Term (CY-25)	4-6 Green transportation, standards, action plans & solutions	Transport Department
Medium Term (CY-24)	4-7 Road Engineering for removing traffic congestion in the major roads of the urban centers	Traffic Police/ Development Authorities/ MC
	5- Monitoring	
Medium Term (CY-24)	5-1 Installation of at least 30 ambient air quality monitoring stations	EPD
	5-2 Installation of at least 15 water quality monitoring stations	EPD
	5-3 Establishment of a reference laboratory	EPD
Short Term (CY-23)	5-4 Establishment of a GIS cell in EPD	EPD
Medium Term (CY-24)	5-5 Establishment of noise monitoring networks	EPD
	5-6 Environmental monitoring of industrial effluents deteriorating the quality of river Ravi in Sheikhupura and Faisalabad	EPD
	5-7 Investigation of sources of particulate matter for informed decision making in Punjab	EPD
	6- Water & Waste Water	
Long Term (CY-25)	6-1 Construction of storm/rain water underground water recharge galleries in establishments (including public as well as private)	LG&CD/ C&W Department
Medium Term (CY-24)	6-2 Water metering for every connection of domestic and industrial establishments along with provision of clean surface water to these	WASAs and municipal authorities
Long Term (CY-25)	6-3 Rehabilitation of dams, rivers, drains, and canals. Also ensure the implementation of watershed management practices and increase in water storage capacity of the province.	Irrigation Department
	6-4 Conservation of natural habitats especially the Ramsar sites	EPD
	6-5 Installation of municipal waste water treatment plants against each existing disposal station	LG&CD/ Housing Authorities
	6-6 Installation of industrial waste water treatment plants	Private/EPD
	6-7 Mandatory provision of construction of municipal waste water treatment plants in new establishment of disposal stations	LG&CD
	7- Solid Waste & Hospital/ Industrial waste	
Long Term (CY-25)	7-1 Establishment of Integrated solid waste management facilities in each urban as well as rural areas	LG&CD
Medium Term (CY-24)	7-2 Cleanup of the heaps of garbage spread around the vicinity and rehabilitation of land	LG&CD
	7-3 Waste minimization (reduce, recycle, and reuses of MSW) to improve waste collection efficiency	LG&CD
Long Term (CY-25)	7-4 Installation of waste to energy projects in urban center	LG&CD/Energy Department
Medium Term (CY-24)	7-5 Provision of hospital waste management facilities by large private hospitals (having more than 30 beds)	Private/ Health Department
Long Term (CY-25)	7-6 Provision of industrial waste management facilities in industrial or cluster levels	Industry Department

Term	Sub-interventions	Responsibility
8- Sustainable Green Financing		
Short Term (CY-23)	8-1 Operationalization of environment endowment fund management unit	EPD
	8-2 Devising operational guidelines for the disbursement of the Fund	EPD
9- Fugitive dust control		
Medium Term (CY-24)	9-1 Area pollution and dust control/urban dust management	EPD/ Housing Authorities/C&W
Short Term (CY-23)	9-2 Devising standards for controlling fugitive/ construction dust from road shoulders and construction sites.	EPD
Medium Term (CY-24)	9-3 Implementation of zero sand spillage regime regarding sand moving trolleys	Mines & Minerals/ District Govt./ Traffic Police
10- Remodeling environmental governance		
Short Term (CY-23)	10-1 Automation regime to expedite the public service delivery in Environment Protection Department	EPD
	10-2 Establishment of Environmental Policy Center	EPD
Medium Term (CY-24)	10-3 Establishment of Environmental Technology Transfer Center	EPD
	10-4 Incentivization the environmentally compliant industries	EPD/ MOCC/ FBR
Long Term (CY-25)	10-5 Collaboration/regional dialogues on transboundary water and air pollution	EPD/MOCC
11- Other		
Medium Term (CY-24)	11-1 Construction of Green Buildings in Lahore	EPD
Long Term (CY-25)	11-2 Research and development for developing/adoption of indigenous technologies for pollution abatement preferably through industry academia.	EPD
	11-3 Establishment of woodlands especially in urban centers of indigenous and environment-friendly species	Forest Department
Medium Term (CY-24)	11-4 Establishment of noise-free zones	EPD/ Development Authorities
Long Term (CY-25)	11-5 Land-use classification of each district to gauge the urban sprawl, development pattern etc.	LG&CD/ Development Authorities

ANNEXURES

Annexure I

Component	Action Plan
Component 1: Assessment for air, surface water and groundwater, and soil quality as extracted from the available monitoring data	
Air	▪ Existing air quality monitoring data of EPA Punjab ▪ Mobile AQMS mobilized for monitoring of 09 Divisional Head Quarters ▪ Available satellite data analyzed
Surface Water	▪ Data acquired from Irrigation Department & PCRWR ▪ Monitoring by EPA Labs
Ground Water	▪ HUD & PHE Department (WASAs) requested for provision of data
Soil Quality	▪ Primary monitoring by EPA certified lab and secondary data

Component 2: Assessment of pollution sources that contributed to air, surface water and soil quality	
Air	▪ Existing monitoring data of EPA Laboratories analyzed for assessment of pollution sources ▪ Monitoring by EPA Labs ▪ Excise & Taxation Department & Transport Department requested for data about registered vehicles & VICs
Water	▪ Irrigation Department & PCRWR requested for provision of data ▪ Monitoring by EPA Labs
Ground Water	▪ HUD & PHE Department (WASAs) requested for provision of data
Soil Quality	▪ Primary monitoring by EPA certified lab and secondary data

