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Household Economic Burden of Pollution Around the Nandipur Power Plant, Pakistan

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ABSTRACT

The system of thermal power generation continues to play the center stage in the electricity production sector of Pakistan, but its local social and economic implications remain under-studied. The article is a research on the economic cost of the household in terms of pollution surrounding the Nandipur Power Plant in Gujranwala, Pakistan. The study based on the cross-sectional survey of 100 respondents in the assessment of the translation of the pollution-related stress into the household cost is examined along three lines of explanations: health impact, migration pressure, and agriculture-related impact. Total Economic Burden (TEB) is used as the dependent variable. The results indicate that the regression model is statistically significant and it explains 46.5% of the variation in TEB. Household burden is positively and significantly related to health impact whereas migration pressure is the strongest predictor in the model. Impact associated with agriculture is also significant; however, it carries a negative value, indicating more complicated relationship to consider. Descriptive results also indicate that there is a general understanding of an increasing smoke, dust, and deteriorating air quality and that there is a strong degree of dissatisfaction with the official attempts to control pollution. Practical mitigation measures such as air filters and green belts are greatly preferred by respondents to relocation. The study reaches a conclusion that pollution surrounding the Nandipur Power Plant is not just an environmental problem but also a problem in the household welfare and governance. It thus requires more vigorous scrutiny, more plausible local mitigation and policy responses that directly alleviate the load on the communities at risk.

1. Introduction

Even as the environmental pressures and air-quality issues have been increasingly becoming a focus of discussions in the national policy, the electricity sector in Pakistan remains largely dependent on thermal generation (NEPRA, 2024). Scenario planning on the power system in Pakistan over long-term also demonstrates that reliance on fossil fuel continues to be a significant sustainability problem to the energy prospects of the country (Joyo et al., 2025). Simultaneously, sectoral analysis of emissions has shown that to decrease greenhouse-gas intensity and enhance the environmental performance, it is crucial to decarbonize the power sector (Umer et al., 2024). These processes render the analysis of not only the energy transitions of countries but also the localized load around the large-scale power plants more and more significant.

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This local outlook is important since it is not through the emission inventories or regulation reports that one would experience pollution. It is also felt in sickness, the expenses of treatment, and disrupted employment, loss of comfort in the environment, and doubt about whether the governmental establishments are doing the right thing. The National Clean Air Policy of Pakistan clearly acknowledges the health, economic and environmental impacts of poor air quality and the industrial and energy-related sources as the priorities of the policy (Government of Pakistan, Ministry of Climate Change, 2023). A recent clean-air initiative by the World Bank in Punjab echoes this idea that long-term institutional change is required in case communities should witness any significant changes in exposure and health protection (World Bank, 2025).

New research also indicates that the environmental governance in Pakistan is limited by the gaps in implementation, disjointed institutions, and the lack of equal enforcement opportunities (Waheed et al., 2024). Consequently, environmental exposure costs tend to be pushed down to households which have to deal with risk by using personal coping mechanisms as opposed to using effective communal protection. This is particularly true in the lower- and middle-income setting where families take on environmental harm via out-of-pocket medical expenditures, mobility adaptation, loss of time, and livelihood stress.

The Nandipur Power Plant has come in handy to discuss this issue at the household level. The current research paper dwells on the translation of pollution around the plant into both direct and indirect economic burden to the households around the area. The model is analytical and focuses on Total Economic Burden (TEB) and assesses three routes by which the burden can escalate: health impact, migration pressure, and agriculture-related impact. This framing is significant since it does not remain in a very technical approach of understanding pollution but how environmental exposure re-formats the daily economic life of the surrounding communities.

Of interest in this respect is the migration pressure. Environmental stress not only affects the health negatively, but also disrupts the household planning, exerts strain on settlement decisions, and adds cost on sustaining the residence and livelihood in the worsening environmental conditions. The study of climate-related human mobility in Pakistan reveals that ecological stress may increase vulnerability and alter movement patterns, as well as create significant adjustment costs to households (UNDP, 2024). Migration pressure in these contexts must not be seen as simply relocation but a broader sense of economic insecurity associated with place, migration and adjustment.

It is against this background that the article raises just one key question: **How does pollution around the Nandipur Power Plant translate into household economic burden for nearby residents?** It contends that the load is organized within recognizable socio-economic channels and supported by a poor trust in the local environmental regulation. Through the analysis of this relationship, the article has input in the discussions of pollution, welfare and the invisible social costs of the fossil-fuel reliant development in Pakistan.

