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Project: Achieving Net-Zero Emissions in the Agriculture Sector of Pakistan

Executive Summary

The agricultural sector of Pakistan is the main source of greenhouse gas (GHG) emissions in the country, contributing approximately 41% of the total GHG emissions. This makes it a crucial sector for climate transition. This project incorporates environmental analytics to assess EDGAR data (1970–2022) to analyse emission trends, identify pollutant hotspots and develop targeted policy recommendations to support Pakistan's net-zero economy ambitions.

The data analysis shows that agricultural GHG emissions have increased by 268% since 1970, with a steep rise in ammonia (NH_3) and nitrogen oxides (NO_x) that are attributed to over-fertilisation and ineffective manure management. Major hotspots that contribute to rising levels of GHG and toxic pollutant levels include agricultural soils and waste burning. Strong positive correlations between emissions and time provide further evidence for increasing growth.

Launching an SBTi-aligned national emissions roadmap, reforming fertiliser subsidies, deploying provincial MRV systems, passing a National Manure Code and forming an Agriculture Carbon Council to strengthen climate governance and finance are key recommendations proposed to achieve net-zero emissions.

Data transparency, policy equity and greenwashing risks are ethical considerations addressed by the project to ensure that Pakistan's net-zero progress does not threaten analytical integrity.

Contents

1. Introduction

The claim made by Pakistan to reach net-zero emissions by 2050 in their Nationally Determined Contribution (NDC) to the UNFCCC signifies a critical pledge of global climate ambitions by cutting 50% emissions by 2030 (Government of Pakistan, 2021). However, the magnitude of the change is vast, especially in agriculture, which contributes to 41% of national GHG emissions (World Bank, 2017). The sector's nature, being climate sensitive and emissions-intensive, makes it a strategic net-zero target for climate transition.

Nevertheless, the agricultural emissions of Pakistan are under-regulated and are not well-monitored and aligned with the Science Based Targets Initiative (SBTi). The country does not have a national roadmap that is specific to net-zero emissions in agriculture. Such an analytical gap obstructs the effectiveness of policymaking and does not solve the problem of emission hotspots. In the absence of evidence-based decision-making tools, mitigation efforts will never be effective or scalable.

This project seeks to address that gap by implementing environmental analytics to assess the long-term emissions of the agricultural sector based on the EDGAR (Emission Database for Global Atmospheric Research) database (EDGAR, 2023). The project uses SPSS and Tableau to identify emission trajectories, hotspot sources and system-level inefficiencies.

This research aligns with a core SBTi target relevant to agriculture:

- Forest, Land and Agriculture (FLAG) Science-Based Target Guidance by quantifying emissions to support decarbonisation and net-zero.

Given Pakistan's 1st ranking in the climate risk index, this project is not only timely but essential (Germanwatch, 2025).

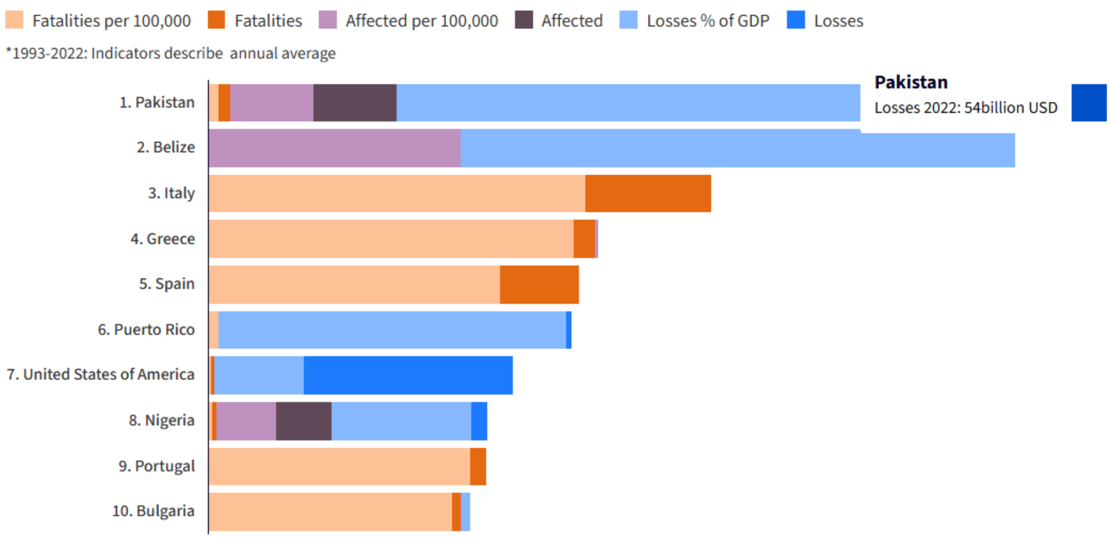

Figure 1: Climate Risk Index: Top 10 most affected countries (Germanwatch, 2025)

The project provides an actual pathway to climate-smart agriculture that does not sacrifice food security and rural resilience with emissions control by integrating environmental analytics into the policy-making process. This project supports the following SDGs through data-driven climate governance:

- **SDG 13 (Climate Action):** Focuses on urgent action to combat climate change and its impacts.
- **SDG 12 (Responsible Consumption and Production):** Focuses on ensuring sustainable consumption and production patterns.