Component 3: Assessment of environmental performance of wastewater treatment facilities and solid waste management facilities"	
Wastewater treatment facilities	▪ Data gathering on Geo-spatial (latitude & longitude) location of WWTPs ▪ Assessment of environmental performance of facilities through monitoring by EPA Labs
Solid waste management facilities	▪ Solid waste management facilities included municipal solid waste management facilities and hospital waste management facilities ▪ Assessment of SWM Facilities in 04 divisional headquarters by hiring short term Consultancy ▪ Scoring of Solid Waste Management Facilities as per SWM Index

Component 4: Measures taken to control pollution and improve environmental quality	
Action taken to control pollution	▪ Data collection from EPA Punjab regarding the regulatory and enforcement actions taken to control pollution during 2022
Actions taken to improve environmental Quality	▪ Data collection from EPA Punjab and SP&IU, EPD Punjab regarding the actions taken to improve environmental quality during 2022

Component 5: Summary of environmental complaints received, classified by type of environmental issue, as well as actions taken in respect thereof	
Actions taken to control pollution	▪ Data collection from EPA Punjab (Headquarter and Field Officers) regarding the environmental complaints received and actions taken thereof

Component 6: Public feedback on the report and EPD's responses thereto
▪ 1st Consultative Session held successfully, SOER uploaded on EPD's website ▪ 2nd Consultative session on 27th April 2023.

Component 7: GoPb's Environmental Action Plan for the following calendar years
Formulation of Environmental Action plan with well-defined timelines and responsibilities

Annexure II

Weather Trends in Punjab during 2022

Pakistan Meteorological Department (PMD) records the data on average monthly weather trends on the basis of following weather parameters:

- o Mean maximum monthly temperature [measured in °C]
- o Mean minimum average monthly temperature [measured in °C]
- o Monthly rain (total/cumulative) [measured in millimetres]

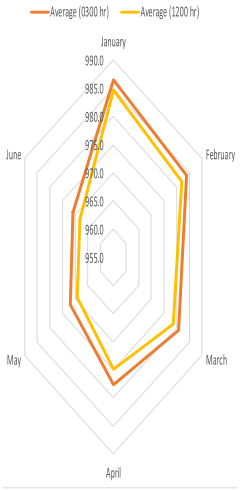
General weather patterns are depicted in **Annexure III.**

The recorded weather patterns experienced in Punjab during 2022 are as follows:

a. Atmospheric pressure: The atmospheric pressure (or air pressure, hereon denoted by AtmP) indicator, monitored at the station level throughout Punjab, depicted a general steady declining trend from January to June (2022).

Station Level Pressure

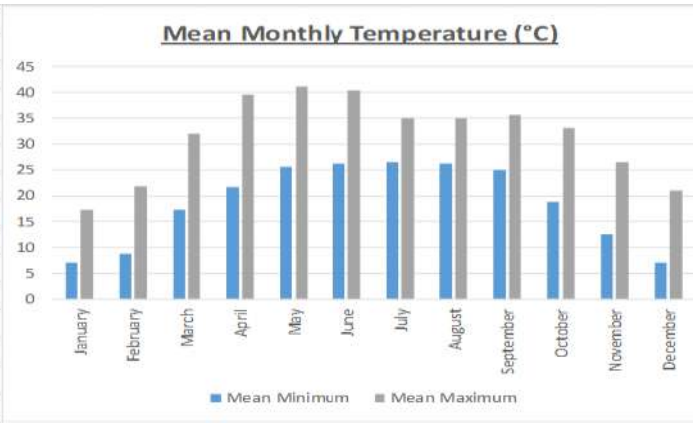
MONTH	STATION LEVEL PRESSURE (hPa)					
	Average		Maximum		Minimum	
	at 0300	at 1200	at 0300	at 1200	at 0300	at 1200
January	986.4	984.7	1,007.4	1,005.0	795.7	795.4
February	984.0	982.0	1,004.1	1,001.6	794.9	794.5
March	980.8	978.6	1,001.2	998.1	798.0	797.6
April	977.5	974.9	996.4	993.2	797.1	796.6
May	972.0	969.2	990.9	987.8	794.4	793.7
June	970.8	968.2	990.3	986.9	793.5	793.0
Average	**978.6**	**976.3**	**1,007.4**	**1,005.0**	**793.5**	**793.0**



b. Average Temperature: Regarding average temperature recordings, a general inverted parabola-shaped trend was observed. The temperatures began to rise at the start of the year and continued to rise till the mid of the year (June). Thereafter – starting July – the temperatures began to dwindle, a trend that continued till the end of the year. Rahim Yar Khan station

Mean Monthly Temperatures

Mean Temperature (°C)		
Month	Minimum	Maximum
January	7.04	17.28
February	8.75	21.75
March	17.28	31.96
April	21.67	39.60
May	25.55	41.03
June	26.13	40.36
July	26.51	35.00
August	26.23	34.99
September	24.91	35.58
October	18.86	33.13
November	12.62	26.54
December	7.02	21.01
Overall	**18.55**	**31.52**

