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Stubble Burning: Grassroot Analysis of Problems and Solutions in Moga District, Punjab

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ABSTRACT

Stubble burning, a prevalent agricultural practice in northern India, has severe environmental and health implications. This study examines the underlying causes and consequences of stubble burning in Moga, Punjab, India, and proposes solutions to mitigate its effects. The research reveals that the emphasis on wheat and rice production, coupled with subsidies and low or non-existent user charges for water and electricity, has led to an over-reliance on these crops, resulting in excessive stubble generation. The lack of effective alternatives for stubble management, such as in-situ and ex-situ methods, has contributed to the persistence of stubble burning. The study highlights the significant negative externalities of stubble burning, including air pollution, soil degradation, and health risks. To address these issues, the research recommends a multi-pronged approach with all stakeholders, including crop diversification, subsidy reform, and awareness campaigns to alter farmer psychology. Additionally, the study suggests the need for more effective and accessible stubble management alternatives, such as machine rentals and energy industry partnerships. By understanding the complexities of stubble burning and implementing innovative solutions, this research aims to contribute to a more sustainable and environmentally conscious agricultural sector in northern India.

Keywords: stubble burning, in-situ management, ex-situ management, Moga district, air pollution, MSP, Crop-rotation, Punjab, surveys, Subsidies, crop diversification, Framer psychology.

Research Question: How far is stubble burning an important factor in spreading air pollution during the winter months in Delhi and its surrounding areas? Why has this process been on the rise in recent years? Have the stakeholders been able to find a viable solution to this problem? What are the grassroot gaps between farmer and administration that are hindering government

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policies from being successful? These and many such questions would be answered in the course of the paper.

I. Introduction

The agriculture sector contributed 18.3% to India's GDP in the financial year 2022-23. the importance of an Agro-based economy in India goes beyond this metric. Firstly, it is extremely important to make full use of endowments of nature like climate and soil. Secondly, to feed its exploding population and contributing to earning foreign exchange. Being an agricultural power-house, India has the largest area under wheat, rice and cotton cultivation in the world. The two states vital for national food security are Punjab and Haryana which boast a higher wheat and paddy yield than the national average. Over the years, Northern states have been labelled as the 'food bowl' of India as they have helped in India becoming a food secure nation. No longer is India spending her precious foreign exchange in importing food grain for her population. India is self-sufficient in basic food crops (since the 1970s). In fact, she has started exporting good quality rice to other countries. Over time the government has built up more than adequate stocks in various FCI (food corporation of India) godowns to meet requirements of the public distribution system and any other emergency that might require grain being distributed to the marginalized population.

To help in reaching this comfortable situation, the government used MSP's (minimum support price) in procurement of major crops. The farmers in the northern belt have become extremely comfortable in growing these two staple crops as they have a dedicated market at a pre-decided price, which over the years has become higher than the equilibrium price as seen through increasing MSP in Fig 1. The availability of subsidized water, electricity and fertilizers have further encouraged northern farmers to stick to growing wheat and paddy.

However, one of the caveats in practicing sustainable agriculture in these two states, is crop-residue management technique known as stubble burning in which millions of tonnes of stubble is burnt because it is a seemingly quick and easy solution for farmers as they need to prepare the soil for the next crop.

Even though there are ample awareness and educational camps being conducted by the government and heavy subsidy on machines that can be used to manage stubble, it is the traditional mind set of the farmer that favours stubble burning rather than adopting greener and sustainable methods. Paddy straw burning in Punjab and Haryana is one of the reasons behind alarming spike in air pollution in both the states and the national capital from October to December.

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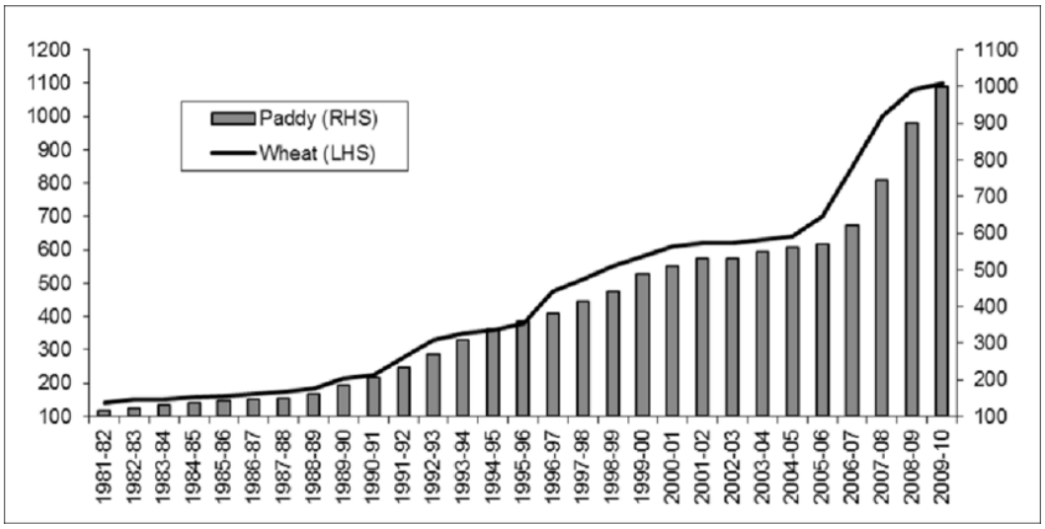
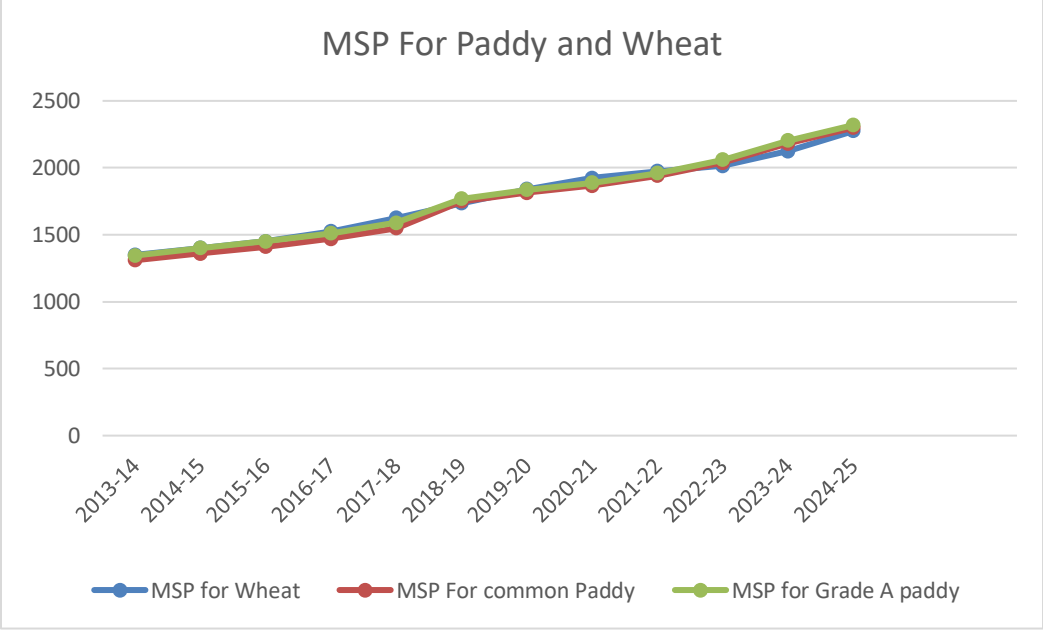
Fig1. Indication of increasing MSP



