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Fields on Fire: Impact and Alternatives to Stubble Burning in India

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Abstract

In almost all states of India, crop residue burning is a common practice that has induced detrimental effects on the environment, soil, and health. Although stubble burning is a felony under Section 188 of the Indian Penal Code (IPC) and the Air and Pollution Control Act (may be utilised for cow feed, composted with manure, rural roofing, beverage production, packaging materials, and bioethanol, among others) but these are adopted rarely because of unawareness. According to various surveys, farmers practice crop residue burning in many states in India. This is mainly due to the government's silence, which cannot stop such activities. The purpose of this review is to illustrate the current state of stubble-burning procedures for agricultural waste disposal in India and present numerous potential strategies for crop residue valorisation. Overall, this review paper gives an in-depth overview of the detrimental impacts of agricultural waste burning in India, as well as other, more promising management options, such as the use of bioenergy. If widely implemented, these strategies could not only reduce the negative environmental effects of crop residue management, but also add value to the crop global agricultural industry.

Keywords: Burning, farmers, impacts, pollution, stubble, substitutes

1. Introduction

According to a study, humans burn biomass at a rate of roughly 90%, with natural fires adding very little to the total amount of plants destroyed (Mittal et al., 2019). Stubble burning is the burning of the residue left after harvesting the paddy crops and done for the sowing of the next season's crops. Paddy stubble burning is practised in Gangetic plains mainly in Punjab Haryana. This practice is a cheaper way to get rid of the stubbles and weeds from the field instead of stubble incorporation in the field. Incorporating stubble in the field is not economical for the farmer. Generally, farmers use a combine harvester which harvests thresh and separate grains which leave 8-12 inches of paddy stalks in the field in northern states. However, problem is that the machine does not cut close enough to the ground, leaving stubble behind that the farmer has no use for. The fast and cheap solution is to clear the field by burning the stubble (Kumar et al., 2015). In India, New Delhi and the other NCR (National Capital Region) cities have been experiencing harsh pollution from smog and haze caused by various anthropogenic activities and lower temperatures during the winter especially during October to December months every year. Recent data from 2019's global air quality report revealed that 14 of the world's 20 most polluted cities are in India, with the city of Ghaziabad in Uttar Pradesh ranking highest (Sikarwar and Rani, 2020). The emission of the different air pollutants attributed to

crop residue burning is non-uniform across states in India as it depends on the type of crop residue burnt. However, Punjab, Uttar Pradesh, Haryana, and Maharashtra were on top of the list of regions with a high incidence of crop burning (Jain et al., 2014)

2. Impact of Stubble Burning

2.1. Environment

The ability of ash and smoke to quickly move over a thousand kilometres and to form obstinate clouds is a well-known phenomenon. Additionally, smog is created by the smoke, which can raise air pollution levels and lead to breathing difficulties as well as other health problems including eye discomfort. Recurrent burning of husk may result in the formation of brown clouds that have an impact on local air quality, atmospheric visibility, and global warming as well. Once a pollutant is released into the atmosphere, it alters the chemical composition of the air quality, which has an impact on human health (Chatterjee, 2018).

According to reports, burning crop stubble accounts for 25% of the winter air pollution that nearly always surrounds the whole capital city. The air quality in central Delhi is poor, claims the American embassy in New Delhi was considered "unhealthy" in the morning since it was more than three times the allowable level. As a result of United Airlines, a US-based airline, the federal government received harsh criticism and



cancelled New Delhi flights because of smog.

Typically, PM in the air is divided into two categories based on the size of its particles: PM_{2.5}, which are fine particles with a diameter lesser than 2.5 µm, and PM₁₀, which are larger particles with a diameter of less than 10 µm. Lightweight PM materials will hang in the air for a long time. With the wind, they can travel for an extended period. PM pollution gets worse when the tiny particles remain in the air for a prolonged period under certain climatic conditions, air pollution over a long time (Porichha et al., 2021)

2.2. Health

In many regions of the world, air pollution increases mortality and morbidity rates by posing a serious threat to human health and well-being. According to the WHO, hazardous air caused by pollution kills roughly 7 million people worldwide each year (WHO, 2018). According to WHO burning paddy straw causes dioxins, including polychlorinated dibenzo-p-dioxins, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated dibenzofurans, to be released into the air (PCDFs). Additionally, the burning of paddy stubble releases

