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# Farmers' Perceptions of Smog in Punjab, Pakistan: A Quantitative Survey-Based Study

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## ABSTRACT

**Background:** Smog has become a major environmental concern in Punjab, Pakistan, with agricultural activities, crop-residue burning, vehicular emissions, and industrial pollution contributing to deteriorating air quality. Farmers are particularly important stakeholders because they both experience the effects of smog and can contribute to its seasonal occurrence through agricultural practices.

**Objective:** This study aimed to quantitatively assess farmers' perceptions of smog, its major causes, perceived effects on agricultural activities and health, and potential mitigation measures in Sargodha District, Punjab.

**Methods:** A quantitative survey was conducted among 218 farmers selected through simple random sampling from two tehsils of Sargodha District. Data were collected using a structured interview schedule based on a five-point Likert scale. The instrument was validated by agricultural extension experts and tested for reliability through a test–retest procedure involving 21 respondents. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used for analysis.

**Results:** The findings showed that 71.6% of farmers had a high overall perception of smog. Crop-residue burning received a high perception score (4.41 ± 0.71), while reduced visibility during farming activities (4.36 ± 0.73) was the most strongly perceived agricultural impact. Air-quality deterioration (4.45 ± 0.67) represented the highest environmental concern. Government intervention received the highest mitigation score (4.52 ± 0.63).

**Conclusion:** Farmers demonstrated substantial awareness of smog and supported integrated mitigation strategies involving awareness, extension services, affordable technologies, and effective government measures.

**Keywords:** Smog; Farmers; Punjab; Crop-residue burning; Air pollution

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## INTRODUCTION

Smog has emerged as one of the most serious environmental and public-health challenges in Pakistan, particularly in Punjab, where rapid urbanization, industrial development, transportation emissions, agricultural activities, and unfavorable winter meteorological conditions contribute to severe episodes of air pollution [1,2,3]. Smog is a complex mixture of particulate matter and gaseous pollutants that can substantially reduce air quality and visibility [4]. Fine particulate matter, particularly $PM_{2.5}$, is of major concern because its small size allows it to penetrate deeply into the respiratory system and enter the circulation, increasing the risk of respiratory and cardiovascular problems [5,6]. In Punjab, the problem becomes particularly pronounced during the autumn and winter months when atmospheric stagnation and temperature inversions restrict pollutant dispersion [7].

Agricultural communities are particularly relevant to the discussion of smog because farming activities can both contribute to and be affected by deteriorating air quality [8,9,10]. One of the most important agricultural sources of seasonal air pollution is open-field burning of crop residues [11,12]. In the rice–wheat cropping system of Punjab, farmers frequently burn rice straw to rapidly clear fields before wheat sowing [13]. Although burning provides a quick and inexpensive method of residue disposal, it releases particulate matter, carbon monoxide, nitrogen oxides, and other pollutants into the atmosphere [14,15,16]. The contribution of crop-residue burning to regional air pollution has consequently received increasing attention in Pakistan and other South Asian countries [17,18].

Farmers' decisions to burn crop residues are influenced by several socioeconomic and agricultural factors [19]. Short intervals between rice harvesting and wheat planting, high labor requirements, inadequate residue-management machinery, and the financial cost of alternative practices can encourage farmers to continue burning [20]. Thus, reducing

agricultural contributions to smog requires more than simply informing farmers about the environmental consequences of burning [21]. Farmers must also have access to practical, affordable, and timely alternatives such as residue incorporation, mulching, composting, baling, livestock utilization, and mechanical residue management [22,23]. Understanding farmers' perceptions is therefore essential for developing policies that are both environmentally effective and socially feasible [24].

Smog can also have direct consequences for agricultural productivity and farm operations [4]. High concentrations of atmospheric particulate matter can reduce visibility and interfere with outdoor activities, creating difficulties for farmers who work in open fields [25]. Particulate deposition on plant surfaces may also affect light interception and physiological processes, while air pollutants such as ozone can negatively influence photosynthesis, plant growth, and crop productivity [26,27]. Although the extent of these effects varies according to pollutant concentration, crop species, environmental conditions, and exposure duration, farmers' observations provide valuable information about locally experienced environmental changes [28].

