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**STUBBLE BURNING IN STATE OF PUNJAB (SPECIAL
REFERENCE TO DOABA REGION): A COMPREHENSIVE
STUDY ON THE LEGAL TUG OF WAR BETWEEN
ENVIRONMENTAL CONCERNS AND FARMERS
LIVELIHOOD**

AUTHORED BY - JOBANPREET SINGH SOHAL

ABSTRACT

To investigate stubble burning in the Punjab state, focusing specifically on the Doaba region. Stubble burning, the act of igniting residual agricultural waste after harvest, is a significant environmental challenge in Punjab, especially in the Doaba region. This region, including districts like as Jalandhar, Kapurthala, and Hoshiarpur, is distinguished by vast rice-wheat agricultural cycles. Due to the brief period between rice harvest and wheat planting, farmers often use stubble burning as a cost-effective method for field clearance. The activity substantially exacerbates air pollution by releasing harmful particulate matter (PM_{2.5} and PM₁₀), greenhouse gases including carbon dioxide, and other pollutants such as carbon monoxide and methane. The consequent poor air quality adversely impacts health, leading to respiratory issues and other ailments, while simultaneously degrading soil health by depleting vital minerals and organic carbon. Despite several legislative measures, including the (Prevention and Control of Pollution) Act of 1981, the Environment Protection Act of 1986, and regional laws such as the Punjab Prevention of Burning of Crop Residue Act of 2013, implementation has been inconsistent. Agriculturalists see socio-economic limitations, limited access to alternatives, and insufficient infrastructure as barriers to adopting sustainable practices. Technologies like the Happy Seeder, which allows direct planting without stubble removal, are feasible alternatives; but, high costs and limited availability hinder widespread use. Recent governmental initiatives, including financial incentives and awareness campaigns, aim to promote sustainable agricultural practices. The effectiveness of these measures is often limited by socio-economic factors, insufficient enforcement, and the ingrained cultural habit of stubble burning. A multifaceted approach including legislative reforms, technical support, agricultural education, and community

engagement is essential for mitigating the adverse effects of stubble burning and advancing sustainable farming practices in Punjab.

Keywords: stubble burning, environmental degradation, sustainable agriculture, air pollution

1. INTRODUCTION

Stubble burning, the act of igniting residual agricultural waste after harvest, has emerged as a major environmental and health concern in Punjab, especially in the Doaba area. Punjab, acknowledged as one of India's most agriculturally prolific areas, has seen significant intensification of farming methods, emphasizing high-yield crops such as rice and wheat under the framework of the Green Revolution. This change has enhanced food security and economic prosperity, although it has also generated ecological concerns, especially with paddy stubble management. Agriculturalists sometimes incinerate stubble as a practical and cost-effective method to ready fields for subsequent crops, mainly wheat, which is planted shortly after the rice harvest in October and November.

The Doaba area, including the districts of Jalandhar, Kapurthala, Hoshiarpur, and Nawanshahr, is especially susceptible to stubble burning owing to its intensive agricultural methods and reliance on rice-wheat crop rotations. The issue exacerbates owing to the scarcity of mechanical alternatives and elevated labor expenses associated with more sustainable stubble removal methods. The magnitude of stubble burning in Punjab is significant, generating roughly 15 million tons of paddy residue each year, with around 80-85% incinerated. This activity considerably exacerbates air pollution by emitting detrimental particulate matter (PM_{2.5} and PM₁₀), carbon dioxide, carbon monoxide, methane, and several other greenhouse gases into the environment. In the stubble-burning season, air quality in Punjab and adjacent areas, including the national capital Delhi, significantly declines, resulting in health emergencies and ecological destruction. The problem is intensified in the Doaba region due to its distinct topographical and climatic characteristics. The area between the Beas and Sutlej rivers has seasonal temperature inversions during winter, resulting in the concentration of pollutants at the surface. This results in extended durations of subpar air quality, exacerbating respiratory ailments among the local populace. Moreover, the fertile alluvial soil and plentiful irrigation resources in Doaba enable large rice growing, resulting in increased stubble production. The escalating environmental issues

linked to stubble burning have prompted response from both the government and civil society; yet, the efficacy of these measures remains constrained.

The government has undertaken several measures to mitigate stubble burning, with inconsistent results. The National Green Tribunal (NGT) and the Supreme Court of India have issued many orders to deter the practice, including imposing penalties on farmers in some instances. The implementation of these restrictions has been irregular, since the socioeconomic difficulties encountered by small and marginal farms sometimes surpass the risk of fines. Farmers in Doaba and surrounding regions of Punjab assert that they lack economically viable alternatives to stubble burning. Many contemporary options, such as the Happy Seeder (a device enabling direct wheat seeding without the removal of paddy residue), the Super Straw Management System (SMS), and other mulching apparatus, are costly and not readily accessible. Notwithstanding governmental incentives, the elevated cost of these devices, along with the limited timeframe for planting the subsequent crop, hinders broad use.

The socioeconomic aspects of stubble burning in Punjab, especially in Doaba, underscore the systemic issues encountered by farmers. The principal farmers in the area manage modest to medium-sized farms, often depending on leased equipment. The elevated expenses associated with manpower, equipment, and materials, along with the narrow profit margins in rice farming, make alternate stubble control techniques economically impractical. Furthermore, the farmers' need to rapidly clear their fields between the rice harvest and the wheat planting diminishes the time available for alternatives to combustion. The onset of the wheat season after the rice harvest exerts significant pressure to expedite field preparation, hence extending the duration of stubble burning.

Stubble burning adversely affects soil health and biodiversity. The practice of stubble burning by farmers to prepare fields for subsequent crops adversely impacts soil fertility over time. The incineration of agricultural waste diminishes the soil's important nutrients, including nitrogen and phosphate, and eradicates vital microbes that contribute to soil health. Furthermore, it results in the depletion of organic carbon in the soil, diminishing its water retention capacity and adversely impacting the land's overall production. The Doaba area, characterized by intensive agriculture

and substantial use of chemical fertilizers and pesticides, is experiencing heightened soil degradation exacerbated by the practice of stubble burning¹.

In recent years, experts and policymakers have underscored the need for sustainable alternatives to stubble burning. The cultivation of diverse crop varieties is seen as a viable method. Modifying the dominance of the rice-wheat cropping system to include less water-intensive and residue-producing crops, such as pulses, oilseeds, and vegetables, might mitigate the stubble-burning problem. Crop diversification faces significant challenges, particularly in regions like Doaba, where agricultural infrastructure, market conditions, and farmer proficiency have traditionally favored rice and wheat cultivation. Furthermore, the government's Minimum Support Price (MSP) system, which guarantees price stability for rice and wheat, deters farmers from shifting to other crops.

Efforts to alleviate stubble burning in Doaba and Punjab should include technological advancements and regulatory enhancements. Advancing sustainable farming practices, bolstered by robust governmental laws and market incentives, is crucial for mitigating the environmental consequences of stubble burning. This involves improving the use of equipment like the Happy Seeder and SMS, increasing access to subsidies, and educating farmers on the long-term benefits of preserving soil health. Furthermore, policy frameworks that encourage crop diversity and the sustainable use of agricultural waste (for purposes such as bioenergy production or animal feed) may provide viable alternatives to incineration.

Community engagement and agriculture education activities are crucial. Collaborative initiatives including farmers, environmental experts, and legislators may improve awareness of the ecological impacts of stubble burning and promote more sustainable practices. Cooperative farming approaches, in which small farmers pool resources to invest in stubble management

¹ Sidhu, H. S, "Sustainable Management of Rice Straw in Punjab" 35 Journal of Environmental Management 113120. (2015).

technologies, have been suggested as a means to overcome the economic challenges of adopting sustainable practices.

The stubble burning in Punjab, particularly in the Doaba region, represents a complex intersection of environmental, economic, and societal challenges. Notwithstanding the enactment of governmental regulations and technological measures, the adoption of sustainable stubble management practices remains limited. A multifaceted approach including economic incentives, technological breakthroughs, agricultural education, and legislative reforms is essential to effectively address this situation. Punjab, especially the Doaba region, may attain a more sustainable agricultural system that aligns productivity with environmental stewardship via a combination of these methods.²

1.1 BACKGROUND OF STUBBLE BURNING IN PUNJAB

During the Green Revolution, which took place in the 1960s and 1970s, the practice of burning stubble in Punjab has historical and structural origins that stretch back to that time period. Prior to this time of profound change, Punjab's agricultural sector was distinguished by its diversity, with farmers cultivating a wide range of crops, including oilseeds, pulses, and millets. The conventional agricultural techniques required a significant amount of manual effort, and the crop leftovers were frequently utilized as organic compost or animal feed. High-yielding varieties of rice and wheat were developed during the Green Revolution in India, which was also accompanied by significant expenditures in irrigation, fertilizers, and pesticides. The Green Revolution was undertaken with the intention of assuring India's food security. These adjustments resulted in a substantial rise in production, which resulted in Punjab being referred

² Jethva, H, "Crop Residue Burning and Associated Environmental Pollution in Punjab, India" 14 Environmental Research Letters 1-10 (2014).

to as the "Granary of India." The old agricultural techniques and crop cycles were thrown off by this transformation, which also resulted in the establishment of a monoculture system that was dominated by rice and wheat.

The widespread use of automated farming in the latter half of the 20th century marked a significant turning point in agricultural history. It became common practice to make use of combine harvesters, which are effective yet leave behind stubble in the fields. As a result of their increased reliance on machines, farmers no longer considered crop residue to be a resource but rather a waste. In addition, the situation was made worse by the short time period (about twenty to twenty-five days) that existed between the harvesting of rice and the planting of wheat. It was discovered that burning the residue was the most efficient and cost-effective method for preparing the fields for the subsequent crop³.

Furthermore, the historical transition to paddy agriculture in an area that is naturally suited for dryland crops contributed to the worsening of the problem. In spite of the fact that rice requires a large amount of water, Punjab's groundwater resources have been overexploited as a result of heavily subsidised power and free water for irrigation, which has resulted in a dependence on paddy-wheat cycles. Because of the policies of the government on procurement, which offered minimum support prices (MSP) for rice and wheat, this pattern was maintained, leaving farmers with little incentive to diversify their crops.

Therefore, the historical trajectory of Punjab's agricultural growth, which was characterized by the Green Revolution, mechanization, and governmental regulations, created the groundwork for stubble burning as a technique that is widely practiced. Despite the fact that the system increased

³ NASA Earth Observatory. (n.d.). Stubble burning in Punjab, India.

<https://earthobservatory.nasa.gov/images/86982/stubble-burning-in-punjab-india>

food production, it gave rise to unanticipated environmental and health problems that are still very much present in the present day⁴.

1.2 THE DOABA REGION : AGRICULTURAL AND ENVIRONMENTAL CONTEXT

The Doaba region, meaning "land between two rivers," is a lush area in the Indian state of Punjab, located between the Beas and Sutlej rivers. This region is geographically delineated by the districts of Jalandhar, Hoshiarpur, Kapurthala, and Nawanshahr (Shaheed Bhagat Singh Nagar). The etymology of "Doaba" reveals its geographical context, with "Do" signifying two and "Ab" representing water or rivers. This area has historical, cultural, and geopolitical significance. Doaba, being the agricultural core of Punjab, has significantly influenced the state's economy.

The Doaba region's strategic location next to rivers guarantees the presence of rich alluvial soil, facilitating its development into a significant agricultural sector. The alluvium produced by the Beas and Sutlej rivers throughout time has made this area one of the most fertile in the nation. Its agricultural potential was recognized in antiquity and is widely used in contemporary agriculture. Moreover, Doaba is a pivotal cultural center, being the birthplace of several distinguished Sikh intellectuals, saints, and warriors, hence forming a crucial element of Punjab's socio-religious framework.

The area has significant political power because to its substantial expatriate population. A significant segment of Punjab's diaspora originates from the Doaba area, including the districts of Jalandhar and Hoshiarpur. The expatriate population has significantly influenced the region's political scene and economy by funding local development initiatives via remittances and other

⁴ Stubble burning in Punjab: A review. (2019). In *Journal of Pharmacognosy and Phytochemistry* (pp. 186–191). <https://www.phytojournal.com/archives/2019/vol8issue1S/PartE/Sp-8-1-50-778.pdf>

investments. The influx of capital has resulted in substantial infrastructure advancement, enhancing living standards and fostering contemporary agricultural practices in the area.

