Centre for Chronic Disease Control
WHO Collaborating Centre for Surveillance, Capacity building and Translational Research in Cardio-Metabolic Diseases

PERCEPTION OF FARMERS BASED IN PUNJAB ON STUBBLE BURNING

ITS IMPACT ON HEALTH, AND ASSOCIATED POLICIES

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ACKNOWLEDGMENT

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We express our deepest gratitude to everyone involved, for their dedication and contributions to this project, which will undoubtedly make a difference in addressing the challenges posed by stubble burning.

ABOUT

CENTRE FOR CHRONIC DISEASE CONTROL

Centre for Chronic Disease Control (CCDC) is a New Delhi based not-for profit organization, established in December 2000. The mission of CCDC is primarily intended to address the growing challenge of chronic diseases, in varied settings of the developing countries through:

Knowledge generation, which can inform policies and empower programmes for the prevention and control of chronic diseases.

Knowledge translation intended to operationalize research results by bridging the critical gaps between relevant research and effective implementation, through analytic work, capacity building, advocacy, and development of educational resources for enhancing the empowerment of people and professionals.

CCDC has been recognized as a Scientific and Industrial Research Organization (SIRO) by Department of Scientific & Industrial Research (DSIR), Ministry of Science and Technology, Government of India. It also holds registration under Foreign Contribution (Regulation) Act, 1976. CCDC undertakes clinical research with special emphasis on chronic non-communicable diseases (NCD). Within the spectrum of chronic diseases, our main focus areas are: cardiology, diabetes and metabolic disease, vascular diseases, cancers and mental health. In addition, basic science research in diet/nutrition and cardiac biochemistry are also carried out. The research work at CCDC has produced major insights into the epidemiology, developmental origin, and biomarkers of CVD and diabetes in India; practice patterns on Acute Coronary Syndrome; translation research in CVDs; and development of low-cost combination drugs for primary and secondary prevention of CVDs in South Asia. CCDC holds recognition as a 'Centre of Excellence in Clinical Research' from the Clinical Development Service Agency (CDSA), Department of Biotechnology, Government of India. It is also a WHO Collaborating Centre for Surveillance, Capacity building and Translational Research in Cardio-Metabolic Diseases.

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LIST OF ABBREVIATIONS

- **APFs** – Agricultural Pumpset Feeders
- **CDP** – Crop Diversification Programme
- **CEA** – Central Electricity Authority
- **CO** – Carbon Monoxide
- **CO_2** – Carbon dioxide
- **COPD** – Chronic Pulmonary Obstructive Disorder
- **CRM** – Crop Residue Management
- **CHC** – Custom Hiring Centres
- **DALYs**- Disability Adjusted Life Years
- **GHG** – Greenhouse gases
- **GoI** – Government of India
- **IARI** – Indian Agriculture Research Institute
- **IGP** – Indo-Gangetic Plains
- **IPCC** – Intergovernmental Panel on Climate Change
- **MoU** – Memorandum of Understanding
- **MNRE** – Ministry of New and Renewable Energy
- **MSP** – Minimum Support Price
- **MSW** – Municipal Solid Waste
- **Mt** – Million tons
- **NAAQS** – National Ambient Air Quality Standards
- **NCAP** – National Clean Air Programme
- **NCR** – National Capital Region
- **NGT** – National Green Tribunal
- **NH3** – Ammonia
- **NMHC** – Non-methane hydrocarbon
- **NOX** – Nitrogen oxide
- **NPMCR** – National policy for management of crop residue
- **NREGA** – National Rural Employment Guarantee Act
- **PAH's** – Polycyclic aromatic hydrocarbons
- **PCDFs** – Polychlorinated dibenzofurans
- **PEDA** – Punjab Energy Development Agency
- **PM** – Particulate matter
- **PSPCL** – Punjab State Power Corporation Limited
- **SOX** – Sulphur oxide
- **SMS** – Straw Management System
- **SVOCs** – Semi volatile organic compounds
- **TPP** – Thermal Power plant
- **UP** – Uttar Pradesh
- **USEPA** – United States Environmental Protection Agency
- **VOCs** – Volatile organic compounds
- **WHO** – World Health Organization
- **µg** – Micro-gram

CONTENTS

EXECUTIVE SUMMARY

THIS STUDY is a follow-up to the report (literature review) "Stubble Burning in Punjab: Assessing the Gaps between Policy and Implementation" that Centre for Chronic Disease Control (CCDC) published, in 2021. Stubble burning is a threat to human health and environmental health. It is known to have negative effects on the respiratory and cardiovascular health of populations. It also pollutes air and deteriorates the quality of land. This study aims to understand the perspectives of farmers from Punjab on issues related to health and policies associated with stubble burning. The study was conducted in two districts of Punjab – Sangrur and Hoshiarpur, with a sample size of 230.

We used a mixed –methods approach where a questionnaire with a mix of quantitative and qualitative questions was administered to the participants to understand the health symptoms they experience during the stubble burning season, access to information, awareness and views about the policies associated with stubble burning.

It was found that 21% of the participants experienced at least one health symptom during the stubble burning season, with coughing and runny nose being at the top of the list. Around 19% of the participants reported to have been previously diagnosed with a chronic condition such as hypertension, diabetes, asthma etc. and out of those 29.5% stated that their condition worsened during the stubble burning season.

Factors such as stubble burning (crop residue disposal method), covering mouth while burning stubble, diagnosed with chronic health conditions, pre-existing health conditions getting worse during stubble burning season were found to be significantly associated with health symptoms during stubble burning season. Those who burned stubble and had chronic conditions were found to be 3.3 and 4.7 times respectively more at the risk of experiencing health symptoms. 88% of participants said that they had come across advisories by the government, about stubble burning.

Around 25% of the participants practiced crop diversification and out of those 60% were aware of the government schemes that promoted crop diversification and 95% were aware of the benefits of crop diversification to soil and groundwater. Participants expressed interest in growing alternative crops but were hindered because of the government not giving good minimum selling price (MSP). A majority of farmers expressed concerns about facing groundwater shortages due to paddy being a water guzzling crop. 55% of farmers reported using alternatives to stubble burning such as happy seeder, rotavator, and super seeder. Those who did not use alternatives expressed challenges such as alternatives being expensive, lack of awareness on alternatives available in the market, ease of burning stubble, and impracticality of using machines such as happy seeder due to texture of the soil. Participants who were aware of crop diversification schemes and who had diverted their lands to grow alternative crops were 0.07 and 0.5 times respectively less likely to burn the stubble than those were not.

1 BACKGROUND

STUBBLE BURNING is a major environmental and health hazard in northern India, particularly in the state of Punjab. The burning of paddy stubble after harvest is a common practice among farmers in the region, as it is a quick and easy way to clear the fields for the next crop. However, the burning of stubble releases large amounts of pollutants into the atmosphere, which contribute to air pollution and impact human health.

Prior to this study, CCDC published a literature review study titled "Stubble Burning in Punjab: Assessing the Gaps between Policy and Implementation" in 2021. The study aimed to understand the multiple intricately related policy factors that can explain the prevalence of stubble burning in Punjab. These include:

- **Groundwater exploitation:** Cultivation of paddy and wheat which are water guzzling crops has led to the extensive exploitation of groundwater resources in the region. To prevent the further reduction in groundwater table, the government of Punjab came up with the Preservation of Subsoil Water Act, 2009 which mandated the farmers to delay the planting of paddy, to align it with monsoon. However, this left the farmers with little time between harvesting rice and planting wheat which has led them to resort to burning of the stubble to clear out fields in a short period of time.

- **Absence of multiple cropping system:** The lack of adoption of a multiple cropping system, which allows for the cultivation of alternative crops during the fallow period, has also contributed to the reliance on burning paddy stubble.

- **Market dynamics supporting rice and wheat cultivation:** Market forces that favour rice and wheat cultivation, coupled with limited avenues for diversification, have created challenges for

small farmers and increased the prevalence of stubble burning.

Lack of facilities for straw management: Inadequate infrastructure and facilities for effective straw management and disposal have added to the propensity for farmers to resort to burning.

