Stubble Burning in India

An Overview
Establishing a Waste-to-Value Ecosystem

Biomass India

We envision a World where abundant renewable biomass transforms industries and stewards the earth with high performance alternatives to conventional materials and products.

About (Biomass India)

Biomass India (BMI) is an initiative commenced in 2021 with the ambition to become the leading Indian forum for biomass upcycling. As a unique waste-to-value ecosystem, the program intends to deliver on the United Nations Sustainable Development Goals, and the Paris Climate Agreement goals. Biomass India brings together entrepreneurs, investors, innovators, farmers and policymakers in innovative partnerships to utilize agricultural waste to create products and services of value for the global market.

Preamble

India has a total geographical area of 329 million hectares, 51% of which is primarily used for agricultural cultivation.[1] Globally, this makes India the second-largest producer and seventh-largest exporter of agro commodities. Simply speaking, during 2019-2020, food grain production was at a record 296.65 million tonnes while production of horticulture crops was estimated at 319.56 million tonnes.[2] Despite posting such astronomical numbers, this growth shows no signs of slowing down. Studies show that farmers shall need to produce 70% more to feed the world's growing population by 2050.[3] With the global economy's dependence on this crucial sector, it is essential to maintain sustainable growth and development without causing any adverse effects on soil and climate, ensuring food security. In the Indian agricultural landscape, the state of Punjab holds a prominent place – Despite occupying only 1.53% of India's geographical area, it contributes the maximum volume to India's central rice procurement pool. This makes Punjab one of the top producers of paddy in the country, however, this also leads to the generation of a large volume of paddy stubble that is subjected to burning. The neighbouring state of Haryana also faces a similar issue.

The amount of surplus crop residue available in India is estimated at around 141 million tons, out of which 92 million tons is burnt every year across the country.[4] In Punjab alone, paddy is grown over 27 lakh hectares of land, resulting in the generation of 20 million tonnes of paddy stubble. Haryana is not far behind, generating 7.93 million tonnes of paddy stubble during the year 2018-19.[5] In fact, in the northern states of India, an estimated 23 million tonnes of paddy stubble are subjected to burning during the months of October and November every year, which severely affects the air quality in the National Capital Region (NCR) and adjoining parts during the winter. The hazy and polluted skies across northern India have been a major cause of concern since 2016. The Ministry of Agriculture has launched several initiatives to reduce these burning instances and has also provided financial assistance particularly to the states of Punjab and Haryana to take appropriate measures to control stubble burning. Programs and techniques developed to efficiently manage stubble on site have looked promising. Yet, the issue continues to remain of grave concern due to certain apprehensions surrounding the scalability of such programs and techniques given the magnitude of paddy stubble generated. Due to a lack of adequate awareness of the importance and significance of sustainable farming practices and the perception that crop burning is a faster and more cost-efficient technique for clearing fields, farmers remain on both sides of the debate. The government and concerned institutions and varsities need to work together to develop a holistic approach and ecosystem to address this problem. The need of the hour is also to create opportunities for a Waste-to-Value ecosystem and alternate usage of paddy stubble for downstream processing and value addition.