The Doaba region's inherent geographical advantages and socio-economic significance have established it as a crucial contributor to Punjab's economy, with agriculture serving as its foundation. This wealth has resulted in environmental issues, including soil deterioration and water shortages, stemming from intensive farming methods. The region's dependence on cash crops like as rice and wheat has exerted considerable strain on its natural resources, resulting in problems including groundwater depletion and pollution from the overuse of fertilizers and pesticides. Notwithstanding these obstacles, the area is integral to Punjab's agricultural and economic framework⁵

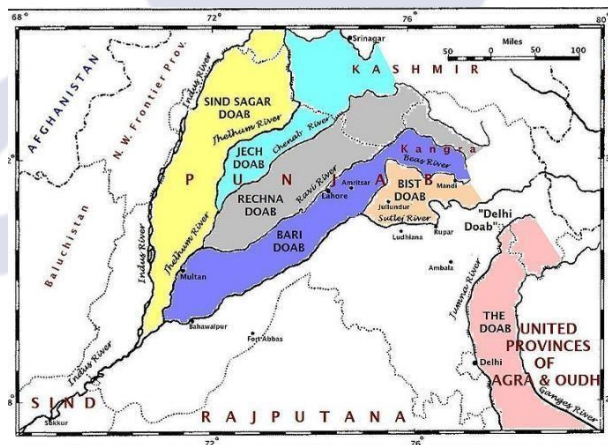


Fig.: A map of the Punjab region showing the different doabs Sources:

<https://shorturl.at/RxR8p>

⁵ Gill, S. & Singh, P., "The Agrarian Economy of Punjab: Challenges and Prospects" (2017).

1.2.1 AGRICULTURAL SIGNIFICANCE OF THE DOABA REGION

Agriculture is essential in the Doaba area, significantly influencing both the local and national economy. Punjab, sometimes called the "Granary of India," attributes a significant portion of its agricultural prosperity to the lush Doaba plains. This area utilizes sophisticated irrigation systems, mostly sourced from the Beas and Sutlej rivers, guaranteeing a reliable water supply for agriculture. Wheat and rice are the primary crops, substantially increasing Punjab's agricultural productivity, with Doaba functioning as a crucial region. The Green Revolution in the late 1960s significantly enhanced agricultural output via the use of new technologies, superior crop varieties, and chemical fertilizers.

Doaba generates significant volumes of food grains, with Punjab contributing 12-15% of India's overall wheat and rice output. Mechanized agriculture and substantial irrigation have augmented yields, resulting in the region's production of sugarcane, maize, vegetables, and fruits. These crops provide agricultural diversification, yet wheat and rice continue to prevail. Agriculture's impact beyond the economic sphere, deeply embedded in the cultural fabric of Punjab, shown by festivals such as Baisakhi that commemorate the harvest.

Nevertheless, issues like as groundwater depletion and soil degradation have arisen owing to intensive agricultural methods, especially the growth of water-intensive crops like rice. The over dependence on wheat and rice has diminished agricultural diversification, hence affecting longterm sustainability. Escalating input costs and rural debt have exacerbated agricultural challenges in the region, underscoring the need for more sustainable methods to guarantee long-term ecological and economic stability⁶.

⁶ Beri, V., "Groundwater Depletion and its Socio-Economic Impact in Punjab: A Case Study of the Doaba Region" 9 *International Journal of Agricultural Economics*, 203-210. (2021).

1.3 RESEARCH OBJECTIVE

i. To assess the environmental impact of stubble burning in the Doaba region of Punjab ii. To analyze the socio-economic factors driving stubble burning practices among farmers in the Doaba region iii. To evaluate the effectiveness of government policies and interventions aimed at reducing stubble burning in Punjab

1.4 HYPOTHESIS

This study hypothesizes that stubble burning in the Doaba region of Punjab significantly contributes to environmental degradation, leading to deteriorating air quality and soil health, which in turn exacerbates public health issues and climate change effects. It further posits that socio-economic factors, such as financial constraints, labor shortages, and lack of access to alternative agricultural practices, drive farmers to continue the practice of stubble burning despite its adverse consequences. Additionally, the research will explore the hypothesis that existing government policies and interventions have been largely ineffective in curbing stubble burning due to inadequate implementation, lack of awareness among farmers, and insufficient support mechanisms, thereby necessitating a comprehensive evaluation and reformation of these policies to promote sustainable agricultural practices.

1.5 RESEARCH QUESTIONS

- I. What are the specific environmental impacts of stubble burning in the Doaba region of Punjab, particularly regarding air quality, soil health, and local biodiversity?
- II. What socio-economic factors contribute to the prevalence of stubble burning among farmers in the Doaba region, and how do these factors vary across different agricultural communities?
- III. How do perceptions of stubble burning among farmers in the Doaba region influence their agricultural practices and decision-making processes?

- IV. What is the effectiveness of current government policies and interventions in reducing stubble burning in Punjab, particularly in the Doaba region, and how do farmers respond to these measures?
- V. What are the barriers and challenges faced by farmers in the Doaba region in adopting alternative crop residue management practices instead of stubble burning, and how can these be addressed through policy and community engagement?

1.6 RESEARCH GAP

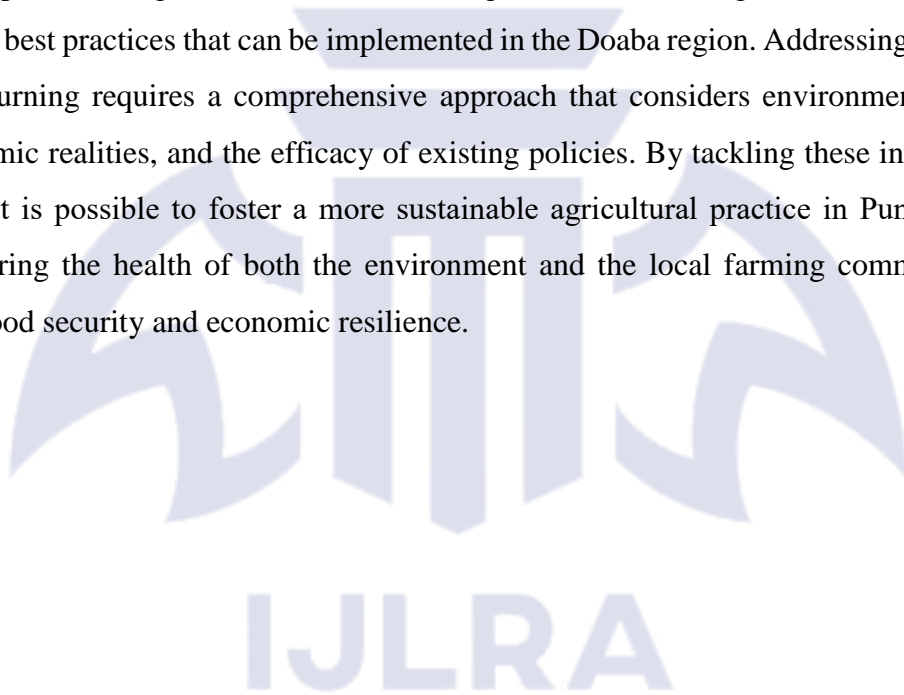
Research on stubble burning in Punjab's Doaba region has acquired importance due to the negative environmental and socioeconomic consequences of this agricultural practice. However, there is a major gap in quantifying the environmental impact of stubble burning in the Doaba region. While studies have established air quality decline and its link with stubble burning on a statewide or national scale, localized research concentrating on the Doaba region's distinct topographical, climatic, and socioeconomic circumstances is rare. Such localized assessments are critical for understanding how stubble burning impacts air quality, soil health, and water resources in the Doaba region. Furthermore, the existing literature frequently lacks in-depth analyses of the cumulative long-term environmental impacts of repeated stubble burning in an intensive agriculture region, necessitating an investigation into how these practices affect local ecosystems and biodiversity in the long run. The socioeconomic elements that influence stubble burning behaviors among farmers in the Doaba region are likewise little understood. While several studies highlight economic pressures, labor shortages, and a lack of awareness about sustainable options, more qualitative and quantitative research is needed to delve deeper into the factors driving farmers' decisions to burn stubble. Understanding these socioeconomic forces necessitates a careful examination of cultural attitudes about agricultural practices, the role of traditional farming methods, and how current agricultural policies affect local life. Furthermore, little study has been conducted to investigate the influence of social networks, access to resources, and information transfer in altering farmers' views toward stubble burning. Addressing this gap may provide insights into how community engagement and education might aid in the

adoption of sustainable practices. Furthermore, the effectiveness of government policies and actions targeted at minimizing stubble burning in Punjab, notably in the Doaba region, should be evaluated critically. Although many government programs have been implemented to address the issue, such as financial subsidies for alternative techniques and information campaigns, the actual impact on farmer behavior and stubble burning rates has not been thoroughly studied. To evaluate these initiatives, empirical research must be conducted to determine their reach, acceptance, and effectiveness among the farming community in the Doaba region. Additionally, there is a need to investigate the challenges that impede the proper implementation of these policies, such as bureaucratic inefficiency, inadequate infrastructure, and limited access to alternative technology. Furthermore, the interaction between policy efficacy and local socioeconomic dynamics deserves additional research. Understanding how local power dynamics, political will, and community engagement affect policy results is critical for developing effective interventions. Finally, combining environmental, social, and policy assessments may result in a more comprehensive knowledge of the Doaba region's stubble burning problem. Thus, bridging these knowledge gaps is critical for developing targeted measures that not only address the immediate difficulties of stubble burning but also encourage sustainable farming practices and improve the overall environmental health of the Doaba area.

1.7 PROBLEM OF THE STATEMENT

Stubble burning in the Doaba region of Punjab presents a multifaceted problem that encompasses significant environmental, socio-economic, and policy-related dimensions. The practice, primarily adopted by farmers to clear fields for the next planting season, has led to serious environmental consequences, including the deterioration of air quality, soil health, and overall ecological balance. This is particularly concerning given the Doaba region's agricultural prominence, where the indiscriminate burning of crop residues contributes to severe air pollution, resulting in adverse health effects on the local population and surrounding areas. In addition to the environmental ramifications, the socio-economic factors driving stubble burning warrant thorough investigation. Many farmers in the Doaba region face financial constraints and labor

shortages, which compel them to resort to stubble burning as a quick and cost-effective method for land preparation. The lack of access to affordable alternatives for managing crop residues exacerbates this issue, creating a cycle where economic pressures take precedence over environmental considerations. Furthermore, understanding the effectiveness of existing government policies and interventions aimed at curbing stubble burning is critical. Despite various initiatives launched by the state and central governments, including subsidies for ecofriendly farming equipment and awareness campaigns, the actual impact on stubble burning practices has been limited. Many farmers remain unaware of or unable to access these resources, highlighting a disconnect between policy formulation and on-ground realities. Evaluating these policies will provide insights into their shortcomings and areas needing enhancement, as well as help identify best practices that can be implemented in the Doaba region. Addressing the problem of stubble burning requires a comprehensive approach that considers environmental impacts, socio-economic realities, and the efficacy of existing policies. By tackling these interconnected challenges, it is possible to foster a more sustainable agricultural practice in Punjab's Doaba region, ensuring the health of both the environment and the local farming community while enhancing food security and economic resilience.



2. LITERATURE REVIEW

(Govardhan et al., 2023)⁷ Stubble burning in northern India significantly contributes to particulate matter (PM) and trace gases, thereby impacting local and regional climates and presenting serious health risks. Research assessing the impact of these burnings on air quality in Delhi is scarce. This study analyzes satellite-derived stubble-burning activities in 2021, using MODIS active fire count data for Punjab and Haryana, and assesses the effects of CO and PM_{2.5} emissions from these biomass-burning activities on pollution levels in Delhi. Data reveals that satellite-derived fire counts in Punjab and Haryana reached their zenith during the last five years (2016–2021). Moreover, the stubble-burning fires in 2021 occurred about one week later than those in 2016. Tagged tracers for carbon monoxide and particulate matter 2.5. Emissions from fire sources are used within the regional air quality forecasting system to assess the influence of fires on air pollution in Delhi. The modeling technique reveals that stubble-burning fires accounted for around 30–35% of the daily mean air pollution in Delhi from October to November 2021. The influence of stubble burning on air quality in Delhi is most pronounced during the tumultuous late morning to afternoon period and least important during the tranquil evening to early morning hours. The quantification of this contribution is crucial for policymakers concerning crop-residue and air-quality management in both source and receptor areas.

(Porichha et al., 2021)⁸ Recent studies indicate that the practice of stubble burning of agricultural residues in India produces approximately 150 million tons of carbon dioxide (CO₂), more than 9 million tons of carbon monoxide (CO), 250,000 tons of sulfur oxides (SOX), 1 million tons of particulate matter, and over 500,000 tons of black carbon. These factors directly contribute to environmental pollution, the fog in New Delhi, and the retreat of the Himalayan glaciers. Despite

⁷ Gaurav Govardhan et al., “Stubble-burning activities in north-western India in 2021: Contribution to air pollution in Delhi” *Heliyon* (2023).

⁸ Gaurav Kumar Porichha et al., “Crop residue management in india: Stubble burning vs. other utilizations including bioenergy” *Energies*, 2021.

the ban on stubble burning of agricultural waste as stipulated in Section 188 of the Indian Penal Code (IPC) and the Air and Pollution Control Act (APCA) of 1981, there is a notable deficiency in the enforcement of these legal measures nationwide. Crop wastes may be used for several purposes, including cow feed, compost combined with manure, rural roofing, bioenergy generation, beverage manufacturing, packaging materials, wood, paper, and bioethanol. This review paper seeks to elucidate the present state of stubble-burning methods for agricultural residue management in India and to assess several alternative approaches for the valorization of these residues. This research study provides a comprehensive examination of the detrimental effects of agricultural residue mismanagement via stubble burning in India, as well as more advantageous management strategies, such as using residues for bioenergy generation. If broadly implemented, these technologies might mitigate environmental impacts and provide substantial benefits to the global agricultural sector.