The health implications of smog are another major concern for farming communities [8]. Farmers frequently spend prolonged periods outdoors and may therefore experience substantial exposure to polluted air during severe smog episodes [25,28]. Exposure to fine particulate matter has been associated with respiratory symptoms, cardiovascular disease, reduced lung function, and premature mortality [2,5]. Individuals engaged in physically demanding outdoor agricultural activities may be particularly vulnerable because increased breathing rates can increase pollutant intake [29]. Consequently, farmers' perceptions of smog-related health effects are important for understanding the broader social consequences of air pollution [30].

Despite the seriousness of smog in Punjab, relatively limited research has focused specifically on farmers' perceptions of the phenomenon and its relationship with agricultural activities [19]. Existing research has largely emphasized air-quality measurements, satellite observations, emission inventories, crop-residue burning, and health impacts [11,17]. While these approaches provide important scientific evidence, understanding farmers' knowledge, attitudes, and perceptions is equally important for designing effective interventions [11]. Studies have indicated that farmers' environmental perceptions, access to information, extension contact, perceived risks, and socioeconomic circumstances can influence their willingness to adopt sustainable residue-management practices [19].

Agricultural extension services have a particularly important role in this context [31]. Extension personnel can communicate information regarding the environmental and health consequences of residue burning and demonstrate practical alternatives [19,20]. Improved access to machinery, technical guidance, financial incentives, and locally appropriate residue-management technologies can further encourage farmers to shift away from open burning [19,20]. Policies that combine awareness with economic and technological support are likely to be more effective than regulatory measures alone [19].

Sargodha District provides an important setting for investigating these issues because agriculture constitutes a major component of rural livelihoods, while farmers may be exposed to seasonal air-pollution episodes [32]. Assessing their perceptions can provide useful evidence regarding their understanding of smog causes, perceived effects on crops and farm activities, health concerns, and expectations regarding government and extension interventions. Therefore, the present study was conducted to quantitatively assess farmers' perceptions of smog in Punjab, Pakistan, with particular emphasis on its perceived causes, agricultural and health impacts, and potential mitigation measures. The findings are expected to provide evidence that can support farmer-oriented awareness programs, sustainable agricultural practices, and more effective smog-management strategies in Punjab.

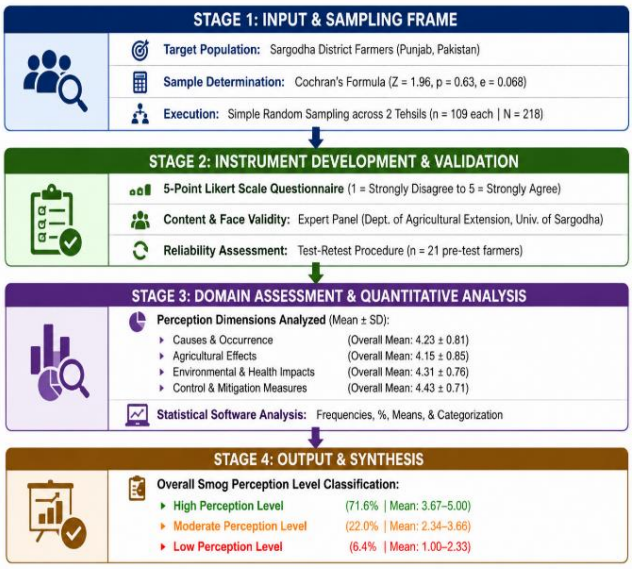
## METHODOLOGY

The study employed a mixed-methods research design; however, the present research article focused exclusively on the quantitative component to provide a concise statistical assessment of farmers' perceptions of smog in Punjab, Pakistan. The target population comprised farmers of Sargodha District, Punjab, and the sampling frame was developed from the list of farmers obtained from the Punjab Agricultural Extension Department. Since surveying the entire population was impractical, an appropriate sample was determined using Cochran's formula. The required sample size was calculated using a Z-value of 1.96 corresponding to a 95% confidence level, an estimated population proportion (p) of 0.63, and a margin of error (e) of 0.068 (6.8%). The resulting sample size was approximately 218 farmers. Two tehsils of Sargodha District were selected for the study, and 109 farmers were randomly selected from each tehsil, giving a total sample of 218 respondents. Simple random sampling was used to ensure that eligible farmers had an appropriate opportunity for selection.