2. Data

2.1 Dataset Overview

This project has an empirical basis, which is the EDGAR data providing a complete longitudinal history of GHG emissions of the agriculture sector of Pakistan from 1970 to 2022. The data is accessible via: https://edgar.jrc.ec.europa.eu/country_profile/PAK

The data is available on the webpage with facts and visualisations. After consideration of a variety of air and toxic pollutants, relevant data were downloaded in CSV format and converted to an Excel worksheet.

The final data set is accessible via OneDrive Link: Agriculture Emissions of Pakistan (final).xlsx

The final dataset for this project consists of the following (see Appendix A):

Greenhouse Gases (GHG):

- GHG Emissions that consist of CH_4 (methane), N_2O (nitrous oxide) and CO_2 (carbon dioxide) (in tonnes CO_2 equivalent/year).

Air Pollutants:

- Ammonia (NH_3) emissions from agricultural soils, manure management and waste burning (in tonnes/year).
- Nitrogen oxides (NO and NO_2, expressed as NO_x) from agricultural soils, manure management and waste burning (in tonnes/year).
- Sulphur dioxide (SO_2) from agricultural waste burning only (in tonnes/year).
- Carbon monoxide (CO) from agricultural waste burning only (in tonnes/year).
- Black Carbon (BC) from agricultural waste burning only (in tonnes/year).

Toxic Pollutant:

- Total Mercury (Hg) from agricultural waste burning only (in tonnes/year).

To ensure compatibility with SPSS for statistical analysis and Tableau for visualisation, the data was cleaned for missing values and structured.

2.2 Rationale for Data Selection

The selection of EDGAR was driven by the following strengths:

- The data covers five decades of emissions, which allows for trend analysis.
- The data differentiates between agriculturally linked GHG and air/toxic pollutants.
- Its gas-by-gas segmentation enables the identification of emission hotspots for NH_3 and NO_x that will help in targeted policy recommendations.
- EDGAR is open-access, scientifically credible and consistent with IPCC methodology (EDGAR, 2016).

However, the data also presents a few limitations:

- It does not disaggregate GHG emissions by sub-source, such as rice paddies or livestock digestion.

- It does not disaggregate all gas emissions into hotspots.
- The emissions are not divided into Scope 1,2, or 3. This makes it difficult to accurately understand the GHG footprint in the agricultural supply chain.
- The data does not offer any regional-level granularity that restricts location-specific policy design.

2.3 Descriptive Statistics

Descriptive analysis was conducted using SPSS to provide a statistical summary across the 1970–2022 period (see Appendix B). Table 1 below summarises key indicators:

Table 1 Descriptive Statistics

Descriptive Statistics					
	Minimum	**Maximum**	**Mean**	**Std. Deviation**	**% Change (1970-2022)**
GHG Emissions (t CO_2 eq/year)	68910083.00	255466094.00	136920185.11	54671165.69	268.47
Ammonia (NH_3) Emissions (t/year)	246287.22	1847011.84	865689.54	466063.54	554.78
Black Carbon (BC) Emissions (t/year)	4169.18	12846.37	8150.31	2515.82	172.06
Carbon Monoxide (CO) Emissions (t/year)	600998.20	1732719.14	1135406.93	329818.43	157.74
Nitrogen oxides (NO_x) emissions (t/year)	42678.03	210146.61	112113.43	48605.26	376.75
Sulphur Dioxide (SO_2) Emissions (t/year)	3724.32	11255.61	7326.45	2246.42	169.37
Total Mercury (Hg) Emissions (t/year)	0.93	2.78	1.84	0.57	169.03

Insights:

- Total GHG emissions are highly volatile with a high mean of approximately 137M t CO_2 eq/year. The sector is an active contributor to climate change, as reflected by the 268% increase in emissions from 1970 to 2022.
- NH_3 emissions had the highest increase among all pollutants, of 554%. This indicates the intensive use of fertiliser and unregulated manure management.
- As a short-lived climate pollutant that has a warming impact up to 1,500 times stronger than CO_2 per unit of mass, the 172% increase poses serious air quality risks (Climate and Clean Air Coalition, 2024).
- The 157% increase in CO emissions suggests inefficient combustion practices.
- NO_x emissions increased by 376%. This increase highlights the need for better soil diagnostics, precision agriculture and regulated fertilisation.
- SO_2 increased by 169%. This indicates the need for cleaner energy transitions in Agri-operations.
- Although smaller in quantity as compared to other pollutants, the 169% increase in Hg emissions is a serious concern given its high toxicity and bioaccumulative nature (United States Environmental Protection Agency, 2014).
- **Signal:** These insights as a whole point to a non-viable agricultural trend that should be addressed immediately with data-based, SBTi-compliant frameworks and climate-smart agriculture.