2. Literature Review

Literature on the power sector in Pakistan reveals that thermal generation is still a significant portion of the electricity production, even though there is increasing pressure to diversify and decarbonize the sector (NEPRA, 2024). Scenario-based modelling also implies that the sustainability of energy in Pakistan in the long-run is contingent on the decrease in fossil-fuel intensity and restructuring of the electricity production structure (Joyo et al., 2025). It implies that the question of the adequacy of supply is no longer the sole one, but the social and environmental cost of the manner of the supply production is also a matter of concern.

The second line of literature connects the pollution burden in Pakistan with the deterioration of health. The outdoor and indoor air pollution are recognized as significant contributors to respiratory illness, cardiovascular disease, and broader public-health risk (Government of Pakistan, Ministry of Climate Change, 2023). WHO health and environment scorecard of Pakistan also shows significant discrepancies between the present exposure status and safe health levels, particularly concerning the burden due to PM2.5 (World Health Organization [WHO], 2025). The climate and health vulnerability assessment by the World Bank equally presents that the health risk and exposure to climate are tightly intertwined in the development situation in Pakistan (World Bank, 2024).

This aspect of health is supported by empirical studies. Lin et al. (2024) discovered that there was a significant relationship between respiratory hospitalization and emergency visits and short-term exposure to PM2.5 and its components in Karachi. Noor et al. (2023) demonstrated that the symptoms of acute respiratory infections in children were linked to the polluting household heating fuels in Punjab. Ishfaq et al. (2024) also revealed that the exposure to indoor air pollution in Multan is highly influenced by socioeconomic factors and domestic conditions. Cumulatively, these studies indicate that pollution in Pakistan is to be construed as both an environmental and household welfare issue.

A third theme is on governance and implementation. Waheed et al. (2024) claim that the environmental governance in Pakistan is still undermined by the disjointed policy implementation and unequal institutional functioning. The wider policy analysis has

also observed that even when there is policy intent on the air-quality regime, Pakistan has been found to have deficits in implementation (Zahid et al., 2025). The policy meaning behind this fact is evident: it is not the mere presence of formal policies that households consider important with regard to environmental governance, but the presence of inspections, standards, and exposure reduction that they can observe. In places where these mechanisms are weak, the pressure on the environment increases due to the fact that the risk is in fact privatized.

A fourth dimension relevant is the literature on mobility and environmental stress. The UNDP recent report on climate-related human mobility in Pakistan states that the environmental pressures can contribute to the household vulnerability and reshape the residence choices, as well as complicate the adaptation routes (UNDP, 2024). This implies that migration pressure cannot be considered merely as a demographic outcome. It can also be interpreted as an economic cost with uncertainty, transportation cost, potential displacement, and the temporary adaptation and breaking livelihood networks. Such pressure can be created even prior to the physical relocation of households in polluted industrial or energy-impacted environments.

The recent air-pollution studies by Pakistan also indicate the more material effects of smog and the exposure of particles. According to Razzaq et al. (2024), smog has become a topical problem in Lahore, which has health and agricultural productivity implications. Similar results are presented by Khan et al. (2025), indicating that PM2.5 exposure in Pakistan is an increasing mortality risk and will likely escalate unless there is a turnaround in the trends of pollution. The relevance of the findings to the current study is that the study confirms the hypothesis that pollution burden is multidimensional and can be working simultaneously by health, livelihood and place-based insecurity.

Lastly, the policy-based environmental evaluation shows that to alleviate the pressure of pollution in Pakistan, technical alleviation and institutional fortification are needed. Slater et al. (2024) approximate that the national PM2.5 emission would decrease significantly should the clean-air policy of Pakistan be implemented provided that priority mitigation measures are implemented in reality. The economic argument of the fact that outdoor air pollution is a significant social cost and that policy action is not only justified by environmental but also economic considerations was previously made by the World Bank (World Bank, 2014). Collectively, these literatures justify a household-burden framework that relies on three propositions: pollution has the potential to create measurable cost associated with health, environmental stress has the potential to augment pressure associated with mobility, and ineffective governance can augment the two burdens.

3. Methodology

The current research design was a cross-sectional survey of households residing near the Nandipur Power Plant in Gujranwala, Punjab to investigate the economic cost of pollution in the area. The study site was chosen due to its close proximity to a large thermal power plant and its suitability in the evaluation of household-level exposure, perceived environmental degradation, and the socio-economic cost. The primary data were gathered by using a structured questionnaire that was to be completed face-to-face by the people in the locality. The last sample was composed of 100 respondents. The Cochran formula was used to derive the sample size and according to the study, the simple random sampling was employed in data collection.