Data were collected through a structured interview schedule developed specifically to assess farmers' perceptions regarding smog, its occurrence, possible causes, effects on agricultural activities, and perceived impacts on farming and the rural environment. The instrument consisted primarily of statements measured on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Before field administration, the questionnaire was evaluated for content and face validity by a panel of experts from the Department of Agricultural Extension and Rural Studies, University of Sargodha. Their recommendations were incorporated to improve the clarity, relevance, and appropriateness of the questionnaire items. The reliability of the instrument was assessed through a test–retest procedure involving 21 farmers who were not included in the final sample. The questionnaire was administered twice at an appropriate interval, and responses were compared to assess the consistency of the instrument. Based on the findings and expert recommendations, necessary revisions were made before the final survey.

The finalized interview schedule was administered to the selected farmers through face-to-face data collection. The purpose of the study was explained to participants before obtaining their responses, and respondents were encouraged to provide information according to their actual perceptions

and experiences. Participation was voluntary, and confidentiality of the collected information was maintained. The completed questionnaires were checked for completeness before coding and entry into a statistical database. The quantitative data were subsequently organized and analyzed using appropriate descriptive and inferential statistical procedures to summarize farmers' perceptions of smog and identify patterns in their responses. Frequency distributions, percentages, means, and standard deviations were used to describe the characteristics of respondents and their responses to the perception statements. The Likert-scale responses were coded numerically from 1 to 5, with higher scores indicating stronger agreement with the respective statements. The resulting quantitative findings were used to evaluate the overall level of farmers' perceptions regarding smog and its implications for agricultural activities in the selected areas of Sargodha District.




## RESULTS

A total of 218 farmers participated in the quantitative survey, with 109 respondents selected from each of the two sampled tehsils of Sargodha District. The results indicated that farmers had a generally high level of awareness and concern regarding smog and its potential effects on agricultural activities. The descriptive findings are presented below.

**Table 1. Demographic Characteristics of the Respondents**

| Variable | Category | Frequency | Percentage |
|---|---|---|---|
| Age | ≤30 years | 42 | 19.3 |
| | 31–45 years | 96 | 44.0 |
| | >45 years | 80 | 36.7 |
| Education | No formal education | 48 | 22.0 |
| | Primary | 53 | 24.3 |
| | Secondary | 61 | 28.0 |
| | Higher education | 56 | 25.7 |
| Farming experience | ≤10 years | 49 | 22.5 |
| | 11–20 years | 83 | 38.1 |
| | >20 years | 86 | 39.4 |
| Farm size | Small | 97 | 44.5 |
| | Medium | 79 | 36.2 |
| | Large | 42 | 19.3 |

The findings showed that the largest proportion of respondents (44.0%) belonged to the 31–45-year age group, followed by farmers older than 45 years (36.7%). Regarding education, 28.0% had secondary-level education, whereas 22.0% had no formal education. A considerable proportion of farmers (39.4%) had more than 20 years of farming experience, indicating that most respondents possessed substantial practical experience in agricultural activities. Small-scale farmers constituted the largest group (44.5%).

