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## **India: Sustainable Solutions for Stubble Management in Northern India**

At the crack of dawn, the countryside in Haryana is peaceful and quiet but the dark gray smoky skies have the tell-tale signs of burning fires through the night. The air is lingering with the smog that is quickly spreading across the three neighboring states in northern India - Uttar Pradesh, Punjab, and Delhi. Satish Singh, a farmer in Haryana, is filled with mixed emotions of relief and guilt. "What choice do we have?" (Ellis-Petersen). Due to the lack of viable stubble management techniques, farmers have little option but to burn the agricultural fields. While the world's leading news-sites are relaying the concerns over high levels of pollution in the world's most polluted city of Delhi (Chakraborty and Singh), the story of Satish Singh is yet to be told.

Agriculture continues to be the mainstay of the Indian economy due to its significant share in employment (*FAO.org*). The Indo Gangetic Plains (IGP), constituting the states of Uttar Pradesh, Punjab and Haryana boast to be the major producer (40%) of wheat and rice, and a significant contributor towards India's food security (Sekar et al). Sadly, these states surround Delhi, the capital of India, that has recently received global attention for the highest anthropogenic emissions (Kumar et al.). Each year during the summer (April-May) and winter (October-November), there is a significant rise in greenhouse gas emissions and aerosol loading in the region due to stubble burning (GSFC, MODIS). Stubble, the base part of paddy or wheat remaining attached to the soil after harvest; is a byproduct of the 'combine harvesting' method used by most farmers in IGP. Both wheat and rice are long-duration crops. "With a short duration between rice harvesting and wheat plantation, lack of short-term labor and affordable machinery, stubble burning is the quickest and economical way for the farmers to manage agro-waste" (Kumar et al.).

This paper will analyze the current practices of stubble management in the region and propose viable solutions that will not only reduce environmental impacts but also make farming more sustainable.

### **Typical Farm Family in Northern India**

A typical farm family in rural India needs environmentally sustainable agriculture solutions in terms of soil conservation, natural resource management and pollution control. However, harsh weather, excessive use of fertilizers and ever-shrinking size of farm plots have plagued Indian agriculture system.

The typical rural family, 66% of the country's population, operates small plots of land - 86% of farmers operate on less than 2 hectares with average farm size being 1 hectare (Agricultural Census). Since only 14% of farmers operate on land greater than 2 hectares, farmers can only increase income if they engage in holistic development. The average farm size has halved over the last 40 years due to the common practice of splitting land amongst male off-springs, making today's farms too small to support an average farm household of 5.4 members. Average monthly income for agricultural households is Rs 8,931 / \$120 (NABARD).

Climate is temperate in IGP with flat to rolling plains along the Ganges. There are three main cropping seasons in India- Kharif, Rabi and Zaid. The Kharif season spreads from July to October, Rabi season from October to March, and Zaid season is between March and June. Crops in the Kharif season include rice, cotton, corn, sugarcane, and soybean. Rabi crops include wheat, barley, grains, and mustard. Zaid

crops include rice, corn, and groundnut (Reddy). Rice, wheat, and pulses are an immovable part of the essential diet of the rural population. While achieving high food production, India is home to “a quarter of the world’s hungry people and over 190 million undernourished people” (FAO.org). A growing population is overstraining natural resources while increasing the demand for food production at the expense of quality. The overall literacy rate in India is 74%. However, female literacy in rural India is just 58% (2018). In rural areas, women and girls are often not given proper access to formal education, and even if they are, many drop out to support their families.

Long-term challenges remain significant, including gender inequality, inadequate food transport and storage infrastructure, poorly-targeted government subsidies and sub-quality education in rural areas—resulting in 22% of the population living below the poverty line. In 2018, India ranked 122 out of 146 in the Gender Inequality Index released by the United Nations Development Programme. Gender inequality has always put education for girls in the backburner in India. Only 39 percent of girls achieved secondary education in comparison to 63.5 percent boys in 2018 (UNDP, 2019). Inadequate health care and high out-of-pocket medical costs are significant challenges for farm families. Poor housing conditions, unsafe drinking water, and lack of sanitation, amongst others, often increase the risk of numerous health problems.

