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Cleaning Up Delhi's Deadly Fall Smog Requires an Even Greener Revolution

Every November and December, farmers outside Delhi burn rice straw in their fields. Smoke from those fields makes its way to the city, where it contributes to respiratory problems. Although it may seem as though the smoke problem could be solved by strict enforcement of existing policies to reduce burning, changing farmers' practices is not that simple.

The annual air pollution crisis in Delhi has roots in the country's famed Green Revolution and is an example of how rapidly rural agriculture is evolving, creating new and highly complex environmental issues in an increasingly industrialized India. The story behind Delhi's smog is a bogglingly complex interplay among multiple factors, including technology, farming practices, market shifts, government policies, and seasonal weather conditions. And its effects aren't confined to health problems: there is increasing evidence that this pollution also has severe and adverse economic impacts that are undermining India's efforts to realize the United Nations' Sustainable Development Goals.

Addressing the complex causes of Delhi's air pollution will require collaboration among many participants—including farmers, regulators, entrepreneurs, and policymakers—to mitigate trade-offs involving resource depletion, food security, and environmental quality. Within that complexity lies a possible path toward a more sustainable mode for the region's agricultural practices. With the disruption caused by COVID-19 and a government willing to provide economic stimuli, now is the time for a significant transformation of farming practices, building on the foundation—as well as the shortcomings—of the previous agricultural revolution.

Smog with green roots

The practice of burning rice straw has roots in India's Green Revolution of the 1960s and '70s, which increased the country's agricultural productivity. The Green Revolution has had its fair share of critics; some argue that it exacerbated social inequalities and left behind the poorest. What this critique fails to appreciate is that the urban poor benefited hugely from the increased food supply, which greatly reduced the price of staples such as wheat and rice.

In the 1960s, the northern states of Punjab and Haryana became the cradle of the Green Revolution when industrious farmers dramatically changed their planting systems. Previously, farmers grew a single crop of rice or wheat every year; with the arrival of quicker-growing varieties of grain, the region's farmers could implement a highly productive dual-cropping system. This entailed growing a high-yielding rice crop from June to October followed by a wheat crop sown in November and harvested in March the following year.

It is this intense cropping schedule that leads to the burning of the rice straw. Often, farmers have only 10 or 20 days between harvesting the rice and planting wheat. Because removing the straw is time consuming, many farmers resort to burning the stalks left in the fields to ensure that the wheat crop can be sown on time. Farmers are well aware of negative consequences of the burning, which includes a loss of soil nitrogen, phosphorus, and potassium, and declining soil quality. The incentives to burn are greater, however, than forgoing the practice, and include an interrelated set of recent economic shifts: increasingly scarce labor, changing market demands, rising mechanization, and groundwater conservation regulations.

When rice was harvested manually, farmers were able to sell rice straw that was left in the fields for animal feed or household fuel. But as labor shortages have become frequent in rural areas of Punjab and Haryana, farmers have turned to mechanized harvesting and gotten rid of their draft animals. Combine harvesters, which can be hired from machine service providers, are especially popular. Although these harvesters make up for the loss of human labor, they leave more loose stalks in fields than manual harvesting, substantially increasing the volume of rice straw that farmers need to remove. This, in turn, has made preparation for the subsequent wheat crop more difficult.

And as people have shifted to cooking on gas stoves, straw is no longer an important source of cooking fuel. Although the shift to cooking with gas has health benefits for those in rural areas, it has further diminished the value of rice straw and inadvertently contributed to in-field burning.

In addition to these compounding pressures, the practice of burning rice straw has been exacerbated by government policies to conserve groundwater. Decades of intensive agriculture in the floodplains of the Indus and Ganges-Brahmaputra rivers has lowered the water table. To conserve groundwater, the governments of Punjab and Haryana have introduced policies that delay transplanting rice from nurseries to farmers' fields until after the onset of the monsoon rains in the first half of June. The delay means farmers extract less groundwater, but it leaves them with less time to prepare their fields for planting the wheat crop in October—making burning an attractive option for quickly clearing the fields.

As a result of these multiple shifts in markets, labor, mechanization, and policy, open burning of rice straw residue in the fields has become an important strategy for farmers who need to plant the subsequent wheat crop at the end of the rainy season in October. Burning rice residues enables farmers to achieve economic efficiencies and avoid delays in sowing wheat that could reduce the yield and quality of the crop.

Rice straw burning has become highly concentrated in the late fall, which happens to coincide with seasonal meteorological conditions that exacerbate air pollution. Most burning occurs in November and early December when temperatures are lower and the winds are weaker than in October. These conditions slow the dispersion of smoke plumes, resulting in worse air pollution in Delhi.