(Yakupoğlu et al., 2022)⁹ The global risk of fire propagation is exacerbated by insufficient management of agricultural waste. In 2019, 3.6% of Turkey's forested land was impacted by fires resulting from stubble burning. The incineration of agricultural leftovers adversely impacts soil characteristics, air quality, and water resources. This ultimately jeopardizes the sustainability of humanity. Nonetheless, there is a paucity of literature about this topic within the context of contemporary policy in Turkey. This article examines existing regulations to determine the precise competences necessary for sustainable fire and forest management. A comprehensive examination of the regulatory frameworks and measures aimed at reducing stubble burning in Turkey reveals farmers' perspectives on the use of fire as an agricultural instrument and the significance of stubble burning in elucidating the incidence and frequency of wildfires. We subsequently evaluated the significance of elucidating the efficacy of legislation designed to mitigate stubble burning and its environmental consequences. We advocate for legislative reforms that empower farmers to manage stubble and urge policymakers to devise innovative

⁹ Tuğrul Yakupoğlu et al., "Stubble burning and wildfires in Turkey considering the Sustainable Development Goals of the United Nations" *Eurasian Journal of Soil Science* (2022).

composting strategies, thereby promoting sustainable management in alignment with the United Nations' Sustainable Development Goals and supporting the Land Degradation Neutrality Challenge.

(Mohite et al., 2022)¹⁰ The onset of COVID-19 has incapacitated the whole globe. Numerous nations, including India, were necessitated to suspend the majority of urban, industrial, social, and other activity because to the epidemic. The extensive lockdowns implemented in India from March 24 to May 17, 2020, followed by targeted limitations, led to a significant decrease in emissions of several air pollutants. This research aims to analyze the variations in pollutant concentrations, namely nitrogen oxide (NO₂), carbon monoxide (CO), and aerosol optical depth (AOD), resulting from control measures, and to assess the impact of agricultural stubble burning on air quality. Data on NO₂ and CO from Sentinel-5P for 2019 and 2020, together with AOD observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) for 2016–2020, were used to identify changes. The findings indicated a significant reduction in NO₂ levels throughout different phases of lockdown. A marginal reduction in CO levels was seen throughout a significant portion of India. With few exceptions, including coastal and desert areas, there was a slight reduction in AOD levels. Additionally, to evaluate the impacts of NO₂, CO, and AOD stemming from agricultural stubble burning, MODIS data on active fire occurrences were collected from the Visible Infrared Imaging Radiometer Suite (VIIRS). The incineration of agricultural residues elevated NO₂ emissions by 22 to 80%. In contrast, carbon monoxide concentrations have increased by 7 to 25%. A notable variance in AOD was documented, spanning from 1% to 426%.

(Abdurrahman et al., 2020)¹¹ Stubble burning is a major source of air pollution in South Asia, releasing pollutants such as CO₂, CO, NO_x, SO_x, CH₄, and particulate matter (PM₁₀, PM_{2.5}),

¹⁰ Jayantrao Mohite et al., “Impact of lockdown and crop stubble burning on air quality of India: a case study from wheat-growing region” *Environmental Monitoring and Assessment* (2022).

¹¹ Muhammad Isa Abdurrahman, Sukalpaa Chaki and Gaurav Saini, “Stubble burning: Effects on health & environment, regulations and management practices” *Environmental Advances*, 2020.

which negatively impact human health and the ecosystem. In India, the rice-wheat agricultural system produces 352 million tons of stubble annually, with 24% being burnt, hence worsening air quality, particularly in the National Capital Region (NCR) around October and November. Air pollution induces considerable health issues, such as asthma, COPD, and cancer, leading to increased death rates. In 2012, it caused 5 million deaths in South Asia. Stubble burning degrades soil fertility and adversely affects the economy. Farmers in North India often lack awareness of other use for stubble, including biofuel production, composting, and industrial usage. Awareness campaigns are crucial for promoting sustainable alternatives.

(Khan et al., 2023)¹² Each year, from October to November, stubble burning in Punjab and Haryana markedly exacerbates air pollution in Delhi. This study examines the impact of stubble burning and firecrackers on air pollution levels in Delhi between 2020 and 2022. Data from the CPCB and NASA's FIRMS reveal that fire incidences peak around mid-November, with the highest reported counts in 2021 (80,505), followed by 2020 (75,428), and 2022 (49,194). Over 90% of incidents happened in Punjab. Stubble burning increases PM_{2.5} concentrations by 50–75% and PM₁₀ concentrations by 40–45%. The use of firecrackers intensifies PM_{2.5} concentrations and increases PM₁₀ by 55%. A strong positive correlation (up to 0.8) was seen between fire counts and pollution concentrations.

(Mittal et al., 2009)¹³ In and around Patiala city, India, there were reports of open agricultural stubble burning. The influence of stubble burning on aerosol, SO₂, and NO₂ levels in the air at five different sites in and around Patiala city was investigated in a ground-level research. These sites included residential, commercial, and agricultural areas. The crops studied were wheat (*Triticum aestivum*) and rice (*Oryza sativa*). In 2007, aerosols were collected over the course of

¹² Abul Amir Khan et al., “Effects of stubble burning and firecrackers on the air quality of Delhi” *Environmental Monitoring and Assessment* (2023).

¹³ Susheel K. Mittal et al., “Ambient air quality during wheat and rice crop stubble burning episodes in Patiala” *Atmospheric Environment* (2009).

24 hours using GMF/A and QMF/A (Whatman) sheets. At the same time, samples of sulfur

dioxide and nitrogen oxide were taken, and the results from the periods when stubble was burned were compared to the results from times when stubble was not burned. Aerosol, SO₂, and NO₂ concentrations rose significantly during agricultural stubble burning times, according to the data.

(Khundrakpam & Sarmah, 2023)¹⁴ For environmentalists in India, the practice of stump burning is a growing problem. In addition to the more obvious pragmatic reasons, the article argues that burning stubble has policy-based antecedents in India's Green Revolution. The research continues by evaluating the current policy responses to the practice in India and their effectiveness. Therefore, the paper argues that in order to achieve ecological holism and sustainability, it is necessary to address stubble burning alongside other environmental problems and the policies that follow.

(Palta & Kaur, 2024)¹⁵ The physiochemical and electrical properties of soil are altered when stubble is burned. This study uses dielectric measurements acquired using remote sensing methods to investigate how stubble burning affects these traits. Researchers in Punjab, India, examined soil samples using a Vector Network Analyzer and a Dak-12 open-ended coaxial probe. The findings show that burn remains may modify soil quality over time by penetrating soil up to 10 cm deep. Outperforming all other regression models studied, the Deep Neural Network model demonstrated the most potential use of machine learning in soil research. Soil fertility and basic properties are altered and diminished when straw is burned.

¹⁴ Prakash Khundrakpam and Jayanta Krishna Sarmah, "Stubble Burning in India: Politics and Policy Responses" *Indian Journal of Public Administration* (2023).

¹⁵ Prachi Palta and Prabhdeep Kaur, "Stubble Burning Effect On Soil's Dielectric Behavior: An Exploration Of Machine Learning-Based Modelling Approaches" *Soil and Sediment Contamination* (2024).

3. RESEARCH METHODOLOGY

This study utilizes both doctrinal and non-doctrinal research approaches to thoroughly fulfill the research objectives, integrating theoretical analysis with empirical data collecting. The technique is meticulously crafted to analyze the jurisprudential evolution in environmental law and criminal responsibility related to stubble burning, while also gathering primary data from the field.

3.1 Doctrinal Research Framework

The doctrinal research method is employed to examine the legal framework and jurisprudence concerning the right to a clean environment and the criminal culpability associated with stubble burning. This facet of the study is based on a comprehensive analysis of case laws, judicial precedents, and significant rulings issued by different courts in India. To substantiate this study, reports from pertinent committees and commissions were meticulously examined to discern crucial concerns and themes associated with the research challenge. The doctrinal study establishes a robust theoretical basis and aids in situating the findings within the wider context of environmental and criminal law.

3.2 Non-Doctrinal Research Methodology

This research primarily emphasizes the non-doctrinal or empirical method, facilitating the acquisition of real, on-the-ground facts. A systematic approach was employed to guarantee dependability and precision.

3.2.1 Data collection tools

An elaborate interview schedule was established to gather essential information directly from participants. Most questions were formulated as closed-ended to enhance answer efficiency. The program was carefully organized to correspond with the study's objectives, guaranteeing comprehensive coverage of all pertinent topics.

Participants comprised farmers, community members, and those directly or indirectly impacted by stubble burning methods. An someone proficient in Punjabi was expressly hired to engage with respondents and obtain accurate information. Local research investigators were enlisted to facilitate data collecting. The scientists possessed a profound comprehension of the region and its dynamics, allowing a more sophisticated approach to data collection.

3.2.2. Informal Discussions

Informal contacts were held with many stakeholders, including attorneys, members of the public, and governmental representatives. The conversations yielded significant insights into the issue, facilitating the identification of practical obstacles and viable solutions.

3.2.3 Input from Police officials:

Insights and recommendations were gathered from police officials to comprehend their viewpoint on enforcement and regulatory difficulties associated with stubble burning.

3.2.4 Government Involvement

Recommendations and results were presented on the Punjab government's official website, establishing a direct contact line with policymakers. This interaction introduces a novel aspect to the study by connecting academic analysis with practical policy suggestions.

4. CONSTITUTIONAL PROVISIONS AND LEGAL FRAMEWORK

The problem of stubble burning overlaps with many legislative measures in India, demonstrating the nation's dedication to environmental preservation and public health. Essential constitutional, legislative, and judicial frameworks tackle the issue, highlighting its criminal and environmental ramifications.

Article 21: Right to Life and Personal Liberty¹⁶

Article 21 of the Constitution of India ensures the right to life and personal liberty. The Hon'ble Supreme Court of India has broadly construed this right via historic cases to encompass the right to a clean, healthy, and sustainable environment. The Court has frequently stated that environmental deterioration, such as air pollution from stubble burning, violates individuals' basic rights to live with dignity in a pollution-free world.

LEGAL FRAMEWORK

• *Bharatiya Nyaya Sanhita (BNS)*

The Bharatiya Nyaya Sanhita (Indian Penal Code) delineates specific clauses that classify stubble burning as a criminal conduct. These clauses emphasize the legal responsibility of persons or entities involved in actions detrimental to public health and the environment. The Act seeks to discourage stubble burning by criminalizing the practice and encouraging adherence to environmental standards.

¹⁶ Constitution of India. (2023, March 31). *Article 21: Protection of life and personal liberty - Constitution of India*. <https://www.constitutionofindia.net/articles/article-21-protection-of-life-and-personal-liberty/>

- ***Air (Prevention and Control of Pollution) Act, 1981¹⁷***

Stubble burning is classified as an infraction under the Air (Prevention and Control of Pollution) Act, 1981. This Act authorizes the government and regulatory bodies to mitigate and regulate air pollution. It also facilitates the enforcement of sanctions and requires steps to mitigate pollutants, thereby tackling the detrimental effects of stubble burning on air quality.

- ***National Green Tribunal Act of 2010***

The National Green Tribunal Act, 2010, adopted by the Indian Parliament, establishes the National Green Tribunal (NGT), a specialized entity for the swift adjudication of disputes pertaining to environmental preservation and conservation. The NGT has been instrumental in tackling the problem of stubble burning by its rulings and recommendations. It has underscored the responsibility of state governments and regulatory agencies in executing actions to avert the practice. The Tribunal offers a venue for impacted persons to pursue restitution and enforce environmental legislation efficiently.

PUNJAB SPECIFIC LEGISLATIONS

In Punjab, there are several laws and regulations related to stubble burning. Stubble burning is a significant environmental and health issue in the state, and the government has taken several steps to prevent it. The following are the key laws related to stubble burning in Punjab:

- ***The Punjab Preservation of Subsoil Water Act, 2009***

This law prohibits the burning of paddy straw or any other crop residue in the state. The law also provides for penalties for violations of the provisions, including fines and imprisonment.

¹⁷ Government of India, “Government of India” (The Air (Prevention and Control of Pollution) Act, 1981. New Delhi: Ministry of Law and Justice, 1981)

• *The Punjab Pollution Control Board (PPCB) Guidelines*

The Punjab Pollution Control Board has issued guidelines for the management of crop residue, which prohibit the burning of crop residue in the fields. The guidelines also provide for penalties for violations of the provisions.

• *The Air (Prevention and Control of Pollution) Act, 1981*

This is a central law that provides for the prevention, control, and abatement of air pollution. It empowers state governments to take measures to control air pollution, including stubble burning.

• *The National Green Tribunal (NGT) Directives*

The NGT has issued several directives to prevent stubble burning in Punjab, including directing the state government to provide incentives to farmers to encourage them to adopt alternative methods of managing crop residue.