Source: Tripathi, Ashutosh ,"Agricultural Price Policy, Output, and Farm Profitability—Examining Linkages during Post-Reform Period in India" January 1, 2023, Asian Journal of Agriculture and Development, Vol 10.

Fig 2: Increasing MSP for rice and Wheat from 2013 to 2025



Source:https://dfpd.gov.in/Home/ContentManagement?Url=msp.html&ManuId=3&language=1

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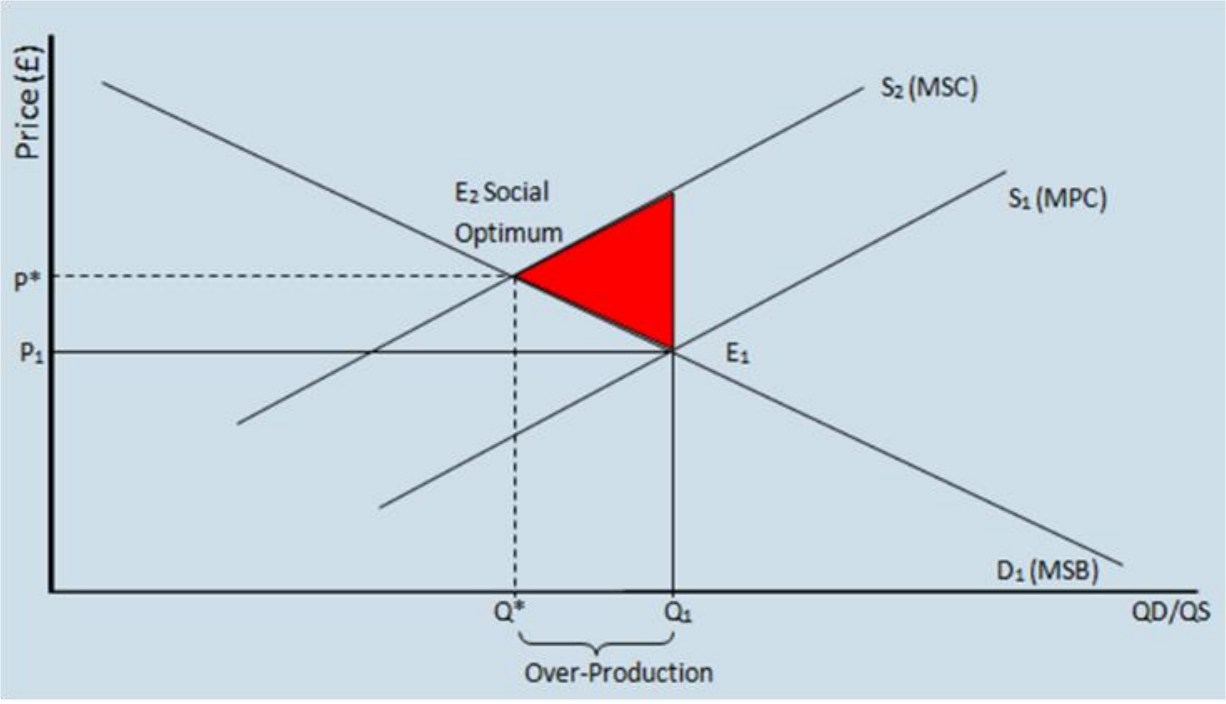
II. Impact of Northern India's two-crop rotation system

Cropping pattern changed from millets, pulses, oilseed to rice and wheat in 1970's (kickstarted green revolution) to ensure food security. Overtime, the two-crop rotation system as well as the various subsidies and high MSP have led to rapid depletion of the water table in Punjab and Haryana. To tackle this impending disaster, policymakers revisited the state's cropping patterns and suggested that the state should take advantage of the monsoon months of June to September to safeguard the water table and shift harvesting and sowing around this time. This resulted in a short time period between the harvesting of kharif crop (namely paddy) and the sowing of the rabi crop (namely wheat) which led to the farmers clearing up their land through stubble burning.