The Problem of Crop Residue

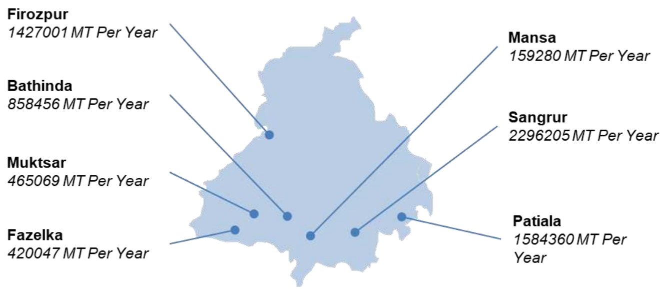
India primarily has two cropping seasons – Kharif (Summer Crop) and Rabi (Winter Crop). Generally, paddy is grown during the summer and is followed by wheat cultivation during the winters. They maintain such a rotation system in line with the climatic conditions, domestic demand, consumption patterns and the Minimum Support Prices established for these crops. The MSP mechanism protects the farmers against any uncertainty or fall in prices which they may not be able to withstand. After the paddy harvest, the produce is sold by the farmers either at Government procurement centres or at the local APMC Mandis. While these are usually happy times for farmers, the crop residue and weeds left behind in the fields remain a pressing issue. The rice-wheat rotation system practised extensively in North India generates large amounts of stubble. Rice is often harvested during September-October while wheat plantations tend to begin from November. This leaves farmers with a short turnaround period, just about 30-45 days, between their rice harvests and wheat plantations to remove paddy stubble from their farms and make the field ready for sowing wheat. If they miss this window, the harvest might disappoint leading to a lower yield, translating to lower earnings. The problem is further aggravated due to the enormous volume of stubble that needs to be removed from fields within this span of 30-40 days. Time constraints and the labour-intensive nature of removing the Paddy straw led to the adoption of mechanised procedures i.e., combine harvesters. However, these in turn seems to have piqued the issue. Mechanised farming of paddy leaves behind a huge amount of scattered, root-bound stubble 1-2 feet high that is unsuitable for use as animal fodder due to its low calorific and high silica content. Every 0.4 hectare of paddy field generates around 2 MT of stubble in the case of basmati and 4 MT in the case of non-basmati produce. The absence of scalable commercial applications of straw leads to its limited offtake. Despite government facilitation, the equipment required to harvest/collect straw remains too expensive for a large segment of farmers. With large amounts of stubble in the field and a ticking clock to deal with, farmers find field burning as a quick, easy and cost-effective way of managing the agro-waste.

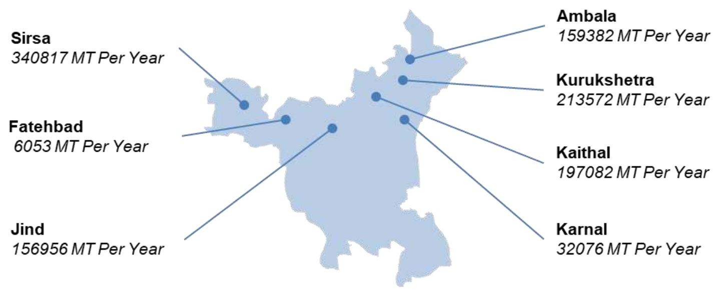
The Burning Issue

The burning of stubble is counterproductive to sustainable farming. Subjecting the field to stubble burning every year severely affects the nutrient budget of the soil. It leads to the destruction of organic matter and minerals which adversely hampers the cultivation of future crops. Burning 1 tonne of stubble or paddy straw destroys 5.5 kg nitrogen, 2.3 kg phosphorus, 25 kg Potassium and 1.2 kg Sulphur, in addition to required organic carbon, making the land unproductive.[6] To compensate for these lower yields, farmers are forced to spend lavish amounts on artificial fertilizers to rejuvenate the soil. A substandard solution! India contributes about 12.2% to the global greenhouse gas emissions and reportedly lost 36% of its expected annual wheat yield in 2018 due to the poor quality of air and drastic change in weather patterns.[7] Farmers in Northern India burn an estimated 23 million tonnes of straw. That enormous volume of straw, if packed into 20 kilograms 38-centimetre-high bales and piled on top of the other, would reach an estimated height of over 4,30,000 kilometres i.e., about 1.1 times the distance to the moon. [8]

The austere situation in India surrounding stubble burning makes it one of the major contributors to air pollution. Most Indian cities, especially within the National Capital Region (NCR) experience harsh pollution often reaching severe levels of Air Quality Index (AQI). An AQI between 0-50 implies air quality to be satisfactory whereas anything above 300 can lead to serious health effects. With that in mind, in November 2019, Delhi recorded a peak AQI of 487, Ghaziabad reported an AQI as high as 493, and Greater Noida recorded 480.[9] The health effects accruing as such range from skin and eyes irritation to severe neurological, cardiovascular and respiratory diseases. The Energy and Resources Institute (2019) reported that in 2012, air pollution alone led to 5 million deaths in South Asia which constitutes 22% of the total deaths in that region.[10]

Following is a depiction of the amount of surplus stubble burnt in Haryana and Punjab alone.