Experimentation with in-situ machinery: The limited adoption and experimentation with in-situ machinery, designed to manage crop residue without burning, has posed challenges to its widespread implementation.

Labor shortage: The scarcity of labor during the crucial window between rice harvest and wheat sowing has left farmers with limited alternatives to expedite field preparation, leading to increased reliance on stubble burning.

Over-reliance on agricultural subsidies: The prevailing subsidy-driven agricultural system, while intended to support farmers, has inadvertently contributed to the persistence of stubble burning by discouraging diversification and sustainable practices.

The study identified a number of gaps that hindered the effective implementation of existing policies to curb stubble burning. These included:

Lack of a comprehensive policy framework: The existing policies to curb stubble burning are fragmented and lack a comprehensive approach.

Inadequate financial and technical support: The government has not provided adequate financial and technical support to farmers to adopt sustainable practices.

Lack of awareness and participation from farmers: Farmers are often unaware of the harmful effects of stubble burning and the available alternatives. They also lack the motivation to adopt sustainable practices due to the lack of financial and technical support.

The study also put forward a series of targeted recommendations to address the problem of stubble burning in Punjab. These included:

Establishing a robust and systematic review process: The government should establish a robust and systematic review process to continually monitor and evaluate the policies proposed for sustainable agriculture interventions in Punjab.

Strengthening financial mechanisms and improving infrastructure: The government should strengthen financial mechanisms and improve infrastructure to alleviate the additional burden placed on the subsidy-

driven agricultural systems, enabling farmers to transition towards sustainable practices.

↘Enhancing the dynamics of Minimum Support Price (MSP): The government should enhance the dynamics of MSP and explore the implementation of deficiency payments to incentivize crop diversification and discourage stubble burning.

↘**Facilitating the adoption of sustainable management practices:** The government should facilitate the adoption of sustainable management practices for crop residue, including promoting crop diversification and encouraging composting, thereby reducing the reliance on burning.

↘**Promoting increased research opportunities:** The government should promote increased research opportunities to identify and adapt to evolving challenges related to labor, irrigation, and soil conditions, ensuring that farmers have access to effective solutions.

↘**Fostering a participatory approach:** The government should foster a participatory approach that actively engages farming communities, empowering them through targeted outreach and education on sustainable practices and alternatives to stubble burning.

↘**Placing heightened emphasis on the substantial impacts of stubble burning on public health:** The government should place heightened emphasis on the substantial impacts of stubble burning on public health, including respiratory problems, heart disease, and cancer. This will help to raise awareness and motivate farmers to adopt sustainable practices.

The study concluded that the problem of stubble burning in Punjab is complex and requires a comprehensive approach to address it. The government should implement the recommendations put forward in the study to reduce the prevalence of stubble burning and improve air quality in the region.

Based on the earlier findings about gaps in a participatory approach to managing the stubble burning issue besides the perceived lack of awareness amongst the farming communities on the impacts of stubble burning on their health and the related policies on stubble management, the CCDC team conducted a follow-up primary research study. The overall aim was to understand what the farmers of Punjab think about stubble burning, if they believe their health gets affected by it and to assess if they have the access to relevant information and what are their views about the government policies related to stubble burning.

HEALTH IMPACTS OF STUBBLE BURNING

Air Pollutants from Stubble Burning

Stubble burning releases a significant number of pollutants into the atmosphere, including particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO2), volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs). These pollutants can penetrate deep into the respiratory system and cause respiratory problems such as asthma, bronchitis, and chronic obstructive pulmonary disease (COPD). A study by Singh et al. (2018) reported the impact of stubble burning on air quality and human health in rural and urban areas of Punjab, India. The study revealed elevated levels of PM, CO, NO2, VOCs, and PAHs during the burning season, indicating the significant release of these pollutants from stubble burning.

Stubble burning is one of the major contributors to atmospheric pollution in the world releasing particulate and gaseous pollutants that have severe effects on human health and the environment (Sharma et al., 2010). It is a significant source of air pollution in many parts of the world being only the 3rd after industrial and vehicular emissions (Gurjar et al., 2016; Krishna et al., 2011). The research found high concentrations of PM and gaseous pollutants, including CO, NO2, and VOCs, resulting from stubble burning activities. The study also highlighted the potential health risks associated with these pollutants. The research identified PM, CO, NO2, VOCs, and PAHs as major pollutants emitted during stubble burning, emphasizing their harmful effects on respiratory health, including the development of asthma, bronchitis, and COPD.

Bray et al. (2019) conducted a study of the Indo-Gangetic Plains of India, analysing the impact of crop residue burning on ambient air quality in Delhi. The study observed significantly increased concentrations of PM, CO, NO2, and VOCs during the burning season, indicating the substantial release of these pollutants from stubble burning. Balakrishnan et al. (2019) investigated the impact of air pollution on deaths, disease burden, and life expectancy across the states of India. The study highlighted the association between exposure to PM and gaseous pollutants, including those emitted during stubble burning, and respiratory problems such as asthma and COPD.

Increased Respiratory Symptoms

Research studies have demonstrated a clear association between stubble burning and increased respiratory symptoms among the population residing in affected areas. High levels of PM2.5 and PM10 in the air due to stubble burning have been linked to increased hospital admissions, emergency room visits, and respiratory-related mortality. Singh et al. (2018), reported a significant increase in respiratory symptoms, including coughing, wheezing, and shortness of breath, among individuals exposed to high levels of PM2.5 and PM10 during the burning season. The study also reported an association between stubble burning and increased hospital admissions for respiratory illnesses. Aggarwal et al. (2021) explored the respiratory health effects of crop residue burning in rural areas

of North India. The study observed a higher prevalence of respiratory symptoms, such as breathlessness and cough, among individuals exposed to stubble burning emissions. The research also highlighted the role of PM2.5 and PM10 in exacerbating respiratory conditions and necessitating medical intervention.

A review by Bhandari and Bhandari (2020) focused on the impact of stubble burning on air quality and respiratory health in India. The review analysed multiple studies and found consistent evidence linking stubble burning to increased respiratory symptoms and respiratory-related hospital visits. The elevated levels of PM2.5 and PM10 during the burning season were identified as key contributors to these health effects. Saggu et al. (2018) studied the association between stubble burning and increased respiratory symptoms, citing several studies that reported a rise in hospital admissions and emergency room visits due to respiratory issues during the burning season.

Jain et al. (2019) reported a significant increase in respiratory symptoms among individuals exposed to stubble burning emissions, including higher rates of coughing, wheezing, and chest tightness. The research emphasized the role of PM2.5 and PM10 as major contributors to these adverse respiratory effects.

Impact on Heart Health

The fine particulate matter generated by stubble burning can penetrate the bloodstream and cause inflammation, oxidative stress, and vascular damage, ultimately leading to adverse cardiovascular effects. This can trigger cardiovascular events such as heart attacks, strokes, and arrhythmias. Several studies have investigated the impact of stubble burning on heart health, highlighting a significant increase in hospital admissions for cardiovascular diseases during peak stubble-burning periods.

Sharma et al. (2018) reported a notable increase in the levels of PM2.5 and gaseous pollutants, including those emitted during stubble burning. The study also observed a correlation between elevated PM2.5 levels and an increase in hospital admissions for cardiovascular diseases during the burning season.

Suggu et al. (2018) identified a consistent link between stubble burning and cardiovascular diseases. The fine particulate matter released during stubble burning was identified as a significant contributor to cardiovascular events such as heart attacks and strokes. The study by Sharma et al. (2022) reported a significant increase in hospital admissions for cardiovascular diseases during periods of high stubble burning activity. Balakrishnan et al. (2019 estimated that outdoor air pollution, including pollutants released from stubble burning, accounted for a substantial number of premature deaths and disability-adjusted life years (DALYs) lost due to cardiovascular diseases.

Vulnerability of Children

Children are particularly vulnerable to the health effects of stubble burning due to their developing respiratory and immune systems. Exposure to air pollution during critical stages of growth can lead to impaired lung function, increased respiratory infections, and long-term respiratory issues. Studies have

also linked exposure to air pollution during pregnancy to adverse birth outcomes and an increased risk of childhood respiratory diseases. Gauderman et al. (2015) investigated the long-term effects of air pollution exposure on lung function development in children. The research found that exposure to fine particulate matter (PM2.5) during early life was associated with reduced lung function growth. The study highlighted the susceptibility of children to the detrimental effects of air pollution on respiratory health.