Table 1: Pollutant emissions in Haryana and Punjab during the harvesting season

Pollutants	Areas in Delhi	Current level (µg m ⁻³)	Permissible Limit (µg m ⁻³)
PM _{2.5}	Punjabi Bagh	650	60-80
PM ₁₀	Punjabi Bagh	1000	60-80
CO	IGI Airport	6.3	2-4
SO ₂	IGI Airport	29.8	60-80
NO _x	Anand Vihar	167	60-80

Source: 2016 report by the Delhi Pollution Control Committee [DPCC]

CO₂ into the atmosphere, causing the oxygen layer to thin and generating the greenhouse effect. Animals die from smog caused by crop stubble burning, and high amounts of CO₂ and CO in the blood can turn healthy haemoglobin into lethal haemoglobin, among other serious negative effects, especially for individuals with respiratory conditions, and cardiovascular disease. Small toddlers and expectant mothers are also likely to suffer from the smoke that comes from burning twigs (Kumar et al., 2015)

2.3. Soil

Due to insufficient application of organic manures and non-recycling of crop residues, the organic carbon content of indo-Gangetic plains soil has been decreased to extremely low and deficient levels. The Burning of crop residue in open fields has detrimental effects on decreasing the soil's fertility and the number of nutrients available in the soil. (Thakur and Halder, 2017). This results in an additional cost for applying compost or fertilizer to restore the soil's fertility. Burning

twigs depletes the soil of nitrogen, phosphorus, and potassium (NPK), as well as other vital elements and Micro-nutrients. For instance, burning rice husks results in a loss.0.445 Mt of NPK, 0.144 Mt in the case of burning wheat straw, and 0.84 Mt for the annual burning of sugarcane residue (Jain et al., 2014). Crop leftovers are crucial in enhancing the physicochemical and biological characteristics of the soil. It serves as a physical buffer and prevents soil erosion caused by wind and water. It also reduces runoff. Although adding straw to the soil improves the organic matter content, it also encourages the production of aggregates and structural stability. Organic matter in the soil serves as a storehouse for vital plant nutrients, inhibits leaching, is necessary for growth, and boosts cation exchange capacity. Utilizing agricultural wastes regularly increases the soil's organic matter content and enhances its ability to hold water. (Singh et al., 2021). Bulk density, mechanical strength, and aggregation. The impacts of soil granulation and the structure are directly impacted by the destruction of organic materials by fire. The decrease in organic matter, soil bulk density, and soil porosity rise and decrease the adverse effects on the growth of plants and microorganisms. They should work harder to grind the soil since it also lessens the adhesion between soil particles, which results in the production of huge lumps during tillage and ploughing. (Parte et al., 2020).

3. Why do Farmers Burn Stubble?

3.1. Lack of awareness

Farmers are unaware of the fact that they are burning soil-friendly insects. Organic matter and causing a huge loss of nitrogen, potassium, and DAP. This is because the farmers thought that if they do not burn the left then it will float over the flooded field prepared for the transplanting of paddy nursery when the windy air will come it will cause damage to the crop.

3.2. Shortage cropping cycles

There are reasons for farmers not stopping themselves from burning crop residue: The farmers want to fulfil the gap for timely sowing of wheat after paddy harvest which is too short. In Punjab and Haryana, the time for paddy harvesting is

Table 2: Nutrient loss due to burning of rice residues in Punjab

Nutrient	Concentration in straw (g kg ⁻¹)	Loss in burn (%)
C	400	100
N	6.5	90
p	2.1	25
K	17.5	20
S	0.75	60

(Source – Singh et al., 2008)



between the first and last week of October. Then the farmers sow the first wheat crop in the first week of November. That's why the menace of the rice straw was burned due to the shortage of labour and lack of time. When we use a combine harvester and thresher for paddy harvesting, the machine leaves behind a significant length of stubble in the field. This is the reason the other machine faces some problems in sowing wheat seeds. Within 10-15 days between the paddy harvesting time and the wheat sowing time, farmers are forced to burn their stubble to quickly get rid of it.