Punjab; 16787332 MT Surplus Biomass p/a

HARYANA: 1827190 MT Surplus Biomass p/a

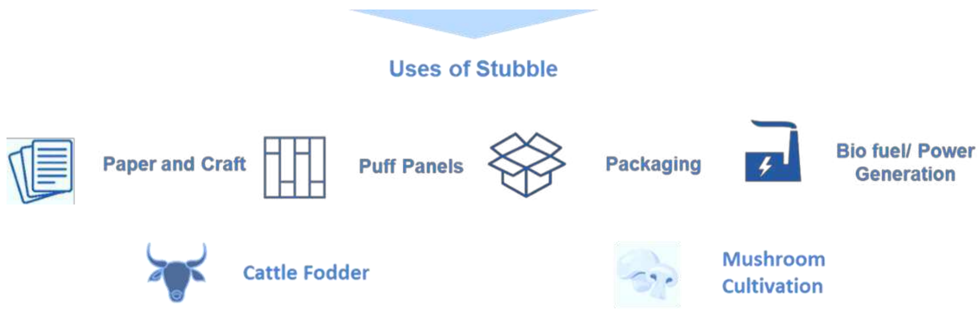
Apart from its effects on health and the environment, the practice of stubble burning adversely affects the growth of a country's economy. The ability to effectively curb air pollution requires astute management both from an economic and technological standpoint. The System of Air Quality and Weather Forecasting and Research (SAFAR) estimates that stubble burning in Punjab and Haryana contributes 40-45% to Delhi's air pollution during peak burning days. As a result of which the inflow of tourists in Delhi has decreased by about 25-30%. Reports claim that the accumulated effects of air pollution cost the Indian economy 4.5-7.7 % of its GDP in 2018, and when projected to 2060, the percentage rose to about 15%.[11]

Is there an Ideal Solution?

> Sustainable agriculture is one which depletes neither the people nor the land.
>
> -Wendell Berry

As the problem of stubble burning burst into the limelight, agencies and universities across the world began conducting extensive research and field studies to further understand the problem and develop viable solutions. As such, crop residue often regarded as 'trash' or agricultural waste, is slowly starting to be viewed as a valuable resource. The Ministry of Agriculture's National Policy for Management of Crop Residue (NPMCR) to prevent agricultural residue burning and to promote technologies for its optimum utilization issued a press release stating that it would not be long before crop residue is no longer perceived as "trash" but a "co-product" or a "bi-product" at best.[12]

Crop stubble is often viewed as a valuable raw material for power and gas generation. The use of bio fuels provides promising alternatives, reducing our dependence on conventional fossil fuels. It is renewable, readily available and can be used successfully in boilers with 99% efficiency. Further, Bio fuel is available at a lower cost compared to coal while also possessing less ash content making it more than just a viable substitute. [13] Setting up bio fuel plants provides an incentive to farmers as an additional source of income while reducing the detrimental effects on the environment. Such energy systems provide an opportunity to utilise these residues to meet local electricity and heat requirements. Paddy Straw is also utilised by paper production industries. It provides a competitive alternative source to fibre and hence can be used to reduce the pressure on forests. The pulp obtained by extracting cellulose from straw is used to produce a variety of paper-based products. While wheat straw and stubble of basmati rice is often used as fodder for farm animals, the majority of non-basmati paddy stubble is burned due to its high silica content. It is believed that almost 40% of the wheat straw produced is used as dry fodder for animals. [14] Punjab Agricultural University has conducted trials on the natural fermentation of paddy straw for use as protein enriched livestock feed. The cattle feed showed improvement in health and milk production paving the way towards a promising new market. This breakthrough will enable farmers to buffer stock and develop fodder banks in deficit regions.



