

Biomass burning and alternatives / suggestions

The practise of burning standing stubble during the late autumn (October, November) months by farmers in the agricultural plains of the Indus basin is sometimes blamed for the intensification of smog events that occur after paddy crops have been harvested there. Farmers in that watershed have long favoured using biomass fire (paddy stubble leftover) to clear cropland. Contrarily, smog is being more frequently linked to burning agricultural biomass, despite consistent agricultural landholding and productivity. According to some research, agricultural biomass burning is a transient occurrence in the basin that may serve as a trigger for an overall decline in the region's air quality. Further findings show that intensified smog episodes are closely correlated with simultaneous saturation of air contaminants, high ambient moisture content, and low wind speeds after the monsoon season. In agricultural locations where farming activities are a significant economic driver for society, the findings from these research should aid in developing comprehensive mitigation and intervention programmes to monitor air quality for sustainability of public health.

Biomass is a broad term whose definition includes all kinds of terrestrial and water based plant life. Or in other words non- human and non-animal living forms. Biomass burning is the partial or complete combustion of living and dead vegetation. This report for the India BioChar and BioResources Network IBBN - is prepared to suggest specific uses / reuses of agricultural waste or dry biomass for various purposes in a sustainable and ecological friendly manner. This biomass is important to reuse since it is a critical bioresource but is generally not returned to the soil/ earth to replenish it thereby losing nutrients and minerals which can help agriculture crops, sustainably. As is obvious this has a high biodiversity in terms of the variety of species of vegetation from which they originate and their uses / reuses can be identified and determined based on these specific forms.

Biomass burning forms in different parts of the world

Biomass burning includes the human-initiated burning of vegetation for clearing land and land-use changes as well as natural, heat, dryness or the lightning-induced fires. Scientists estimate that humans are responsible for about 90% of biomass burning¹ with only a small percentage of natural fires contributing to the total vegetal loss due to burning. But with increasing climate change forest fires raging in drier agro-climatic zones and even in places with permafrost like Siberia have impacted large regions repeatedly. Receding polar ice cap cover, receding glaciers, have been attributed to the impact of climate change. These are affecting very large regions in different nations including through seasonal temperature variations, and the increasing intensity of cyclones and tornadoes. It can also be affecting the arrival of the seasonal monsoon rains in south Asia as well as global ocean currents such as the Gulf Stream in the Atlantic Ocean which is critical for maintaining the weather patterns in the east coast of the United States (which is weakening due to climate change impacts).

Burning biomass does release large amounts of particles (emitted by burning of solid carbon) and gases, including greenhouse gases (GHGs) that lead to Global warming. Greenhouse gas emissions have led to an increased warming of the Earth due to human initiated global climate change. Studies suggest that biomass burning has increased on a global scale over the past 120 + years², and indicated that a hotter Earth resulting from global warming will lead to more frequent and larger fires. Burnt biomass particulates impact climate and affect human health when they are inhaled, causing severe respiratory diseases and fatalities. In India air pollution as a cause of death is only 2nd after cardio vascular diseases and related heart ailments.

¹ Biomass Burning: A Hot Issue in Global Change , U S National Aeronautics and Space Admin -NASA 2001
<https://www.nasa.gov/centers/langley/news/factsheets/biomass.html>

² Biomass Burning: A Hot Issue in Global Change , U S National Aeronautics and Space Admin -NASA 2001
<https://www.nasa.gov/centers/langley/news/factsheets/biomass.html>

Agrarian biomass activities

Various activities carried out by human beings to prepare land for farming, shifting cultivation or change of land use such as - house construction activities on agricultural lands and urbanisation / sprawl etc are accompanied by biomass burning as the first stage for clearing the land of existing vegetation. A large number of these are traditional activities being carried out as per age-old practices. But due to unequal population pressure on land such as in Africa and Asia and lack of access to land resources, various forms of air, soil and water pollution and climate change impacts are unleashed during such activities since they result in felling of trees, forests and steady depletion of common land resources. This is a situation where there are existing long-term conflicts and the local experiential knowledge of land use preparation is not sufficient to influence the outcomes of such burning.

In the Indian agrarian context, which is a focus of this brief report the different biomass forms have to be regularly and systematically utilised after the crops are harvested and before the next sowing season. There has to be a sustainable solution for these uses and a long term solution which can be deployed in various agro-climatic zones, depending on ecological and rainfall conditions. With water, fertiliser and pesticide use - intensive crops such as rice, the paddy residue, especially paddy straw, is likely to be reused only if it is to be treated as an economic resource and not only as a agricultural waste product. Similarly, a long term options also should consider a move away from the existing land use forms to less resource intensive and the strategic adoption of different cultivated crop species to decrease and ultimately eliminate the final waste products (paddy residue / rice waste stubble). Along with such options it should be possible to consider adopting crop rotation practices which can make use of the decomposition of organic wastes.