3.3. Increased mechanization of harvesting

The use of machine harvesters leaves 10-30 cm of stubble in the ground of the field depending on the crop type, which was not in the case of manual harvesting by labours. But it is too expensive to hire labours to do this work.

3.4. Labour shortage

Use of expensive labour is not a great option. As in Punjab, the fields are large and use mechanized harvesters which is common. Most of the farmers who cannot afford mechanized harvesters which are expensive also use the method of burning which is cheaper and easier to be done.

3.5. No market for stubble

As it formerly did, the local economy is unable to absorb straw for use in roofing houses and other structures. Crop residue has poor commercial and economic value, and when combined with high processing costs, it has less value for farmers. Even though the amounts of waste created are the entire amount of residue that has little to no economic value and is equivalent to the overall crop output. But it can serve as the foundation for several items that haven't been fully investigated yet.

3.6. Reduce use of stubble

Earlier, the stubble which is left behind was used as fodder for the animals and also as hay for the animals and humans' homes warm. But now it became outdated and also because of the high content of silica it is not suitable as fodder.

3.7. Government policies

A policy named as Punjab preservation of subsoil water act of 2009, had unintentionally affected the promotion of stubble burning. This law was acted because of water scarcity as this early transplanting of rice (before mid-June) resulted in unsustainable withdrawals of groundwater with the monsoon still far, the temperature going high, and the rate of evapotranspiration reaching its peak. That is why the farmers are forced to do the harvesting and sowing in a small gap.

4. Should Farmers be Blamed for Burning Stubble?

The limited amount of time between harvesting rice and planting wheat is the primary cause of stubble burning. This small window of time between rice and wheat can be partially due to the Punjab Preservation of Subsoil Act (2009), which fixes June 20 as the date for paddy transplanting, delaying

rice harvesting. Farmers choose the quickest and easiest method since they have less than 20–25 days between two crops as a result. In Punjab paddy is sown in 75000 acres of area and there is a prerequisite of ₹ 16000–17000 for one hectare of land that farmers need to physically eliminate stubble. The government of Punjab distributed the tractors to mounted happy seeders to simultaneously sow the wheat seed and cut rice stubble. But the requirement for a happy seeder was 50000 in Punjab and the government distributed only 24000. To rent a happy seeder it costs around 1000 and 2000 for diesel (Barman and Mukhopadhyay, 2020). Farmers believe that burning will eliminate all dangerous insects and weeds, which will minimize the need for insecticide and agricultural costs. Some farmers also realized that burning stubble in the field decreased their tractor's fuel costs. The ash produced when stubble is burned serves as a potassium supply and can also lessen the acidity of the soil. The fact that farmers' incomes are low makes it difficult for them to purchase expensive tools like rotavators, which are necessary to thoroughly mix these stubbles into the soil. Tractors with a lot of horsepower are necessary for these kinds of gadgets to function. Agriculture cannot be done without labour because labourers can help farmers with a range of field operations that are impossible for machines to complete. Punjab used to have a large workforce that helped farmers with hand harvesting (Singh and Verma, 2020)

5. Steps Taken by the Government to Reduce Stubble Burning Suggestions to Check Stubble Burning

- Promoting the use of crop residue-based biochar briquettes in local industries, brick kilns, and hotel/Dhaba as an alternate fuel.
- Creating a market for crop residue and mandating nearby thermal power plants to undertake to co-fire them with coal.
- Promoting infrastructure for setting up biomass depots for storage of bailed crop residue in areas that have shown high fire incidents or high production of a particular crop.
- Providing special loans for financial farm equipment and working capital for the private sector.
- Promoting pollution control as a parameter for deciding incentives and allocation to states and UTs.