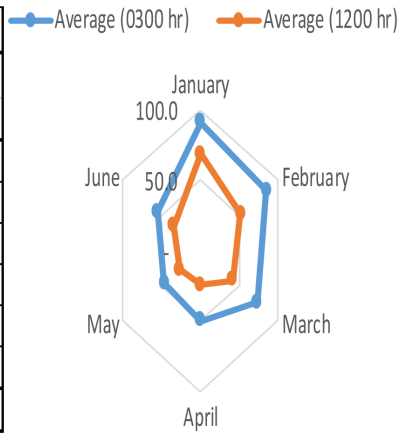


reported the highest average temperature recorded for a particular month (May, 44.7 °C), summer season), while Murree station (being located in a high-altitude/hilly area) reported the lowest average temperature recorded for a particular month (January, winter season, -0.5 °C).

c. Relative Humidity: With regards to relative humidity, a general declining trend was observed that appeared to taper off towards the end of the monitoring period, especially true for monitoring at 0300 hours. Multan City (@ 0300 hours) and Narowal (@ 1200 hours) stations reported the highest average relative humidity levels recorded for a particular month (January 2022), while Rahim Yar Khan station reported the lowest average relative humidity levels recorded for a particular month (April 2022, both times). Furthermore, as expected, it is also evident that the average relative humidity levels decrease gradually as the day progresses.

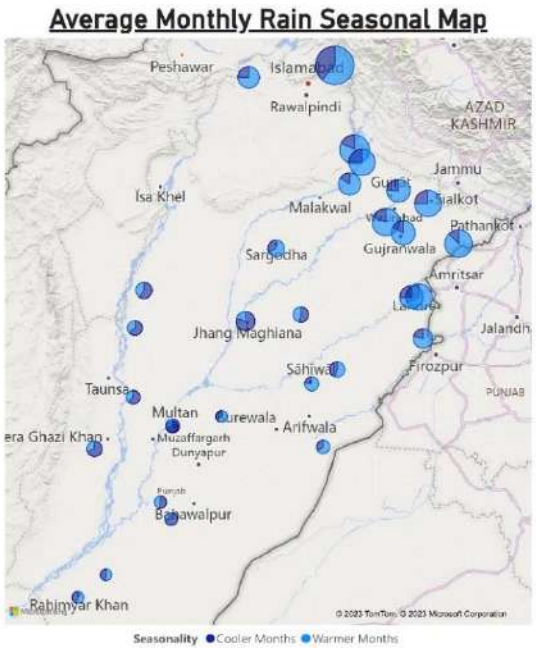
Relative Humidity

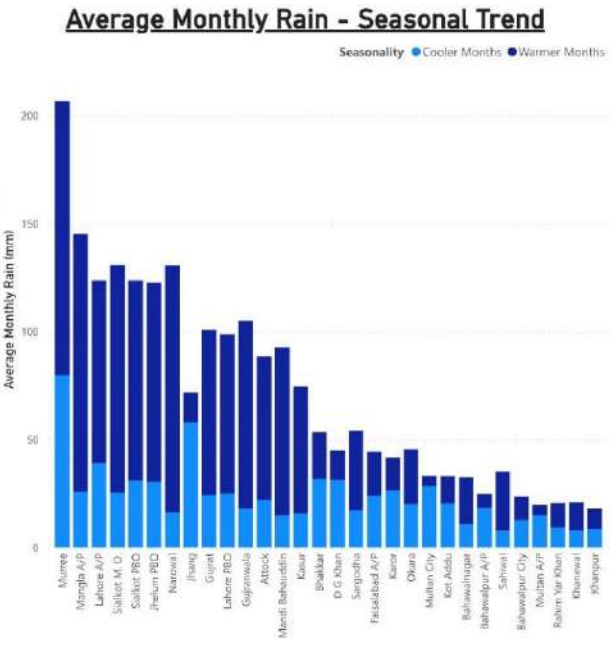
MONTH	RELATIVE HUMIDITY (%)					
	Average		Maximum		Minimum	
	at 0300	at 1200	at 0300	at 1200	at 0300	at 1200
January	90.8	68.3	96.0	80.0	69.0	50.0
February	85.0	51.6	94.0	65.0	55.0	36.0
March	73.3	41.8	84.0	53.0	41.0	26.0
April	50.2	24.4	65.0	39.0	37.0	13.0
May	46.6	26.6	54.0	46.0	41.0	18.0
June	55.0	34.7	66.0	46.0	47.0	28.0
Average	**66.8**	**41.2**	**96.0**	**80.0**	**37.0**	**13.0**



D. Cumulative Monthly Rain: Regarding cumulative/total monthly rain measurements, a general inverted parabola shaped trend (⌒) was observed during the monitoring period i.e., higher in January, declining to low levels before sharply rising and reaching peak levels around mid-year (incorporating the effects of monsoons around mid-year). Following a sharp peak, the cumulative rain levels exhibit a declining trend to low levels in the later months. This is expected and in accordance with the general weather pattern of lesser rain in winters compared with more in summers. Gujranwala station reported the highest cumulative monthly rainfall recorded for a particular month (494.0 mm in July) in the summer season; Narowal station reported the most cumulative monthly rainfall (203.1 mm in January) in the winter season), while several stations reported the lowest cumulative monthly rainfall recorded for a particular month (0 mm or traces) in both summer and winter seasons. Furthermore, on average, the highest average cumulative rain for a single month was observed in July (252.4 mm) followed by August (136.9 mm), while April (2.9 mm) observed the least average rainfall in the province, with December (4.6 mm) trailing close.