The questionnaire included data on demographic, household economic status, environmental awareness, and perceived impacts of pollution and perceptions of government response and mitigation strategies. Secondly, the survey was a source of the main analytical variables in the regression model. Total Economic Burden (TEB) was the dependent variable, which is in the form of household economic cost. The explanatory variables were Health Impact Index (HEALTHINDEX1), Migration Index (MIGRATIONINDEX), and Agriculture Impact Index (AGRICULTUREINDEX1). These variables were chosen since the conceptual framework of the study considered health-related cost, migration pressure, and agriculture-related stress as the primary channels by which the pollution impacts on the households around the study area.

Data analysis was done with the aid of SPSS. The analysis plan was a combination of descriptive statistics and multiple regression. The numbers of households and their characters and perceptions of pollution were summarized with frequency distributions and the regression analysis to test whether the 3 explanatory indices could explain the TEB. The approximate model is:

$$\mathbf{TEB = \beta_0 + \beta_1(Health\ Impact) + \beta_2(Migration\ Pressure) + \beta_3(Agriculture\ Impact) + \varepsilon.}$$

The model summary reported $\mathbf{R = 0.682}$, $\mathbf{R^2 = 0.465}$, **adjusted** $\mathbf{R^2 = 0.449}$, and $\mathbf{F(3,96) = 27.852}$, $\mathbf{p < .001}$, indicating that the model explained a meaningful share of the variation in household burden. The **Durbin-Watson statistic of 1.825** suggested that autocorrelation was not a serious concern.

The research further recognizes the constraints in the practical fieldwork such as time, transport challenges, and social constraints to access and disclosure of respondents. The results can only be viewed as evidence of correlation and not causation since the survey was cross-sectional and relied on self-reported answers.

4. Results and Discussion

The descriptive evidence shows that pollution around the Nandipur Power Plant is more of a long-lasting local issue and not a nuisance. The majority of the respondents said they were witnessing more smoke or dust, worse air quality, regular unpleasant smell or smog in the neighborhood. Such reactions indicate that the burden of households is based on their recurring exposure and daily environmental distress. Such trends are not isolated to Pakistan, and broader clean-air issues, in which industrial and energy-related emissions are seen as a significant contributor to the local exposure and health risk (Government of Pakistan, Ministry of Climate Change, 2023).

Spatial spread perceptions are also interesting. A large number of the respondents felt that there were both similar and broadly similar impacts in the rural and urban areas. This implies that pollution is not perceived to be a limited issue that is defined to say one installation, but is a broader environmental state concerning settlements and livelihoods related to other areas. Practically speaking, that extends the definition of household burden: families can be affected by pollution not just by being close, but also by more extensive economic and social connections within the locality.

One of the main findings of the research is related to governance. There was poor confidence in government policy, the respondents were lowly trusting the frequency of the inspection, and the views of the official mitigation efforts were highly negative. This analytical significance is important since it demonstrates that it is not just exposure to pollution that is felt, but regulatory failure also. Such interpretation aligns with broader studies that the environmental governance system in Pakistan tends to be weakened by implementation gaps and lack of even enforcement capacity (Waheed et al., 2024). It is also congruent with the most recent policy analysis that suggests that the air-quality regime in Pakistan is not so bad due to lack of policy as it is bad due to poor implementation of the current commitments (Zahid et al., 2025).

This is further enhanced by the preferences of mitigation that were indicated in the survey. Majority of the respondents were not in support of relocation but practical measures like air filters or green belts were strongly supported by majority. This implies that neighboring households are not at the forefront to get out of the area, but they want to be seen to have exposure-reduction efforts so that they can maintain residence, livelihood, and continuity in social life. The rationale of the clean-air policy of Pakistan is that such a preference is to control and mitigate emissions rather than to displace (Government of Pakistan, Ministry of Climate Change, 2023).

These descriptive patterns are confirmed by the inferential results to be attributable to household cost that can be measured. The regression model is statistically significant in general and it explains 46.5% of the variation in Total Economic Burden. This is a significant amount of explanatory power in the case of a household environmental survey. It implies that the economic strain which households report is not arbitrary and purely perceptional, but systematically connected to discernible routes of stress.