**Table 2. Farmers' Perceptions Regarding the Occurrence and Causes of Smog**

| Statement | Mean ± SD | Perception level |
|---|---|---|
| Smog is a serious environmental problem in the study area | 4.32 ± 0.78 | High |
| Smog has become more frequent in recent years | 4.18 ± 0.84 | High |
| Crop-residue burning contributes to smog | 4.41 ± 0.71 | High |
| Vehicular emissions contribute to smog | 4.27 ± 0.80 | High |
| Industrial emissions contribute to smog | 4.16 ± 0.86 | High |
| Weather conditions contribute to the persistence of smog | 4.05 ± 0.88 | High |
| Overall mean | 4.23 ± 0.81 | High |

Farmers demonstrated a high level of perception regarding the occurrence and causes of smog. The highest mean score was recorded for the statement that crop-residue burning contributes to smog (4.41 ± 0.71), followed by the perception that smog is a serious environmental problem (4.32 ± 0.78). Vehicular emissions also received a high mean score (4.27 ± 0.80). The overall mean of 4.23 indicated strong agreement among respondents concerning the major sources and increasing occurrence of smog.

**Table 3. Perceived Effects of Smog on Agricultural Activities**

| Statement | Mean ± SD | Perception level |
|---|---|---|
| Smog reduces visibility during farming operations | 4.36 ± 0.73 | High |
| Smog negatively affects crop growth | 4.12 ± 0.86 | High |
| Smog reduces sunlight available to crops | 4.25 ± 0.79 | High |
| Smog delays agricultural activities | 4.08 ± 0.91 | High |
| Smog affects crop productivity | 4.17 ± 0.84 | High |
| Smog can increase crop disease and pest problems | 3.89 ± 0.96 | High |
| Overall mean | 4.15 ± 0.85 | High |

The respondents perceived several adverse effects of smog on

agricultural activities. Reduced visibility during farming operations received the highest mean score (4.36 ± 0.73). Farmers also strongly agreed that smog reduces sunlight availability (4.25 ± 0.79) and affects crop productivity (4.17 ± 0.84). The lowest, although still relatively high, score was observed for the perception that smog increases crop disease and pest problems (3.89 ± 0.96).

**Table 4. Farmers' Perceptions of Smog-Related Environmental and Health Impacts**

| Statement | Mean ± SD | Perception level |
|---|---|---|
| Smog reduces overall air quality | 4.45 ± 0.67 | High |
| Smog causes breathing difficulties | 4.38 ± 0.74 | High |
| Smog reduces outdoor working comfort | 4.29 ± 0.78 | High |
| Smog affects visibility on roads | 4.34 ± 0.72 | High |
| Smog negatively affects the rural environment | 4.21 ± 0.81 | High |
| Smog creates difficulties for farm workers | 4.16 ± 0.83 | High |
| Overall mean | 4.31 ± 0.76 | High |

The overall mean score for perceived environmental and health impacts was 4.31 ± 0.76, indicating a high level of concern. The highest agreement was recorded for the statement that smog reduces overall air quality (4.45 ± 0.67), followed by breathing difficulties (4.38 ± 0.74) and reduced visibility on roads (4.34 ± 0.72). These findings suggest that farmers perceived smog not only as an agricultural problem but also as an important environmental and occupational concern.

**Table 5. Farmers' Perceptions of Smog Control and Mitigation Measures**

| Statement | Mean ± SD | Perception level |
|---|---|---|
| Farmers should avoid unnecessary crop-residue burning | 4.46 ± 0.69 | High |
| Government should strengthen anti-smog measures | 4.52 ± 0.63 | High |
| Farmers need awareness about alternatives to residue burning | 4.43 ± 0.70 | High |
| Public transport and vehicle emissions should be regulated | 4.38 ± 0.74 | High |
| Agricultural extension services should provide smog-related guidance | 4.35 ± 0.77 | High |
| Farmers should adopt environmentally friendly farming practices | 4.41 ± 0.71 | High |
| Overall mean | 4.43 ± 0.71 | High |

Farmers expressed strong support for measures aimed at reducing smog. Government intervention received the highest mean score (4.52 ± 0.63), while avoiding unnecessary crop-residue burning also received strong agreement (4.46 ± 0.69). Respondents further emphasized the need for awareness programs and extension services to promote alternatives to residue burning and environmentally sustainable agricultural practices.