• *The Punjab Agricultural University Act, 1970*

This law empowers the Punjab Agricultural University to conduct research and development activities related to agriculture, including the development of alternative methods of managing crop residue.

JUDICIAL PRONOUNCEMENTS

MC MEHTA V. UNION OF INDIA¹⁸

The Supreme Court's ruling in *M.C. Mehta v. Union of India* (2019-2020) marked a pivotal moment in addressing environmental pollution in Delhi and the National Capital Region (NCR), highlighting the balance between environmental protection and sustainable development. The case focused on the enforceability of Directive Principles of State Policy (DPSP) under Article 21, reaffirming that a pollution-free environment is integral to the fundamental right to life. The

¹⁸ *M.C. Mehta v. Union of India*, (2020)

court acknowledged stubble burning in Punjab, Haryana, and Uttar Pradesh as a significant contributor to the deteriorating air quality in Delhi NCR, along with industrial emissions, construction activity, and vehicular pollution. It issued directions to mitigate these impacts, including providing financial support to small and marginal farmers (Rs. 100 per quintal) and making agricultural equipment available at subsidized rates or on lease, ensuring farmers were not unfairly burdened while adopting sustainable practices.

The court further invoked the public trust doctrine and reinforced the polluter pays principle, imposing fines on entities responsible for pollution and emphasizing strict compliance with industrial and waste management standards. While advocating penalties for stubble burning, it stressed the need for government assistance to farmers, recognizing their socio-economic challenges. The ruling harmonized environmental preservation with sustainable development by easing restrictions on construction activities, conditional on air quality safeguards. This judgment underscores the judiciary's proactive role in environmental justice, asserting that Article 21's scope extends to a clean and healthy environment, and calls for aligning punitive measures with support for ecologically responsible practices. Through this landmark decision, the court showcased its commitment to balancing public health, environmental sustainability, and economic welfare.

COURT ON IT'S OWN MOTION V. STATE OF PUNJAB¹⁹

The case *Court on Its Own Motion v. State of Punjab (2021)* arose from an incident where an individual accused of a minor infraction was unjustifiably handcuffed by the Punjab Police. The Punjab and Haryana High Court took suo motu cognizance of the matter to evaluate the legality and constitutional validity of handcuffing accused persons, particularly for minor offenses. The primary issues included the legality of handcuffing without sufficient cause or requisite permission, which was argued to violate fundamental rights under Articles 14, 19, and 21 of the

¹⁹ Court On v. State of Punjab, (2021) SCC Online P&H 1438

Indian Constitution; compliance with established guidelines from the landmark judgment *Prem Shankar Shukla v. Delhi Administration (1980)*, which mandated strict requirements for handcuffing accused persons; and police accountability for misuse of power in such situations. The High Court ruled that handcuffing without judicial authorization or extraordinary circumstances constitutes a breach of Article 21, which guarantees the right to life and personal liberty. The judgment reaffirmed the principles from *Prem Shankar Shukla*, emphasizing that handcuffing should only occur in exigent circumstances, such as when the accused poses a significant flight risk or threat to others. Furthermore, the court held that unjustifiable handcuffing violates human dignity, a core element of Article 21, and reinforced the requirement for mandatory judicial approval prior to handcuffing. In cases of urgent need, such action must be followed by justification to the court.

To address the specific incident, the court directed that disciplinary investigations be conducted against the implicated officers for violating established legal standards. The State of Punjab was instructed to ensure strict compliance with these legal provisions across all law enforcement agencies. In conclusion, the judgment unequivocally declared arbitrary and unreasonable handcuffing as illegal, upholding the principles of personal dignity and freedom. It reaffirmed the duty of law enforcement agencies to protect the rights of accused individuals and prevent degrading treatment in custody, except where expressly required and justified by law.

ICELA V. STATE OF PUNJAB²⁰

In the case of *Indian Council for Environment-Legal Action v. State of Punjab (2020)*, the Indian Council for Environment-Legal Action (ICELA), a non-governmental organization, filed legal action against the State of Punjab for environmental violations. ICELA argued that the state's

²⁰ *Indian Council v. State of Punjab*, (2020) 0 SCC 798

negligence in regulating pollution from industrial sites had caused significant harm to the environment and posed severe risks to public health. The key issues before the court were

whether the State of Punjab had failed to enforce environmental laws adequately, whether the polluting industries had violated environmental regulations and were accountable for the resulting damage, and whether the "polluter pays" principle was applicable to determine liability.

The Supreme Court of India ruled that the State of Punjab had a constitutional obligation to ensure environmental protection under Article 48A of the Directive Principles of State Policy and Article 21, which guarantees the Right to Life. The court found that the state's failure to implement and enforce environmental regulations had led to unchecked industrial pollution, causing environmental degradation. The judgment emphasized that the state's inaction amounted to a violation of its constitutional duty to safeguard the environment.

The court issued several directives to address the issue. It ordered the stringent implementation of environmental laws to prevent further violations and directed polluting industries to compensate for the environmental harm caused, in accordance with the "polluter pays" principle. Furthermore, the court held state officials accountable for their noncompliance with environmental regulations, instructing disciplinary measures against those responsible for neglecting their duties.

This verdict underscored the importance of environmental justice and reinforced the need for state authorities to act decisively and effectively in preventing environmental degradation. It highlighted the application of the "polluter pays" principle as a critical tool for ensuring accountability and deterring future violations, thereby promoting sustainable environmental governance.

5. REASONS FOR STUBBLE BURNING

5.1 LIMITED TIME BETWEEN THE CROPS

In India, particularly in states like Punjab, there is a limited time window between the harvesting of one crop and the sowing of the next, creating a significant challenge for farmers. The short period available for field preparation forces farmers to clear their fields quickly to ensure timely planting of the subsequent crop. In this context, stubble burning becomes a preferred method for many farmers, as it is perceived as a quick and efficient way to dispose of the crop residue.

Focusing on Punjab, the state government has implemented specific measures to regulate the sowing of paddy crops, especially in regions like Doaba, where the sowing date is fixed as June 15. This policy was introduced with the goal of preserving the increasingly depleting underground water reserves in the state. The government's decision to mandate a fixed date for sowing is intended to reduce excessive water usage, particularly for irrigation, which is a critical issue in Punjab due to its reliance on water-intensive paddy cultivation. However, this policy also has an unintended consequence: it reduces the time farmers have between harvesting the previous crop and preparing the field for the next sowing.

No farmer to sow or transplant paddy before the notified date

3. (1) No farmer shall sow nursery of paddy before 10th Day of May of the agricultural year or such other date as may be notified by the State Government by notification in the Official Gazette for any local area.

Explanation – For the purpose of this section, 'agricultural year' means the year commencing on the 16th day of June or on such other date as may be appointed by the State Government by

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To comply with this timeline, farmers use machinery such as combines and threshers for harvesting, which often leaves behind a significant amount of crop residue. Given the limited time available for field preparation and the absence of efficient alternatives for dealing with the leftover straw, many farmers resort to burning the residue. This practice is seen as a quick solution to clear the fields, even though it has detrimental environmental and health impacts. The farmers, constrained by the tight schedule, are left with little choice but to engage in stubble burning, as it is the most expedient method to prepare for the upcoming crop.

7. (1) Any farmer, who contravenes the provision the provisions of this Act, shall be liable of penalty of rupees ten thousand for every month or part thereof, per hectare of the land till the period, such contravention continues.

Penalty

While the government has imposed penalties for violations of agricultural practices, such as levying a fine of ₹10,000 for farmers who fail to comply with the fixed sowing date, these regulations further exacerbate the time pressures on farmers. The combination of stringent sowing deadlines, the need for efficient field clearing, and the lack of accessible alternatives to stubble burning, creates a complex situation for farmers, who are caught between government regulations and the practical realities of crop management.

5.2 COST OF ALTERNATIVES

Despite extensive acknowledgment of the issue, the absence of feasible and economical options for stubble management continues to be a primary factor in the persistent practice of stubble burning. Innovative technologies such as the Happy Seeder, which enables farmers to sow wheat straight onto stubble without incineration, have shown potential but remain too costly for most farmers. Despite governmental incentives, the use of these technologies has been constrained, mostly owing to insufficient awareness and practical obstacles, such as equipment availability and the need for specialized training.

In-situ stubble management involves integrating stubble into the soil to enhance organic matter content, necessitating substantial changes in agricultural techniques and investment in equipment such as rotavators and zero-till drills. Moreover, the logistics of moving stubble for bioenergy or paper manufacture applications are sometimes impractical owing to associated expenses. The absence of infrastructure and value chains for stubble reutilization has forced farmers to see burning as their only alternative. The issue is exacerbated by the presence of smallholder farmers who operate with less money. The financial burden of adopting new technology or alternative

techniques, even with incentives, is seen as excessive relative to the fast and economical solution of garbage incineration.²¹

5.3 MECHANIZED FARMING AND THE RICE-WHEAT CROP CYCLE

Mechanized agriculture has significantly altered the agricultural environment in the Doaba region. The introduction of combine harvesters has accelerated the harvesting process, although it has produced shorter straw lengths, known as stubble, which are insufficient for traditional use such as feed. This is particularly relevant to paddy, where the straw is often left at a height that requires its removal before to sowing the ensuing crop. With the stubble reduced to a level inadequate for human collection, incineration becomes the only viable option for farmers who cannot afford the additional costs of robotic stubble removal or alternatives like happy seeders.

The rice-wheat planting method intensifies the issue. Both crops need substantial water and labor, and their continuous rotation depletes soil nutrients, hence demanding further inputs of fertilizers and water. The current crop cycle's challenge is the over reliance on groundwater for paddy agriculture, leading to over-extraction and subsequent state-imposed restrictions on early planting to save water supplies. The Punjab Preservation of Subsoil Water Act, 2009 prohibits early paddy planting, hence diminishing the narrow window between paddy harvesting and wheat sowing, which subsequently promotes stubble burning as the only feasible method for swiftly clearing fields.²²

²¹ Yadvinder-Singh and Humphreys, E., "Improving the Sustainability of the Rice-Wheat System in Punjab Through Conservation Agriculture" 10 (2018).

²² Brar, A., "Socioeconomic Drivers of Stubble Burning Practices in Punjab" 74 *Indian Journal of Agricultural Economics* 223-237 (2019).

5.4 LACK OF AWARENESS AND EDUCATION

Another contributing cause is the farmers' insufficient understanding of the long-term environmental and health consequences of stubble burning. Despite efforts to educate farmers about the hazards of air pollution and the advantages of sustainable agricultural methods, these activities have not effectively reached all segments of the farming community, especially in rural regions.

5.5 POLICY AND INSTITUTIONAL GAPS

Notwithstanding the government's implementation of several regulations and attempts to address the problem of stubble burning, significant shortcomings persist in their execution. The Punjab government's attempt to provide subsidized agricultural equipment has been criticized for its poor targeting and ineffectiveness in reaching small and marginal farmers. The enforcement of penalties for stubble burning has been inconsistent, leading many farmers to continue the practice due to insufficient enforcement measures²³.

5.6 SOCIO-ECONOMIC PRESSURES

The decisions of farmers about stubble burning are profoundly affected by socioeconomic factors. In the Doaba region, like in all of Punjab, agriculture is the economic base, and farmers experience considerable pressure to maintain yields to secure their livelihoods. Profit margins in agriculture are often limited, especially for small and medium-sized farmers that lack the financial means to invest in advanced technology or alternative farming practices. In some cases, the costs related to personnel and equipment required for manual stubble removal or the adoption of ecologically friendly techniques often surpass the expected benefits, particularly when faced with constrained planting intervals between crops.

²³ Muhammad ISA Abdurrahman, Sukalpaa Chaki , Gaurav Saini, *et.al.*, “Stubble Burning: Effects on Health & Environment, Regulations and Management Practices” 2 (2020).

The stubble burning choices of farmers in Doaba are significantly shaped by land tenure arrangements, since many lease land on a yearly basis, which diminishes their propensity to use long-term practices such as stubble management. Immediate financial gain is valued, and stubble burning is seen as a rapid, economical option. Peer influence and tradition significantly contribute, since stubble burning is a firmly entrenched habit. The lack of awareness about its detrimental effects and budgetary limitations sustains the practice. Mechanized agriculture, the rice-wheat cropping pattern, and short harvest-sowing intervals, coupled with a scarcity of economical alternatives, make stubble burning a prevalent practice.

Addressing this issue requires a comprehensive approach that includes the development of alternative technologies, agricultural policy changes, economic incentives, and farmer education. Policy-makers must recognize the financial and logistical constraints faced by small-scale farmers and provide customized support to promote the widespread adoption of sustainable agriculture practices. Resolving the stubble burning problem requires a cooperative initiative among all parties involved farmers, governmental bodies, and civil society to improve environmental conditions and the economic well-being of farmers in the Doaba region.²⁴

5.7 CULTURAL FACTORS:

Stubble burning has been ingrained in the agricultural methods of Punjab over time, with many farmers continuing the practice out of habit or tradition. Modifying this behavior requires not just financial incentives and technological solutions but also a shift in the cultural outlook of the farming community.