3. Analysis

3.1 Emission Trends

The trends in the agricultural emissions of Pakistan show a drastic increase in both climate-forcing and toxic pollutants.

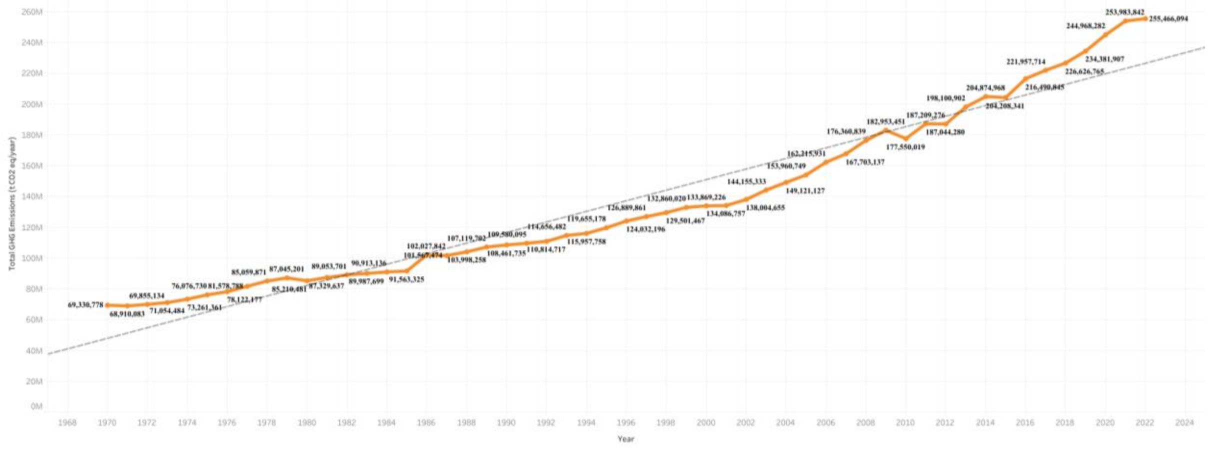

Figure 2: Total GHG Emissions

The agricultural GHG emissions in Pakistan have increased at a dramatic level since 1970 to 2022, as shown in Figure 2, where they increased by nearly 300% from 69M t CO2eq/year to over 255M t CO2eq/year during the same period. This sharp upward trend is especially noticeable in the 2010s, when farming activities in Pakistan were intensified, mechanisation was adopted, and urea became widely used. Urea has a share of 65% of the overall fertiliser manufacturing, and it meets 75% of the nitrogen requirements (Ali et al., 2016). This extreme dependence on nitrogenous fertilisers has been associated with poor nitrogen-use efficiency and high gaseous losses, resulting in NH3 and N2O emissions. The minor stagnation in the emissions during the period of 2007-2009 can be explained by major climate disturbances. During this period, Pakistan faced serious floods such as the 2007 South Asian floods and the 2009 Karachi floods that wiped out cropland and agricultural activities (Syed et al., 2022). These developments, however, failed to turn back the general trend of increasing GHG emissions as shown in the above graph.