Average Monthly Rain

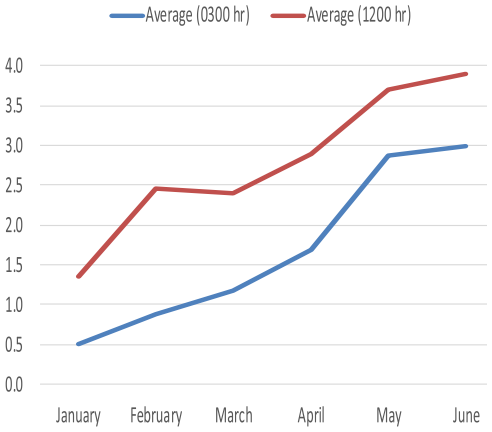




Wind Speed: Regarding wind speed recording, a gradual rising trend was observed throughout the monitoring period. Lahore A/P station reported the highest average wind speeds recorded for a particular month (May 2022, summer season); several stations reported the lowest average wind speeds (0 knots) recorded for a particular month (reported in the winter season)

Mean Wind Speed

MONTH	MEAN WIND SPEED (knots)					
	Average		Maximum		Minimum	
	at 0300	at 1200	at 0300	at 1200	at 0300	at 1200
January	0.5	1.4	1.8	4.0	0.0	0.1
February	0.9	2.5	2.9	7.1	0.0	0.4
March	1.2	2.4	5.5	9.8	0.1	0.3
April	1.7	2.9	6.5	9.9	0.1	0.1
May	2.9	3.7	9.6	10.1	0.4	0.5
June	3.0	3.9	8.9	10.1	0.3	0.9
Average	**1.7**	**2.8**	**9.6**	**10.1**	**0.0**	**0.1**



Annexure III

General Weather Patterns – PMD Stations in Punjab [Jan-Jun 2022]

S #	STATION	STATION LEVEL PRESSURE		RELATIVE HUMIDITY		TEMPERATURE		MONTHLY RAIN	MEAN WIND SPEED		RESULTS	DOMINANT WIND DIRECTION	
		AT 0300	AT 1200	AT 0300	AT 1200	MEAN MAX	MEAN MIN	ACC.	AT 0300	AT 1200		AT 0300	AT 1200
1	MURREE	795.60	795.13	49.50	52.67	18.97	9.20	95.53	2.50	2.12	Average	NE	SE
											Trend		
2	M.O. SIALKOT	980.23	977.98	63.67	39.83	30.78	16.30	52.15	2.93	5.00	Average	NE	SW
											Trend		
3	JHANG	990.47	988.13	70.67	38.67	32.85	17.60	43.30	0.47	0.67	Average	NE	SW
											Trend		
4	SARGODHA	986.35	983.87	70.67	44.83	32.57	18.55	23.85	1.28	2.25	Average	NE	NE
											Trend		
5	MULTAN CITY	DNA	DNA	68.83	40.33	32.90	18.73	20.55	1.52	2.60	Average	SW	SE
		DNA	DNA								Trend		
6	MULTAN A/P	993.47	990.88	64.67	32.50	33.12	19.43	11.60	3.13	5.58	Average	NE	SW
											Trend		
7	BAHAWALNAGAR	988.98	986.97	61.17	44.00	33.97	19.23	14.50	0.40	2.32	Average	NE	NW
											Trend		
8	KAROR LAL ESAN	DNA	DNA	67.17	38.00	32.88	17.07	22.70	0.20	0.45	Average	N	NW
		DNA	DNA								Trend		
9	KOT ADDU	993.42	991.67	67.00	38.33	33.67	19.02	17.88	0.75	1.48	Average	NW	NW
											Trend		
10	BAHAWALPUR CITY	993.97	991.48	68.67	37.83	34.05	18.43	12.08	2.98	3.02	Average	SW	NW
											Trend		
11	BHAKKAR	DNA	DNA	69.50	41.33	33.62	17.20	28.40	0.93	2.17	Average	NE	SE
		DNA	DNA								Trend		
12	FAISALABAD AIRPORT	987.35	984.92	66.67	38.17	32.15	18.33	22.83	2.45	3.52	Average	NE	NW
											Trend		
13	PBO JHELUM	981.10	978.42	69.17	43.33	32.25	17.02	51.15	0.93	2.45	Average	NW	NW
											Trend		
14	MANGLA AIRPORT	977.95	975.92	66.00	39.00	31.33	15.97	57.02	1.47	5.00	Average	NW	NW
											Trend		
15	BAHWALPUR A/P	993.83	991.35	68.33	42.50	33.82	23.38	14.37	4.65	5.98	Average	NE	NW
											Trend		
16	KASUR	DNA	DNA	71.17	45.17	28.08	20.10	30.08	0.50	1.27	Average	SW	SW
		DNA	DNA								Trend		
17	MANDI BAHAUDDIN	983.03	980.47	68.17	43.83	32.37	17.67	35.83	1.08	1.55	Average	NW	NW
											Trend		
18	RAHIM YAR KHAN	998.38	995.43	63.50	29.00	35.63	18.32	9.98	2.75	3.53	Average	SW	NW
											Trend		
19	PBO SIALKOT	979.10	976.68	71.50	45.17	28.62	14.70	61.86	0.55	2.18	Average	NE	NW
											Trend		
20	KHANEWAL	990.03	988.13	71.50	45.17	33.18	16.45	14.40	1.02	1.05	Average	NE	NW
											Trend		
21	GUJRANWALA	DNA	DNA	71.33	48.17	31.20	16.45	41.05	1.90	3.70	Average	NW	NW
		DNA	DNA								Trend		
22	ATTOCK	966.12	963.33	66.17	39.00	30.37	15.68	36.82	0.25	0.97	Average	NE	NE
											Trend		
23	LAHORE A/P	980.97	978.52	62.67	38.50	31.27	18.35	54.22	5.47	8.50	Average	NW	NW
											Trend		
24	DG KHAN	989.57	986.85	61.17	42.50	33.67	18.80	25.38	3.12	4.63	Average	NE	SE
											Trend		
25	KHANPUR	997.13	994.13	69.33	35.83	34.95	18.20	8.88	1.13	1.53	Average	NW	SW
											Trend		
26	GUJRAT	DNA	DNA	65.50	41.67	31.08	17.17	41.68	1.33	1.90	Average	NE	SE
		DNA	DNA								Trend		
27	SAHIWAL	988.55	986.13	70.17	42.83	32.15	18.00	14.33	1.60	2.60	Average	SE	SW
											Trend		
28	PBO LAHORE	983.67	981.38	62.17	39.67	31.35	19.18	41.25	0.77	2.10	Average	NW	SW
											Trend		
29	NAROWAL	980.50	978.62	75.17	49.83	30.73	16.12	49.00	0.97	2.20	Average	NE	NW
											Trend		
30	OKARA	986.63	984.33	63.50	39.33	33.93	19.53	21.92	1.40	1.20	Average	SE	SW
											Trend		
	OVERALL	**978.60**	**976.28**	**66.82**	**41.23**	**32.00**	**17.74**	**31.98**	**1.68**	**2.78**	Average	-	-
											Trend		