²⁴ Dhillon, S. S, "Government Policies and Farmers' Perspectives on Stubble Burning in Punjab" 4 12-15. (2018).

6. IMPACT OF STUBBLE BURNING

6.1 Environmental and Health Impacts

Environmental pollution denotes the contamination of air, water, and soil, resulting in detrimental effects on ecosystems and human health. Pollution, in its many manifestations stemming from industrial effluents, automobile emissions, or agricultural methods leads to biodiversity decline, intensification of climate change, and soil deterioration. The environmental consequences are substantial; for example, air pollution may lead to acid rain, which negatively impacts agriculture, soil quality, and aquatic ecosystems. Water bodies get contaminated by industrial effluents, resulting in a decline in aquatic life and rendering the water unfit for drinking. The health effects of environmental contamination are similarly harmful. Environmental pollutants in the air, water, and soil may result in many health complications, including respiratory ailments, cardiovascular disorders, and cancer. Heavy metals such as mercury and lead, often present in contaminated water, may bioaccumulate in the human body, resulting in significant health issues, especially in children and pregnant women. These pollutants aggravate chronic illnesses, disproportionately impacting marginalized persons often living in more contaminated regions.

6.1.1 Air Pollution and its Effects on the Environment

Air pollution mostly results from industrial activities, fossil fuel burning, and agricultural pollutants. The release of carbon dioxide (CO₂), sulfur dioxide (SO₂), nitrogen oxides (NO_x), and particulate matter (PM) has immediate and enduring effects on the environment. Carbon dioxide and other greenhouse gases directly contribute to global warming and climate change by trapping heat inside the Earth's atmosphere. When SO₂ and NO_x combine with precipitation, they generate sulfuric and nitric acid, leading to acid rain that erodes buildings, harms aquatic ecosystems, and reduces agricultural yield by altering soil pH.

Furthermore, air pollution deteriorates air quality and visibility. Forest ecosystems are particularly vulnerable, since airborne pollutants may damage plant tissues, reduce photosynthesis, and impede development. Moreover, certain air pollutants, such as ozone (O₃),

are produced at ground level by the interaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) during sunlight exposure. Ground-level ozone adversely affects plants and crops, leading to reduced yields and impaired foliage.

In urban areas, haze, produced by the interaction of sunlight with air pollutants, is a significant environmental issue. Smog degrades air quality, jeopardizing both the ecosystem and human health. Studies demonstrate that metropolitan regions with high air pollution have reduced biodiversity in both plant and animal life. Moreover, these pollutants may permeate regions, affecting distant ecosystems and resulting in phenomena such as forest dieback, desertification, and the deterioration of aquatic systems.



Fig.: Stubble Burning: Environmental Impact

Ssources: <https://shorturl.at/ranHS>

6.1.2 Health Hazards Due to Particulate Matter and Smog

Particulate matter (PM), especially fine particles like PM_{2.5} and PM₁₀, is among the most harmful pollutants to human health. Particles emitted by automobiles, industrial activities, and agricultural methods may penetrate the lungs and even enter the circulation. Exposure to high levels of particulate matter (PM) has been linked to many respiratory disorders, including asthma,

bronchitis, and chronic obstructive pulmonary disease (COPD). Research by ²⁵demonstrates that prolonged exposure to particulate matter is associated with cardiovascular diseases and increased death rates. Children, the elderly, and those with pre-existing health conditions are especially susceptible²⁶.

Smog, including ground-level ozone and particulate matter, exacerbates these health risks. Prolonged exposure to pollution may irritate the respiratory system, reduce lung function, and aggravate asthma and other chronic pulmonary conditions. The World Health Organization (WHO) has recognized air pollution, including particulate matter and smog, as a significant environmental factor in cancer development. Studies demonstrate that exposure to increased levels of pollution is associated with a higher risk of lung cancer and other malignancies, such as bladder cancer.

In urban areas, where vehicular emissions and industrial activities are common, residents have a heightened risk of exposure to particulate matter and smog. The health impacts are often exacerbated by substandard living conditions, restricted access to healthcare, and many socioeconomic factors. A study conducted in Delhi, one of the most polluted cities worldwide, indicated that residents, especially youth, suffer from chronic respiratory problems due to persistent exposure to air pollution.

A recent study conducted at Sir Ganga Ram Hospital (SGRH) in New Delhi examined 150 patients diagnosed with lung cancer, revealing that nearly 50% of them had never smoked. This finding challenges the long-standing belief that tobacco use is the primary cause of lung cancer, as smoking has traditionally been seen as the most significant risk factor. Lung cancer is the leading cause of cancer-related deaths in India, and this new data highlights the importance of considering other factors that could contribute to the disease's development. The findings suggest

²⁵ Stolbach, A., Anderson, J. O., Thundiyil, J. G., *et.al.*, "Clearing the Air: A Review of the Effects of Particulate Matter Air Pollution on Human Health" 8 *Journal of Medical Toxicology* 166–175. (2012).

that environmental, genetic, and lifestyle factors might play a more substantial role in lung cancer cases among non-smokers.

This revelation calls for a broader understanding of lung cancer's etiology, prompting researchers and healthcare professionals to investigate other possible causes. Factors such as air pollution, prolonged exposure to secondhand smoke, occupational hazards, and even genetic predispositions may be contributing to the rise in lung cancer cases among non-smokers. In India, where air pollution levels are a growing concern, the need for public health initiatives addressing these environmental factors becomes urgent. The study underscores the need for expanded prevention strategies and awareness campaigns, focusing not only on tobacco cessation but also on mitigating other risk factors that are increasingly linked to lung cancer in non-smokers²⁶.

6.2 Impacts Specific to Doaba (Rivers, Soil Degradation, etc.)

The Doaba region of Punjab, located between the Beas and Sutlej rivers, is renowned for its superior soil and agricultural productivity. Environmental degradation has become a major issue due to intensive farming practices, overreliance on chemical fertilizers, and monoculture, leading to soil nutrient depletion and water pollution. Industrial effluents and agricultural runoff have contaminated the Beas and Sutlej rivers, leading to increased levels of heavy metals such as cadmium, lead, and arsenic, jeopardizing aquatic ecosystems and human health. Excessive groundwater extraction for irrigation has resulted in the depletion of the water table, hence intensifying stress on agriculture.

²⁶ Sanghera, T., Sanghera, T., & Indiaspend. (2018, August 3). Indiaspend. Indiaspend. <https://www.indiaspend.com/toxic-air-to-blame-for-lung-cancer-no-longer-just-a-smokers-disease-27211/>

The practice of stubble burning during the rice harvest intensifies air pollution in the region, significantly deteriorating air quality and resulting in widespread respiratory issues. The local population, especially farmers, has economic challenges owing to declining soil fertility and pollution, which negatively impact agricultural production and contribute to a rise in waterborne diseases.

To mitigate these challenges, the adoption of sustainable agricultural practices, the enforcement of stringent environmental regulations, and the improvement of water management are essential for conserving natural resources and protecting public health in Doaba.²⁷

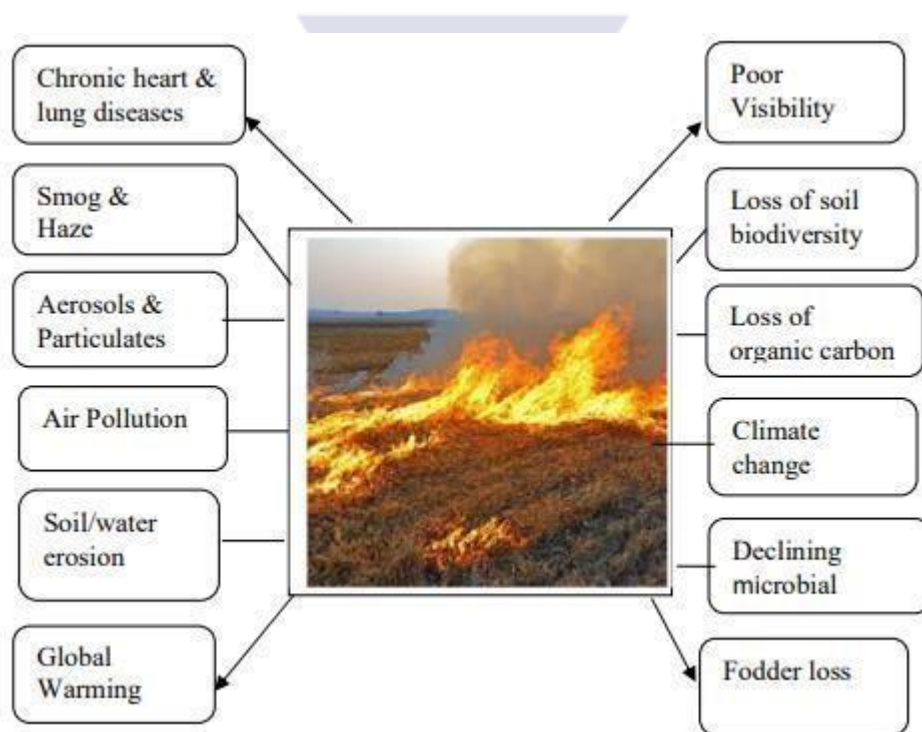


Fig.: Impact of stubble burning

Sources- <https://shorturl.at/pNVVd>

²⁷ Ranjan Bhattacharyya, Birendra Nath Ghosh & Biswapati Mandal, *et.al.*, "Soil Degradation in India: Challenges and Potential Solutions" 7 3528-3570 (2015).

7. INITIATIVES BY GOVERNMENT OF PUNJAB

7.1 IEC ACTIVITIES

The Department of Agriculture will spearhead and coordinate a comprehensive awareness campaign, in collaboration with the Department of Information and Public Relations, Punjab Agricultural University (PAU) Ludhiana, and other relevant stakeholders, to address the issue of paddy straw burning. The campaign will involve various Information, Education, and Communication (IEC) activities, including the following strategies:

- (a) Broadcasting radio jingles to reach a wide audience,
- (b) Creating and disseminating advertisement films to raise awareness,
- (c) Airing films on television channels to inform the public,
- (d) Placing display boards on the rear of Punjab Roadways and PRTC buses to capture attention during daily commutes,
- (e) Installing display boards at bus stands, market committee yards, and cooperative societies across the state to ensure visibility and continuous engagement with the public.

These efforts aim to significantly raise awareness about the harmful effects of straw burning and promote sustainable alternatives.

7.2 PROVISION OF MACHINERY TO INDIVIDUAL FARMERS AND GROUPS

- (a) The Department of Agriculture will offer subsidies for the purchase of agricultural machinery for managing paddy straw, available to both individual farmers and groups, as well as agricultural cooperative societies. The aim is to ensure widespread utilization of this machinery. To expedite the process and prevent delays, subsidies will be disbursed through an online system,

with payments made within seven days of the physical verification of the machinery. Additionally, the Commission is urged to work with the Ministry of Agriculture & Farmers Welfare, Government of India, to secure compensation for farmers at the rate of Rs. 100 per quintal of paddy produced, for a period of at least three years, until industries for alternative uses of paddy straw are fully operational.

(b) Promotion of Diversification and Staggered Sowing of Paddy: To reduce the volume of paddy straw produced in the state, the Department of Agriculture will encourage crop diversification, urging farmers to shift from paddy to other crops. The state will actively seek to provide Minimum Support Price (MSP) for alternative crops to incentivize this shift. In addition to diversification, the department will promote staggered sowing of paddy, focusing on the cultivation of short-duration paddy varieties to further minimize straw production.

7.3 RESPONSIBILITY OF COMMISSION AGENTS

The Department of Agriculture will ensure that Commission Agents (Arhtiahs), registered with the Agriculture Produce Market Committees (APMCs) in Punjab, comply with the ban on crop residue burning. These agents, as key intermediaries in the agricultural market, will be held responsible for not engaging in or facilitating stubble burning. The Department will closely monitor their activities and collaborate with APMCs to ensure adherence to the regulations. In the event of violations, appropriate legal action will be taken, including penalties, to enforce the ban. The initiative aims to reduce environmental pollution and promote sustainable farming practices.

7.4 RESPONSIBILITY FOR USES OF BASMATI RESIDUE

The Department of Agriculture will take the necessary steps to ensure that basmati residue is not left unused or burned, but is instead repurposed for beneficial uses, such as fodder. The

Department will explore avenues for using basmati residue as animal feed in districts where fodder consumption is high, both within the state of Punjab and in neighboring states. Efforts will include establishing transportation routes to facilitate the movement of this residue to areas where it can be put to good use. This initiative not only helps in reducing stubble burning but also creates a valuable resource for livestock farmers, contributing to sustainable agricultural practices and waste management.

7.5 SENSITIZE FARMERS

The Department of Agriculture will ensure that farmers who have leased their land for crop cultivation under contract farming agreements are contacted and sensitized about the harmful effects of burning paddy straw. Communication will be carried out primarily via phone calls to these farmers to encourage them to adopt alternative methods for managing crop residue. The Department will also emphasize the legal implications and environmental impact of stubble burning, urging farmers to adopt sustainable residue management practices to ensure compliance with environmental regulations.