Figure 3. below represents the negative externalities of production (private plus social) due to stubble burning. Externality refers to the costs borne by society who not directly involved in the economic process in the form of extra health care costs due to spike in allergies and respiratory problems because of polluted air etc or road accidents due to smog and fires resulting from stubble burning. The Red shaded region represents the welfare loss to all stakeholders of the economy due to overallocation of resources to production processes.

Fig 3: Welfare loss due to negative externality of stubble burning



Source: https://learneconomicsonline.com/externalities.php

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III. Stubble Burning as a cause for air pollution in India

Delhi NCR is India's largest and most polluted airshed. Given the direction of the wind and other factors like increased vehicular traffic, industrial emissions, dust that is stirred up by traffic, construction and forest fires have led to increased air pollution during the winter months. Particulate pollution has increased over time, For example, from 1998 to 2021 average annual particulate pollution has increased by 67.7%. Life expectancy by 2.3 years. From 2013 to 2021, 59.1% of the world's increased population has come from India. India ranks third amongst the ten countries with worst air quality in 2024. This is the report published by IQAir. This tracks air quality world-wide and is revealed that 83 cities situated in India, surpassed the World Health Organization's air quality guidelines by over tenfold. The clear definition is indicated in Fig 1. The current situation in the last couple of decades has been the impact of stubble burning on air pollution in northern India.

Fig 4. WHO Air Quality Guidelines

Pollutant	Averaging Time	2005 AQGs	2021 AQGs
$PM_{2.5}$, $\mu g/m^3$	Annual	10	5
	24-hour[a]	25	15
PM_{10}, $\mu g/m^3$	Annual	20	15
	24-hour[a]	50	45
O_3, $\mu g/m^3$	Peak season[b]	-	60
	8-hour[a]	100	100
NO_2, $\mu g/m^3$	Annual	40	10
	24-hour[a]	-	25
SO_2, $\mu g/m^3$	24-hour[a]	20	40
CO, mg/m^3	24-hour[a]	-	4

Source: https://www.who.int/news-room/feature-stories/detail/what-are-the-who-air-quality-guidelines

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Stubble burning comes with self-declared hazards which are counterproductive and fatalistic in excessive amount. It is the source of major gaseous pollutants, i.e., GHGS, NO_2, SO_2 , and Particulate Matter (PM) (PM_{10} and $PM_{2.5}$), causing major human and environmental health issues like pulmonary disease resembling asbestosis, acute bronchitis, bronchial asthma and pneumonia especially for young children and the elderly. There is an increase in hospital admissions during October to January, so much so that the government has constituted various checks that are mandatory for the state to follow when the pollution levels are high: The severity of pollution for implementation of GRAP has been categorised into four stages, based on Delhi's AQI levels:

Stage I — 'Poor' (AQI 201-300); Includes bans on open burning of waste, limits the use of diesel generators and prohibits the use of coal or firewood in eateries

Stage II — 'Very Poor' (AQI 301-400); Enforces a ban on the use of coal and firewood, including tandoors in hotels, restaurants, and open eateries, as well as diesel generator sets, except for emergency and essential services. Measure adopted to reduce AQI under stage 2 involve-Water-sprinkling on roads and high traffic areas and proper disposal of dust.

Stage III — 'Severe' (AQI 401-450); a strict ban on all dust-generating or air pollution-causing construction and demolition activities in the entire NCR, including earthwork for excavation and filling including boring and drilling works; structural construction works including fabrication and welding operations except — projects for railway services, railway stations, metro rail services and stations, airports and inter-state bus terminals, national importance, hospitals or health care facilities, highways.

Stage IV — 'Severe+' (AQI > 450). Includes stopping entry of trucks in Delhi except for LNG/CNG trucks and those involved in essential services; and banning Delhi-registered diesel operated Medium Goods Vehicles (MGVs) and Heavy Goods Vehicles (HGVs) in the national capital, except those carrying essential commodities. It also empowers authorities in Delhi and NCR to take a decision on discontinuing physical classes for grades VI, IX, XI and 50% work from home for officegoers.

Approximately 63 Mt of crop stubble can emit CO (3.4 Mt), CO_2 (91 Mt), CH_4 (0.6 Mt), NOx (0.1 Mt), and PM (1.2 Mt) into the environment adding to the tumult of global warming. It reduces soil fertility by destroying Soil nutrients like nitrogen, potassium and phosphorous. The intense heat from stubble burning can harm soil-dwelling organisms, disrupting ecosystems and leading to a decline in biodiversity. When fields nearing highways or roads are set on fire it severely worsens visibility due to smoke and smog formation leading to road accidents.