Biomass burning

In many big cities and dense human populated areas, organic or dry waste landfills catch fire due to build-up of gases within the landfills resulting in spontaneous combustion and also due to human negligence. The poor and the waste pickers / rag pickers have been forced to work for their livelihood in such toxic circumstances due to municipal governments and other policy makers / authorities having been unable to provide durable and long lasting solutions.

One way to deal with this problem is to decrease this burning so as to improve the quality of life and the huge human / nonhuman living being health benefits which will be the outcome of such a decrease. The entire Indo-Gangetic plains with a population of 400-500 million or more end up with a state of severe air pollution and smog cover during the winter months which is often accompanied by smoke bearing winds coming from the agricultural fields where the burning takes place towards large capital cities like Gurugram, Chandigarh or New Delhi. There is also a temperature inversion sometimes during these months which ensures that the pollution lies close to the land surface as well as harming these vast numbers of people especially the children, the youth, and the poor underprivileged that constitute over 50% of the population here.

To decrease the wilful burning of agricultural waste, farmers / agriculturists/ landowners need to be encouraged through economic incentives. Even locally tradable credits can be created so that those who stop such burning and can be verified will also get an economic benefit. The economic and health benefits of reduced pollution can be quantified and used for the purpose of tradable credits. Improved airshed air quality will lead to clearly defined health changes such as cardiological, neurological and pulmonary improvements and general well-being. Economic losses of billions of rupees can turn into benefits. India has a huge loss of lives (globally the largest) due to air pollution every year which - according to

some research calculations - is approximately 1.9 mn (Health effects Institute, USA) to 2.3 mn (Lancet Institute, UK) fatalities in 2019. So the benefits of decreasing this pollution (around 50- 55 % of which is due to biomass burning) by giving tangible economic benefits to reuse this biomass in sustainable ways will save millions of human lives and billions of rupees. A portion of these resources and savings can be prospectively deployed towards incentives for the safe and sustainable reuse of this biomass, agricultural wastes and residue which can be in the form of biomass briquettes, bio-fuels, biochar, bio-gas and such tried and tested alternatives. But similar to the climate credits which were launched around 10 -15 years ago some efforts and resources need to be deployed for 'Air pollution' credits to be paid to the farmers in exchange for safe and non-polluting disposal of this dry and waste biomass.

It appears that in China, India and the USA, the most commonly used option for removal of agricultural residue is burning. There is a worldwide need for increasing the recovery of resources such as biomass, bio waste, organic waste, leaf litter, and similar other resources which can help generate organic based energy, biofuel etc. This can be done through recycling the waste through bio-gasifiers which can generate methane to be turned into energy. Motors, generators etc can be run from such energy sources. Kitchen stoves can also be run as has been done in the recent past. Are residential uses for inefficient biomass burning without proper combustion giving rise to more problems? The government apparently thinks so. Is cooking with other fuels still possible?

The case for alternatives to burning biomass

While large urban agglomerations generate huge amounts of pollution in India due to vehicular and industrial emissions and these cities have a large airshed in which there can be pollution impacts, agriculture operations seasonally and in episodic forms also impact air pollution in these airsheds. Airshed areas such as those for Bengaluru or New Delhi etc. could cover millions of cubic kms of space where the impacts could be experienced.

Large and detailed epidemiological research studies have shown the harmful impacts of inhaling PM₁₀, PM_{2.5} and PM fine particulates which get lodged deep inside the lungs of impacted individuals. While the WHO has issued in September 2021 lower indicators for PM levels in the ambient air thereby creating more stringent standards, the Indian government has fixed AQI at a higher level. Almost no place in India can meet the current WHO standards. The health effects of this range from skin and eye irritation to severe neurological, cardiovascular and respiratory diseases, asthma, chronic obstructive pulmonary disease (COPD), bronchitis, lung function, emphysema, cancer. These have been conducted for over 30 years globally as well as more recently in India. Therefore it is imperative to generate systematic and conscious alternatives which will lead to a decrease in burning in a sustainable manner.