6. Ban on Crop Residue Burning

- In the state of Punjab, the state of Rajasthan, the state of Haryana, and the state of Uttar Pradesh the national green tribunal has passed the order of directed and prohibited agricultural residue burning in any place of NCT of Delhi on 10.12.2015.
- Farmers who engage in stubble burning have begun to face penalties in Punjab and Haryana. The Supreme Court has also requested a response from the Center and others over a request for instructions to fully prohibit mustaches. (Press Information Bureau, 2019)



• The National Environment Appellate Authority Act, 1997, the Air Prevention and Control of Pollution Act, 1981, the Environment Protection Act, 1986, the National Tribunal Act, 1995, and Section 144 of the Civil Procedure Code (CPC) are a few of the laws that are currently in effect regarding crop residue burning. The National Green Tribunal (NGT) has adopted strict steps, particularly in the states of Rajasthan, Uttar Pradesh, Haryana, and Punjab, to reduce agricultural waste burning. (Kumar et al., 2015)

• Although a total ban would seem to be the best course of action, it is not practical until problems like the lack of machine availability for small farms are resolved. The issue is made worse by the government schemes' slow execution.

• Some farmer unions are even challenging the officials conducting unexpected field inspections and fining farmers who are caught burning stubble. The government's gentle approach to reprimanding farmers, who make up a significant voting bloc, has compounded the situation.

• To prepare the fields for the seeding of the Rabi Crop, paddy stubble is primarily burned in the Indo-Gangetic plains of the States of Punjab, Haryana, and Uttar Pradesh. However, several States have notified us that the severity of uncontrolled crop residue burning incidents is not very high.

7. National Policy for Management of Crop Residue (NPMCR)

The situation demands that an appropriate policy package of technical and policy interventions for crop residue management is formulated for adoption by the States. Accordingly, "National Policy for Management of Crop Residue (NPMCR)" has the following major objectives:

Control of burning of crop residue to prevent environmental degradation- and loss of soil nutrients and minerals by promotion of in-situ management (incorporation in soil, mulching, baling/binding for use as domestic/industrial fuel, fodder) of crop residue;

Diversified use of crop residue for various purposes like charcoal- gasification, power generation, as industrial raw material for the production of bio-ethanol, packing material, paper/board/panel industry, composting and mushroom cultivation, etc.; Capacity building and awareness about ill effects of crop residue burning- and its effective utilization and management; and Formulation and implementation of suitable law and legislative/policy measures to curb burning of crop residue.

8. Cases Against Farmers for Stubble Burning in Haryana, Punjab, And Uttar Pradesh

8.1. In the state of Haryana

The state parliament was informed on Wednesday that 2,943 farmers in Haryana had complaints or cases filed against them for burning stubble from 2019 to 2021 and that 736 of them had been taken into custody in 2019 and 2020.

J P Dalal, the minister of agriculture, responded in writing to a query posed by INLD member Abhay Singh Chautala with the information. Chautala wanted to know how many cases of farmers being fined and detained for burning stubble had been filed against them during the previous three years in the state, broken down by year and district. The House was also informed that defaulters were fined more than Rs 37

Table 3: State-wise crop residue generated, residue surplus and burned (Crop residue in Million Tonne) S.N.

States	Residue generated	Residue surplus	Residue burned
Arunachal Pradesh	0.40	0.07	0.04
Andhra Pradesh	43.89	6.96	2.73
Assam	11.43	2.34	0.73
Bihar	25.39	5.08	3.19
Chhattisgarh	11.25	2.12	0.83
Goa	0.57	0.14	0.04
Gujarat	28.73	8.90	3.81
Haryana	27.83	11.22	9.08
Himachal Pradesh	2.85	1.03	0.41
Jammu and Kashmir	1.59	0.28	0.89
Jharkhand	3.61	0.89	1.10
Karnataka	33.94	8.98	5.66
Kerala	9.74	5.07	0.22
Madhya Pradesh	33.18	10.22	1.91
Maharashtra	46.45	14.67	7.42
Manipur	0.90	0.11	0.07
Meghalaya	0.51	0.09	0.05
Mizoram	0.06	0.01	0.01
Nagaland	0.49	0.09	0.08
Odisha	20.07	3.68	1.34
Punjab	50.75	24.83	19.65
Rajasthan	29.32	8.52	1.78
Sikkim	0.15	0.02	0.01
Tamil Nadu	19.93	7.05	4.08
Tripura	0.04	0.02	0.02
Uttarakhand	2.86	0.63	0.78
Uttar Pradesh	59.97	13.53	21.92
West Bengal	35.93	4.29	4.96
Total	501.73	140.84	92.81

*Source: Government of India Ministry of Agriculture Department of Agriculture & Cooperation (Natural Resource Management Division) KrishiBhawan, New Delhi November 2014



lakh in 2019, more than Rs 1 crore in 2020, and more than ₹ 82 lakh in 2021.