Table 1

Summary of main empirical findings

Dimension	Main finding	Interpretation
Environmental perception	Respondents reported worsening smoke/dust, poorer air quality, and recurrent smog/unpleasant smell	Pollution is experienced as continuous and locally significant
Spatial reach	Many respondents believed rural and urban areas are affected alike	Burden is understood as regionally shared, not site-confined
Government response	Low confidence in policy effectiveness, inspections, and mitigation effort	Pollution is also interpreted as a governance failure
Preferred response	Stronger support for filters/green belts than relocation	Households prefer in-place mitigation over displacement
Model fit	$R = 0.682$; $R^2 = 0.465$; adjusted $R^2 = 0.449$; $F(3,96) = 27.852$, $p < .001$	Household burden is systematically explained by modeled pressures
Health impact	Positive and significant predictor of TEB	Pollution raises burden through illness and treatment costs
Migration pressure	Strongest predictor of TEB	Environmental insecurity creates major adjustment and mobility-related cost
Agriculture impact	Significant but negative coefficient	Agriculture-related stress matters, but its direction is more complex

The Health Impact Index is positively and significantly associated with Total Economic Burden (**$B = 125{,}156.24$; $\beta = 0.352$; $t = 4.613$; $p < .001$**). This means that pollution increases household expenses in terms of illness, cost of treatment, medical checkups and coping expenses. The outcome is plausible substantively and conforms to broader Pakistani data on the

relationship between the exposure to particulate matter and respiratory injury and household stress on health. Pakistanese research has recently revealed that PM2.5 exposure can be linked to respiratory morbidity, whereas polluted household energy conditions are still related to acute respiratory symptoms, particularly in Punjab (Lin et al., 2024; Noor et al., 2023).

The Migration Index is the strongest predictor in the model (B = 132,878.70; β = 0.677; t = 8.666; p < .001). This is among the significant results as it indicates that the burden in the house extends beyond direct medical expense. Migration pressure is a measure of the instability in residence, uncertainty in adaptation, the adjustments that are made when moving, and the economic stress that is brought about when environmental insecurity is imposed on household planning. Although a family might not physically move, the strain that comes with the potential movement can be expensive in itself. Such a reading aligns with the recent studies that have found that mobility in Pakistan due to climate factors is directly connected with vulnerability, insecurity, and challenging adaptation decisions (UNDP, 2024).

The Agriculture Impact Index is also statistically significant, but its coefficient is negative (**B = -63,322.80; β = -0.165; t = -2.154; p = .034**). This finding is to be handled with reservations. The sign indicates that the effect of agriculture-related stress is not a mere direct-loss effect in this sample, and, perhaps, represents mixed livelihoods, coping mechanisms, or variable-construction effects. The least risky explanation is that agriculture is still a component of the burden environment, and the economic connection between agriculture and health and migration is less direct than health and migration pathways. That warning is justifiable as there is more Pakistani evidence that pollution and smog can indirectly and directly impact agriculture and livelihoods (Razzaq et al., 2024).

The results, combined, depict high internal consistency. Homes indicate a deteriorating pollution, low confidence in the governmental reaction, and obvious approval of practical reduction. Meanwhile, the regression model shows that household economic burden is mainly caused by health impact and migration pressure. The greater implication is that pollution in the area of the Nandipur Power Plant is to be considered a local welfare issue that is influenced by both environmental exposure and institutional weakness concomitantly. Awareness in itself is not likely to make any difference as there is already awareness. It requires plausible enforcement, overt check-up, and alleviation that lessens the load of households exposed.

5. Conclusion

This research demonstrates that air pollution surrounding the Nandipur Power Plant is not just an environmental issue; it is an economic cost that is quantifiable on a household level. This burden is felt by the households in the vicinity in health-related costs, pressure of migration, and livelihood pressure at large. The model accounts for a significant proportion of change in Total Economic Burden with migration pressure being the most important predictor and a significant positive impact of health.

The statistical results are supported by the descriptive data. Respondents said that there were deteriorating smoke, dust, and air quality and low confidence in the effectiveness of policies, how often it is inspected and official mitigation efforts. Meanwhile, they favored sensible exposure-reduction strategies (air filters and green belts) to relocation. This shows that there is a need to have credible local protection as opposed to policy commitment.

The implication of the policy is obvious. The communities that are located around major thermal power installations need to be more inspected, more enforced and practical mitigation which minimizes exposure at both the source and household levels. A significant component of the cost of fossil-fuel dependence in the broader energy and environmental debate in Pakistan directly falls on household budget, insecurity and adaptation pressures. The burden on the environment of that household-level should not be considered secondary but central in the governance of the environment and in energy-policy design.