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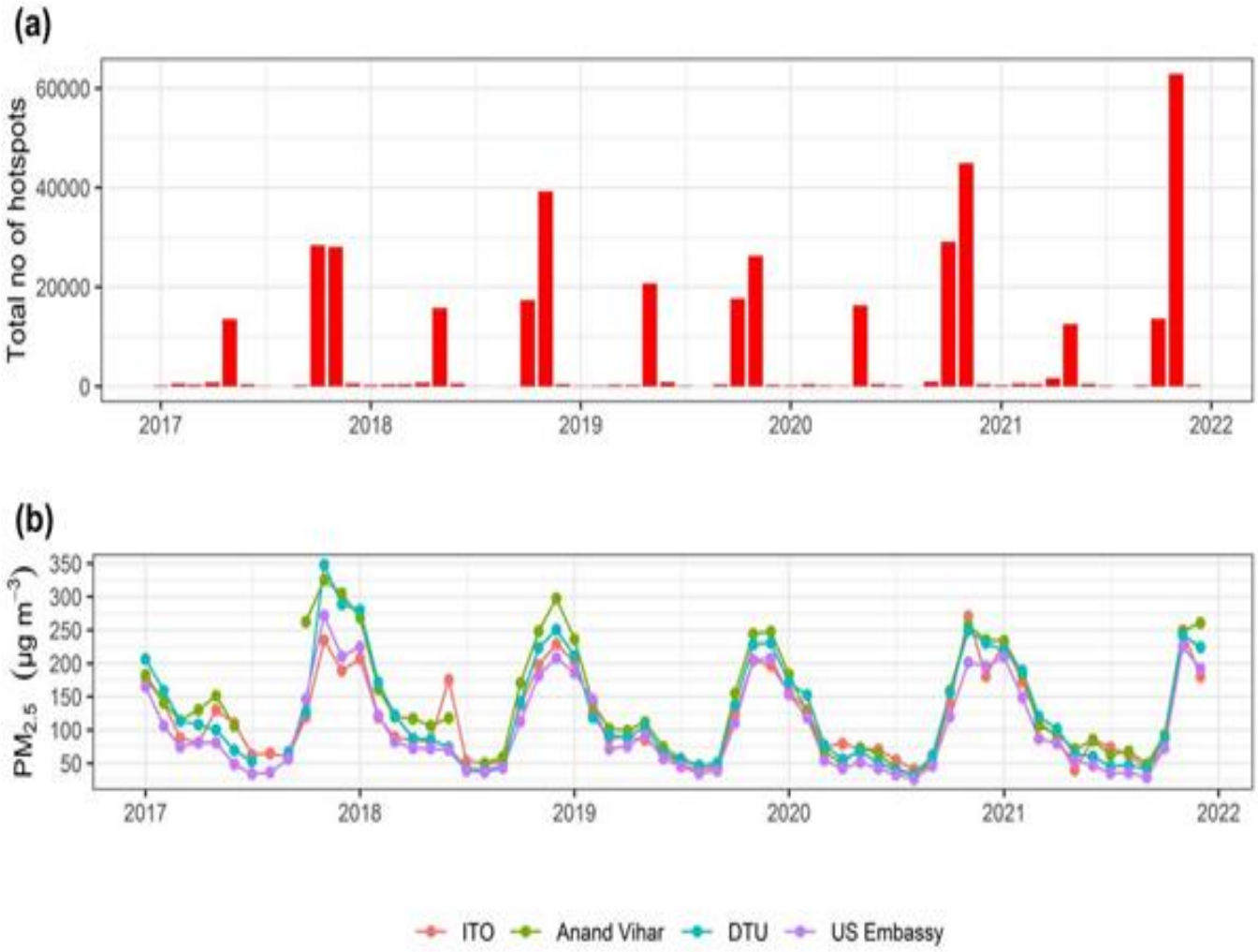
Fig 5. Levels of pollution in NCR during the winter months for 2017 to 2022



Source: https://aaqr.org/articles/aaqr-22-04-ssea-0191

IV. Definition and reasons for stubble burning by farmers

Stubble refers to the short, remaining stalks of crops left in the field after harvesting. It includes the cut stems and leaves of plants, typically cereal crops like wheat, paddy(rice), or maize. Stubble burning is the agricultural practice of intentionally setting fire to this crop residue. According to the Ministry of New and Renewable Energy, India yields about 500 million tons of crop leftovers per annum. The residue produced is mainly utilized as fodder and fuel for various industrial and domestic uses. Out of which,140 million tons are in excess, of which 92 million tons are burned yearly.

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Micro-level reason for burning stubble

After cutting of paddy, farmers in Punjab mostly sow wheat. However, the time gap between cutting paddy & sowing of wheat is too little. To protect crop form cold weather in November, farmers need to follow timelines strictly. Hence, to sow the next crop faster they resort to burning of stubble (paddy residue). Largely, farmers who practice on rented fields or have very small land holdings are the ones who burn stubble This is because they have low profits, small tractors and less machinery, most of the work done is manual, so to save time and expenses they burn stubble. It should be noted that some farmers have no limitations are financially sound but are still burning the stubble just because there is a general trend of burning in their village or because of rigid thought processes, making them averse to change.

Macro-level reasons for stubble burning

The underlying reason for stubble burning is emphasis given on wheat and rice production. This was earlier encouraged so that India could become self-sufficient in food grains. The measures that were followed for higher production levels were-

- High MSP for both crops. As their market is perfectly competitive, supply boosts put downward pressure on prices and farmers become price takers instead of price makers. To protect farmers (producers) from low prices, MSP is given. However, due to political reasons the MSP is rising every year.
- Low or non-existent user charges for water and electricity
- Subsidizing fertilizers

Farmers in the northern belt of India used the above incentives to sow various strains of wheat and rice which would cost less and give maximum return per hectare of soil as basic other resources namely fertilizer, electricity, water are almost provided free of cost. These farmers started sowing the PUSA variety of wheat which were long standing, extremely water intensive and produced a lot of stubble after harvesting (adding to air pollution). Research through various agricultural institutes like the Punjab Agriculture University, Ludhiana, developed high yielding varieties like PR 126, PR 130, PR 131 which consume less water and similar yield per hectare as the PUSA variety and in turn due to it being short standing it would reduce stubble and hence less amount would have to be burnt to clear the farm land for the next crop.

The methods to handle stubble are of two types: Ex-situ and In-situ methods.

In-Situ methods aim to incorporate crop-residue into the soil which will keep the amount of organic matter in the soil intact and also improve its fertility

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This is done using machines and diesel which is quite expensive as it incurs a cost of around 3000 - 4000 Rs/Acre. These expenses are a lot for some farmers (with low profit).

Ex-situ methods aim to transport stubble out of farms in the form of bales to power generation factories, brick-kilns, bakeries or cow shelters etc.

This requires labor which is either expensive or unavailable to do the job in a specified period of time.

When stubble is managed by Ex-situ method it requires godowns to store large quantity of stubble as it is consumed by industry (such as fuel) at a slow pace and transportation costs. Secondly, when it is lying near the fields it becomes a breeding ground for pests which harms human health and the crops.