Currently some examples of biomass burning include the burning of agricultural waste, forest fires, and land clearing, domestic biofuel burning (e.g. wood/ crop residues, cattle dung) for cooking /heating and might also be domestic/industrial burning for electricity generation. The highest crop residue quantities are generated from rice cultivation after the rice is harvested. Residue burning is a major source of carbon dioxide (CO₂), volatile organic compounds (VOCs), nitrogen oxides (NO_x) and hydrocarbons (HC) accounting for about 10% of the total emissions in the world (Liu³ et al., 2019). Kaskaoutis⁴ et al. (2014)

³ Seasonal impact of regional outdoor biomass burning on air pollution in three Indian cities: Delhi, Bengaluru, and Pune, Tianjia Liu et al a Department of Earth and Environmental Sciences, Columbia University, New York, 10027, USA
Atmospheric Environment Volume 172, January 2018, Pages 83-92
<https://pdf.sciencedirectassets.com/271798/1-s2.0-S1352231017X00216/1-s2.0-S1352231017306854/main.pdf>

pointed out that air quality is considerably affected by agricultural burning due to the emission of aerosols and gaseous pollutants. PM_{2.5} and PM₁₀ are reported to have the highest effect on the health of the exposed population. Due to residue burning, the soil micro-organisms and essential micro-nutrients in the soil are also burnt off so it is not correct to assume that it benefits in some way. Obviously this is a crucial aspect of the burning process which happens because of incomplete understanding of the benefits / losses to soil, the resources and the local /global ecology.

⁴ Crop Residue Burning: A Threat to South Asian Air Quality A Snapshot of Pollution, BY R. P. SINGH AND D. G. KASKAOUTIS
<https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2014EO370001>

Various alternatives to biomass burning

The reasons for adopting alternatives to biomass burning have been explained in the discussion earlier in the report. There is a series of such options⁵ which can be used but they have to be based on enhancing local knowledge, the need for alternatives to burning and preferably based on a philosophy of; 1) do no harm and 2) working with nature. This could result in community and society-wide benefits derived from the alternative processes which are adopted as an outcome. Combined with the economic incentives to individual farmer households even collective benefits could be derived. Agricultural operations will be classified as semi- mechanised or fully mechanised or manual (non- mechanised) depending on the availability of machinery suited to various agro-ecological regions and conditions.

1. **Agricultural waste and biomass gasifier generating stable fuel**

production: Household and village level cooking fuels can be generated and village backup power generators can be powered (for when grid electricity is not supplied due to maintenance or other breakdowns).

2. **Zero till drill post loose straw burning:** The loose straw produced with combine harvesting was burnt directly and wheat was sown in the remaining standing stubbles using 'Tractor drawn zero till drill'. No preparatory tillage is required in this practice.

3. **Rota seeder/super seeder post loose straw burning:** The loose straw produced with combine harvesting was burnt directly and wheat was sown in the remaining standing stubbles using 'Tractor operated rota seeder/super seeder'. No separate preparatory tillage is required in this practice as the seed

⁵ **Paddy Straw Management in Punjab: An Economic Analysis of Different Techniques** Gurinderpal Singh, Jatinder Sachdeva and Gurjeet Singh Walia* Department of Economics and Sociology, Department of Math, Stat and Physics, Punjab Agricultural University, Ludhiana-141 004, India Indian Journal of Ecology (2022) 49(1): 302-308
http://indianecologicalsociety.com/society/wp-content/themes/ecology/volume_pdfs/1645802693.pdf

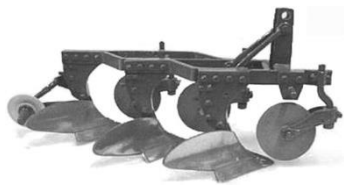
bed preparation and sowing along with straw management is done in a single operation.

4. **Straw baler:** After harvesting the paddy using a combine harvester, straw was chopped with a straw cutter - spreader. Then the rotary rake run by tractor is used to collect straw into wind rows which are then turned into straw bales by a 'Tractor operated straw baler'. The straw bales are then collected from the field manually and transported/stored by the farmers.
5. **Happy seeder:** After harvesting of paddy with 'Super SMS fitted Combine harvester' and wheat was sown in the standing stubbles using 'Happy seeder'



run by tractor. No preparatory tillage is required in this practice.

6. **Straw incorporation with MB plough:** After harvesting of paddy, 'Tractor operated Straw mulcher / Straw cutter cum spreader' is used for chopping of paddy straw and then straw incorporated into the soil with



'Tractor mounted Mould board plough'. (see image)

7. After incorporation, various tractor-pulled implements like disc harrow, cultivator, rotavator, etc. were used for the tillage. The sowing was done with



seed-cum fertilizer drill

8. **Super seeder:** After harvesting of paddy with 'Super SMS Paddy Straw Management in Punjab 303 fitted Combine harvester' and wheat was sown in

the standing stubbles using 'Super seeder' run by tractor. No separate preparatory tillage is required in this practice as the seed-bed preparation and sowing along with straw management is done in a single operation.

There are some drawbacks as well but they are not negatives and can be overcome with improved local knowledge practices. If time, effort, resources and money have to be utilised and invested by the farmers, the farm labourers and their families and this is supposed to be done without visible returns and /or economic incentives (in return for the ample health benefits generated for the entire society) it could be a losing battle which cannot be enforced only through rule making or new statutory provisions (law making).