Clark et al. (2017) studied the association between exposure to air pollution during early life and the risk of respiratory infections in children. The research found a significant correlation between higher levels of PM2.5 and increased respiratory infections, including bronchitis and pneumonia, among children. The study emphasized the vulnerability of children to the respiratory health impacts of air pollution. A systematic review by Kloog et al. (2019) assessed the evidence on the association between air pollution exposure and adverse birth outcomes. The review identified a link between exposure to air pollution during pregnancy and increased risk of preterm birth, low birth weight, and respiratory conditions in children. The study highlighted the importance of minimizing exposure to air pollution during pregnancy to protect the health of both the mother and child.

Patel et al. (2020) found that exposure to high levels of PM2.5 and other air pollutants, including those emitted during stubble burning, was associated with an increased risk of asthma and other respiratory conditions in children. The study emphasized the vulnerability of children to the respiratory health impacts of air pollution.

Fuertes et al. (2014) conducted a multi-center birth cohort study to investigate the long-term effects of air pollution exposure during early life on lung function and respiratory symptoms in children. The study found that exposure to air pollution, including PM2.5, during infancy was associated with reduced lung function and an increased risk of wheezing and asthma in children. The research highlighted the need to protect children from the harmful effects of air pollution, particularly during critical periods of development.

While the impacts of stubble burning on health are gaining importance in recent times, the practice of stubble burning continues to be the most used method for managing stubble, due to its ease. As described in the first part of the study, it is a vicious circle where the policies and programmes are made in silos which encourages the farmers to resort to burning stubble, which in turn impacts their health. There are not a lot of studies that focus both on health- and policy-related aspects and this study intends to understand both. The inclusion of both qualitative and quantitative methods to gain farmer-centric insights on matters of health and policies in the context of stubble burning will be helpful in building evidence in an integrated manner and is expected to encourage further research.

2

AIM, OBJECTIVES AND METHODOLOGY

OBJECTIVES

- To understand the perception of farmers on the issue of stubble burning

We intend to understand the farmers' perspectives on the policies introduced on the issue of crop residue burning in Punjab (2009-19) and to validate the findings from the Part-1 study

- To investigate the extent to which farmers are aware of the harmful effects of stubble burning on their health

We hypothesise that farmers, despite being aware, often overlook the adverse impacts of stubble burning on health and do not consider it as 'serious issue'.

AIM OF THE STUDY

To understand the perspective of farmers of Punjab on health and policy issues related to stubble burning.

Survey sites

Sangrur and Hoshiarpur districts in Punjab

METHODOLOGY

Study site selection

In total there are 22 districts in Punjab which comprise subdivisions, Tehsils, and blocks. For the purpose of rural development, each district is further divided into development blocks or simply called as blocks. There are around 147 blocks and under each block there are villages. According to 2011 census, there are around 13,000 inhabited villages in Punjab.

Primary Criteria

Quantum of Fire emissions – The quantum of emissions from fires across districts was used as the primary criterion. To monitor prevalence of fire cases in each district, the carbon emissions inventory for the last ten years was reviewed (VIIRS Data, 2009-19). We used the data specifically during the stubble burning period (September-December) to avoid any confusion. Based on the data, two districts were selected; one with higher emissions and the other with lower emissions, to provide a comparative analysis of the reasons behind the practice. ***See Figure 1.***

Secondary Criteria

Various secondary factors were included such as

- Farming patterns- *w*
- Area, Production and Yield under the dominant crops
- Area of the district
- Population and Population Density

The sites were chosen after doing the prioritisation of the aforementioned criteria in order

Figure 1: Average monthly carbon emissions for districts of Punjab, from Sep - Dec

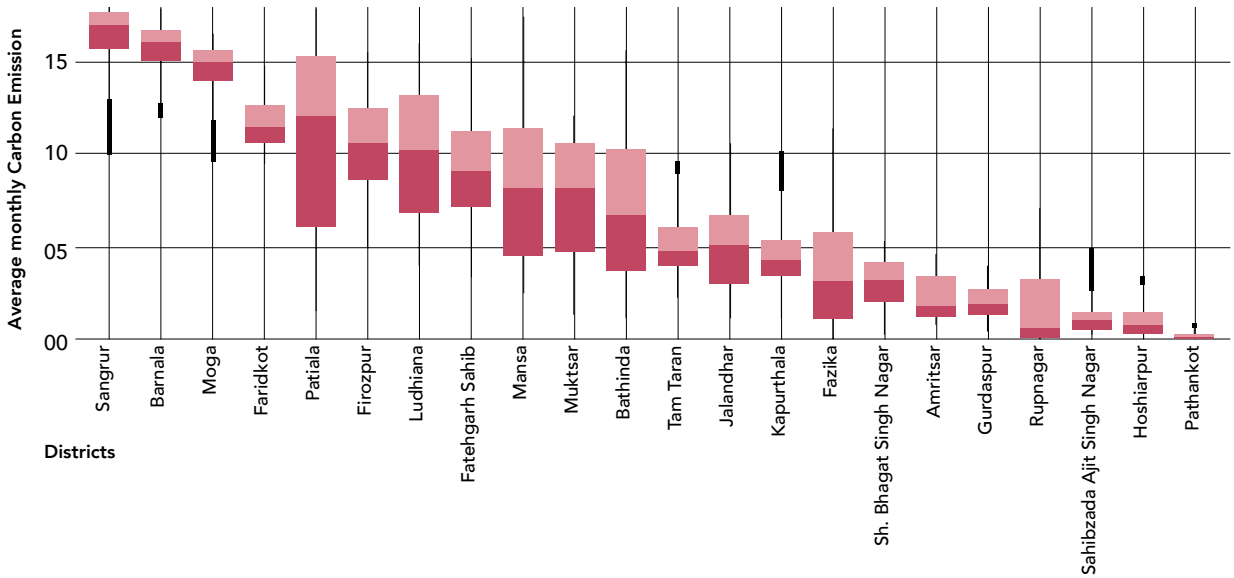


Table1

Criteria	Parameters	Sangrur	Hoshiarpur
Primary	Fire Prevalence	High	Low
Secondary	Principle crop	Rice and Wheat	Rice and Wheat
	Area under rice (Thousand hectare)	289	79.4
	Production under Rice (Thousand metric ton)	1362	3
	Yield per hectare in kg	5264	4005
	District Area (km	2,848	3365
	Population	1655169	15,86,625
	Population Density	4	469

Data source: PUNJAB-AT-A-GLANCE (DISTRICT WISE), 2020

Table 2

District	Block	Village
Sangrur	Dhuri	Kandhargarh
		Dhura
		Ruldu
		Sherpur
		Manwala
Hoshiarpur	Mukerian	Dharampur
		Bhati
		Pohari
		Bhabnaur
		Sukhchainpur

to choose only representative sample sites – Sangrur and Hoshiarpur. ***See Table 1.***