Currently, these bales are acquired by industries at the rate of Rs 169 per Quintal. The less moisture the stubble has the higher the rate goes. The shortcoming of the universal use of the ex-situ method is lack of Industries/factories in the vicinity of farmers. Secondly, straw pellets have low calorific values than coal so at times they remain “Kacchi” making them unfavourable for use. Thirdly, there are transport issues, like few trolleys, tractors, trucks and other infrastructure to remove huge bales from farms or delays in transportation due to which the bales create nuisance for the farmer in which case burning seems a convenient solution. Lastly, inventory or storage capacity to store bales appropriately is deficient which leads to creation of local dumping grounds.

V. Research methodology

This study employs mixed-methods approach to analyse the practice of stubble burning in the Moga district of Punjab. Primary data was collected through structured surveys administered to a representative sample of farmers in the region. The survey instrument, a detailed questionnaire, was designed to capture comprehensive information about crop growing practices, residue management techniques, and the factors influencing the decision to burn stubble. The questionnaire included both closed and open-ended questions to elicit quantitative data and qualitative insights. The survey was conducted by surveyors to ensure accurate data collection and to build a rapport with the farmers, all of these facilitating a deeper understanding of their practices and challenges. Secondary literature was also looked at to understand existing solutions which are proposed through research and why they are not fully effective. This methodological approach enabled a thorough examination of the stubble burning phenomenon, encompassing both the statistical prevalence and the underlying reasons for its persistence.

VI. Case-study of stubble burning in Moga District, Punjab

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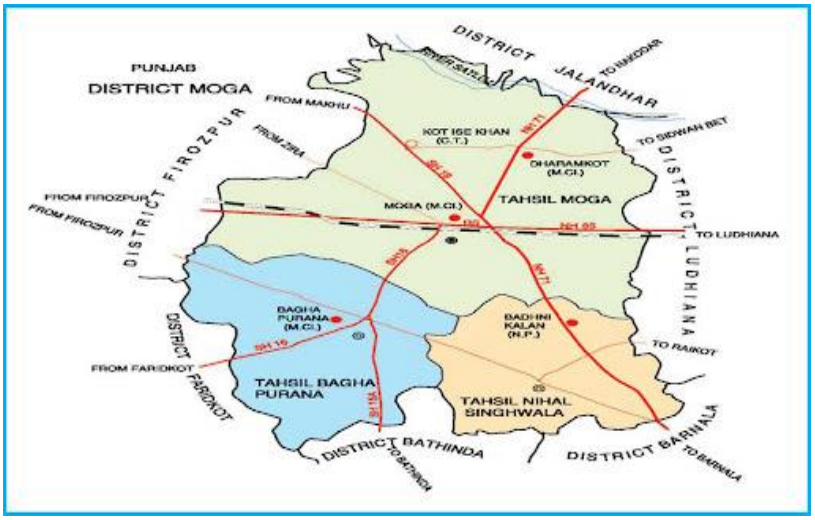
Fig 6. Map of Moga



Source: http://gazeis.in/villages-in-punjab-moga/

Current Scenario of Moga District

There are 50,711 farmers in the Moga. With a total of 330 villages and 177 co-operatives. The total cultivable land area under Moga District is 1,96,000 hectares, out of which 1,75,000 cultivates paddy and produces 11,58,000 metric tons of stubble, out of which only 2,00,000 tonne is managed by ex-situ methods.

Steps taken by the government authorities to manage stubble burning in Moga:

In-situ management: subsidies on machines (Happy Seeder, Super Seeder, Smart Seeder, Surface Seeder, Baler), awareness camps through cooperative societies, changing variety of paddy to reduce stubble.

Ex-situ management: existing industries which buys stubble bales like Vishnu Solve Ex in Ajitwal and Green Planet Agro-energy plant in Manuke.

The main objective of this survey are as follows:

- Unravelling the gaps and loopholes on the grassroot level.
- Understanding the farmer perspective through primary data
- To come up with ideas for effective implementation of pre-existing solutions to stubble burning.

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VII. Survey Results

Data of 45 Framers from Moga district

Table 1

Land Holdings

	No. of farmers	Percentage
0-5	11	24.45
6--10	12	26.67
>10	12	26.67
Rented +own <5	10	22.24

Table 2

No. of crops sown per year

No. of crops	No. of farmers	Percentage
2	34	75.6
>2	11	24.45

Table 3

Method of sowing

Method	No. of farmers	Percentage
Machines	1	2.23
Manual	44	97.8

Table 4

Harvesting	No. of farmers	Percentage
With SMS	3	6.68
Without SMS	42	93.34

Table5

Method of handling stubble	No. of farmers	Percentage
In-situ	17	37.78
Ex-situ	16	35.56
Burning	14	31.12

Table 6

Co-operate societies	
Present	44
Absent	1

Table7

Choice of handling stubble	No. of farmers	Percentage
Ex-situ	20	44.45
In-situ	25	55.56