Waste to Value Supply Chain

While the primary aim is to manage stubble on site (In-situ management), the sheer volume of stubble generated requires high scale transportation and storage infrastructure, critical to support various industries. If not managed properly, the efficacy of stubble is at risk. The central objective is to establish a value chain that reaches all farmers cost-efficiently. Typically, straw is processed in one of three ways – Shredding, bailing and compacting.

Bailing and Compacting

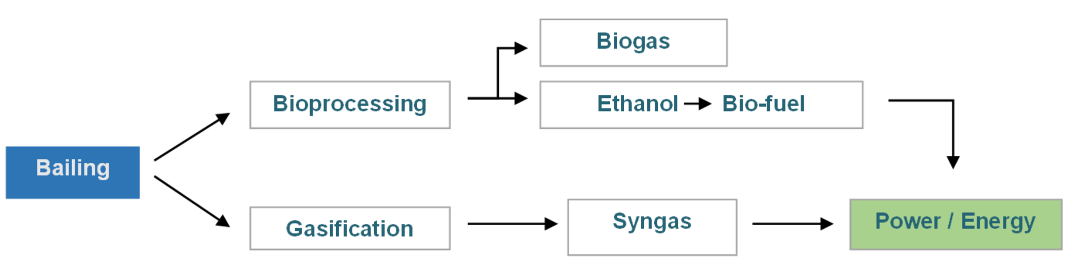
Bailing and Compacting, both are primarily used to compact stubble for efficient utilization of storage space and to maintain its longevity. The process undertaken depends on the material being reduced and its further intended use. Some materials are suited to a particular function while others (like straw) can be baled or compacted with an eye on its further use. Key benefits include;

- Reduction of storage and space requirements
- Ease of storage due to a well-defined shape
- Ease of transportation
- Reduction in handling costs

The following are two examples of how bailing and compacting lead to the production of waste-to-value products.

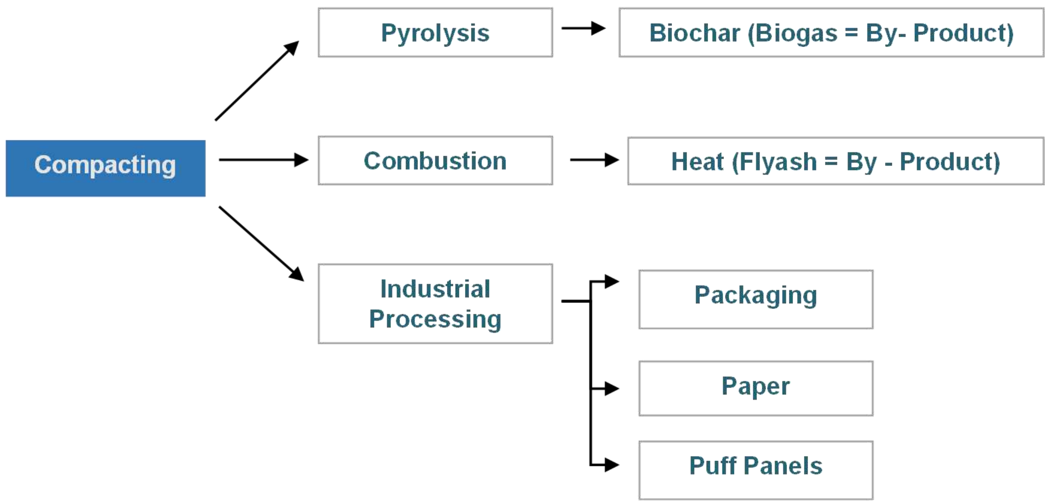
Bailing

Typically, the Bailing system of paddy straw from produce to end product is as follows



Compacting

Typically, the Compacting System of paddy straw from produce to end product is as follows



All further processes are undertaken to meet the requirements of our growing energy and industry demands. They have gained large commercial interest due to the green advantages of using biomass over conventional energy sources such as fossil fuels. In 2017, the International Energy Agency described bioenergy as the most important source of renewable energy, [15] urging the need to accelerate its deployment across the industry.