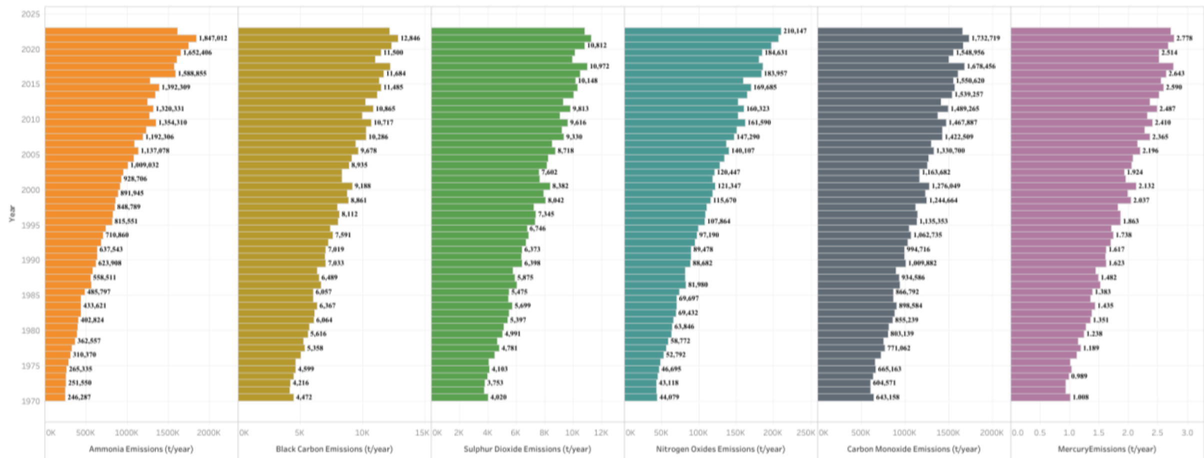

Figure 3: Air and Toxic Pollutants over time

Similar patterns of alarming growth are shown in Figure 3. The amount of NH_3 emitted in the atmosphere had risen tremendously from 0.2M t/year in 1970 to approximately 1.5M t/year in 2022. The increase is directly connected to the overuse of urea in crops (Ali et al., 2016). The NO_x emissions rose to 210K t/year in 2020 compared to 44k t/year in 1970, most likely due to nitrification emissions that came because of soils that were treated with chemical fertilisers as well as combustion sources related to farm machinery (Aziz et al., 2021). In the meantime, the CO emissions level increased from 0.6M t/year in 1970 to 1.7M t/year in 2022, with this tendency being linked to the popular practice of burning crop residues that is common in the Punjab and Sindh regions (Lin & Begho, 2022). In the same way, BC emissions were almost threefold and contributed to climate forcing and local air pollution. Although lower in quantity, the SO_2 and Hg emissions rose by 169% in line with the uncontrolled agricultural waste-burning.

These consistent trends of an increase in GHGs and air/toxic pollutants are an indication of the failure of the current regulations regarding agricultural emissions. The NDCs of Pakistan predict an increase in agricultural emissions of about 160% in the period between 2015 and 2030 (Climate Transparency Report, 2020). However, according to recent tendencies, real emissions are increasing at an even greater pace (268%). This discrepancy highlights a lack of an SBTi-compatible roadmap in agriculture and an overall failure to manage soil and fertilisers.

3.2 Hotspot Identification

The hotspot analysis is aimed at defining the main agricultural sources of NH_3 and NO_x emissions, as they are the only pollutants in the data set that have disaggregated source data. The graphs make it obvious that some sources are more dominant than others in the volume of emissions and the trends of growth.

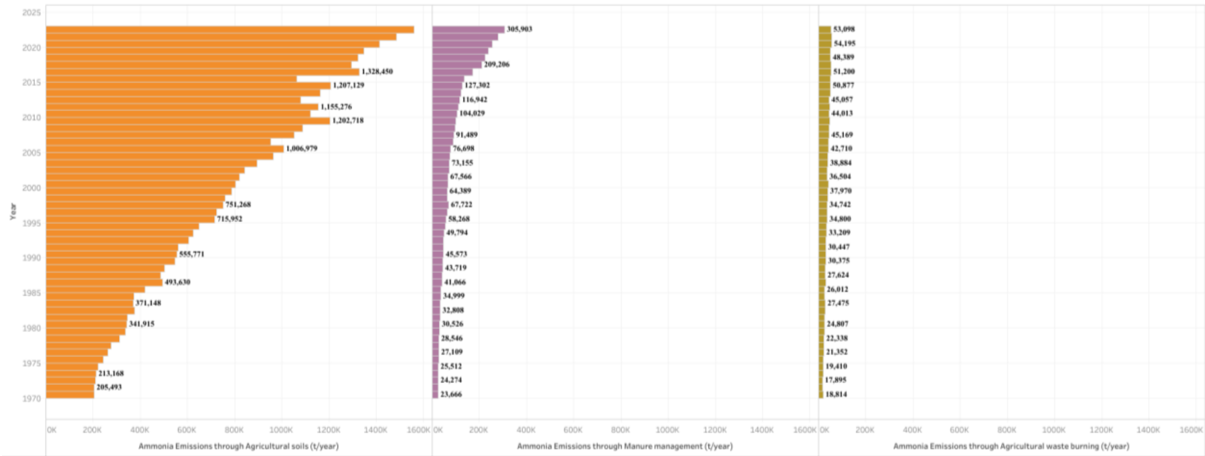

Figure 4: NH3 Emissions Breakdown

As Figure 4 shows, the release of emissions into agricultural soils vastly outweighs all other total NH3 emissions. In 2022, this type of emission was about 1.6M t/year. Its trend is sharply upwards since the 2010s and is associated with the increased application of the urea-based fertilisers and the increased area of irrigated agricultural land (Ali et al., 2016). As Aziz et al. (2021) explain, the use of nitrogen fertiliser in Pakistan has increased dramatically in the past twenty years, which has led to a lot of ammonia volatilisation.