The House was informed that while 397 farmers were arrested in 2019, 339 were arrested in 2020, but no arrests were made in 2021. In 2019, Jind (515) received the most complaints or cases, followed by Karnal (438) and Fatehabad (431), while in 2020, Jind (439) received the most cases during the year. However, in 2021, the total number of complaints filed in the state fell to 100 from 1,975 in 2019, with as many as 82 cases coming from the Karnal district. In 2021, no farmers were detained, the minister continued. (Business Standard 2022)

8.2. In the state of Punjab

Farm fires have also occurred often in the state. Punjab reported 71,024 fire incidences up through November 21 of this year, while the data for 2020 showed 76,592 fires. Farm fires occurred 55,210 times in 2019, 50,590 times in 2018, and 45,384 times in 2017. Following information obtained from the Punjab Pollution Control

Board (PPCB), the state's overall paddy stubble burning area as of November 15, 2021, was 12.9 lakh hectares, or almost 43% of the state's total rice acreage (PRSC). 17.96 lakh hectares of paddy crop were burned in 2020. (The Indian Express, 2022)

8.3. Paddy straw burning: (Kharif season)

About 2,647 thousand hectares of paddy are grown in Punjab, producing 100 million tonnes of rice straw, and between 70 and 80 million tonnes of rice are burned to dispose of it (Badrinath *et al.*, 2006). In situ integration and field burning are essentially the only alternatives remaining for appropriate management of the leftover straw area. Since the breakdown of residue takes a long time and interferes with the growth of the wheat crop, in situ inclusion is not practical. Burning the leftovers on the field is therefore more convenient and cost-effective for farmers. Burning residue outdoors releases pollutants, depletes nutrients, harms soil biota, and lowers the total N and C content of the topsoil. Along with contributing to global warming, this irresponsible burning results in enormous energy waste. Additionally, it poses a health risk to the local populace. (Singh, 2008)

8.4. In the state of Uttar Pradesh

In the year 2021, up to 350 agricultural fire events were recorded from various districts in Uttar Pradesh, which worsened the state's air quality. The ongoing incidences of stubble burning are reflected in the flames. Farm fires are a significant source of wintertime air pollution, and the Central Pollution Control Board's AQI (air quality index) data clearly shows this influence (CPCB). Four cities in Uttar Pradesh—Hapur, Bulandshahr, Ghaziabad, and Baghpat—recorded extremely high levels of air pollution, with air quality indices (AQI) that exceeded 401 during the day. The average AQI recorded there was 246, which is classified as “bad,” and the air quality there also came close to the 300-mark. The Uttar Pradesh Pollution Control Board (UPPCB) uses the agricultural

fires detected by satellite data to track instances of burning farm trash, including stubble. NASA's Fire Information for Resource Management System (FIRMS) satellite data show (National Aeronautics and Space Administration), which is also used by UPPCB, the above-mentioned incidents of farm fires were recorded between Sunday evening and Monday evening on November 2021.

In Uttar Pradesh during the harvest season, no FIR has been filed against any farmers for burning stubble. Rakesh Kumar Singh, the deputy director for agriculture in Saharanpur, asserted that by intervention, the administration was able to lessen the incidences of stubble burning. We communicate with the local farmers, and many of them have found alternate ways to clear stubble. In the district, there have been fewer cases of stubble burning, according to him. On the other hand, the farmers contend that more practical and expensive alternatives to clearing stubble are unavailable. We paid extra for the use of specialized combined enzyme solution spraying to eliminate stubble. The larger farms may be able to afford them, but we smaller farmers have no other options. (The Hindustan Times, 2022)