Sample size

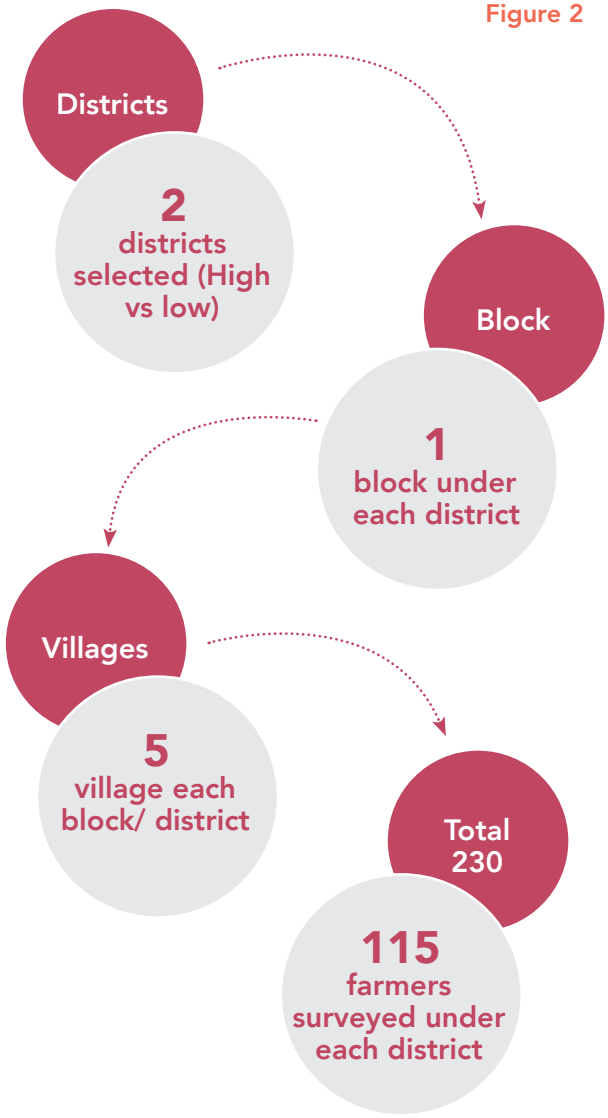
Based on a study conducted by Choudhary et al., the prevalence (awareness level) was taken as 82% and the sample size was calculated accordingly.

$$n = \frac{Z_{1-a/2}{}^2 \, xp(1-p)}{d^2} = \frac{1.96^2 \times 0.02 \times 0.18}{0.05^2} = 226.8 \approx 230$$

Where
n = sample size
$Z_{1-a/2}$ = standard normal variate (95% confidence interval)
p (prevalence) = 0.82
1-p = 0.18
d (precision) = 0.05

Based on the above criteria, two districts were chosen, using a purposive sampling approach. Within each district, one block and subsequently five villages were randomly chosen. The sample size was divided equally across the ten villages (23 participants per village). The surveys were carried out using mixed method sampling strategy. ***See Table 2 and Figure 2.***

Figure 2



Selection criteria for farmers

- Inclusion criteria – farmers who have farming experience of 5 or more years and are currently practicing
- Exclusion criteria – farmers who own land but are not practicing farming themselves

About the questionnaire

The questionnaire has a mix of quantitative and qualitative questions. It was developed with an aim to capture the following information:

- To understand if the farmers perceive an association between stubble burning and their health, what are the discomforts in health they experience during stubble burning season, and if they are able to access information relating to the impact of stubble burning on health.
- Their viewpoints on the policies implemented and the benefits received because of the same.

Survey administration

A survey agency, Morsel Research and Development, was onboarded for administering the questionnaire, collecting, and analysing the data. They established contacts with local leaders to get access to farmers. Trained surveyors visited the sites for data collection to seek the requisite information. Farmers were approached in their households as well as farmlands. Data was collected over a period of 30 days, from 9 November to 9 December 2022.

3 RESULTS

Figure 3:

Size of the farmland

- Marginal (2.5acres)
- Small (2.5-5 acres)
- Semi medium (5-10 acres)
- Medium (10-25 acres)
- Large (>25 acres)

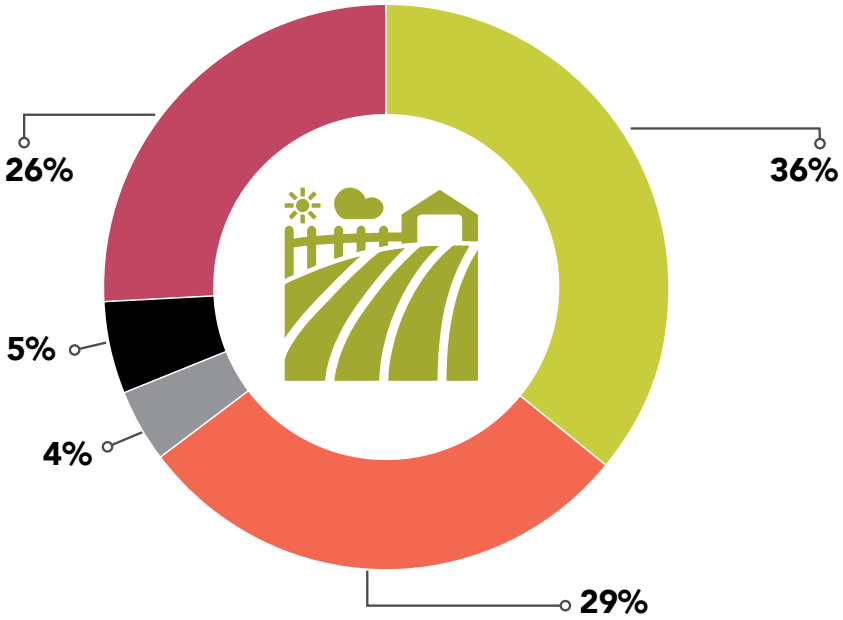


Table 3:

Sociodemographic characteristics of the participants

Characteristics	Hoshiarpur (n=115)	Sangrur (n = 115)	Total (n = 230)
Age			
21 – 30	22 (19.1%)	14 (12.1%)	36 (15.6%)
31 – 40	24 (20.9%)	9 (7.8%)	33 (14.3%)
41 – 50	26 (22.6%)	31 (27%)	57 (24.8%)
51 – 60	20 (17.4%)	23 (20%)	43 (18.7%)
61 – 70	14 (12.1%)	20 (17.4%)	34 (14.8%)
71 – 80	8 (7%)	17 (14.8%)	25 (10.9%)
>80	1 (0.9%)	1 (0.9%)	2 (0.9%)
Education level			
Postgraduate	2 (1.7%)	2 (1.7%)	4 (1.8%)
Graduate	15 (13%)	12 (10.5%)	27 (11.7%)
Intermediate/ diploma	15 (13%)	14 (12.1%)	29 (12.6%)
High school	24 (20.9%)	20 (17.4%)	44 (19.1%)
Middle school	22 (19.1%)	17 (14.8%)	39 (17%)
Primary school	6 (5.3%)	6 (5.3%)	12 (5.2%)
Illiterate	31 (27%)	44 (38.2%)	75 (32.6%)
Marital status			
Married	90 (78.2%)	101 (87.9%)	191 (83.1%)
Single	25 (21.8%)	14 (12.1%)	39 (16.9%)
No. of members in the family			
1 – 5	61 (53.1%)	75 (65.3%)	136 (59.1%)
6 – 10	52 (45.2%)	38 (33%)	90 (39.1%)
11 – 15	2 (1.7%)	2 (1.7%)	4 (1.8%)
Stay close to farmland			
Yes	52 (45%)	39 (34%)	91 (39.5%)
No	63 (55%)	76 (66%)	139 (60.5%)
Monthly income			
5,000 – 10,000	46 (40%)	52 (45.2%)	98 (42.6%)
>10,000 – 15,000	39 (34%)	34 (29.5%)	73 (31.7%)
>15,000 – 20,000	21 (18.2%)	8 (6.9%)	29 (12.6%)
>20,000	9 (7.8%)	21 (18.2%)	30 (13.1%)

The median age for the participants was 49 years. The minimum was 22 years and maximum was 88 years.

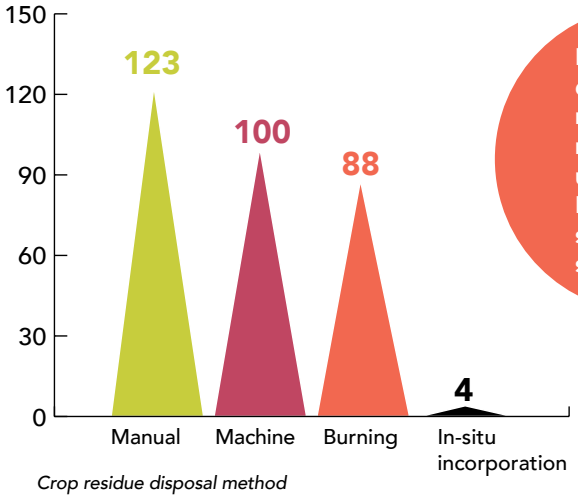
There were no female participants. Nearly one-third of the participants were illiterate.