The second largest source is manure management. In the year 2022, it constituted 305K t/year. The upward trend indicates the rise in intensification of the livestock production, especially in peri-urban dairy areas that have little infrastructure to accommodate proper waste management (Subhan, 2012). The lack of anaerobic digesters and the inefficiency of the old methods of storing waste have resulted in uncontrolled leakage of NH3 into the air. Finally, the burning of agricultural waste is a small-scale source that stays at a level of 53K t/year in 2022. Although this figure seems relatively small, its aggregate effect with BC, CO, SO2 and Hg aggravates it to be a cross-cutting emission issue.

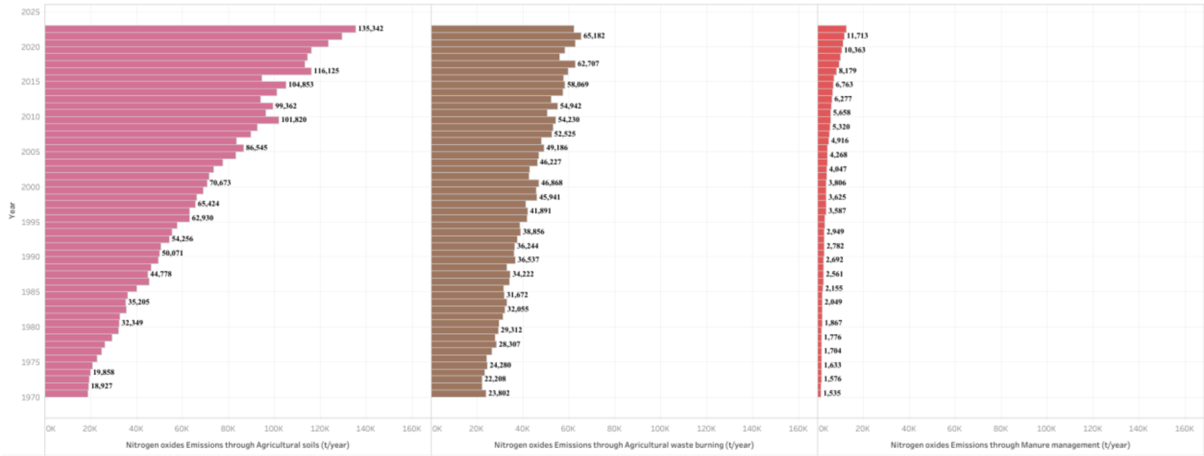

Figure 5: NOx Emissions Breakdown

An almost mirror trend can be seen in Figure 5. The highest contributor to NOx emissions was agricultural soil, which amounted to more than 135K t/year in 2022. This is associated with increased nitrification and denitrification processes that are triggered by the use of urea (Aziz et al., 2021). As Pakistan is one of the leading nitrogen over-users in South Asia, the soil-based NOx emissions indicate a systematic failure of fertiliser application and soil health management (Shahzad et al., 2019). In 2022, agricultural waste burning and manure management contributed to about 65k t/year and 11K t/year respectively. Waste burning NOx emissions relate to crop residue clearance patterns, and NOx associated with manure management has doubled since 1990, reflecting an increase in herd size and uncontrolled open-pit manure management in the rural areas (Riaz, 2022).

Although NH3 and NOx enabled disaggregation by source, BC, CO, SO2 and HG are simply ascribed to agricultural waste burning in the data because they do not enable multi-source hotspot separations.

3.3 Correlation between Time and GHG

A Pearson correlation analysis was conducted between time (variable 'Year' in the dataset) and various emission types to assess the dynamics of emissions (see Appendix C).

Table 2: Pearson Correlation Results

Variable	Pearson Correlation with Year	Significance (p-value)
Total GHG Emissions (t CO_2 eq/year)	0.971	<.001
Total Ammonia (NH_3) Emissions (t/year)	0.986	<.001
Total Black Carbon (BC) Emissions (t/year)	0.99	<.001
Total Carbon Monoxide (CO) Emissions (t/year)	0.99	<.001
Total Nitrogen Oxides (NO_x) Emissions (t/year)	0.991	<.001
Total Sulphur Dioxide (SO_2) Emissions (t/year)	0.992	<.001
Total Mercury (Hg) Emissions (t/year)	0.992	<.001

Table 2 shows a strong positive correlation between Year and Total GHG Emissions with a Pearson coefficient of 0.971 ($p < 0.001$). This statistically significant correlation suggests that as time progresses, total GHG emissions in Pakistan's agriculture sector have consistently increased.