7.6 HOT SPOT MANAGEMENT

To effectively manage stubble burning in areas with high occurrences, the Department of Agriculture will collaborate with the Punjab Remote Sensing Centre (PRSC) to identify hotspots—regions where stubble burning is most prevalent. In these areas, the Department will appoint dedicated officers at the Block level to raise awareness among farmers. These officers will ensure that crop residue management machinery is available on a priority basis and will conduct Information, Education, and Communication (IEC) activities focused on educating farmers about sustainable residue management techniques. The goal is to mitigate stubble burning by providing practical solutions and immediate support to affected areas.

7.7 ENSURING SUPER SMS ON COMBINE HARVESTERS

The Department of Agriculture will initiate a campaign to ensure that Super Straw Management Systems (Super SMS) are fitted onto all combine harvesters used in the state for paddy harvesting. This exercise will involve direct contact with combine owners and manufacturers, starting from the first week of September each year. The integration of Super SMS technology helps in cutting and spreading the straw evenly, which makes it easier for farmers to manage the crop residue without resorting to burning. By ensuring that all combines are equipped with this technology, the Department aims to significantly reduce the volume of stubble left in fields and prevent the harmful practice of stubble burning.

7.8 SETTING UP OF CONTROL ROOM

The Punjab Mandi Board will establish a Control Room during the Kharif harvesting season to monitor and manage stubble burning activities across the state. This Control Room will act as the central point for coordinating efforts to prevent stubble burning, providing real-time information, and responding quickly to incidents of residue burning. The Control Room will also facilitate communication between various departments, farmers, and authorities, ensuring that timely intervention is made to prevent any environmental violations and promote alternative methods of residue disposal.

7.9 REGULAR TRAINING & NGO INVOLVEMENT

To ensure the successful implementation of crop residue management programs, Punjab Agricultural University (PAU) will conduct regular training sessions for agricultural and allied departments, including call centers and other technical staff involved in crop residue management. These training programs will focus on providing the latest knowledge on best practices for residue management and how to operate the necessary machinery. Additionally, the Department of Agriculture will collaborate with NGOs working on agricultural sustainability to promote community-based interventions. These NGOs will be supported in their efforts to engage

farmers at the grassroots level, providing on-field assistance and ensuring that crop residue management strategies are implemented effectively.

7.10 MOBILE APP FOR CROP RESIDUE MANAGEMENT

In an effort to modernize the management of crop residue, the Department of Agriculture will develop a mobile application designed to facilitate access to crop residue management equipment. This app will operate on a rental basis, similar to ride-sharing platforms like Uber and Ola, allowing farmers to easily rent machinery for residue management. The app will be integrated with the "Cooperative Machinery Tracker", a tool that will track the usage of equipment from all Custom Hiring Centres (CHCs). This will ensure that machinery is used efficiently and data on its utilization is readily available. The app will also provide farmers with access to necessary resources, such as training materials and guidance on using the machinery for effective residue management.

7.11 PUBLIC AWARENESS AND ROLE OF NGOS

Public awareness is essential in mitigating the adverse effects of stubble burning. A significant number of farmers in Punjab, particularly in the Doaba region, often participate in stubble burning due to inadequate awareness of its harmful consequences and a lack of knowledge on alternatives. Non-governmental groups have led initiatives to educate farmers about the environmental and health consequences of stubble burning, especially its contribution to air pollution and respiratory diseases. Singh et al. (2019) demonstrate the critical function of NGOs in raising awareness about the harmful effects of stubble burning and providing training in sustainable agricultural practices.

These organizations have used many platforms, including community meetings, seminars, and social media campaigns, to engage farmers and increase awareness. The Punjab Farmers' Union has collaborated with local NGOs to facilitate dialogue between farmers and environmental experts, therefore enhancing comprehension and encouraging the use of sustainable farming

techniques. The involvement of NGOs augments knowledge and motivates farmers to take responsibility for their agricultural practices, enabling informed decisions that benefit both their livelihoods and the environment.

7.12 AWARENESS CAMPAIGNS IN DOABA

The Doaba area, including the districts of Jalandhar, Kapurthala, and Hoshiarpur, is especially susceptible to the repercussions of stubble burning owing to its elevated population density and agricultural intensity. Awareness campaigns in this domain have been customized to tackle the specific difficulties encountered by farmers. Initiatives like "Save Environment, Save Punjab" have been established to engage both farmers and the general populace, emphasizing the need of sustainable agricultural techniques.

Kaur (2020) contends that these programs use diverse methodologies, including field demonstrations of alternative crop residue management methods, such as using equipment for in-situ stubble management. These demonstrations have effectively dispelled myths around stubble burning and shown the feasibility of alternatives. Moreover, local educational institutions have implemented similar initiatives, in which students engage in activities that foster environmental consciousness, therefore impacting families and communities. The partnership between educational institutions and NGOs has been crucial in promoting environmental awareness among the public.

Social media channels have emerged as potent instruments for increasing awareness in the Doaba area. Campaigns use channels such as Facebook and WhatsApp to disseminate information, videos, and testimonies about the hazards of stubble burning and the advantages of sustainable practices, attracting considerable attention. This online program has included a younger

demographic and promoted community discourse around environmental stewardship and agricultural methods.²⁸

7.13 ROLE OF LOCAL NGOS AND ENVIRONMENTAL ACTIVISTS

Local NGOs and environmental advocates have initiated initiatives to tackle the issue of stubble burning in Punjab, particularly in the Doaba region. Organizations such as "Kheti Virasat Mission" and "Sustainable Agriculture Initiative" have made significant attempts to address the issue of stubble burning. They provide information and training to farmers, enabling them transition to more sustainable practices. The Kheti Virasat Mission has conducted extensive research and communication efforts to promote organic farming and reduce dependence on chemical fertilizers, which might exacerbate the need for burning agricultural residues. The organization collaborates with farmers to implement techniques that mitigate stubble burning while enhancing soil quality and agricultural productivity. Environmental activists associated with these NGOs have advocated for legislative measures that promote sustainable agricultural practices and mitigate the economic burdens on farmers using eco-friendly methods. Moreover, the collaboration between local NGOs and governmental agencies has led to the development of innovative solutions for stubble management. Programs like the "Paddy Straw Management Scheme" provide financial assistance to farmers who use alternative methods, such as converting stubble into bioenergy or using it as livestock feed.

This joint strategy has been essential in creating a supportive framework for farmers while addressing the environmental challenges associated with stubble burning. The battle against stubble burning in Punjab, particularly in the Doaba region, depends on effective public

²⁸ Kaur, R., "Awareness Campaigns and Their Impact on Sustainable Agricultural Practices in Punjab." 12 Journal of Agricultural Research 45-57 (2020).

awareness initiatives and the active involvement of local NGOs and environmental campaigners. These organizations are addressing the pressing concerns of stubble burning by increasing awareness, educating farmers, and advocating for sustainable agricultural practices, so advancing a more sustainable agricultural future in Punjab. Continuous awareness campaigns, along with supportive legislation and community engagement, are crucial for mitigating the environmental impacts of stubble burning and promoting a more sustainable ecosystem for future generations.²⁹



7.14 GOVERNMENT COMPENSATION AND FINANCIAL AID PROGRAMMES

Government rules and initiatives designed to provide compensation and financial assistance to farmers are essential in tackling the problem of stubble burning. The Punjab government has implemented several initiatives to encourage farmers to embrace alternate methods for crop waste

²⁹ Sharma, P and Kaur, M, "Role of NGOs in Promoting Sustainable Agriculture in Punjab" 5 Punjab Journal of Environmental Studies 101-115 (2019).

management, including equipment subsidies and financial assistance for sustainable agricultural practices. The efficacy of these programs has been obstructed by bureaucratic impediments, insufficient communication, and a deficiency in farmers' understanding of available resources. Moreover, the compensation provided is sometimes inadequate to cover the expenses borne by farmers using other techniques. The disparity between official goals and the actual circumstances encountered by farmers underscores the need for a more cohesive strategy that incorporates direct interaction with agricultural communities to get a thorough understanding of their needs and concerns.

The socio-economic determinants influencing stubble-burning behaviors among farmers in the Doaba area are intricate and varied. Economic factors, especially affecting small and marginal farms, substantially support these practices. The functions of cooperative societies and farmer unions are essential in advancing sustainable agricultural practices and provide necessary assistance to farmers. Government compensation and financial assistance programs may mitigate some economic challenges; nevertheless, their efficacy largely depends on successful implementation and communication. Resolving the stubble burning problem requires a cooperative strategy including farmers, cooperatives, and government agencies, focused on promoting sustainable agriculture methods that emphasize economic viability and environmental sustainability.³⁰

8. PUNJAB POLLUTION CONTROL BOARD (PPCB)

(i) The Punjab Pollution Control Board (PPCB) will collaborate with the Punjab Remote Sensing Centre to monitor incidents of paddy straw burning across the state. In real-time, the

³⁰ Chadha, G., "The Economics of Crop Residue Management in Punjab" *34 Agricultural Economics Research Review* 57-66. (2021).

PPCB will utilize SMS alerts to notify field functionaries, enabling them to take swift action on reported cases of stubble burning. This proactive monitoring mechanism will ensure prompt responses to mitigate the harmful environmental impact of stubble burning.

(ii) In addition, the PPCB will ensure the development and implementation of a mobile and webbased application specifically designed for the paddy season. This application will feature rolebased logins for various officials, including those at the village, cluster, sub-division/tehsil, and district levels. This system will enable seamless reporting and tracking of every stubble burning incident, ensuring that appropriate action is taken at each administrative level.

(iii) To ensure efficient management, the mobile-based application will be made operational on both Android and iOS platforms by 15th September 2022. This timely launch will facilitate the real-time reporting of stubble burning incidents during the critical paddy season, allowing authorities to respond quickly and effectively.

(iv) To ensure the smooth operation of the mobile application, the PPCB will organize training programs for all relevant field functionaries. These training sessions will equip officials with the necessary skills and knowledge to effectively use the application, thereby ensuring that the data related to stubble burning is accurately reported and acted upon.

(v) The PPCB will also ensure that all data related to crop residue burning, sourced from remote sensing authorities, as well as the actions taken by field functionaries, are accessible through a web-based application. This platform will feature a dashboard for real-time monitoring and detailed analysis, allowing officials to drill down into the data and track the progress of the actions taken.

(vi) For persistent offenders involved in the illegal burning of crop residue, the PPCB will take coercive and punitive measures. This includes launching legal action under Section 15 of the Environment Protection Act (1986), ensuring that defaulters are held accountable for their actions and discouraging repeat violations of environmental regulations.

(vii) The PPCB will also be responsible for monitoring the ambient air quality in major cities of Punjab. Data on air quality will be made available to district authorities and the state government, enabling timely interventions if air quality deteriorates due to the ongoing stubble burning. This monitoring will serve as an early warning system, prompting necessary actions to safeguard public health and the environment.

9. FINDINGS OF THE SURVEY

9.1 SURVEY OF FARMERS

- The survey conducted encompassed a broad cross-section of farmers from various landholding categories, including small, medium, and large-scale farmers, ensuring comprehensive representation of Punjab's agricultural community. Approximately 40% of respondents indicated an annual income of less than ₹10 lakh, placing them in the small and medium-scale farming categories. On the other hand, 10% of the participants had annual incomes exceeding ₹40 lakh, which corresponds to the large-scale farming category. This income distribution illustrates the diverse economic backgrounds of the respondents and ensures that the findings reflect the experiences and concerns of farmers across different scales of operation. By including farmers from all income brackets, the survey provides a holistic understanding of the factors influencing stubble burning practices across Punjab's farming community.
- The results of the survey revealed that nearly 95% of the farmers expressed a desire to discontinue the practice of stubble burning. However, they noted that a lack of viable

alternatives forces them to resort to this harmful practice. This indicates that most farmers are aware of the negative consequences of stubble burning but feel constrained by external factors beyond their control. The primary reasons cited for continuing stubble burning included the absence of affordable, accessible machinery and the high cost associated with alternative methods of managing crop residue. These findings suggest that although farmers are conscious of the environmental and health risks associated with stubble burning, their limited resources and lack of support push them into continuing the practice. This points to a significant gap in government policy and support systems aimed at providing farmers with cost-effective and practical alternatives.

- The survey also found that nearly all of the respondents were well aware of the harmful effects of stubble burning. Many acknowledged the significant health risks posed by air pollution, including respiratory problems, and the long-term environmental damage such as degradation of soil fertility. Despite this awareness, farmers expressed that the lack of practical and affordable solutions forced them to burn the stubble, as other methods like natural decomposition were time-consuming and not feasible within the tight agricultural schedules. Some farmers explained that it would take approximately 25–30 days for the stubble to decompose naturally, and this process would require stagnant water to speed up the breakdown. With such a lengthy time requirement and the absence of resources to facilitate this, burning becomes the most expedient option to clear fields for the next planting season.
- A recurring theme among the survey respondents was a sense of helplessness, as reflected in the common expression “*Hor dasso ki karriye,*” which translates to “*What else can we do?*” This phrase captures the frustration and despair felt by farmers who feel trapped in a cycle of stubble burning due to a lack of viable alternatives. Despite being fully aware of the environmental and health implications, the farmers seemed to be resigned to the practice because they lacked the necessary support from the government or access to more sustainable

solutions. This sentiment underscores the urgency of addressing the underlying systemic challenges that farmers face, such as inadequate resources and support mechanisms.