Among the educated ones, most of them had completed high school.

Most of the participants (42.6%) earned Rs 5,000 – 10,000 per month, on an average.

Figure 4:

Farming related aspects



Participants reported using combination of methods to dispose off stubble. As seen in the figure above, the most used method was manual (i.e. removing the stubble manually with hand held equipment). This might be most used by participants who own marginal size farmlands. Many of them used machines as well as burning to manage stubble. Only 1% of the participants in Hoshiarpur practiced stubble burning whereas in Sangrur 75% did.

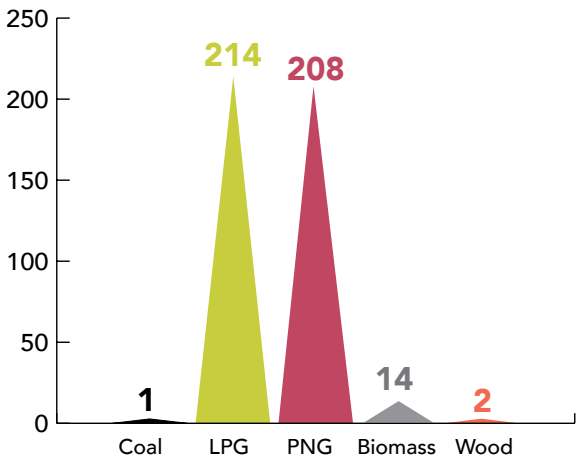
LIFESTYLE PRACTICES

Table 4:

Distribution of participants based on lifestyle practices

Characteristics	N	%
Farmers who cover their mouth while practicing stubble burning or in the vicinity of it		
☒ No	177	76.96
☑ Yes	53	23.04
Farmers who use tobacco products (n = 230)		
☒ No	181	78.7
☑ Yes	49	21.3
Frequency of tobacco use (n = 49)		
2-3 days per week	2	4.08
Daily	47	95.92

Figure 5:



PERCEPTION ON HEALTH-RELATED ASPECTS

The participants were asked why they think stubble burning affects/ does not affect their health. Around 36% of the participants said that they do not think stubble burning affects their health because they have a lot of trees in their surroundings which is why the pollution is controlled whereas 20% felt so because they do not experience any symptoms. About 21% participants felt stubble burning impacts their and their family's health as they experienced symptoms due to stubble burning.

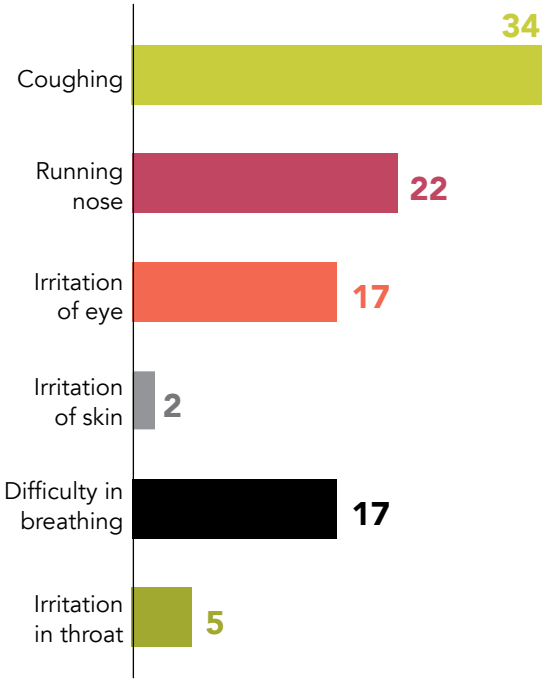
Table 5:

Distribution of participants based on how they think stubble burning impacts air quality and human health

Characteristics	N	%
Do you think stubble burning causes air pollution?		
☒ No	**26**	**11.3**
☑ Yes	**204**	**88.7**
Do you think stubble burning affects their and their family's health?		
☒ No		**182**
☑ Yes	**48**	**20.87**

Figure 6:

Symptoms experienced during stubble burning season



**Multiple response question*

Table 6:

Distribution of participants based on the time of the year their health gets affected the most and health symptoms experienced due to stubble burning

Characteristics	N	%
Time of the year health gets affected the most		
Jan - Mar	**15**	**6.52**
Apr - Jun	**7**	**3.04**
Jul - Sep	**1**	**0.43**
Oct - Dec	**29**	**12.61**
Health doesn't get affected during any specific time of the year	**178**	**77.39**
Farmers who experienced at least one symptom during the stubble burning season		
☒ No	**181**	**78.7%**
☑ Yes	**49**	**21.3%**

Table 7:

Distribution of participants based on health seeking behaviour

Characteristics	N	%
Visit the doctor (n = 49)		
☒ No	5	10.2
☑ Yes	44	89.8
Type of Health Facilities		
Private	40	90.91
Public	4	9.09
Doctor explains the impact of stubble burning on health (n = 44)		
☒ No	27	61.36
☑ Yes	17	38.64

Participants were asked what advice the doctors give out. The most common advices were to

- **Cover mouth with handkerchief/mask**
- **Avoid fried and oily food**
- **Not burn stubble**
- **Go out only when needed**

Table 8:

Distribution of participants based on out-of-pocket expenditure and pre-existing chronic conditions

Money spent on doctor visits during stubble burning season		
Less than Rs 100	5	11.36
Rs 100 – 300	6	13.64
Rs 301 – 500	2	4.55
Rs 501 – 700	7	15.91
More than Rs 700	24	54.55
Diagnosed with any health condition		
Asthma	12	5.22
Cardiovascular Diseases	5	2.17
Diabetes	8	3.48
Hypertension	16	6.96
Other Respiratory Disease	3	1.3
None of these	186	80.87
Pre-existing conditions get worse during stubble burning season (n = 44)		
☒ No	31	70.45
☑ Yes	13	29.55

LOSS OF PRODUCTIVITY AT WORK

Figure 7:

Types of advisories

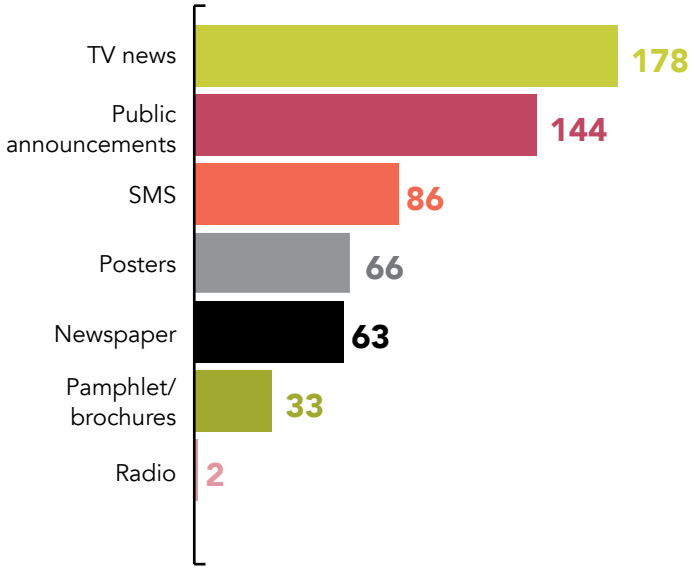


Table 9:

Distribution of participants based on access to advisories by government

Characteristics	N	%
Advisories published/announced by the government		
☒ No	27	11.74
☑ Yes	203	88.26

PERSPECTIVES ON ASSOCIATED POLICIES

Figure 8:

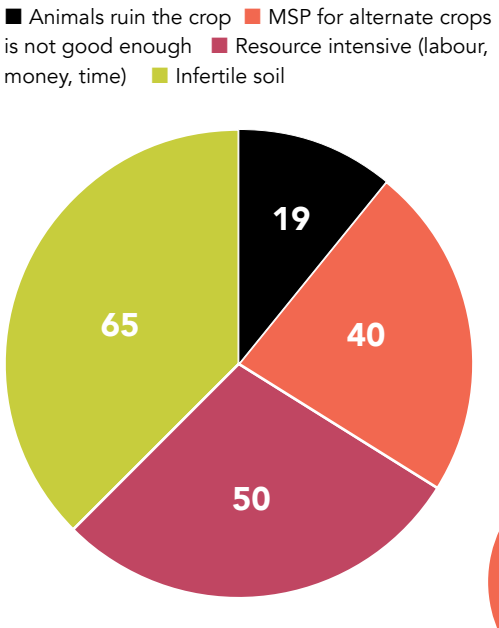


*Figure SEQ Figure * ARABIC 8: Distribution of participants based on the reasons for not growing alternative crops*

Table 10:

Distribution of participants based on the practice of crop diversification

Characteristics	N	%
Diverted part of land to grow other crops (besides wheat and rice)		
☒ No	174	75.65
☑ Yes	56	24.35

Participants who have diverted their lands to grow crops besides wheat and rice, grew crops like maize, potatoes, mustard, sugarcane, vegetables, millets, and animal feed.
Those who did not practice crop diversification, reported reasons such as soil not being fertile enough to grow alternate crops and it being resource intensive.