Access to quality food is another concern in rural areas. As per World Food Programme, the share of expenditure on food in rural areas has declined over time but is still considerably high for poor households, thus indicating food insecurity in rural families (UNDP-HDI-India). In rural India, the per capita per day consumption of energy and protein has also declined over the past decade, even when an increase in household per capita total expenditure has been noted. The food basket is changing with lesser expenditure on cereal and more expenditure on milk products and fruits. Levels of mortality and malnutrition have declined in the past decade but sadly, the majority of the states still fall under the ‘very high’ category of malnutrition as defined by the World Health organization. Based on the recent survey of 400 rural adolescents (Ganpule-Rao et al.), children with easy food and water availability had higher BMI as compared with the ones with limited access. Overall, dietary diversity was poor and anemia was prevalent. This demonstrates a strong link between food access and nutritional status in an under-nourished, mostly vegetarian, rural population.

### **Impacts of Stubble Burning**

The Farming community in northern India desperately needs a viable alternative to stubble burning. This is even more urgent now that the National Green Tribunal has levied fines on the farmers for stubble burning (Bhuvaneshwari et al.). The gap between farmers’ earnings and the high costs of stubble management has led to food insecurity in the region. Many farmers resort to crippling loans to buy or rent the machinery. This leads to decreased food consumption in farm families; impacting nutrition (Sehgal). IGP alone contributes 42% of the staple food production. If bans are enforced without a meaningful support system, it could lead to unproportionate migration to alternate crops. The resultant rice shortage could lead to a price hike that reduces food affordability and accessibility across the lower-income communities.

Stubble burning also has a degrading impact on the environment and human health. Each winter, it significantly increases greenhouse gas emissions and aerosol loading. Stubble burning produces a “cloud of particulates visible from space” described by Sarkar, a NASA scientist, as a “toxic cloud” (327). On December 9, 2019, air quality in Delhi was in “severe” category, with Air Quality Index ranging from 350-450; with PM2.5 (Fine Particulate Matter) causing serious health issues (Jenner). Higher health cost correlates to lower food affordability leading to a downward spiral for farm families.

While occasional burning controls pests, studies have shown that long-term burning (15+ years) can have significant negative impacts on soil health. Burning leads to a reduction in organic matter and volatile nutrients such as nitrogen, soil hardening and reduced water infiltration capacity. Poor soil health impacts food production and thus, access to affordable food within the region.

### **The Progress Report**

NASA's Aqua satellite recorded a 300 percent increase in the fires in IGP between 2003 and 2017 (NASA, 2018). Due to global attention on Delhi's pollution levels, Cabinet Committee on Economic Affairs (CCEA) approved a Rs 1,151 crore scheme in 2018 to facilitate stubble management. Under the scheme, financial assistance of 80% to cooperatives and 50% to individuals has been allocated for the purchase of Happy Seeder machinery. Happy Seeder supports the direct sowing of wheat without removing the rice stubble. Recent efforts have led to a reduction in stubble burning (Kapil). Regardless, NASA recorded an astounding 1,031 fires in a single day in October 2019 in the region (Figure 1).