N.B.:

1. 'DNA' means that data was not available for that particular station.
2. Data for station level pressure is not available for 6 stations; thus, averages and trends are calculated taking the available data into account. For other parameters, data is available for all stations; thus, all available data is employed into these computations.
3. Data is not available for 6 months for temperature (both max and min) and cumulative rainfall for a number of stations. All computations are thus undertaken with consideration of this limitation.
4. Wherever monthly rain is designated as 'TR', it is taken as zero (0) mm for computation purposes.
5. The dominant wind direction is the predominant wind direction for the overall monitoring period as determined from averaged monthly wind direction data.

Annexure IV

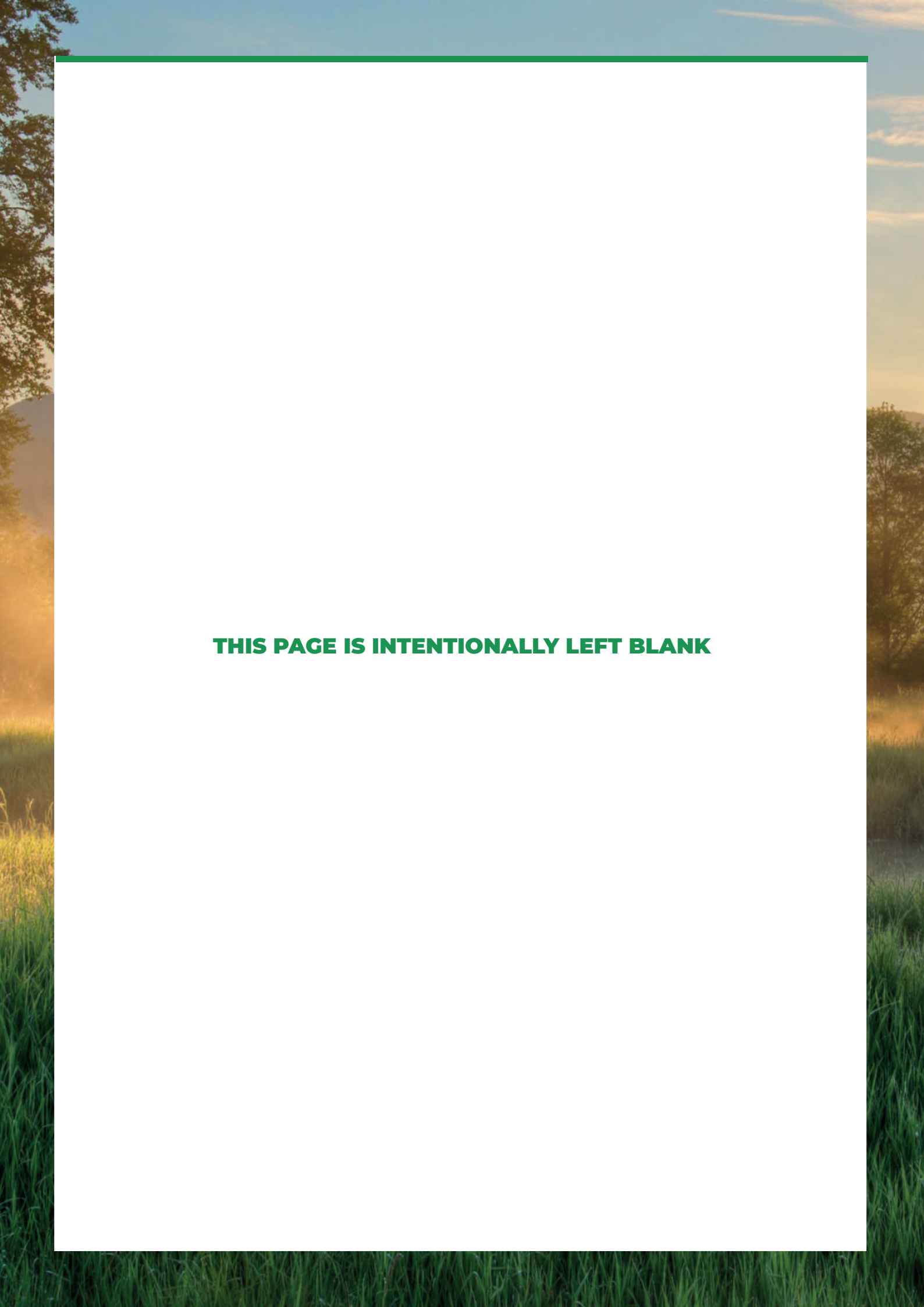
Breakpoints for calculation of AQI by EPA Punjab