- Furthermore, 83% of respondents indicated that they believed the government had failed to provide sufficient assistance or resources to tackle the issue of stubble burning. Many felt that the government's programs and subsidies did not reach the lower-income or smallscale farmers who are most vulnerable to the economic pressures of agricultural production. The survey revealed that the benefits of government assistance, if any, often do not effectively reach the farmers in need, especially those in rural areas who may not have the Required and sufficient means to access or utilize the resources provided. This highlights a significant issue of accessibility and equity in government programs that must be addressed to ensure that all farmers, irrespective of their income levels, can benefit from the support provide.



- Lastly, the survey revealed that all of the respondents were willing to abandon the practice of stubble burning if the government could provide the necessary help, including affordable machinery, viable alternatives for residue management, and financial incentives. This unanimous response underscores that farmers are not inherently opposed to adopting sustainable practices, but they need the right resources and support to make such transitions possible. In addition to this, several respondents offered valuable suggestions for improving the situation, such as better access to machinery, government-sponsored training programs, and financial subsidies for adopting alternative methods of stubble management. These suggestions have been compiled and forwarded to the Punjab government's official channels, ensuring that the voices of the farmers are heard and can potentially influence future policy decisions. By incorporating these suggestions, the government can better tailor its interventions to the specific needs of farmers, ensuring that practical and effective solutions are put in place to address the issue of stubble burning.

9.2 SURVEY OF WORKERS

The workers who participated in the survey displayed remarkable awareness of the dangerous implications of stubble burning. Despite their understanding of the environmental and health risks associated with the practice, they expressed a sense of powerlessness in altering the situation. One worker encapsulated this sentiment by stating, "*Hamm kya karr sakte hain, jo malik bolta hai, woh humein karna padhta hai, hamari marzi nahi chalti*" (What can we do? Whatever the landowner tells us, we have to do, we do not have a say in the matter). This statement underscores the workers' subjugation to the decisions made by landowners, highlighting their lack of autonomy and control over their work environment. It also reveals the complex dynamics between the landowners and the agricultural laborers, where the latter are often compelled to follow the orders of the former, regardless of the risks involved.

The workers surveyed were directly involved in the physically hazardous task of burning stubble in the fields. One worker shared a personal experience in which he fainted due to the smoke and suffocation while performing this task but was fortunately rescued by a fellow worker. This anecdote sheds light on the severe health risks faced by agricultural laborers who are often exposed to harmful pollutants while engaged in the process of stubble burning. It underscores the human cost of this agricultural practice, highlighting the physical toll it takes on workers who may not have the means or opportunity to protect themselves from the harmful effects of smoke inhalation and other related hazards.

Additionally, the workers noted a social influence that perpetuates the practice of stubble burning. They explained that initially, individual farmers are reluctant to engage in stubble burning, but once one farmer in a village adopts the practice, others tend to follow suit, creating a "dominion effect." This reflects a social contagion phenomenon, where the behavior of one individual sets a precedent, leading others in the community to adopt the same practice, even if they are aware of its harmful consequences. This collective behavior can be attributed to various factors, including peer pressure, economic necessity, and the perceived lack of alternatives. As a result, despite recognizing the negative impact of stubble burning, workers and farmers often feel compelled to conform to the established norms within their community, perpetuating the cycle of environmental degradation and health risks.

9.3 INTERVIEW OF ENVIRONMENTAL EXPERT

From an environmental standpoint, stubble burning releases a range of harmful pollutants, including particulate matter, carbon monoxide, and volatile organic compounds, which significantly contribute to air pollution. This practice is a major source of greenhouse gas emissions, which play a substantial role in exacerbating climate change. The environmental impact of stubble burning is a growing concern, particularly in regions of India where air quality is already compromised.

From a public health perspective, the smoke produced by stubble burning can lead to various health complications, such as respiratory issues, eye irritation, and other related ailments. The harmful effects of this smoke further compound the health risks associated with the already severe air pollution in many parts of India.

Experts have consistently emphasized that stubble burning represents a critical environmental and public health challenge in India that requires immediate attention. While the government has initiated certain measures to address this issue, there is a pressing need for more comprehensive strategies to incentivize farmers to adopt alternative, sustainable methods of managing crop residues. Education campaigns are essential to raise awareness among farmers about the detrimental effects of stubble burning, and promoting environmentally-friendly agricultural practices is key to ensuring both a healthier environment and an improved quality of life for the population at large.

9.4 INTERVIEW OF POLICE OFFICIAL

In anticipation of the upcoming paddy season, law enforcement agencies, including the police, have expressed their preparedness to address the issue of stubble burning. According to police officials, there will be heightened surveillance in areas under their jurisdiction to ensure strict adherence to laws governing stubble burning. Police officers will actively monitor for violations, and any individual found engaging in illegal practices will be held accountable and subjected to legal penalties.

To enhance the effectiveness of enforcement, the police will utilize satellite imaging technology to quickly identify the sources of stubble fires. This technological approach will enable more rapid detection and timely intervention, improving the overall response to violations. Furthermore, a whistleblower system has been established, where individuals providing information about stubble burning perpetrators will have their identities kept confidential. In recognition of their contribution, informants will be rewarded, encouraging greater community involvement in combating this issue.

In response to the environmental and health concerns associated with stubble burning, various government initiatives and organizations are advocating for alternative methods of crop residue management. These alternatives include the use of mechanized harvesting techniques, mulching, and repurposing crop residue for purposes such as livestock feed or biofuel production. Not only do these methods offer environmentally sustainable solutions, but they also provide potential economic benefits to farmers, thereby offering an incentive to adopt more eco-friendly practices.

Police officials, in turn, have appealed to farmers to abandon the practice of stubble burning, emphasizing its detrimental effects on public health and agricultural land. The appeal stresses that stubble burning not only poses significant health risks to communities but also harms the long-term fertility of the soil, thus negatively impacting farmers' own livelihoods. By encouraging farmers to adopt alternative practices, the police aim to promote both public wellbeing and sustainable agricultural development.

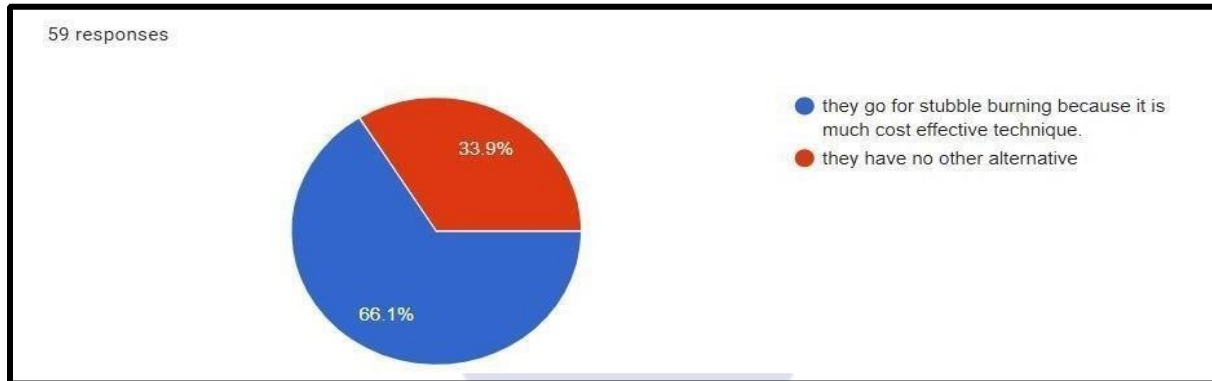
9.6 GENERAL SURVEY

GENERAL SURVEY (60 RESPONDENTS)

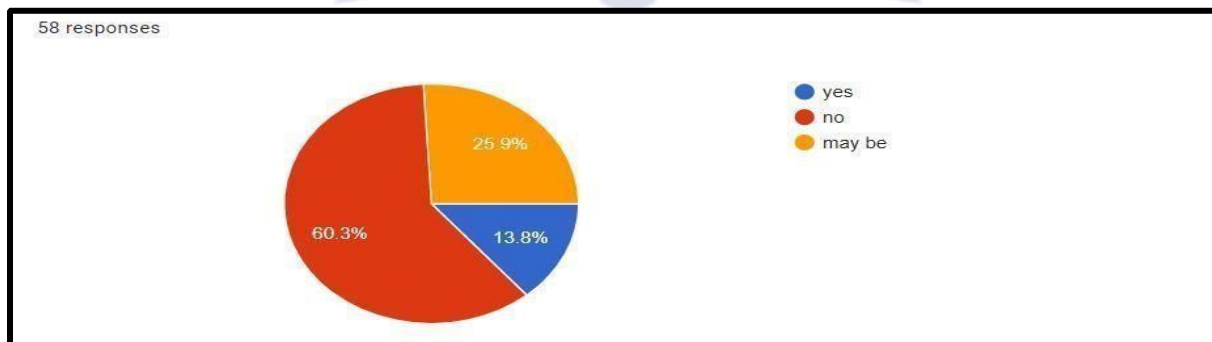
Apart from other surveys being conducted, survey via google forms was also conducted in order to get the view point of the general people as a whole . respondents include number of students of various age groups , farmers, environmentalist and other stakeholders which are directly or indirectly affected by the practise of stump burning.

Around 60 were the total number of respondents in the survey and they answered in the following way:-

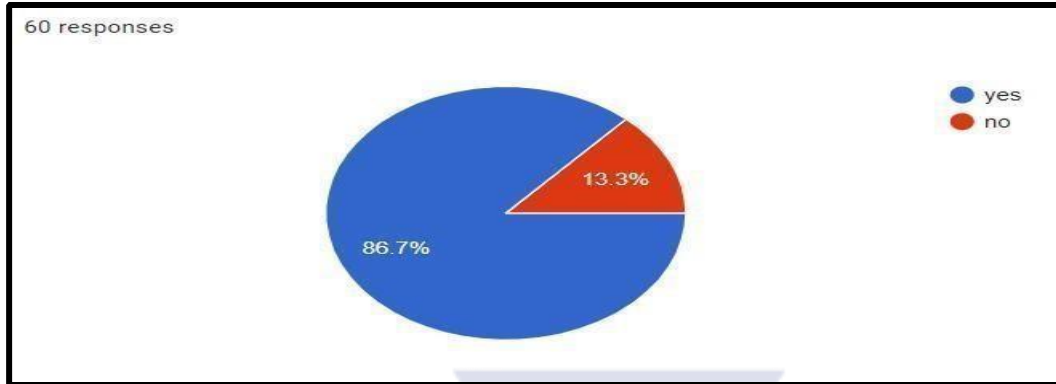
Question asked-according to your considerate opinion, do you think that farmer strata opt for the practise of stubble burning as a matter of choice or they have no other alternative?



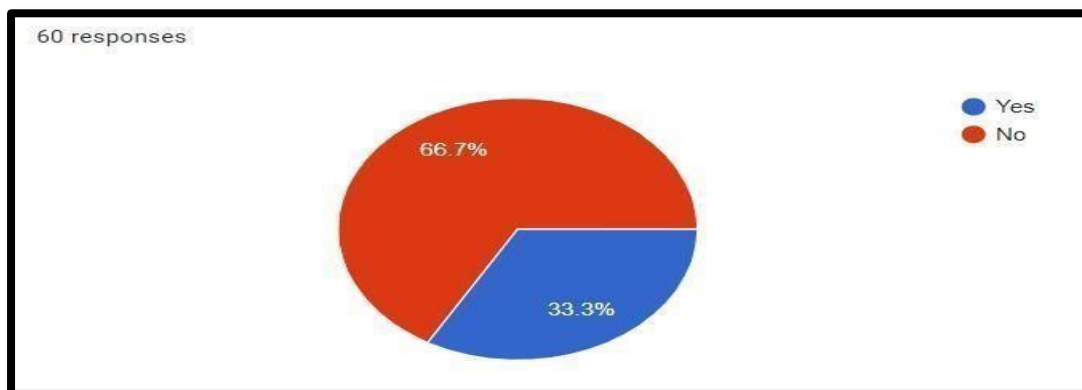
Question asked- do you think that a farmer earns enough to purchase highpriced and sophisticated machionery?



Question asked- are you aware about the hazardous impact of stubble burning to the health of both soil and humans ? if yes, then what?



Question asked- do you think that the government and the law enforcing agencies have taken all requisite steps in order to curb the problem?