Source: Own Source

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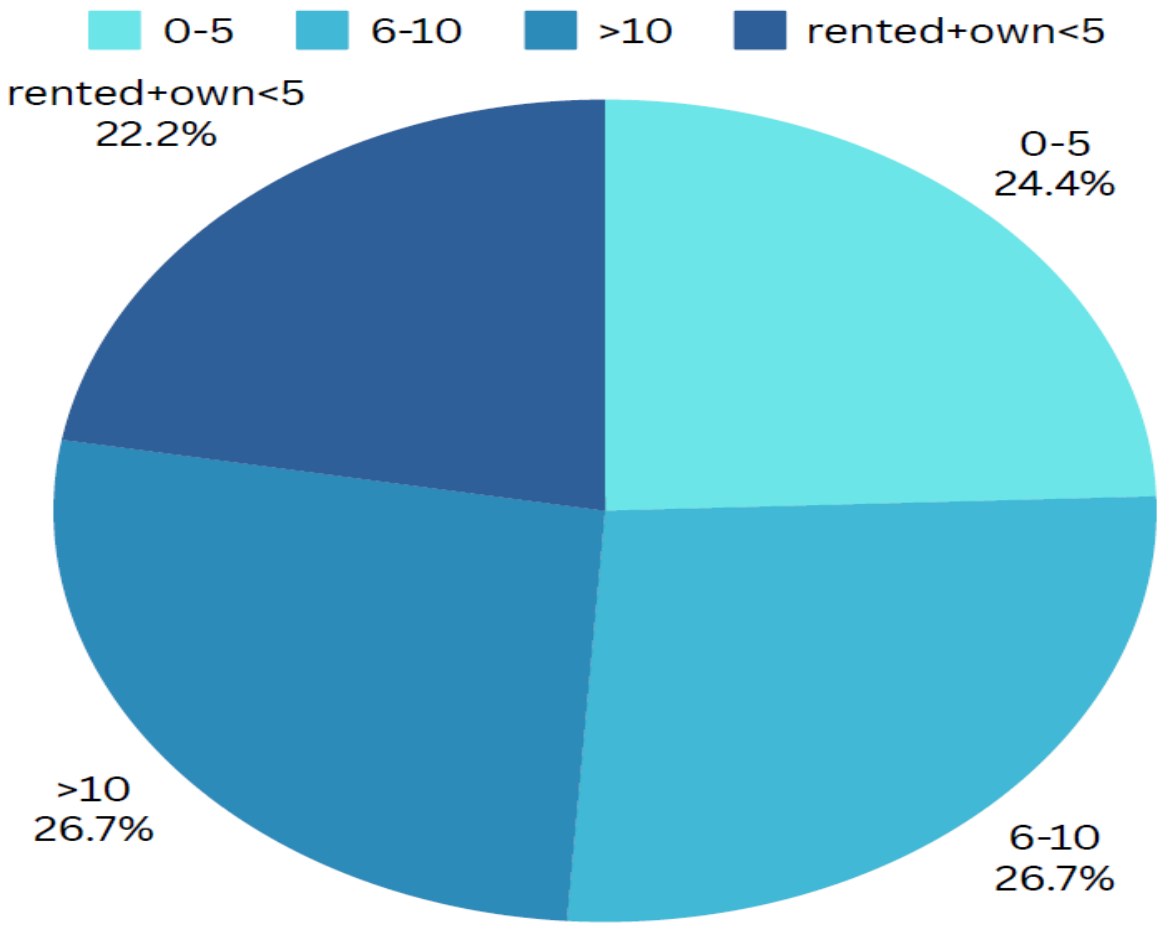
The information from the table above has been depicted in pie charts below for greater visibility and emphasis.

According to Table 1

Acres of farmer holdings

Fig. 7



Source: Own source

This indicates that owned land holdings are primarily less than 10 acres. Out of these close to 50% are between 0-5 acres.

According to table 3

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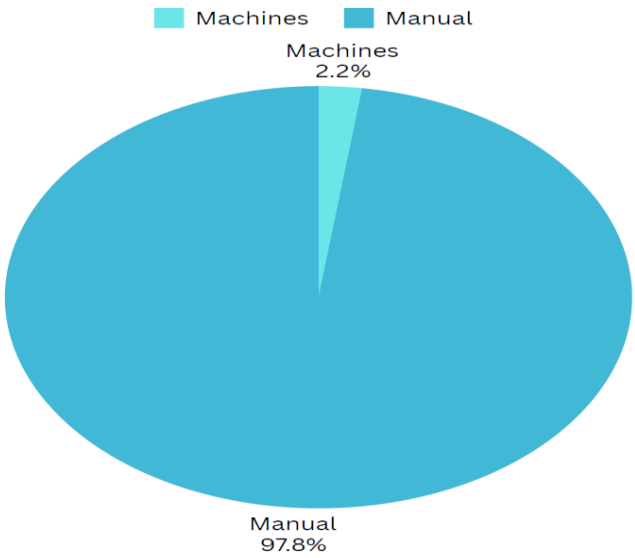
Fig. 8

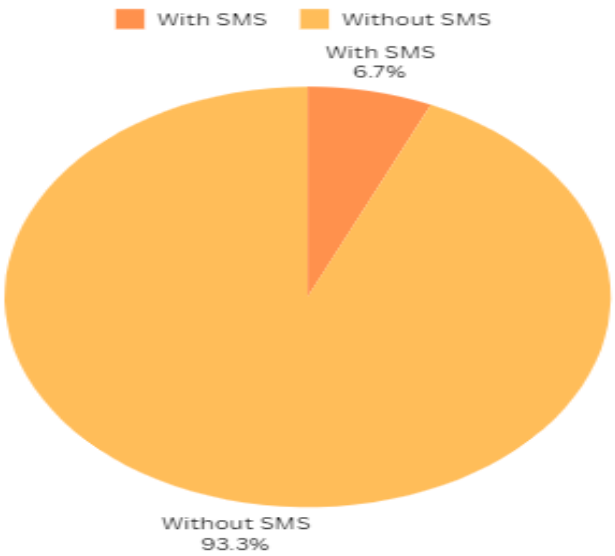


Source: Own Source

This indicates that majority of the farmers (97.8%) use manual methods for harvesting.