Seeking solutions in the Happy Seeder

Reducing Delhi's smog demands a coordinated and interdisciplinary approach involving technologies, crop diversification, market development, and institutional and policy changes to give farmers incentives—rather than penalties—to reduce burning. There is potential for a win-win-win outcome: farmers gain financially from not burning, soil quality improves, and air pollution is reduced, alleviating adverse health and economic impacts.

New technologies could substantially, but indirectly, reduce the air pollution. For example, the Happy Seeder is a machine that lets farmers sow wheat seeds in unburned, stubbly rice fields. Government subsidies have enabled farmers to hire the Happy Seeder at harvest time from private machine service providers, leading to a reduction in straw burning.

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Another technological approach is to develop rice varieties with shorter growing seasons, buying farmers more time between the harvest and wheat planting. While this second approach may not reduce burning, it could stretch out the burning season to coincide with more favorable meteorological conditions.

A complimentary approach is to increase the amount of basmati rice that farmers grow in Punjab and Haryana. Basmati rice commands a price premium and farmers tend to harvest the crop by hand because it does less damage to the rice grain than mechanical harvesters. There is evidence of lower incidence of rice residue burning in basmati-growing areas in northern India.

Other potential changes include new crop management practices that enable farmers to grow rice with less water without compromising the yield. Rice seedlings are generally raised in a nursery and

then transplanted to farmers' flooded fields. A different and less labor-intensive approach, called direct seeded rice (DSR), allows farmers to sow rice directly in the field. There is evidence that more farmers in Punjab and Haryana practiced DSR during the COVID-19 pandemic because of extraordinary labor shortages caused by restrictions on migrant labor. Importantly, DSR uses less water but achieves the same yields. This means that farmers could sow before the onset of the monsoon rains without severely depleting groundwater, and then harvest—and if necessary burn the rice straw—before the onset of smog-inducing meteorological conditions.

But agricultural technologies and practices alone are not the answer to reducing the trade-offs among resource depletion, food security, and environmental quality. In northwest India, entrenched government subsidies present a hurdle to incentivizing change. Over the years, attempts to replace rice with less water-dependent crops have failed because of subsidies that strongly favor rice, including free electricity for irrigation, assured output markets, and minimum support price guarantees.

Addressing the pollution problem will therefore require changing policies to encourage farmers to scale back rice-wheat farming to grow higher value crops such as vegetables. This would not necessarily imperil India's food security—rice production could be increased in the eastern areas of the Indo-Gangetic Plain. In this region, water is more abundant and existing crop-livestock systems mean there is already a market for crop residues for fodder. Advanced geographic information system technologies and remote sensing tools can enable agronomists and land-use planners to identify suitable areas for sustainable rice intensification in new areas.

In addition, there is room here for learning among countries in the Global South by exploring how farmers elsewhere have found new uses and markets for rice straw. Researchers and farmers in Southeast Asia have explored alternative uses for rice residues, including bioenergy and mushroom production, and have identified rice varieties with higher crude protein levels that produce higher-quality animal fodder. The expansion of such markets in northern India could provide a sufficient incentive for farmers to sell the residues rather than burning them.

The potential for transformation

Feeding millions of people without undermining the natural resources that sustain agriculture is a huge challenge, one that is at the core of the UN's Sustainable Development Goals. Few places better exemplify this challenge and opportunity than northwest India. Here, in a region that transformed agriculture in the last century, pressing challenges have created a new matrix of trade-offs and synergies among technology, markets, policies, and the human experience. Judicious institutional and policy support is needed to ensure that this matrix leads to another transformation of Indian agriculture—this time along a more sustainable pathway.

Collaboration among farmers, researchers, policymakers, development practitioners, and the private sector suggests that the COVID-19 pandemic may allow for overdue and much-needed agricultural transformation in the region. Emerging evidence of the links between air pollution, susceptibility to COVID-19, and negative economic impacts is providing an opportunity for Indian federal and state governments to foster a reduction in crop burning. Action becomes even more urgent as India continues to battle the pandemic.

Farmers are well aware of negative consequences of the burning, which includes a loss of soil nitrogen, phosphorus, and potassium, and declining soil quality. The incentives to burn are greater, however, than forgoing the practice, and include an interrelated set of recent economic shifts.

Broad economic stimulus plans could include incentives to farmers in northwest India to reduce residue burning, diversify into other crops, and oversee a more sustainable agriculture. This may include farmers receiving payments for ecosystem services such as safeguarding clean air. The result could be that the birthplace of the Green Revolution becomes a poster child for another transformation of agriculture—one that delivers on a different green promise.

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