10. HEROES IN OUR STORY

10.1 NAME - JAGDEEP SINGH RANDHAWA , PLACE OF RESIDENCE- JALANDHAR

Punjab family beats paddy-wheat trend, earns Rs 50L profit growing mushrooms in 1.5 acre 'AC farm'



Mr. Randhawa's decision to diversify his farm by shifting from the traditional practice of growing wheat and paddy to mushroom cultivation has led to impressive results. On his 1.5-acre farm, he now earns a profit of 50 lakh rupees annually, a testament to the profitability of mushroom farming. His success has set an inspiring example for other farmers in the region, showing that venturing into alternative crops can be a highly rewarding choice. By exploring innovative agricultural practices, Mr. Randhawa has demonstrated that farmers can achieve financial stability while adapting to changing environmental and market conditions.

In addition to the financial benefits, Mr. Randhawa's mushroom cultivation also plays a significant role in reducing environmental pollution. Unlike paddy farming, which often leads to the burning of crop residues, mushroom farming does not contribute to air pollution. This shift in farming practices not only increases Mr. Randhawa's income but also promotes sustainable agriculture. His story encourages fellow farmers to consider environmentally friendly alternatives that can enhance both their earnings and the health of the land.

10.2 NAME- JAIDEEP SINGH SANGHA, PLACE OF RESIDENCE – HOSHIARPUR



Jaideep, who cultivates paddy on over 40 acres of land, decided to abandon the practice of stubble burning in order to improve the health of his soil. Initially, his soil had a high pH value of 9.9, which is above the optimal range for most crops (7.5 to 8.5), and it was deficient in organic matter, with a mere value of 0.30. By eliminating stubble burning, Jaideep observed significant improvements in his soil's health. The pH value of his soil has now decreased to a more balanced 8.2, while organic matter has increased to 0.75, which is conducive to the growth of healthy crops.

As a result of these improvements, Jaideep has seen a positive impact on both his soil's nutrient content and his crop yield. With the soil now enriched with surplus nutrients, he has been able to reduce his urea usage by half, which has contributed to more sustainable farming practices. Moreover, the yield of his wheat crop has significantly increased, rising from 15-16 quintals per acre to 20-21 quintals, demonstrating the direct benefits of soil health management and the abandonment of stubble burning. This approach has not only enhanced the productivity of his land but also exemplifies the long-term advantages of adopting environmentally friendly farming techniques.

11. RECOMMENDATIONS

11.1 REPEAL PUNJAB PRESERVATION OF SUBSOIL WATER ACT 2009

The Punjab Preservation of Subsoil Water Act, 2009, was enacted with the primary goal of preserving the state's groundwater levels, a critical resource for agricultural activities. The legislation aimed to regulate the excessive extraction of groundwater and control the timing of paddy sowing to prevent the depletion of this vital resource. However, despite being in effect for over 15 years, the Act has failed to achieve its intended objectives. Groundwater levels in Punjab continue to decline at an alarming rate due to unsustainable water usage practices, especially in agriculture. The lack of effective enforcement, inadequate awareness, and loopholes in the implementation of the Act have rendered it largely ineffective. In light of these ongoing challenges, one must question the utility of such a piece of legislation that has not been able to address the root causes of groundwater depletion. The failure of this Act highlights the need for a more comprehensive and practical approach to water conservation in the state.

11.2 PROVIDING FINANCIAL INCENTIVES

Governments can provide financial incentives to farmers to encourage them to adopt alternative methods of disposing of crop residue. This could include subsidies for purchasing machinery to manage crop residue or offering tax breaks for farmers who adopt eco-friendly farming practices.

There are various machioneries available in the market in todays time which helps the farmers to get rid of stubble from their fields . the problem is that stubble management machines are very expensive piece of machioneries and no small/middle scale farmers can afford them . therefore, government should provide more subsidies on theses machines so that theses can be provided to farmers at much lesser costs.

11.3 PROMOTING THE USE OF CROP RESIDUE MANAGEMENT MACHINERY

Governments can also promote the use of machinery such as happy seeders, mulchers, and balers

that can help farmers manage crop residue without burning it. These machines can be expensive, but the government can provide them on rent to farmers to encourage their use.



11.4 INCREASING AWARENESS

Educating farmers about the harmful effects of stubble burning on the environment and their health can encourage them to adopt alternative methods of managing crop residue.

11.5 ENCOURAGING CROP DIVERSIFICATION

Encouraging farmers to diversify their crops and adopt crop rotation practices can also help reduce the amount of crop residue that needs to be managed. Farmers need to focus more towards growing other crops like millets, pulses, fruits and vegetables which requires less amount of water and will help in solving the problem of stubble burning as well. India is opting ethanol blending as well for which crops like maize can be very useful.

11.6 STRENGTHENING ENFORCEMENT

Governments can strengthen enforcement of laws against stubble burning to discourage farmers from engaging in the practice. This can include fines and penalties for those who violate the laws.

11.7 INVESTING IN RESEARCH AND DEVELOPMENT

Investing in research and development to develop new technologies and methods for managing crop residue can also help reduce the reliance on stubble burning.

By implementing these suggestions, we can reduce the problem of stubble burning and its negative impact on the environment and public health.

12 . CONCLUSION

Stubble burning in Punjab, particularly in the Doaba region, represents a major environmental, economic, and public health challenge. The practice of burning agricultural residues after the rice harvest, especially given the constraints of a limited crop cycle, contributes significantly to air pollution and soil degradation. Each year, the combustion of millions of tons of paddy straw releases harmful pollutants into the atmosphere, degrading air quality not only in Punjab but also in neighboring regions such as Delhi. The resulting increase in particulate matter (PM_{2.5} and PM₁₀), carbon monoxide, and other toxic emissions leads to severe public health repercussions, especially during the winter season, exacerbating respiratory illnesses and posing significant health risks to vulnerable populations.

Farmers, particularly small-scale cultivators, face substantial economic constraints that hinder the adoption of more sustainable stubble management practices. High costs associated with advanced residue management technologies, such as the Happy Seeder, and a shortage of skilled labor make stubble burning an attractive, low-cost, and time-efficient solution. Despite numerous government interventions, including subsidies for residue management equipment and penalties for those engaging in stubble burning, progress has been limited. Structural challenges such as inadequate infrastructure, weak enforcement of regulations, and insufficient awareness about the long-term environmental and health impacts further complicate the issue.

Addressing this crisis requires robust collaboration among government bodies, nongovernmental organizations (NGOs), and the agricultural sector. Promoting sustainable farming practices, crop diversification, and other alternatives to stubble burning must be a priority.

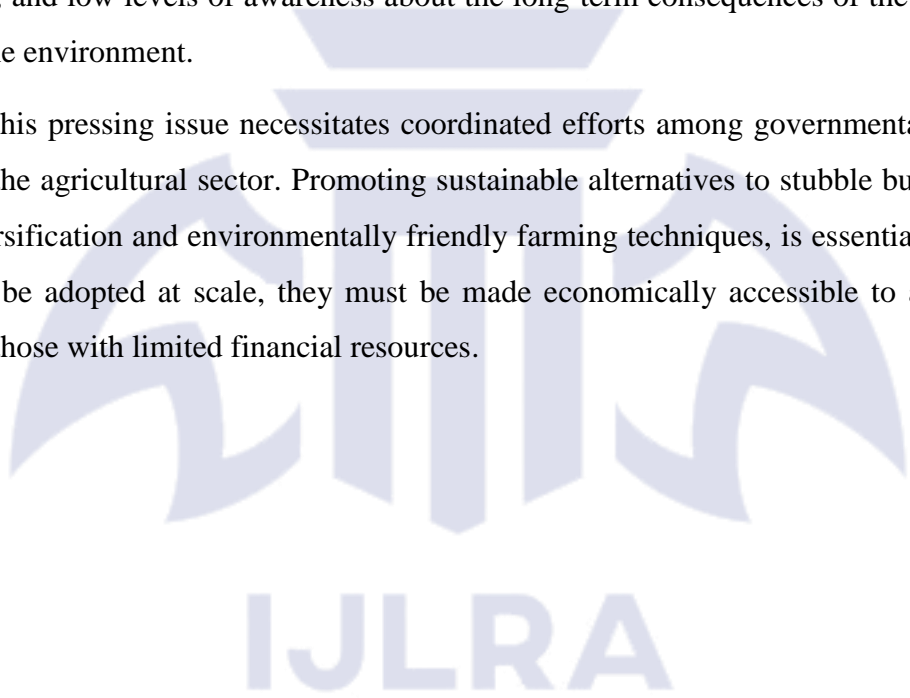
However, these solutions need to be economically viable for farmers, particularly those with limited resources. With advancements in technology and the provision of appropriate financial incentives, sustainable agriculture can emerge as a feasible alternative, ensuring environmental conservation without compromising agricultural productivity.

Stubble burning in Punjab, particularly in the Doaba region, presents a significant and recurring environmental, economic, and public health issue. The burning of residual agricultural waste after rice harvesting, primarily driven by the narrow window of the crop cycle, is a major contributor to air pollution and soil degradation. Every year, the large-scale combustion of millions of tons of paddy straw releases massive quantities of pollutants into the air, negatively impacting air quality across Punjab and extending to neighboring regions like Delhi. The

increased concentration of particulate matter (PM_{2.5} and PM₁₀), carbon monoxide, and other hazardous pollutants in the atmosphere during the winter months exacerbates respiratory conditions and heightens the public health burden on affected populations.

The economic limitations of farmers, especially those with small landholdings, create significant barriers to adopting sustainable alternatives to stubble burning. The high costs of advanced equipment such as the Happy Seeder and the scarcity of trained labor force many farmers to resort to stubble burning as a quick and cost-effective solution. Government efforts to mitigate the issue, including subsidies for equipment and penalties for stubble burning, have achieved only limited success due to challenges such as insufficient infrastructure, weak enforcement mechanisms, and low levels of awareness about the long-term consequences of the practice on health and the environment.

Addressing this pressing issue necessitates coordinated efforts among governmental agencies, NGOs, and the agricultural sector. Promoting sustainable alternatives to stubble burning, such as crop diversification and environmentally friendly farming techniques, is essential. For these solutions to be adopted at scale, they must be made economically accessible to all farmers, particularly those with limited financial resources.



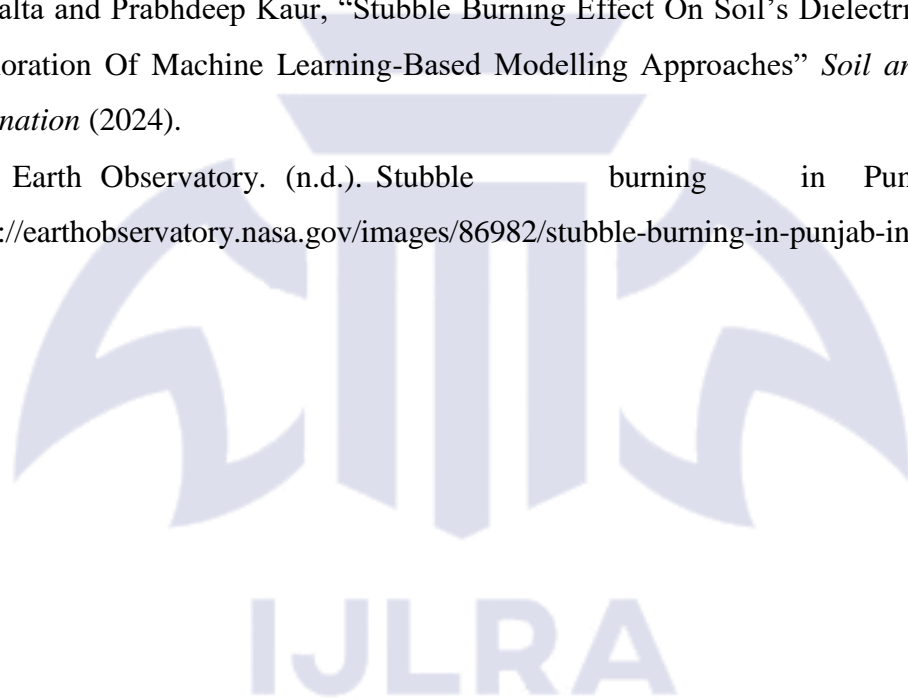
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14. APPENDI

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SURVEY

SURVEY FROM FARMERS

Farmers were requested to fill the questionnaire the sample of the same in english language has been provided below

STUBBLE BURNING – IT’S IMPACT AND A WAY FORWARD

A QUESTIONNAIRE

This questionnaire is solely meant for the research perspective. The respondents are requested to answer the following question with honesty and to the best of their knowledge.

Your name

Your landholding (including leased land)

Your approximate yearly income

Below 10 lacs

Below 20 lacs

Below 30 lacs

Above 40 lacs

Number and the names of the crops grown by you?

.....

Do you want to go for the practise of stubble burning?

Yes

No

What are your views on stubble burning?

.....

.....

.....

.....

What according to you are the reasons which forces a farmer to go for stubble burning?

.....
.....
.....
.....

Is there any help/assistance being provided from the government side?

Yes No

.....
.....

Are you aware about the hazardous impacts of stubble burning to the health of both humans and soil? If yes , then what?

Yes

No

Not aware

.....
.....
.....

What do you expect from the government to tackle this problems?

.....
.....
.....

If the requisite help is provided from the government side, will you give up this practise of stubble burning?

Yes

No

May be



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