**Table 6. Overall Level of Farmers' Perception of Smog**

| Perception category | Mean score range | Frequency | Percentage |
|---|---|---|---|
| Low | 1.00–2.33 | 14 | 6.4 |
| Moderate | 2.34–3.66 | 48 | 22.0 |
| High | 3.67–5.00 | 156 | 71.6 |
| Total | | 218 | 100.0 |

Overall, 71.6% of the farmers demonstrated a high level of perception regarding smog, whereas 22.0% showed a moderate level and only 6.4% demonstrated a low level. The findings indicate that the majority of farmers were aware of the seriousness of smog, its major contributing factors, and its potential consequences for agricultural activities and the rural environment.

Taken together, the results demonstrate that farmers in the selected areas of Sargodha District perceived smog as a significant environmental and agricultural concern. The strongest perceptions were related to air-quality deterioration, crop-residue burning, reduced visibility, health effects, and the need for stronger governmental and agricultural extension interventions

## DISCUSSION

The present study revealed that farmers in the selected areas of Sargodha District had a high overall perception of smog, with 71.6% of respondents demonstrating a high level of perception. This finding suggests that the majority of farmers were aware of smog as an important environmental problem and recognized its potential consequences for agriculture, human health, and the rural environment. Similar findings have been reported in previous studies showing that farmers' awareness of environmental pollution and the risks associated with agricultural residue burning can influence their perceptions and willingness to adopt more sustainable practices [19,32].

Among the perceived causes of smog, crop-residue burning received the highest mean score (4.41 ± 0.71). This finding is particularly relevant to Punjab, where rice–wheat cropping systems generate large quantities of crop residues [20]. Farmers often burn rice residues because burning provides a rapid and inexpensive method of field clearance before wheat cultivation [16]. Previous research in Punjab has shown that short sowing intervals, high labor costs, limited availability of residue-management machinery, and the cost of alternative practices are important factors encouraging farmers to burn crop residues [19,31]. Therefore, although farmers may be aware of the environmental consequences of burning, economic and operational limitations can make residue burning a convenient management option [19,31].

The respondents also strongly associated smog with vehicular emissions (4.27 ± 0.80) and industrial emissions (4.16 ± 0.86). These findings indicate that farmers perceived smog as a multifactorial environmental problem rather than attributing it solely to agricultural activities. Air pollution in Punjab is influenced by several sources, including transportation,

industrial emissions, agricultural burning, construction activities, dust, and other combustion processes [1,3,4]. In addition, winter meteorological conditions such as low temperatures, weak atmospheric mixing, and temperature inversions can restrict the dispersion of pollutants and contribute to persistent smog episodes [7]. Farmers' recognition of multiple pollution sources therefore reflects the complex nature of smog formation.

The study further demonstrated that farmers perceived considerable effects of smog on agricultural activities. Reduced visibility during farming operations recorded the highest mean score (4.36 ± 0.73), followed by reduced sunlight availability (4.25 ± 0.79) and perceived effects on crop productivity (4.17 ± 0.84). Poor visibility can interfere with outdoor agricultural activities, transportation, machinery operation, and other field operations [28]. Moreover, atmospheric particulate matter can influence the amount of radiation reaching plant surfaces and may interfere with plant physiological processes [10]. Air pollutants such as ozone have also been shown to negatively affect photosynthesis, plant growth, and crop productivity [26]. However, because the present study assessed farmers' perceptions rather than directly measuring crop physiological parameters or yield losses, these findings should be interpreted as farmers' perceived agricultural effects.

Farmers demonstrated particularly strong perceptions regarding the health and environmental impacts of smog. The highest mean score in this category was recorded for the statement that smog reduces overall air quality (4.45 ± 0.67), followed by breathing difficulties (4.38 ± 0.74) and reduced visibility on roads (4.34 ± 0.72). These findings are consistent with established evidence that exposure to particulate air pollution is associated with respiratory and cardiovascular health risks [2,5]. Fine particulate matter can penetrate deep into the respiratory tract and contribute to inflammation and other adverse health effects [2,5]. Farmers may be particularly exposed because their occupations require prolonged outdoor activity during periods of poor air quality [28,29].