Management of Stubble

In-situ Management

As mentioned earlier, owing to a narrow window, the disposal of paddy straw after harvest remains a major concern to all farmers. Managing stubble on site involves techniques used to embed huge piles of residue creating organically rice soil. However, the pressing concern surrounding time persists as traditional paddy residue left by farmers can take anywhere between 2-3 months to naturally decompose. Extensive research has been conducted in recent years to provide farmers with a solution. Persistent efforts by the Government and the IARI led to the development of 'Pusa Decomposer'. This microbial spray acts on the straw, breaking down its molecular structure to release the nutrients into the field quickly. Its application brings down the required time for decomposition to just 25 days.

Other Initiatives by the Government involve the distribution of 'Happy Seeders' and 'Straw Management Systems' which help farmers cut down the rice stubble and sow wheat seeds simultaneously. Even though farmers expressed a willingness to adopt such machinery in their fields and despite the consistent subsidies offered by the Government, they remain too expensive and inadequate for the farmers' cause.

Carbon sequestration in the soil is of the utmost importance to the agricultural community. This has seen an increasing interest in biochar as a soil amendment to stabilize its organic content. Biochar, the by-product of pyrolysis, is a fine-grained carbon-rich porous product. This nature of biochar enables us to integrate it back into the soil to improve its water retention and reduce the use of fertilizers. [16] Thereby mitigating greenhouse emissions while also reducing the volume of agricultural waste. Fly-ash can also be used for soil amelioration. The silt-sized particles, low bulk density (BD), higher water holding capacity (WHC), favourable pH, and significant presence of plant nutrients in Fly ash make it an ideal source for soil amendment.[17] The co-application of fly-ash along with organic and inorganic materials such as lime, animal manure, composts… possess enormous potential in agriculture and forestry.

Bio fuels

In the context of biomass energy, biofuel refers to any fuel that is derived from biomass i.e., crop residues and other biological products. Living biomass takes in carbon during its growth and the same is released when used for energy, resulting in a carbon-neutral cycle. This avoids the increase of atmospheric concentration of greenhouse gases, reducing carbon footprints. Several transportation fuels can be produced from biomass, helping to alleviate the demand for petroleum products in the transportation sector. Liquid biofuel continues to garner large interest due to the required infrastructure already in place. Leading liquid biofuels include ethanol and biodiesel. Agricultural produce used to develop ethanol includes corn, sugarcane and various crop residues, often blended with gasoline. Biodiesel, on the other hand, is made primarily from plants with larger oil extracts such as soybean or oil palm. The fast growth in biofuel production is expected to continue as it remains a promising area of interest for researchers. A variety of crop residues realised around the world could be converted into second-generation biofuels using different treatment and production methods. The Government of India proposed a target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel by 2030 and has introduced multiple initiatives to increase indigenous production of biofuels. [18] To reduce import dependence, the government aims to cut down the use of fossil fuels by 10% by 2022.

Industrial Processing

With rapid growth in population, urbanization and industrialisation, the demand for paper and packaging materials is on the rise. While pulp and paper mills use large amounts of wood to meet the ever-present demand, the pressure on forests is only growing. Rice straw can prove to be a competitive alternate source. This application would be especially useful in wood deficit countries. As a virtue of having less lignin content, rice straw requires less harsh conditions for cooking and can be easily pulped.[19] The pulp obtained through the extraction of cellulose can be used extensively in the industry.

When stubble undergoes combustion to generate heat, fly-ash is normally the by-product of this process. While flyash can be used for soil amelioration, it also possesses some interesting applications in the construction industry. Fly-ash has various cementations and pozzolanic properties. In simple terms, this refers to its ability to harden when mixed with liquid substances like water. This enables the use of fly-ash in concrete and cement products. [20] Biochar, the by-product of pyrolysis, can also be used in industries such as construction, food and cosmetics. Based on its wide applicability, it remains a valuable resource with huge potential.

The need for eco-friendly and economical solutions to meet growing demands remain indispensable towards achieving sustainable growth.

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