According to Table 4

Fig. 9



Source: Own Source

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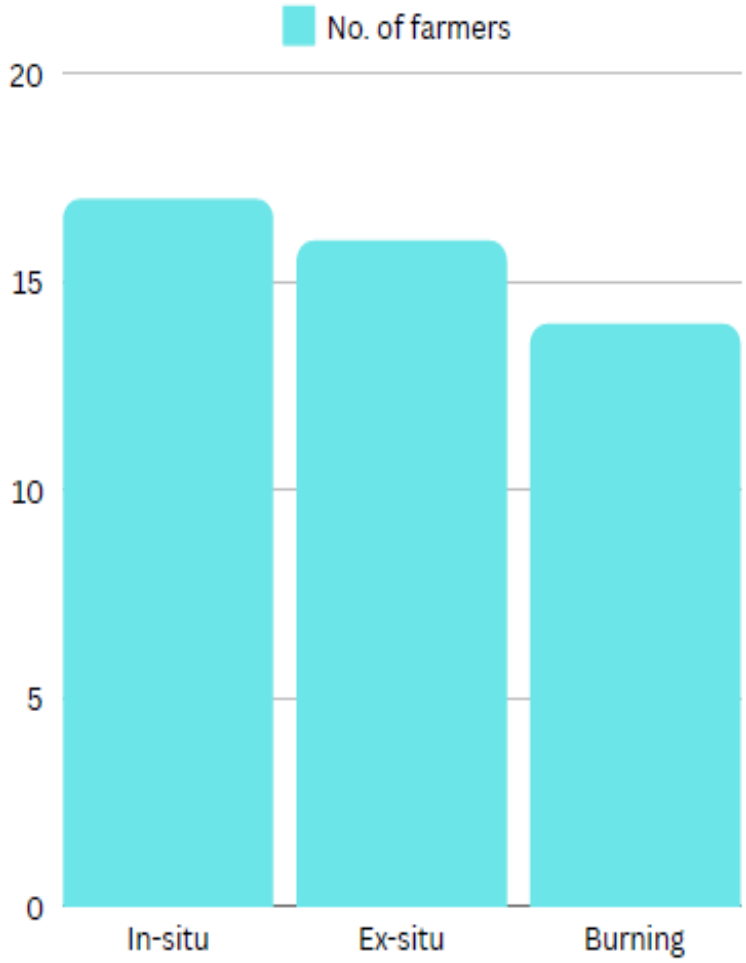
According to table 4, over 90% of the farmers did not use the SMS (Super Straw Management System) technology to harvest paddy.

According to Table 5

Method of stubble management by farmers

Fig. 10



Source: Own Source

Approximately one-third of the farmers used all the three techniques namely: in-situ, ex-situ and burning

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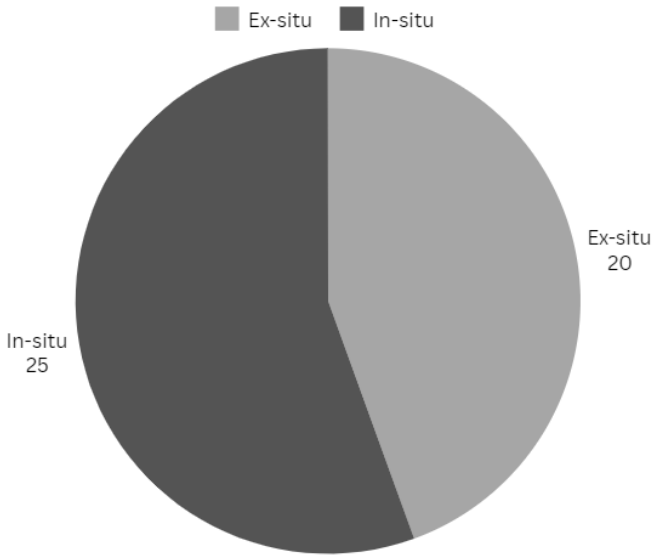
According to Table 7

Choice of handling stubble

Fig. 11



Source: Own Source

This indicates that the preferred method of handling stubble by the farmers is the In-situ one.

The above tables and diagrams convey that a large number of the farmers had small holdings and they were open to use various methods to get rid of stubble as has been indicated in the graph above. The farmers were open to use less polluting or zero-polluting techniques in the form of in-situ and ex-situ methods but there were certain external compulsions that prevented them from doing so.

Over the years the farmers resorting to stubble burning has declined but the numbers are still large enough to impact air pollution

VIII. Analysis and Discussion

Based on data collected and personal interviews.

Current state of affairs: Tabular representation of the problem, solution and the gap between the two.

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Table 8.

PROBLEM	SOLUTION BY GOVERNMENT	GAP
1. <u>Expensive Machines</u> Machines used in farming are expensive and require higher horsepower tractors for them to be effective. For **In-situ treatment** of stubble usually **super seeder, happy seeder, Smart Seeder, Surface Seeder** are used which also aid weeding require larger tractors to operate. Therefore, small to medium farmers who do not own bigger tractors can't use these machines and resort to burning or take loans to buy bigger tractors.	1. Subsidies on machines and other equipment being given by the government. 2. Government is providing machines to co-operate societies of the villages for use of farmers. 3. Compensation given by government **NDRF-** National Disaster	1. These subsidies of the government are applicable with certain conditions which a small farmer cannot fulfill like: ➢ ownership of land ➢ RC of tractor ➢ An advance in the form of DD/cheque in name of firm. So, only resourceful and economically sound farmers are able to avail these subsidies. Ironically, farmers who actually need them are not able to fulfill the documentation process so unable to take advantage of such schemes. 2. ➢ More than one village is sometimes attached to one co-operate society. ➢ Machines are less ➢ Time span to handle the stubble burning limited. Hence, it takes a lot of time for the farmers to use the machines one by one. Everyone needs to get the fields ready in 15 days for which the availability of these machines is not enough for the number of farmers which require them. 3. Late compensation - After 6 months to 14 years ✓ Only announcements of promises which are not fulfilled. ✓ Amount compensated is less. ✓ Does not reach the actual needy beneficiary.