In statistical terms, a Pearson correlation coefficient close to +1 implies a near-perfect linear relationship. Therefore, a value of 0.971 indicates that the rise in GHG emissions is tightly aligned with time, revealing a long-term systemic trend rather than random fluctuations. This escalation likely stems from intensified farming practices, growing reliance on synthetic fertilisers, increased livestock populations and expanded agricultural land use, especially in provinces like Punjab and Sindh (Jamil et al., 2021).

This trend is mirrored across other pollutants as well. NH_3 ($r = 0.986$), BC ($r = 0.99$), CO ($r = 0.99$), NO_x ($r = 0.991$), SO_2 ($r = 0.992$) and Hg ($r = 0.992$) all display similarly high correlations with time, underscoring the growing environmental externalities of conventional agriculture. The consistent rise across pollutants also highlights that GHGs are not increasing in isolation; air/toxic pollutants are following a concurrent upward trajectory, which may compound ecosystem degradation and public health risks.

3.4 Policy & System-Level Gaps

This review of past trends in GHG and air/toxic pollutants in Pakistan's agriculture sector has shown that there has been a systematic failure to reduce emissions, despite accumulating evidence of their environmental and health effects. The sharp and continuous increase in overall GHG emissions, as illustrated in Figure 2, shows that structural decoupling between agricultural productivity and environmental degradation does not exist. However, this is not merely a shortcoming of the farm-level practice but policy, institutional and data governance gaps that have plagued the sector throughout decades.

To begin with, Pakistan does not have a roadmap for the agriculture sector aligned to SBTi. In contrast to the Netherlands and Denmark, which have already adopted decarbonization pathways specific to various sectors with targets, the NDCs of Pakistan under the Paris Agreement treat agriculture as a cross-cutting issue of vague concern instead of a sector that needs specific attention. Thus, although the emissions have skyrocketed in all categories, there are no binding caps, sectoral incentives or emission performance thresholds to act as a mitigation guide.

Second, on the farm level, lifecycle emissions accounting is not well developed. The emissions data are aggregated and outdated and have not been disaggregated at the regional, crop type or production method levels. It not only hinders evidence-based policymaking but also hinders the implementation of carbon credit mechanisms or regenerative agricultural programs. The 2020 Census of Agriculture in Pakistan did not even attempt some form of environmental indicator integration, due to a lack of satellite-based Monitoring, Reporting and Verification (MRV) systems as used in Brazil and Indonesia (Joseph et al., 2013).

The third important gap is the excessive use of reactive and distortionary policy measures like input subsidies on urea fertiliser, water-intensive crops and diesel-powered irrigation pumps by Pakistan (Nizamani, 2024). Such short-term policies have inadvertently encouraged emissions-intensive activities and displaced investment in climate-resilient technologies such as drip irrigation, crop diversification and biofertilisers. As an example, the annual budget on urea subsidies amounts to PKR 200B, with no allocation of those funds requiring any environmental adherence (Anjum, 2021).

Moreover, there is no official incorporation of emissions responsibility in the agricultural extension system. The productivity of provincial agriculture departments is assessed on measures such as hectares farmed and yields per acre, with no connection to environmental performance. This forms a siloed system of governance in which environmental issues are considered marginal.

NH_3 and NO_x emissions are localised in agricultural soils and manure management, thus indicating the existence of certain hotspots that can be addressed. However, there are no compulsory manure management codes in Pakistan as it is in the EU through the Nitrates

Directive (European Commission, 2021). This is an indication of a regulatory vacuum with an untrained farmer without incentives.

4. Recommendations

To achieve a net-zero economy in the agriculture sector of Pakistan, policy action should go beyond a collection of piecemeal efforts. Considering the analysis conducted, the following five target-oriented recommendations are proposed:

4.1 Launch a National Agriculture Emissions Strategy

The agriculture sector in Pakistan does not have a formal roadmap for emissions reduction. To deal with this, the government needs to initiate a National Agriculture Emissions Strategy by 2026. This plan must aim to achieve a 25% reduction in GHG emissions by 2035 by keeping 2022 as a benchmark.

The strategy should include:

- Emission reduction targets by provinces tailored to land use and crop profiles.
- A layered emissions reduction model focusing on high-impact districts first.
- Integrate the local agriculture systems with an embedded MRV system using satellite data.
- A net-zero registry for farms above 100 acres to record annual emissions.