Therefore for taking this initiative every year on a continuous basis and in a sustainable manner so that there is a local ecosystem benefit and the local agriculture based economic system benefits needs more consideration of the above mentioned suggestions. This should ensure that external agents such as revenue extracting operations through traders, commerce or business or industry (other than that which is already integrated into the local economy) alternatives to burning suggested above also take into account the cost incurred per hectare of land and appropriately and adequately compensate the agriculturists for efforts supported by them. A truly win –win situation can emerge if the costs are defrayed / compensated and an financial incentive based on the public health objectives is used to achieve the above alternatives and the villagers, agriculturists and urban dwellers can find common goals when they work together.

Another policy option is that additional compensation for farmers be done through including the costs of crop residue management in the government administered Minimum Support Price (MSP)⁶, ensuring the availability of residue management machines at

⁶ **Paddy Straw Management in Punjab: An Economic Analysis of Different Techniques** Gurinderpal Singh, Jatinder Sachdeva and Gurjeet Singh Walia* Department of Economics and Sociology, Department of Math, Stat and Physics, Punjab Agricultural University, Ludhiana-141 004, India Indian Journal of Ecology (2022) 49(1): 302-308
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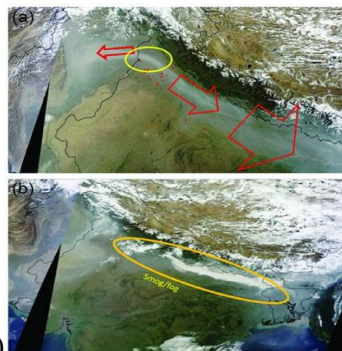
subsidised rates, better custom hiring services. Just like sugarcane bagasse can be used to produce good quality wood free paper (thereby preventing large scale tree felling or captive plantations) and promoting the use of rice straw in paper mills or even mixing with sugarcane bagasse, and other industries such as rice straw fuel pellets can easily become viable circular economy options for addressing the rice crop stubble management problem. Of course these options will have to be deployed in local sensitive solutions and not a one size fits all approach. This means such solutions need to examine whether per capita income, availability of finances and resources as well as technical machinery repair and maintenance outreach etc. exists.

An excellent model for local entrepreneurs to be skilled and shared through local knowledge generation and deriving better and sustainable ecosystem benefits is the: citizen service centre (CSCs) which has become a central point for computer / internet use, printouts, xeroxes, IDs, passport services, PAN card services etc. At a small fee in the CSC services are provided which have proved useful for local citizens.

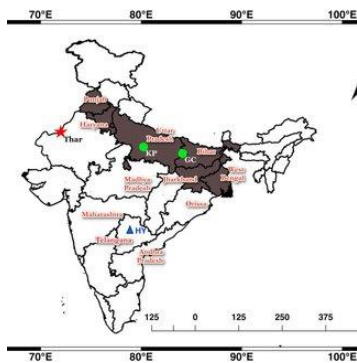
Similarly a well-trained group of skilled personnel could be prepared to deal with this problem deploying tested solutions in a dedicated manner during the stubble burning season. The team could be under the overall charge of and compensated by the gram panchayat as well to ensure local economic development. After the alternative options are chosen and deployed the ecosystem and health benefits could be quantified by the team to ensure compensations and benefits to the farmers and the local agriculture based economy, the families, the agricultural workers and labourers etc.

We have understood that this issue requires huge awareness and outreach programmes as well as a governance mechanism which allows ecosystem and urban and rural human health benefits which need to be supported through compensation of many local villagers / agriculturists with local oversight and monitoring to achieve sustainable outcomes. Myths

need to be broken and new knowledge generated to bring in a much better understanding of how to deal with this problem in the short, medium and longer terms. So far it appears as if only the adverse impacts of pollution dispersal, smog, breathing difficulties and the huge inequalities have been witnessed and experienced. This issue arose due to the ushering in of the green revolution in the 1960s and early 70 especially in the North West Indo Gangetic plains (IGP). But now seasonally it affects at least 40+ % of the Indian population (known as



the brown cloud (since 20+ years) whose life expectancy is reduced by at least 7-9 years partly due to the agricultural residue waste burning and partly other pollution and spreads from the Punjab Haryana regions / states



to the bay of Bengal 900+ kms away (see map / graphics).

While over the bay the pollution is the least there is a huge increase in harmful gases including nitrous oxide (NO₂) throughout the IGP from the North West to the south east. As explained earlier meteorological conditions and cooler temperatures post monsoon keep the pollutants close to the surface and low speed winds etc. ensure they remain suspended causing more harm.