($\mu g/m^3$)					(mg/m3)	AQI	AQI Category
PM_{10}	$PM_{2.5}$	SO_2	NO_2	O_3	CO		
0.0-75.0	0.0-15.0	0.0-60.0	0.0-40.0	0.0-65	0.0-2.5	0-50	Good
75.1-150.0	15.1-35.0	60.1-120.0	40.1-80.0	65.1-130.0	2.6-5.0	51-100	Satisfactory
150.1-250.0	35.1-70.0	120.1-220.0	80.1-130.0	130.1-195.0	5.1-7.5	101-150	Moderate
250.1-350.0	70.1-140.0	220.1-320.0	130.1-180.0	195.1-260.0	7.6-10.0	151-200	Unhealthy for sensitive group
350.1-450.0	140.1-250.0	320.1-800.0	180.1-380.0	260.1-450.0	10.1-25.0	201-300	Unhealthy
450.1-550.0	250.1-350.0	800.1-1600.0	380.1-580.0	450.1-550.0	25.1-40.0	301-400	Very unhealthy
550.1+	350.1+	1600.1+	580.1+	550.1+	40.1+	401-500+	Hazardous

Annexure V

Location-wise Analysis of Biochemical Indicators

S #	Site- ID	Alk.	HCO_3	Ca	Cl	EC	Hrd.	Mg	pH	K	SO_4	Na	TDS	Tur.	N	As	COD	BOD	T.C.	F.C.	E.Coli	R
1	Ravi Siphon (Lahore)	2.39	119.55	23.55	11.47	274.00	100.91	10.22	7.45	1.02	20.91	26.64	169.18	12.49	0.83	5.74	63.00	32.62	-	-	-	A
		0.87	43.44	15.11	29.20	128.73	24.09	5.95	0.20	0.19	18.28	19.15	65.21	1.86	0.52	12.50	-	-	11.64	5.40	-	D
																						T
2	Manga Mandi Lahore (Ravi River)	3.55	177.73	39.36	46.62	550.73	162.73	15.63	7.30	1.65	40.00	54.45	315.31	15.15	2.28	3.52	119.64	59.24	-	-	-	A
		2.73	136.68	39.54	34.46	451.18	119.69	8.13	0.26	0.10	50.09	53.42	256.00	6.55	1.12	6.47	132.49	63.04	0.00	0.00	-	D
																			-	-		T
3	Ravi River (Checha Watni)	6.49	324.55	71.00	122.65	1,307.09	319.82	34.58	7.32	2.71	170.18	175.91	808.73	14.09	7.99	7.15	239.09	140.27	-	-	-	A
		1.32	66.16	23.72	36.04	406.66	84.40	6.83	0.44	0.00	53.70	55.40	218.43	7.67	2.42	-	53.20	35.42	-	-	-	D
																						T
4	Sutlej River (Kasur)	2.95	147.27	23.36	13.75	330.27	120.00	14.97	7.63	1.25	23.09	30.64	198.67	13.85	0.67	9.25	84.18	45.50	-	-	-	A
		2.34	116.95	26.47	38.41	310.05	68.30	3.90	0.39	0.00	23.71	37.09	177.20	9.52	1.26	7.78	34.28	20.37	0.00	0.00	-	D
																			—	—		T
5	Haydara Drain Laloo (Lahore)	9.62	480.91	83.73	96.18	1,324.27	337.73	31.20	7.37	3.02	54.00	159.82	762.91	18.49	9.99	5.77	557.09	298.73	-	-	-	A
		0.40	20.05	3.58	3.96	29.81	21.65	5.02	0.29	0.00	7.40	5.37	23.02	4.52	0.15	10.38	-	-	8.50	2.75	-	D
																						T
6	Haydara Drain Laloo G/W (Deep)	8.07	403.64	71.55	69.82	1,140.82	307.73	31.31	7.38	2.64	132.82	142.64	706.31	4.31	3.05	17.39	-	-	0.00	0.00	-ve	A
		0.85	42.68	10.24	7.71	78.70	54.38	11.20	0.30	0.00	4.37	4.98	48.69	8.90	0.10	3.02	-	-	10.57	3.89	-	D
																						T
7	Haydara Drain Laloo G/W (Shallow)	6.89	344.55	44.00	28.49	866.27	250.45	34.13	7.75	2.22	76.36	95.82	489.84	4.50	0.16	11.81	-	-	1.20	0.40	-ve	A
		0.62	30.78	7.87	4.56	49.35	33.70	7.71	0.36	0.00	7.24	8.77	33.38	7.89	0.10	1.14	-	-	10.25	4.99	-	D
																						T
8	Rangy Wala Drain (Kasur)	19.64	981.82	119.36	437.91	3,946.00	705.45	98.91	7.85	6.67	351.82	581.55	2,273.15	20.75	20.01	5.44	375.36	242.18	-	-	-	A
		1.29	64.71	19.86	16.71	200.84	65.46	6.43	0.43	0.00	25.44	18.93	117.61	8.63	1.05	15.78	45.35	28.62	0.00	0.00	-	D