Example: India's Long-Term Low Carbon Development Strategy that quantifies and categorises decarbonising rice and livestock systems can be taken as an example (Ministry of Environment, Forest and Climate Change, 2022).

Target: A 25% reduction in agricultural GHGs by 2035.

4.2 Reform Fertiliser Subsidies

The Pakistani government subsidies on urea encourage overuse; however, the hotspot analysis revealed that the majority of NH_3 and NO_x emissions are related to agricultural soils. A subsidy reform programme should be implemented to shift to emissions-weighted subsidies.

This policy should:

- Provide 50% cost-sharing for controlled-release and bio-based fertilisers for smallholders under 10 acres.

- Offer input vouchers only for low-emission irrigation drip systems.
- Ban subsidies for urea applications above a per-acre threshold without a soil nutrient test certificate.

Example: India's Nutrient-Based Subsidy scheme (Ministry of Chemicals and Fertilizers, 2018) and China's Zero Growth Fertiliser Use initiative show that justifying input use can increase yields and reduce emissions (Cheng et al., 2024).

Target: Convert 40% of Punjab and Sindh's fertiliser subsidy budget to climate-smart inputs by 2027.

4.3 Operationalise Provincial Climate Units

Provinces cannot respond because of the centralised character of emissions tracking in Pakistan. An emissions governance system should be developed by creating Provincial Climate Units (PCUs) by 2026. These PCUs will be responsible for:

- Collect field-level emissions data through IoT.
- Develop district-wise emission heatmaps for strategic planning.
- Host public dashboards linked with the National Database and Registration Authority (NADRA) infrastructure.

Example: The GHG MRV system in Ethiopia can be taken as an example. The system offers sub-national emissions governance (Environmental Protection Authority, 2019). Each PCU should be mandated to publish an annual emissions bulletin.

Target: Establish functional PCUs in Punjab, Sindh, KP and Baluchistan by 2026 with operational MRV dashboards.

4.4 Introduce a National Manure Management Code

Pakistan lacks any legal code of practice on manure use, although manure management caused 305K tonnes of NH_3 emissions in 2022. A National Manure Management Code (NMMC) must be implemented by 2026 and should be regulated by the Ministry of National Food, Security and Research.

Key components should include:

- Legal mandates for covered manure storage on all farms.

- Incentives for the use of biodigesters with 50% capital cost grants.
- A cooperative-led manure marketplace that would enable resale to biogas firms.

Target: Achieve 60% compliance with the NMMC among commercial farms by 2028.

4.5 Establish an Agriculture Carbon Council

Fragmented governance is a critical barrier to controlling agricultural emissions. A high-level Agriculture Carbon Council (ACC) must be formed by 2026 under the Ministry of Climate Change. The ACC would:

- Standardise emissions across all climate-agriculture programs.
- Serve as the national accreditor for carbon offset schemes in agriculture.
- Coordinate access to climate finance.
- Facilitate public-private partnerships for Agri-tech innovation and emissions tracking.

Target: KPIs must include measurable emissions reduction, cross-institutional program integration and mobilisation of at least PKR 200B in climate finance by 2030.

5. Ethical Considerations

The goal of net-zero emissions in the agriculture sector in Pakistan needs to be more than just technical and must include an ethical system that protects the integrity of data, fairness of policy and rights of the vulnerable farming communities.

5.1 Analytical Integrity and Data Ethics

This project uses the EDGAR database that combines the emissions of each sector and pollutant over time. Although this increases transparency and accessibility, ethical research practice requires an understanding of how the data can be processed, interpreted and visualised. SPSS and Tableau were applied to analyse variables without altering raw values, and all transformations of the data, including trend segmentation and correlation analysis, have been reported. Nevertheless, there are still limitations. The data is only aggregated at the national level, with no regional or farm-level granularity. In the case of further analysis, findings should not be overgeneralised, and any assumptions should be well communicated.

5.2 Policy Equity and Just Transition

Not only is the agricultural sector of Pakistan the biggest contributor to GHGs, but it is also the biggest provider of rural jobs. Mitigation policies such as fertiliser limits and manure control may damage smallholder farmers who are financially vulnerable and do not have technical options available. As Adow et al. (2023) note, ethical decarbonisation should be aligned to the principle of a just transition, which is that emission reductions must be socially inclusive and marginalised groups must be supported in the process through subsidies, access to credit and capacity-building. The design of policy instruments should consider the size of land, the level of income and resource limitations.

5.3 Bias and Data Gaps

The project has found the most important hotspots of emissions, although the socio-demographic details are not present because of the limitations of the data. Therefore, the varying effects by gender or type of farm have not been evaluated. This emphasises the moral imperative of future datasets to combine environmental information with human development metrics for equitable policymaking.