Table 11:

Distribution of participants based on awareness about crop diversification

Characteristics	N	%
Awareness of any govt scheme that promotes crop diversification (n = 56)		
☒ No	23	41.07
☑ Yes	33	58.93
Farmers who receive any kind of financial incentives/logistical help for growing alternate crops		
☒ No	54	96.43
☑ Yes	2	3.57
Awareness of benefits of growing alternate crops to land and groundwater		
☒ No	3	5.36
☑ Yes	53	94.64

Table 12:

Distribution of participants based on awareness about Punjab Preservation of Subsoil Water Act

Characteristics	N	%
Awareness of Punjab Preservation of Subsoil Water Act 2009		
☒ No	20	8.7
☑ Yes	210	91.3

Farmers were asked about their views on current groundwater situation and a majority of them reported facing shortage of groundwater due to rice being a water guzzling crop. They also reported their interest in growing alternate crops to save groundwater but are hindered by the government not giving them good MSP for it.

Table 13:

Distribution of participants based on the use of alternatives to stubble burning

Characteristics	N	%
Farmers who use alternatives to curb stubble burning (n = 230)		
☒ No	103	44.78
☑ Yes	127	55.22
Type of alternatives used (n = 127)		
Ex-situ	1	0.79
In-situ	126	99.21

Out of the farmers who used alternatives to stubble burning, **29.13%** used happy seeder, followed by **25.2%** who used 82 super seeder. Some of them used combinations such as happy seeder and rotavator or rotavator and super seeder.

52.76% of the farmers who used alternatives reported that they did not face any challenges using it, while **37%** stated the cost is too high. Remaining reported challenges such as less yield and pest infestation due to use of happy seeder.

Farmers who did not use alternatives to stubble burning stated reasons such as

- Impracticality of machines such as happy seeder, rotavator due to texture of the soil
- Unawareness of the alternatives available in the market
- Alternatives being expensive
- Ease of burning stubble instead of using the machines

COMPARATIVE ANALYSIS FOR SANGRUR AND HOSHIARPUR

Table 14:

Distribution of participants from Hoshiarpur and Sangrur based on farming, health, and policy related aspects

Characteristics	Hoshiarpur	Sangrur
Farming related aspects		
Size of farmland		
Marginal (< 1 hectare)	28 (24.3%)	31 (27%)
Small (1-2 hectares)	51 (44.4%)	32 (27.8%)
Semi-medium (2-4 hectares)	33 (28.7%)	33 (28.7%)
Medium (4-10 hectares)	1 (0.9%)	9 (7.8%)
Large (> 10 hectares)	2 (1.7%)	10 (8.7%)
Stubble disposal method*		
Manual	113 (98.2%)	10 (8.7%)
Machine	7 (6.1%)	93 (80.8%)
Burning	1 (0.9%)	87 (75.6%)
In-situ incorporation	0	4 (3.5%)
Others	0	0
Health related aspects		
Do you think stubble burning causes pollution?		
☒ No	13 (11.3%)	13 (11.3%)
☑ Yes	102 (88.7%)	102 (88.7%)
Do you cover your mouth with mask while practicing stubble burning or in the vicinity of it?		
☒ No	104 (90.4%)	73 (63.5%)
☑ Yes	11 (9.6%)	42 (36.5%)
Do you think stubble burning affects your and your family's health?		
☒ No	107 (93%)	75 (65.2%)
☑ Yes	8 (7%)	40 (34.8%)

Characteristics	Hoshiarpur	Sangrur
Do you use any tobacco products (cigarettes, bidi, snuff)?		
☒ No	79 (68.7%)	102 (88.7%)
☑ Yes	36 (31.3%)	13 (11.3%)
What fuel do you use for cooking?*		
Coal	1 (0.9%)	0
LPG	106 (92.1%)	108 (93.9%)
PNG	1 (0.9%)	1 (0.9%)
Biomass burning	1 (0.9%)	13 (11.3%)
Wood	106 (92.1%)	102 (88.7%)
During what time of the year does your health get affected the most?		
Jan – Mar	7 (6.1%)	8 (7%)
Apr – Jun	1 (0.9%)	6 (5.2%)
Jul – Sep	0	1 (0.9%)
Oct – Dec	5 (4.3%)	24 (20.8%)
Health doesn't get affected during any specific time of the year	102 (88.7%)	76 (66.1%)
Experienced at least any one health symptom during stubble burning season		
☒ No	105 (91.3%)	76 (66.1%)
☑ Yes	10 (8.7%)	39 (33.9%)
Do you visit a doctor to get your symptoms treated?	(n = 10)	(n = 39)
☒ No	0	5 (12.8%)
☑ Yes	10 (100%)	34 (87.2%)
What kind of healthcare facility do you visit?	(n = 10)	(n = 34)
Private	10 (100%)	30 (88.2%)
Public	0	4 (11.8%)
Does the doctor explain to you about the potential health impacts of stubble burning?		
☒ No	7 (70%)	20 (58.8%)
☑ Yes	3 (30%)	14 (41.2%)
Diagnosed with any of the following conditions	(n = 115)	(n = 115)
Asthma	5 (4.3%)	7 (6.1%)
CVDs	2 (1.7%)	3 (2.6%)
Diabetes	2 (1.7%)	6 (5.2%)
Hypertension	11 (9.5%)	5 (4.3%)
Other respiratory diseases	0	3 (2.6%)
Do your preexisting illnesses get worse during the stubble burning season?	(n = 20)	(n = 24)
☒ No	19 (95%)	12 (50%)
☑ Yes	1 (5%)	12 (50%)

Characteristics	Hoshiarpur	Sangrur
Policy related aspects		
Have you diverted a part of your land to grow crops besides wheat and rice?		
☒ No	95 (82.6%)	79 (68.7%)
☑ Yes	20 (17.4%)	36 (31.3%)
Are you aware of any government scheme that promotes crop diversification?	(n = 20)	(n = 36)
☒ No	16 (80%)	7 (19.4%)
☑ Yes	4 (20%)	29 (80.6%)
Do you receive any kind of financial incentives/logistical help from the government for growing alternate crops?		
☒ No	20 (100%)	34 (94.4%)
☑ Yes	0	2 (5.6%)
Are you aware of the benefits to land and ground water, of growing alternate crops?		
☒ No	1 (5%)	2 (5.6%)
☑ Yes	19 (95%)	34 (94.4%)
Are you aware of the Punjab Preservation of Subsoil Water Act, 2009 to reduce groundwater exploitation?	(n = 115)	(n = 115)
☒ No	17 (14.8%)	3 (2.6%)
☑ Yes	98 (85.2%)	112 (97.4%)
Do you use any alternatives available in the market to curb the stubble burning issue?		
☒ No	95 (82.6%)	8 (6.9%)
☑ Yes	20 (17.4%)	107 (93.1%)

**Multiple choice questions*

Hoshiarpur and Sangrur were selected on the basis of the fire prevalence count being low and high respectively, while other parameters such as yield per hectare and population density were similar. Supporting this, it was found that only about 1% of the participants from Hoshiarpur practiced stubble burning, in contrast with 75.6% participants from Sangrur. Only 7% of participants from Hoshiarpur thought that stubble burning affects their and their family's health. Around 34% of participants from Sangrur experienced at least one health symptom during the stubble burning season as opposed to only 9% of participants from Hoshiarpur. Similarly, participants whose pre-existing illnesses worsened during the stubble burning season were more in Sangrur than in Hoshiapur. Overall, the level of awareness about crop diversification, groundwater exploitation, alternatives to stubble burning was observed to be more in Sangrur than in Hoshiarpur. This might be related to the overall low prevalence of fire counts in Hoshiarpur which has probably kept them away from the health impacts and thereby relatively lesser awareness as well. Around 93% of participants from Sangrur reported using alternatives to stubble burning as opposed to 17.4% from Hoshiarpur. These alternatives were used in conjunction with stubble burning and it would be difficult to gauge which method was used primarily. This can act as a confounding factor in the study.