																			—	—		T
9	Rangy Wala Drain (Kasur) G/W (Deep)	4.91	245.45	49.73	36.91	705.73	201.36	18.72	7.62	2.13	77.55	79.00	411.96	5.50	0.11	5.38	-	-	0.00	0.00	-ve	A
		4.42	221.15	44.12	64.26	660.60	115.05	5.60	0.23	0.31	87.85	97.06	384.01	5.90	5.07	6.43	350.26	103.25	0.00	0.00	-	D
																						T
10	Rangy Wala Drain (Kasur) G/W (Shallow)	6.55	327.27	83.18	155.45	1,314.45	329.09	29.44	7.55	2.93	166.64	162.00	799.20	4.71	0.63	9.99	-	-	2.60	1.00	-ve	A
		1.10	55.00	10.69	32.13	152.59	29.33	3.54	0.36	0.00	65.34	18.91	98.83	8.64	2.80	2.88	68.26	47.88	-	-	-	D
																						T
11	Shahdra Drain (Lahore)	7.95	397.27	105.73	115.18	1,474.64	392.27	31.09	7.35	3.31	186.82	171.00	929.62	18.95	17.94	7.91	748.09	394.55	-	-	-	A
		2.17	108.44	22.97	27.31	257.02	61.11	15.66	0.46	0.00	47.07	53.91	168.50	13.19	4.27	4.81	80.13	34.61	0.00	0.00	-	D
																			—	—		T
12	Shahdra Drain (Lahore) G/W (Deep)	3.15	157.27	23.36	12.55	357.64	127.00	16.67	7.72	1.04	33.00	34.27	215.72	4.94	0.12	26.52	-	-	0.00	0.00	-ve	A
		1.55	77.39	17.81	61.43	306.74	36.14	4.59	0.58	0.00	38.83	48.69	172.63	5.82	0.22	1.12	-	-	2.57	0.84	-	D
																						T
13	Shahdra Drain (Lahore) G/W (Shallow)	2.91	145.45	27.09	13.51	329.27	125.18	13.96	7.38	0.87	30.18	32.27	205.97	8.67	0.13	36.71	-	-	15.80	6.20	+ve	A
		2.23	111.48	27.94	31.65	308.62	76.33	19.30	0.35	0.00	44.53	44.80	200.81	9.55	8.93	6.72	170.31	68.53	-	-	-	D
																						T
14	Babu Sabu Drain (Lahore)	7.63	381.36	48.45	73.91	1,091.00	305.45	44.79	7.35	1.98	116.64	128.82	655.81	15.01	2.87	13.51	445.45	263.36	-	-	-	A
		3.08	154.13	25.37	31.75	364.56	102.25	16.62	0.44	0.00	60.09	46.16	231.53	2.84	3.48	1.41	210.72	21.92	0.00	0.00	-	D
																			-	-		T
15	Babu Sabu Drain (Lahore) G/W (Deep)	3.24	161.82	26.64	14.93	384.55	139.82	17.79	7.82	1.02	36.00	36.36	230.28	4.42	0.09	9.51	-	-	0.80	0.00	-ve	A
		2.05	102.48	20.41	79.16	480.90	55.68	10.94	0.20	0.00	53.05	94.69	327.25	8.58	15.11	12.04	94.25	38.63	0.00	0.00	-	D
																			—	—		T
16	Babu Sabu Drain (Lahore) G/W (Shallow)	3.42	170.91	28.91	12.60	389.73	139.55	16.35	7.76	1.22	33.00	39.27	235.58	6.54	0.23	5.79	-	-	7.20	3.50	-ve	A
		1.51	75.64	23.56	20.21	191.35	67.50	15.61	0.60	0.00	29.23	22.74	104.73	3.13	1.06	3.83	-	-	4.79	1.63	-	D
																						T
17	Khudpur Drain (Lahore)	9.95	497.27	95.36	101.82	1,521.64	402.27	39.82	7.43	3.20	127.18	172.00	893.67	21.30	11.82	6.10	673.55	329.73	-	-	-	A
		2.49	124.44	4.96	23.80	204.22	68.31	16.77	0.29	0.00	20.96	27.18	127.40	8.09	1.47	5.25	35.66	59.08	0.00	0.00	-	D
																			–	–		T
18	Khudpur Drain G/W (Deep)	10.38	519.09	79.64	71.96	1,352.73	343.18	35.01	7.35	2.69	144.64	176.91	829.76	6.18	1.58	16.19	-	-	2.80	0.20	-ve	A
		1.02	51.01	10.48	14.84	77.75	28.84	5.94	0.23	0.00	10.93	10.70	41.22	5.86	0.10	10.88	-	-	8.86	4.00	-	D
																						T
19	Khudpur Drain G/W (Shallow)	8.18	409.09	72.36	101.09	1,365.55	296.82	28.17	7.60	3.29	149.82	183.00	788.50	9.18	1.11	13.85	-	-	4.10	2.00	-ve	A