5.4 Accountability, Risk and Greenwashing

The danger of greenwashing increases due to the increasing policy trend of carbon neutrality as a buzzword. Net-zero agriculture claims should have third-party verification, lifecycle emissions and quantifiable results. In the absence of transparency and verification, net-zero targets are likely to turn into mere window dressing instead of proper climate action.

6. Conclusion

This project critically analysed the agriculture sector of Pakistan based on environmental analytics and sustainability objectives. It used 52 years of longitudinal data to find concerning patterns in GHG and air/toxic pollutant emissions. The analysis showed that there was a steady increase in emissions over the period, proving how dire the situation is and how much intervention is needed.

The systemic obstacles of fragmented policy, non-alignment with SBTi and inadequate monitoring exist. The recommendations suggested providing a focused, evidence-based roadmap. In addition, the realisation of net-zero in agriculture should also be ethical. Mitigation policies should not overburden the smallholders who are already susceptible to climate shocks.

Responsible use of environmental analytics has the potential to aid in the fair design of policies and speed up the process of climate resilience transformation in Pakistan. The moment is here, and the tools, data and structures are already at hand.

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Appendix

Appendix A

Agriculture Emissions of Pakistan (final).xlsx

Appendix B

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Total GHG Emissions (t CO2 eq/year)	53	68910083.000	255466094.00	136920185.11	54671165.692
Total Ammonia (NH3) Emissions (t/year)	53	246287.22	1847011.84	865689.5391	466063.54340
Total Black Carbon (BC) Emissions (t/year)	53	4169.18	12846.37	8150.3060	2515.82180
Total Carbon Monoxide (CO) Emissions (t/year)	53	600998.20	1732719.14	1135406.9319	329818.43335
Total Nitrogen oxides (NOx) emissions (t/year)	53	42678.03	210146.61	112113.4289	48605.26244
Total Sulphur Dioxide (SO2) Emissions (t/year)	53	3724.32	11255.61	7326.4511	2246.41835
Total Mercury (Hg) Emissions (t/year)	53	.926172	2.777825	1.84341538	.566117984
Valid N (listwise)	53				

Appendix C

Correlations

		Year	Total GHG Emissions (t CO2 eq/year)	Total Ammonia (NH3) Emissions (t/year)	Total Black Carbon (BC) Emissions (t/year)	Total Carbon Monoxide (CO) Emissions (t/year)	Total Nitrogen oxides (NOx) emissions (t/year)	Total Sulphur Dioxide (SO2) Emissions (t/year)	Total Mercury (Hg) Emissions (t/year)
Year	Pearson Correlation	1	.971**	.986**	.990**	.990**	.991**	.992**	.992**
	Sig. (2-tailed)		<.001	<.001	<.001	<.001	<.001	<.001	<.001
	N	53	53	53	53	53	53	53	53
Total GHG Emissions (t CO2 eq/year)	Pearson Correlation	.971**	1	.989**	.974**	.969**	.988**	.968**	.963**
	Sig. (2-tailed)	<.001		<.001	<.001	<.001	<.001	<.001	<.001
	N	53	53	53	53	53	53	53	53
Total Ammonia (NH3) Emissions (t/year)	Pearson Correlation	.986**	.989**	1	.987**	.984**	.996**	.984**	.981**
	Sig. (2-tailed)	<.001	<.001		<.001	<.001	<.001	<.001	<.001
	N	53	53	53	53	53	53	53	53
Total Black Carbon (BC) Emissions (t/year)	Pearson Correlation	.990**	.974**	.987**	1	1.000**	.993**	.999**	.998**
	Sig. (2-tailed)	<.001	<.001	<.001		<.001	<.001	<.001	<.001
	N	53	53	53	53	53	53	53	53
Total Carbon Monoxide (CO) Emissions (t/year)	Pearson Correlation	.990**	.969**	.984**	1.000**	1	.991**	1.000**	.998**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001		<.001	<.001	<.001
	N	53	53	53	53	53	53	53	53
Total Nitrogen oxides (NOx) emissions (t/year)	Pearson Correlation	.991**	.988**	.996**	.993**	.991**	1	.991**	.988**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001		<.001	<.001
	N	53	53	53	53	53	53	53	53
Total Sulphur Dioxide (SO2) Emissions (t/year)	Pearson Correlation	.992**	.968**	.984**	.999**	1.000**	.991**	1	.999**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	<.001		<.001
	N	53	53	53	53	53	53	53	53
Total Mercury (Hg) Emissions (t/year)	Pearson Correlation	.992**	.963**	.981**	.998**	.998**	.988**	.999**	1
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	<.001	<.001	
	N	53	53	53	53	53	53	53	53

**. Correlation is significant at the 0.01 level (2-tailed).