BIVARIATE ANALYSIS

For both districts together, significant association was found between stubble burning symptoms and factors such as stubble burning (crop residue disposal method), covering mouth while burning stubble, diagnosed with health conditions, pre-existing health conditions getting worse during stubble burning season. For Hoshiarpur, significant association was found between the size of farmland and health symptoms associated with stubble burning. The general idea for connection between farmland size and stubble burning associated symptoms is that the size can determine the method farmers use to get rid of the stubble.

Significant association was also found between burning of stubble and variables such as crop diversification, and awareness of crop diversification schemes.

Significant association indicates that the relationship between two variables is caused by something other than chance.

Table 15:

Association of health symptoms during stubble burning season with stubble burning, covering of mouth, pre-existing chronic conditions

Characteristics	Did not experience health symptoms	Experienced health symptoms	p value
Burns stubble			
☒ No	123 (67.9%)	19 (38.7%)	0.000**
☑ Yes	58 (32.1%)	30 (61.3%)	
Covers mouth while burning stubble or in the vicinity of it			
☒ No	150 (82.8%)	27 (55.1%)	0.000**
☑ Yes	31 (17.2%)	22 (44.9%)	
Diagnosed with chronic conditions such as asthma, hypertension, diabetes			
☒ No	157 (86.7%)	29 (59.2%)	0.000**
☑ Yes	24 (13.3%)	20 (40.8%)	
Pre-existing conditions getting worse (n = 44)			
☒ No	24 (100%)	7 (35%)	0.000**
☑ Yes	0	13 (65%)	

$^{**}p < 0.001$

Table 16:

Association of stubble burning with crop diversification practice and awareness

Characteristics	Does not burn stubble	Burns stubble	p value
Diverted a part of land to grow alternative crops			
☒ No	114 (80.3%)	60 (68.2%)	0.038*
☑ Yes	28 (19.7%)	28 (31.8%)	
Aware of crop diversification schemes			
☒ No	19 (67.8%)	4 (14.3%)	0.000**
☑ Yes	9 (32.2%)	24 (85.7%)	

*$p < 0.05$
**$p < 0.001$

MULTIVARIATE ANALYSIS

Table 17:

Relationship of stubble burning and pre-existing chronic condition with health symptoms during stubble burning season

Binary logistic regression was used to find the direction of association of stubble burning symptoms with the practice of stubble burning and presence of chronic conditions. The risk of stubble burning symptoms was 3.3 times higher in participants who burnt stubble as opposed to those who did not. Similarly, participants who were diagnosed of chronic conditions such as asthma, CVDs etc. were 4.7 times more at risk of stubble burning symptoms than those who were not.

Characteristics	B	S.E.	Adjusted O.R.	95% C.I.	p value
Burns stubble					
No			1		
Yes	1.208	0.334	3.348	1.74 – 6.44	<0.001*
Diagnosed with any one of the chronic conditions					
No			1		
Yes	1.556	0.366	4.738	2.31 – 9.71	<0.001*

Table 18:

Relationship of crop diversification with the practice of stubble burning

Participants who were aware of crop diversification schemes were 0.07 times less likely to burn the stubble than those were not. Similarly, participants who had already diverted their lands to grow alternate crops were 0.5 times less likely to burn stubble than those who were not practicing diversification.

Characteristics	B	S.E.	Adjusted O.R.	95% C.I.	p value
Aware of crop diversification schemes					
No			1		
Yes	-2.657	0.685	0.07	0.02 - 0.27	<0.001*
Diverted a part of land to grow crops other than rice or wheat					
No			1		
Yes	-0.642	0.311	0.526	0.29 – 0.97	<0.001*

DISCUSSION

The overall prevalence of health symptoms among farmers of Sangrur and Hoshiarpur, during stubble burning season was found to be 21.3%. A study conducted by Dr Vitul Gupta in Bathinda and Malwa region of Punjab reported 84.5% of participants suffering from health problems due to stubble burning, which is about four times more than this study (Batra, 2017).

The most commonly experienced symptom was coughing (69.4%) followed by runny nose (44.9%), irritation of eyes (34.7%), difficulty in breathing (34.7%), irritation in throat (10.2%), and irritation of skin (4.1%). This is in line with the findings of the study by Kumar et al. which was conducted in Dhanori, Ajnauda Kalan, and Simro districts of Punjab. The most commonly reported health issues were coughing (34.1%) and irritation of eyes (81.25%). CO2 emitted from the smoke released due to stubble burning can cause irritation of eyes and oxides of sulphur and nitrogen can affect lungs, blood, skin which can lead to coughing, irritation of skin, difficulty in breathing in short term and cancers, COPD in long term (Batra, 2017). Exposure to high level of PM2.5 can lead to a decrease in functionality of lungs as well (Abdurrahman et al., 2020).

In this study, 90% of the participants who suffered from health symptoms during stubble burning season visited a doctor and around 55% of them spent more than Rs. 700 on doctor consultation and medicines. Kumar et al. reported that on an average, households in Punjab spent more than Rs. 1000 on non-chronic respiratory conditions like coughing, difficulty in breathing, irregular heartbeat etc. during the year 2008-09. However, 40-50% of this total expenditure was spent in the months of October and November which coincided with the stubble burning period. Stubble burning not only affects health and environment but can also increase health expenses and reduce productivity in an economy (Batra, 2017).

The study observed that 19% of the participants were previously diagnosed with chronic conditions such as asthma, hypertension, diabetes, CVDs etc. and out of those, 29.5% reported that conditions worsened during stubble burning season. This is supported by findings from the study by

Kumar et al. wherein 49% participants reported the same. Smoke from stubble burning can have serious health effects on exposed people who have pre-existing chronic conditions, especially respiratory conditions (Saggu et al., 2018). Inhalation of PM has been found to intensify chronic cardiac and pulmonary ailments and furthermore, is related to premature deaths in people with pre-existing chronic conditions (Singh, 2018).

Despite being mostly aware of the policies and programs to curb stubble burning, 38% of the participants still practiced stubble burning. This is in line with the findings of the study conducted in Haryana by Choudhary et al., where most of the farmers reported being aware of adverse effects of stubble burning on soil health, air health, and human health. They were also aware of the ban on stubble burning and other government measure but still resorted to stubble burning, as it was the only viable option.

4

STRENGTHS AND LIMITATIONS OF THE STUDY

The questionnaire had a mix of quantitative and qualitative questions which helped to understand the perspective of farmers a bit more in detail. Two districts of Punjab were selected – one with high prevalence of fires (Sangrur) and other with low prevalence (Hoshiarpur) – to understand if there is any difference in the health perspectives of farmers.

There may have been self-reporting bias in terms of recalling the health symptoms they experience, or the difficulties associated with the policies relating to stubble burning due to political sensitivity.

CONCLUSION

Around 21% of the participants had experienced at least one health symptom resulting from stubble burning. There are a lot of factors that can influence the health status besides stubble burning itself, such as size of the farmland, education, monthly income, usage of tobacco, access to relevant information, and awareness of policies.

The qualitative answers provide some insight into where the participants are coming from and what their reasons can be behind continuing with the practice of burning stubble. It is interesting to note that while 88.7% of the participants think that stubble burning causes air pollution, 80% of the participants reported that their or their family's health is not affected by stubble burning and only 20% reported covering their mouths with mask while practicing stubble burning or in the vicinity of it. The reasons they mentioned for that were having trees in the surroundings or not experiencing any symptoms. This can be indicative of lack of seriousness due to unawareness about the link between air pollution and health and about the long-term effects of stubble burning on the air quality and human health.