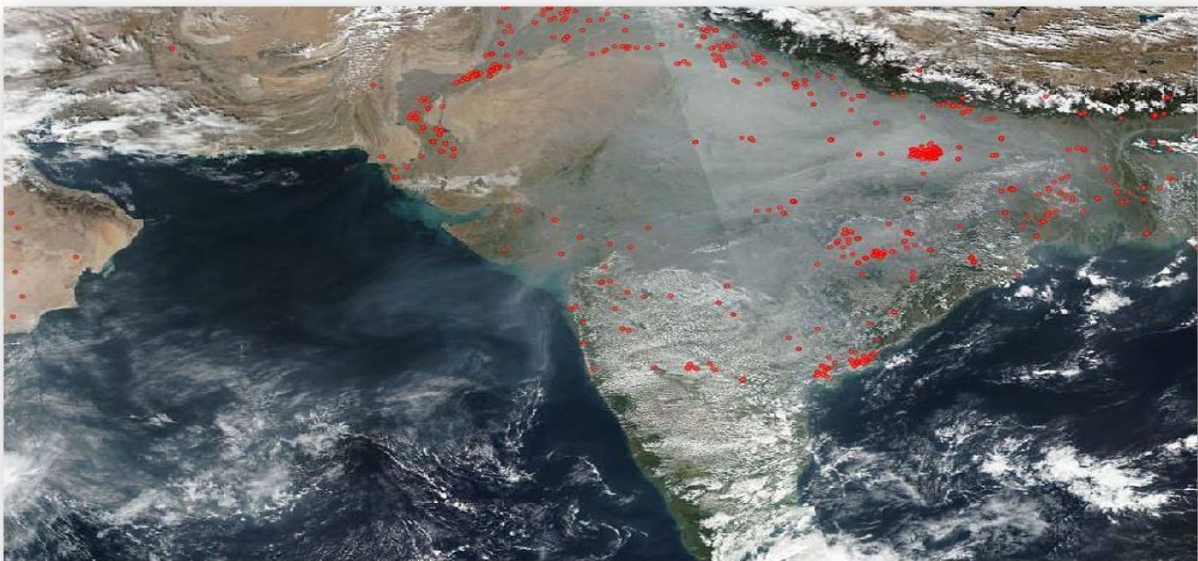


Figure 1: The US National Aeronautics and Space Administration (NASA)'s satellite "VIIRS" reportedly located 1,031 fires on October 9, 2019

Source: National Aeronautics and Space Administration

For some farmers affordability to purchase or rent is the key reason to not use Happy Seeder, others are fearful of lower yield. Since majority farms are either smallholdings or a lease; such machinery is currently being used for only 20% of the land cultivated (Davison). With the high tag of Rs 150,000 on Happy Seeder, a 50 percent subsidy still keeps the cost to Rs 75,000. For rent through Custom Hiring Centers (CHC), farmers still need Rs. 1500 per acre while dealing with the uncertainty of availability. Satguru Singh, who has cultivated 18-acres land with Happy Seeder, is apprehensive "I am nervous as I heard this machine lowers the output" (IANS). There is a need for comprehensive solutions beyond regulatory actions and subsidies.

### **Recommendations**

Although stubble burning is essentially an environmental and agricultural sustainability issue, consequential change in democratic India can only be achieved through stakeholders' motivation and financial incentives as in Manitoba, Canada. The Agriculture and Resource Development noted, "Producer's willingness to comply with the policy" was the primary reason for the successful stubble burning program in Manitoba (Agriculture: Province of Manitoba). The first and foremost step should be onboarding of farmers by motivating them through financial and other incentives. Through reviewing the

political climate of India, one sees that the implementation of the regulatory ban is weak due to strong opposition from farmer unions. “Should the government try to enforce the burning ban, a massive farmer backlash would follow” (Forbes, 2019). In comparison to China's success in combating pollution, “India must operate within the constraints of the democratic system” (Slater).

There is an urgent need to address this issue beyond regulations. A multi-prong short term strategy should include awareness and education, inventory management, nutrition-centric approach, and continued financial incentives. The immediate focus should be to increase awareness by educating the farmers about benefits of in-situ stubble management, alternative crop-cycles, repurposing stubble, impacts of stubble burning on soil fertility. Academia and Kisan Sabha should lead the awareness effort through Kisan-camps and on-farm demonstrations regarding sustainable practices and skill enhancement.

Real-time machinery tracking is another crucial step to ensure peak utilization of rental machines held by Farmers Cooperatives. Currently, marginal farmers like Maninder Singh do not consider rental through CHC to be reliable. Maninder explains, "There is only one Happy Seeder for three villages in our area. I do not know when my turn will come" (IANS). By sharing availability and allowing advance booking of the machinery, inventory management can help build confidence within the farming community. Current cooperatives should explore partnerships with private enterprises to get technical assistance on inventory management.

A nutrition and food security centered approach through crop diversification should be followed to control stubble burning. This approach allows for the creation of markets for diversified crops such as sorghum (jowar) and millets (bajra, ragi). From a nutritional standpoint, these crops have higher values of calcium and iron. TERI estimates that such a transition would lead to improvement of nutrition levels for 40 percent of underweight children, and 50 percent of anemic women (Sehgal). Food Corporation of India should incorporate this diversification effort into their policies and allow for a government-led grain procurement and distribution system. Calibrating the minimum support price of these “C4 crops” (water-resistant) in comparison to paddy (water-guzzling) should help diversify the Indian diet.