Five farmers were charged by the police in one of the most recent incidences in Uttar Pradesh's Shamli district for burning agricultural leftovers, according to authorities. Ilyas, Vinod, Satbir, Suresh Pal, and Rajkumar, according to District Magistrate Akhilesh Singh, were charged for burning stubble under section 278 of the IPC and each received a punishment of ₹ 2,500. In this context, at least 25 farmers have been located in the district, he continued. The concept of blaming farmers who lack the necessary equipment to clear the stubble left after harvesting the crops for burning it is opposed by many leaders, nevertheless. Bhagwant Mann, a lawmaker from the Aam Aadmi Party, and Anupriya Patel, a leader of the Apna Dal, defended the farmers in the Lok Sabha last month, arguing that they shouldn't be held responsible for stubble burning, which is one of the primary causes of air pollution, and demanded that they instead be encouraged to grow crops that don't leave a residue. To encourage farmers to sell their stubble, they also suggested that the government look into methods to use it in biogas production and cardboard making. Mann stated farmers should be encouraged to produce crops like pearl millet (bajra) and sunflower since they do not leave stubble after harvesting while taking part in a debate on “Air Pollution and Climate Change.”

According to him, farmers produce crops that leave stubble to receive the minimum support price (MSP). According to Mann, who represents Sangrur in Punjab, farmers would be motivated to produce pearl millet and sunflower if the government announced an acceptable MSP on such crops. (The statesman, 2019)

9. Crop Residue Management by Agricultural Machinery

9.1. Happy seeder

It is a no-till planter for paddy stubble that is mounted on



tractors. Without first preparing a seedbed, it may cut and lift rice straw and sow wheat right into the ground. The leftover straw is then spread over the planted area as mulch, providing the soil with much-needed organic matter. The machine cuts

Table 4: Year wise data of fire imposed , FIR , and arrests of farmers

YEAR	Fire imposed	FIRs	Arrests
2019	Rs. 3,632,000	1,975	397
2020	Rs. 10,298,750	868	339
2021	Rs.8,263,500	100	0
TOTAL	Rs. 22,193,250	2,943	736

Source: The Times of India, 2021

down on the expense, time, and effort needed to complete this task manually. Even though these devices are provided at a reduced cost by the state governments, numerous farmers have recently complained about a shortage of equipment.

9.2. Pusa bio-decomposer

It is a low-cost microbial bio-enzyme solution that supposedly takes 15–20 days to turn crop debris into manure. Farmers will till and irrigate the fields a day or two after applying the solution, which will speed up the decomposition of residue. A combination of seven fungi called Pusa Decomposer produces enzymes that break down the cellulose, lignin, and pectin in paddy straw. When paddy is harvested and wheat is sown, the temperature is between 30 and 32 degrees Celsius, and this is when the fungi flourish.

9.3. Rotavator

Land preparation and incorporation of crop residue in the soil. A rotavator often referred to as a rotary tiller, is a piece of rotational tillage equipment that is operated by a tractor that levels, cuts, pulverizes, and mixes soil. Cultivators, disc harrows, and levelers can all be replaced with efficient and economical rotavators. Primarily used to prepare seed beds in one or two passes, it is effective at removing and mixing leftovers from crops like maize, wheat, and sugarcane. This improves soil health and saves fuel, money, time, and energy.

9.4. Baler

A baler, also known as a hay baler, is a piece of farm equipment used to condense a cut and raked crop into manageable, transportable, and storage-friendly bales. Balers are used for baling recyclable materials like cardboard, paper, plastic, and metal for bulk pickup. These machines compress the recyclables into compact bales, which can be easily stacked and transported for recycling.

9.5. Zero till seed drill

To plant seeds underground, equipment called a “Zero Till Seed Drill” is employed. The seeds are placed properly in the ground with the aid of this machine, at an appropriate distance

and spacing between them. Given that this equipment is autonomous, we can guarantee that seeds will be drilled at an appropriate depth and distance apart. Additionally, it will adequately cover the seeds with dirt to prevent seed spread. Since this Zero Till Seed Drill has several uses, it can drill any kind of seed. Additionally, this device is secure to use and specifies the depth at which seeds should be planted.

10. Conclusion

Due to the risks it brings to the environment and human life, burning of twigs and other waste has been a difficult issue in India. Different causes of residue burning have been uncovered by farmers, specialists, and government officials. Burning agricultural fields has a number of detrimental consequences on the environment and human life. Farmers are powerless despite being aware of the harmful impacts of stubble burning since there are no practical alternatives that would be financially worthwhile for them.

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