Keeping in line with the low prevalence of stubble burning in Hoshiarpur, it was observed that the prevalence of stubble burning symptoms was also lower than that in Sangrur. Participants from Hoshiarpur who were diagnosed with a chronic condition and reported that their condition worsened during the stubble burning season was a lot lesser than those in Sangrur (5% vs 50%).

While around 90% of the participants said they had come across advisories

published/announced by the government, it remains to be seen what kind of content was put out through the advisories.

The practice of burning stubble and presence of chronic conditions were found to be significantly associated with health symptoms. Those who burnt stubble and/or were diagnosed with chronic conditions such as asthma, CVDs, hypertension etc. were more at the risk of health impacts.

While the awareness regarding crop diversification, Punjab Preservation of Subsoil Water Act, alternatives to stubble burning is considerably good, the reasons mentioned for not practicing crop diversification or using alternatives to stubble burning were in line with the findings from the first part of the study. Reasons such as not getting good MSP for alternative crops, resource intensiveness of growing alternative crops, alternatives to stubble burning being expensive, and unawareness about it are reflective of shortcomings of the policies, which leads to more dependence on stubble burning.

5 WAY FORWARD

As is indicated from the findings of the study, the awareness about linkage among stubble burning, air pollution, and human health is low and must be addressed. Designing awareness programs that address how stubble burning causes air pollution and how that, in turn, affects human health should be the starting point. These programs should not be limited to farmers but should also cater to healthcare workers. Health professionals must be equipped with knowledge and resources to educate their patients and the community about the health impacts of stubble burning.

Preventive and promotive healthcare will help to address the higher levels of poor health amongst communities in regions practicing stubble burning. The health expenditure attributed to stubble burning related ill-health can have impacts on household incomes through unplanned out-of-pocket expenditure during acute illness. Having data for farmers coming in for health issues during stubble burning season and the out-of-pocket expenditure on it can facilitate informed policymaking.

There are practical challenges associated with the policies that have been introduced to curb stubble burning. Policymaking should be an inclusive process wherein all stakeholders, especially the ones who will be directly affected, should be consulted. This will ensure efficient on-ground implementation of policies and programmes. The ease of burning stubble as opposed to buying machines to manage stubble or the lack of market/good MSPs for alternative crops is something that needs to be acknowledged and addressed by the governments – both state and central. Inter-sectoral/inter-ministerial coordination while devising policies is a must. Ministries pertaining to agriculture, environment, and health must work in an integrated manner for a holistic approach to policymaking.

Empowering farmers with knowledge about sustainable farming practices and facilitating formation of self-help groups to access resources on rent are some of the solutions that can be adopted. While large scale farmers may have access to expensive machinery to manage stubble, it is the small-scale farmers who do not have the means for financially reasonable yet environment-friendly machinery. The government can establish centres that have a fixed day collection for stubble at a fixed place for a reasonable price. Last but not least, consistent research that is both inclusive and participatory needs to be done to understand the complexities associated with farming practices, and constraints of farmers, to help bring the voices of farmers to policymakers, and to advocate evidence-based policymaking.

BIBLIOGRAPHY

1. Sharma, A. R., Kharol, S. K., Badarinath, K. V. S., & Singh, D. (2010, February). Impact of agriculture crop residue burning on atmospheric aerosol loading–a study over Punjab State, India. In Annales Geophysicae (Vol. 28, No. 2, pp. 367-379). Copernicus GmbH.

2. Sharma, R., Singla, V., Kaushik, A., & Gupta, L. (2022, November). Mortality Assessment Due to Fine-PM Exposure During 2019 Stubble Burning Season in Punjab, Haryana, and Delhi Using WHO AirQ+ model. In Advances in Manufacturing Technology and Management: Proceedings of 6th International Conference on Advanced Production and Industrial Engineering (ICAPIE)—2021 (pp. 630-640). Singapore: Springer Nature Singapore.

3. Balakrishnan, K., Dey, S., Gupta, T., Dhaliwal, R. S., Brauer, M., Cohen, A. J., ... & Thornburg, V. L. (2019). The Impact of Air Pollution on Deaths, Disease Burden, and Life Expectancy across the States of India: The Global Burden of Disease Study 2017. The Lancet Planetary Health, 3(1), e26-e39.

4. Bray, C. D., Battye, W. H., & Aneja, V. P. (2019). The role of biomass burning agricultural emissions in the Indo-Gangetic Plains on the air quality in New Delhi, India. Atmospheric Environment, 218, 116983.

5. Gurjar, B. R., Ravindra, K., & Nagpure, A. S. (2016). Air pollution trends over Indian megacities and their local-to-global implications. Atmospheric Environment, 142, 475-495.

6. Gauderman, W. J., Avol, E., Gilliland, F., Vora, H., Thomas, D., Berhane, K., ... & McConnell, R. (2015). The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age. New England Journal of Medicine, 372(21), 2058-2067.

7. Clark, N. A., Demers, P. A., Karr, C. J., Koehoorn, M., Lencar, C., Tamburic, L., & Brauer, M. (2010). Effect of early life exposure to air pollution on development of childhood asthma. Environmental health perspectives, 118(2), 284-290.

8. Kloog, I., Melly, S. J., Ridgway, W. L., Coull, B. A., & Schwartz, J. D. (2019). Using Satellite-Based Spatiotemporal Resolved Air Temperature Exposure to Study the Association between Ambient Air Pollution and Birth Outcomes in Massachusetts. Environmental Health Perspectives, 127(1), 017003.

9. Patel, M. M., & Miller, R. L. (2009). Air pollution and childhood asthma: recent advances and future directions. Current opinion in pediatrics, 21(2), 235.

10. Fuertes, E., Bracher, J., Flexeder, C., Markevych, I., Klümper, C., Hoffmann, B., ... & Schulz, H. (2015). Long-term air pollution exposure and lung function in 15 year-old adolescents living in an urban and rural area in Germany: the GINIplus and LISAplus cohorts. International journal of hygiene and environmental health, 218(7), 656-665.

11. Sunyer, J., Esnaola, M., Alvarez-Pedrerol, M., Forns, J., Rivas, I., López-Vicente, M., ... & Julvez, J. (2015). Association between Traffic-Related Air Pollution in Schools and Cognitive Development in Primary School Children: A Prospective Cohort Study. PLOS Medicine, 12(3), e1001792.

12. Calderón-Garcidueñas, L., Torres-Jardón, R., Kulesza, R. J., Park, S. B., & D'Angiulli, A. (2014). Air pollution and detrimental effects on children's brain. The need for a multidisciplinary approach to the issue complexity and challenges. Frontiers in human neuroscience, 8, 613.

13. Batra, M.C. (2017). Stubble Burning in North-West India and its Impact on Health. Journal of Chemistry, Environmental Sciences, and its Applications, 4(1), 13-18.

14. Kumar P., Kumar S., Joshi L. (2015). Socioeconomic and Environmental Implications of Agricultural Residue Burning – A Case Study of Punjab, India. Springer Briefs in Environmental Science.

15. Abdurrahman, M. I., Chaki, S., & Saini, G. (2020). Stubble burning: Effects on health & environment, regulations and management practices. Environmental Advances, 2, 100011.

16. Saggu, G. S., Mittal, S. K., Agarwal, R., & Beig, G. (2018). Epidemiological study on respiratory health of school children of rural sites of Malwa region (India) during post-harvest stubble burning events. Mapan, 33, 281-295.

17. Singh, J. (2018). Paddy and wheat stubble blazing in Haryana and Punjab states of India: A menace for environmental health. Environmental Quality Management, 28(2), 47-53.

18. ANURADHA, K. K., & Meena, M. S. (2021). Reasons and awareness levels of farmers on residue burning in Indo-Gangetic Plain of India: An exploratory research.

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Centre for Chronic Disease Control

WHO Collaborating Centre for Surveillance, Capacity building and Translational Research in Cardio-Metabolic Diseases