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2. Natural Disasters Natural disasters like heavy rains, floods, etc. destroy ripe crops of farmers, shattering them financially and mentally. It not only affects an individual but also other businesses related to agriculture and the economy.	Relief Fund **SDRF-** State Disaster Relief Fund In case of a Natural Disaster, DC/ collector of the area orders special survey of the fields to analyze percentage of destroyed crops. According to percentage of destroyed crop, compensation is decided which is approximately, 15000 Rs/Acre for maximum 5 acres.	
3. Mandi Board When the farmer takes his crops to the Mandi, (Market) moisture content of the crops is checked. As per government rule the moisture content of paddy crop should be 17% for purchase but actually when the farmer brings his produce to the Mandi the moisture level is 20% to 25%as he brings it as soon as it is harvested. Meeting the criteria of 17% moisture compels the farmer to hasten everything- cutting-selling - sowing of next crop. Gradually more and more crop pile up in the Mandi resulting in shortage of space.		The current threshold criteria of 17% moisture level was fixed years ago and is an old criteria. Now considering that varieties of paddy which are sown are different and also the climate has changed drastically, government should reconsider this criteria. Therefore Administrators, farmers, agriculture experts, Artiyas (middle-men) should form a committee to consider all aspects and lay down new criterion which would benefit all.
4. Shortage of Industries There is lack of industries, factories, bakeries, Brin kilns near the vicinity of farmers which can use	Currently, in the Moga district there are just a handful of industries which utilize stubble's potential as a renewable source of energy. Namely: Green Planet Agro-	Straw pellets have low calorific value than coal, hence sometimes they remain uncooked and less energy dense.

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stubble pellets as fuel to produce energy.	Energy plant in Manuke, Vishnu Solve Ex in Ajitwal, TLG and Nestle plants.	

Source: Own Source

IX. Lessons learnt and the way forward

Crop Diversification

Focus needs to move away from "self-sustenance" as we have long crossed that stage. The Central and state governments need to enact strict laws on crop diversification. This will be of two types:

- Diversifying into crops other than wheat and rice: Encouragement to grow other crops like maize, oilseeds, pulses which are suitable to land of northern states. India's main imports are edible oils and pulses. As demand for pulses increases imports may go up by 8-10 million tonnes possibly creating a current account deficit. Pulses are less water and fertilizer consuming if the government rewards farmers growing pulses with the subsidies given to rice cultivators-power and fertilizer-the country will tend towards self-sufficiency and people will have healthier diets. A researcher at ICRIER says that giving 35000/ha in Punjab Haryana belt to farmers for 3-5 years could encourage shift from paddy to pulses.

However, in this strategy, the biggest hurdle is the MSP criteria and the government is responsible for its importance as today, nothing is more profitable than growing wheat and rice because the government buys these two commodities. Unlike, Mazie, for which there is no profitable MSP.

Today 84% of Punjab's gross cropped area is under rice and wheat leading to 76% of blocks being overexploited for water. To save Punjab and Haryana from ecological disaster 1.5 hectares need to be shifted to pulses, oilseeds, soya and maize. Inspiration can be taken from Andhra Pradesh, which has successfully added 74% (2023) more value due to crop diversification and moving out from rice wheat rotation.

- **Diversifying into different varieties of wheat and rice**: According to vice-chancellor of the Punjab Agricultural University (PAU), Dr SS Gosal, PR-126 variety of paddy developed by the university produces less stubble and requires less water. "it could lead to milder farm fires and reduce the annual pollution impact on the national capital after cultivation this November." The quicker PR-126 variety has accounted for only 10%-

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15% of the sowing every year. The average height of PR variety is 100cm and that of Pusa-44 (most used currently) is 115cm — the shorter the paddy stubble, the less of it has to be burned, hence the shift to newer varieties will be beneficial. However, Pusa-44 gives up to 71% of rice in the given quantity of paddy while PR-126 give 62-64%," said rice millers association president Tarsem Saini. Therefore, rice millers fear less rice yield from the new variety. Farmer unions have called for compensation for the extra effort taken to prevent stubble burning. bonus of ₹100 per quintal over and above the MSP,"

Measures to be adopted by the government:

- **Subsidy schemes**: Implementation of subsidy schemes should be rationed out to low income (small land holdings) or rental lands should be given subsidy on equipment. Criteria to avail subsidies should be reconsidered. Moreover, transparency must be ensured in the execution of various government schemes. Fool proof methods to identify needy farmers with small holdings so that aid is not wasted.

- **Machines on rent**: The harvesting season lasts for 20 to 25 days so provisions for access of machinery should be thought of. One of the methods could be that companies that manufacture these machines could give them on rental basis to economically weak farmers to reduce monetary burden on them and the government.

- **Moisture:** Change in moisture level cut off can be reconsidered after discussions with experts so that panic created after the harvest decreases.

- More options of stubble utilization by other industries should be created aggressively and at priority. So that a larger mobilization of stubble can occur.

- **Increase Awareness to alter farmer psychology:** A major observation from the primary data is the farmer psychology of "follow the easy way out". Their traditional mind set favours stubble burning rather than adopting greener and sustainable methods which prevents them from going the extra mile. Additionally, there is Lack of regulations and strictness in imposing fines and punishments for people who violate the ban on stubble burning. However, this needs to be addressed and changed because the government policies are of no use if the beneficiary is not receptive enough to adopt them.

- Bridge the above mentioned grass-root gaps.

- Power of farmer Unions which incite farmers to burn stubble to create political unrest should be kept in check.

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- Stop or limit measures such as free power and diesel subsidy due to which ground water is being over-exploited.
- The government has declared on 16th October 2024 a hike in the MSP of six rabi crops including barley, wheat, mustard, lentil, gram and safflower to encourage growing of alternatives to rice and wheat.

Thus, the government has a major role to play in reduction of stubble burning.

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