		4.64	231.88	42.80	147.79	926.60	164.65	19.95	0.32	0.42	100.67	166.47	584.74	3.59	10.94	10.01	216.04	92.38	0.00	0.00	-	D
																			-	-		T
20	Sukhrawa Drain (Sahiwal)	14.29	714.55	101.73	214.55	2,623.91	513.18	62.90	7.53	4.13	269.55	386.09	1,601.53	17.84	32.70	21.85	499.36	286.91	-	-	-	A
		1.83	91.66	39.20	65.20	328.77	102.15	17.61	0.42	0.00	62.10	43.81	201.18	6.78	3.25	3.54	-	-	4.60	1.41	-	D
																						T
21	Sukhrawa Drain (Sahiwal) G/W (Deep)	6.96	348.18	56.91	62.29	1,067.91	290.91	36.12	7.39	2.07	119.18	126.73	614.50	4.93	0.48	31.85	-	-	0.00	0.00	-ve	A
		2.52	125.92	33.01	30.00	291.00	84.15	20.62	0.37	0.00	36.27	40.77	181.68	14.61	10.16	14.14	132.61	73.22	4.62	0.58	-	D
																						T
22	Sukhrawa Drain (Sahiwal) G/W (Shallow)	5.58	279.09	55.82	62.62	916.36	233.18	22.75	7.66	1.96	98.00	105.00	516.65	6.38	0.39	11.37	-	-	6.80	1.70	+ve	A
		1.81	90.71	18.44	75.43	488.52	80.93	17.09	0.22	0.40	111.16	81.77	253.43	8.36	4.22	7.25	162.61	106.69	0.00	0.00	-	D
																			–	–		T
23	Madvana Drain (Toba Tek Singh)	23.69	1,184.55	145.09	343.36	4,014.91	777.27	100.73	7.60	6.40	357.09	553.09	2,282.79	18.69	12.36	9.40	594.09	314.64	-	-	-	A
		1.00	49.96	19.52	44.31	178.23	35.43	9.80	0.41	0.00	61.77	21.17	116.23	15.30	6.66	4.68	93.33	92.83	6.50	3.00	-	D
																						T
24	Madvana Drain (Toba Tek Singh) G/W (Deep)	4.89	244.55	42.73	55.05	855.45	206.36	24.19	7.83	2.56	106.00	110.27	495.32	6.69	2.06	4.01	-	-	4.00	1.80	-ve	A
		3.28	163.83	41.83	77.49	561.83	105.60	34.35	0.43	0.00	81.98	96.01	297.50	13.53	6.28	21.23	104.08	56.17	5.43	2.40	-	D
																						T
25	Madvana Drain (Toba Tek Singh) G/W (Shallow)	8.29	414.55	88.36	149.64	1,712.09	369.09	36.01	7.78	3.53	191.82	224.82	959.53	4.37	3.56	16.25	-	-	1.10	0.60	-ve	A
		2.63	131.30	24.50	67.04	303.77	95.87	20.12	0.33	0.00	64.51	65.28	206.20	9.40	10.70	8.55	118.59	53.32	8.36	3.73	-	D
																						T
26	Upper Chenab Drain (Sharqpur)	2.55	127.27	27.73	25.64	401.09	120.73	12.49	7.25	1.33	39.00	43.00	235.40	14.19	2.02	6.04	146.45	110.27	-	-	-	A
		6.09	304.62	15.96	135.15	1,208.64	230.75	50.66	0.30	0.52	111.38	159.94	637.57	15.24	11.33	5.87	153.16	113.38	0.00	-	-	D
																						T
27	Upper Chenab Drain (Sharqpur) G/W (Deep)	5.22	260.91	44.91	38.56	709.00	216.82	25.40	7.52	1.89	67.82	77.36	413.87	4.34	0.31	16.19	-	-	0.00	0.00	-ve	A
		13.33	666.65	42.58	185.94	1,709.78	395.78	72.51	0.33	0.64	137.21	241.05	997.43	10.18	14.29	9.75	142.72	72.44	14.76	6.99	-	D
																						T
28	Upper Chenab Drain (Sharqpur) G/W (Shallow)	4.56	228.18	39.64	25.24	634.18	176.82	18.89	7.55	1.85	65.91	68.09	357.86	5.70	0.37	30.05	-	-	9.30	4.10	+ve	A
		7.77	388.67	48.61	122.94	864.11	210.49	50.42	0.30	0.00	149.33	125.65	435.76	14.76	9.55	9.14	187.81	99.09	-	-	-	D
																						T



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Environmental Protection Agency

Government of the Punjab

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