References

Government of Pakistan, Ministry of Climate Change. (2023). *National clean air policy (NCAP)*. https://mocc.gov.pk/SiteImage/Misc/files/NCAP%20%2828-02-2023%29%20v1.pdf

Ishfaq, M., Gill, A. R., & Ali, M. (2024). The socioeconomic determinants of indoor air pollution in Pakistan: A case study of Multan District. *Discover Sustainability, 5*, 420. https://doi.org/10.1007/s43621-024-00464-3

Joyo, F. H., Groppi, D., Kumar, L., Nastasi, B., & Astiaso Garcia, D. (2025). Achieving energy sustainability of Pakistan's power sector through long-term scenario modeling and analysis. *Energy, 328*, 136549. https://doi.org/10.1016/j.energy.2025.136549

Lin, Q., Lin, Z., Lin, S., Fatmi, Z., Rizvi, N. A., Hussain, M. M., Siddique, A., Moyebi, O. D., Carpenter, D. O., & Khwaja, H. A. (2024). Impact of fine particulate pollution exposures on respiratory health in a megacity of Pakistan. *Atmospheric Pollution Research, 15*(11), 102277. https://doi.org/10.1016/j.apr.2024.102277

National Electric Power Regulatory Authority. (2024). *State of the industry report 2024*. https://www.nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202024.pdf

Noor, A., Aftab, A., Aslam, M., & Imanpour, S. (2023). Household heating fuels impact on acute respiratory infection (ARI) symptoms among children in Punjab, Pakistan. *BMC Public Health, 23*, 2380. https://doi.org/10.1186/s12889-023-17044-1

Razzaq, A., Zafar, M. M., Zahra, L. T., Qadir, F., Qiao, F., Ullah, M. H., Shehzad, S., Rasool, G., & Jiang, X. (2024). Smog: Lahore needs global attention to fix it. *Environmental Challenges, 16*, 100999. https://doi.org/10.1016/j.envc.2024.100999

Slater, J., Aftab, L., Jamshaid, H., Amjad, M., Bashir, S., Shafique, S., Bathan, G., Espita-Casanova, D., & Malley, C. S. (2024). Modeling air pollutant emission reductions from implementation of Pakistan's 2023 Clean Air Policy. *ACS ES&T Air, 1*(1), 815–836. https://doi.org/10.1021/acsestair.4c00003

Umer, M., Abas, N., Rauf, S., Saleem, M. S., & Dilshad, S. (2024). GHG emissions estimation and assessment of Pakistan's power sector: A roadmap towards low carbon future. *Results in Engineering, 22*, 102354. https://doi.org/10.1016/j.rineng.2024.102354

United Nations Development Programme. (2024). *Anticipating the impacts of climate change related human mobility in Pakistan and Viet Nam*. https://www.undp.org/sites/g/files/zskgke326/files/2024-09/undp-ap-research-anticipating-the-impacts-of-climate-change-related-human-mobility-in-pakistan-and-viet_nam-2024.pdf

Waheed, A., Kousar, S., Khan, M. I., & Fischer, T. B. (2024). Environmental governance in Pakistan: Perspectives and implications for the China-Pakistan Economic Corridor plan. *Environmental and Sustainability Indicators, 23*, 100443. https://doi.org/10.1016/j.indic.2024.100443

World Bank. (2014). *Cleaning Pakistan's air: Policy options to address the cost of outdoor air pollution*. World Bank. https://openknowledge.worldbank.org/entities/publication/c747e7b5-c674-5ba6-a833-66e7940b6bb4

World Bank. (2024). *Pakistan climate and health vulnerability assessment*. World Bank. https://openknowledge.worldbank.org/entities/publication/cf397b19-6784-4882-845e-39a54b3bad37

World Bank. (2025). *Punjab clean air program (P508222): Environmental and social systems assessment*. World Bank. https://documents1.worldbank.org/curated/en/099022025154579912/pdf/P508222-d158acc9-958b-468a-8b24-14ef6258bc4b.pdf

World Health Organization. (2025). *Pakistan: Health and environment scorecard*. https://cdn.who.int/media/docs/default-source/country-profiles/environmental-health/environmental-health-pak-2025.pdf

Zahid, M., Khan, S., Saeed, A., & Haq, A. (2025). Current landscape and future directions of policies addressing air pollution and climate change in Pakistan. *Frontiers in Public Health, 12*, Article 1510678. https://pmc.ncbi.nlm.nih.gov/articles/PMC12746533/