To effectively curb stubble burning, there is a need to further incentivize the farmers, especially marginal and women farmers. The current financial assistance plan is targeted equally for all farmers and planned to end in 2020. CCEA should expand financial assistance with focus on special groups such as farmers holding less than 2 acres, women-managed farms, or other farmers with low economic status. Financial incentives should be tiered with most going to those who can afford these machines the least. Individual farmers are not economically equipped to buy these machines. Heavy subsidies with loans for “groups of farmers” should be made available as in Ghana, Africa (GhanaWeb).

Funding is crucial for the success of these short-term initiatives. CCEA should lead the effort collaborating with state governments and expand financial assistance for three more years with a target to curb 90% of stubble burning. Cooperatives should play a strong role at the grass-roots level. The progress should be reviewed at the end of sowing season annually and should be compared against other developing nations worldwide. For example, Thailand, another large rice producer, has succeeded in reducing its national rice residue burning average down to 7% by repurposing stubble (Junpen et al.).

To achieve a sustainable alternative to stubble burning, “Band-Aid relief (assistance for renting machinery) every winter won’t help” (Sehgal). Although the grave nature of this issue necessitates immediate actions, long term strategic solutions should focus on research and policy changes that would bring sustainability to farming practice.

Markets for alternate “end use of stubble” should be created and advocated as an economic opportunity. In addition to the current focus on biofuel in power plants (Pearson), there is a tremendous demand for fuel in the cold storage units and brick kilns (Dhingra). National Institution of Transforming India, NITI Aayog in partnership with Food and Agriculture Organization of the United Nations, should work with states and other stakeholders to formulate policy, align infrastructure, and to build local capacity. At the grass-roots level, the farming community is already nestled in cooperatives, which can play a pivotal role in creating local marketplaces. A holistic end-to-end solution should address the collection, transportation, and sale of stubble, and infrastructure needed in various industries. Policies should direct further research to make the collection and transportation process efficient.

Research should be focused on machinery advancement. With the current use of multiple machineries, there is a need to research and eventually transition to a “multi-utility machinery” that is lightweight (works with tractors), promotes Conservation Agriculture (CA), and is economical for the farmers. The Borlaug Institute in South Asia-Punjab Agricultural University (BISA-PAU) joint team developed a Super SMS attachment to allow for even distribution of stubble (BISA). BISA-PAU should continue the effort to further research and develop multi-utility machinery. Indian Council of Agricultural Research should establish policy and fund research promoting CA. Given the scale of wheat and rice production, machinery advancement would be a logical solution for IGP.

In addition to machinery improvements, there is a need to further research shorter-duration paddy to increase the time between harvest and sowing. The traditional varieties take 160 days to mature. In 2016, PAU introduced a new variety with 125 days maturing time. It had low adoption due to lesser yield proficiency than the conventional variety. (Goyal, et al.) Policy and funding should be established to encourage academia such as PAU to collaborate with global institutions such as Norman Borlaug Institute for Plant Science Research to research and develop paddy varieties with short maturing time and high-yield proficiency.

The recommendations specified above are paired with unique challenges India poses. One key challenge to implementing these recommendations in the democratic country of India could be a lack of political willingness and bureaucracy. Reliance on global support and science can help mitigate the political resistance. With increasing awareness about the impacts of stubble burning on human health, citizens of India can be instruments of change in bringing meaningful government policies in play. In addition to political resistance, there is an inherent challenge related to stubble management due to the mere scale of operations to manage multi-million tons of stubble. However, the multi-prong approach prescribed above can help transition to more sustainable practices over time.

Dr. Borlaug once helped revolutionize the IGP in the 1960s, which is now proudly known as the “heart-belt of the Green Revolution”. History reminds us that Dr. Borlaug pioneered the Green Revolution not only through innovating crop varieties but also by “overcoming huge political and community resistance” (Quinn). Dr. Borlaug recognized the need to support “millions of farmers - mostly small and humble - who for many years have been fighting a quiet, oftentimes losing war on the food production front” (Norman Borlaug – Nobel Lecture). The story of Satish Singh is representative of many small and marginal farmers in IGP who are desperately in need of viable alternatives to stubble burning. While the central government action in 2018 has proven to be a step in the right direction, there is an essential need for more immediate action to increase farmer engagement through awareness, policy and funding; along with the political will and global support. A comprehensive solution through research,

machinery advancement, and market establishment for alternate end-use of stubble would ensure we leave behind a cleaner and sustainable IGP for tomorrow's generations.

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