The high perception of health effects is also important because farming communities may experience repeated exposure during seasonal smog episodes [33]. Previous research has demonstrated associations between agricultural burning and adverse health outcomes among farming households, particularly during periods of intensive residue burning [11,15]. Therefore, the strong health-related concerns expressed by farmers in the present study support the need to integrate occupational and public-health considerations into agricultural smog-management policies.

Another important finding was the strong support for government intervention, which received the highest mean score among the proposed mitigation measures (4.52 ± 0.63). Farmers also strongly supported awareness regarding alternatives to crop-residue burning, agricultural extension guidance, and environmentally friendly farming practices. This finding is consistent with previous research indicating that access to information, extension services, and awareness programs can positively influence farmers' intentions to adopt sustainable residue-management practices [19,32]. Agricultural extension departments can therefore play an important role by providing farmers with practical information about residue incorporation, composting, mulching, livestock utilization, and mechanical residue-management technologies [19,20].

However, the high level of perception observed in this study does not necessarily mean that farmers will automatically change their agricultural practices. Farmers may understand that residue burning contributes to air pollution but continue burning because alternative practices can require additional labor, machinery, time, or financial investment. Research conducted in Punjab has shown that economic and logistical constraints are important determinants of farmers' residue-management decisions. Thus, awareness campaigns should be accompanied by affordable alternatives and institutional support [19,31].

The strong agreement with environmentally friendly farming practices (4.41 ± 0.71) suggests that farmers are generally receptive to sustainable approaches. This provides an important opportunity for agricultural extension programs. Providing access to appropriate machinery, technical training, financial incentives, and timely information could help convert farmers' positive perceptions into actual environmentally responsible behavior [19,31]. Such interventions could reduce open-field burning while also promoting productive utilization of agricultural residues [20,22].

Overall, the findings demonstrate that farmers in Sargodha District recognize smog as a serious environmental, agricultural, and health-related problem. The high perception scores for crop-residue burning, reduced visibility, air-quality deterioration, health effects, and government intervention indicate substantial awareness among the surveyed farming community. Nevertheless, effective smog mitigation requires an integrated approach combining farmer education, agricultural extension, affordable residue-management technologies, economic incentives, and appropriate regulatory measures. [19,20] Future research should complement perception-based surveys with direct measurements of $PM_{2.5}$ and $PM_{10}$, meteorological observations, crop-yield records, and actual residue-burning practices to establish stronger empirical relationships between smog exposure and agricultural productivity in Punjab.

## CONCLUSION

The study concluded that farmers in Sargodha District had a high level of perception regarding smog and its environmental, agricultural, and health-related impacts. Most respondents identified crop-residue burning, vehicular emissions, and industrial activities as important contributors to smog. Farmers also perceived reduced visibility, poor air quality, breathing difficulties, and potential effects on crop productivity as major concerns. Strong support was expressed for government intervention, agricultural extension services, farmer awareness, and environmentally friendly farming practices. However, awareness alone may not be sufficient to eliminate residue burning because farmers face economic, technological, and operational constraints. Therefore, effective smog mitigation should combine awareness programs with affordable residue-management technologies, financial incentives, extension support, and appropriate regulatory measures to encourage sustainable agricultural practices in Punjab.

### Ethical Approval

Not applicable. This review used previously published literature and did not involve human participants, animals, or identifiable personal data.

### Informed Consent
Not applicable, as this study did not involve human participants or direct data collection from individuals.

### Data Availability Statement
All data analyzed in this review were obtained from previously published studies. Additional information is available from the corresponding author upon reasonable request.

### Author Contributions
Sadia Batool, Khadija Tul Kubra, and Nimra Shahzadi contributed to the conceptualization, methodology, data curation and analysis, writing of the original draft, review and editing, and final approval of the manuscript.

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### Conflict of Interest
The authors declare that they have no competing interests.

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### Use of Artificial Intelligence
ChatGPT was used solely for grammar, spelling, punctuation, and language correction.

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