Man setting ablaze paddy stubble after harvest to prepare the field for sowing of wheat crops. © TNC India

Punjab-Haryana
Foodscape

Target incentives to jointly improve crop production, water security and human health

INDIA

LOCATION: Northwest India
AREA: 9.5 million hectares

SYNOPSIS

The Punjab-Haryana foodscape in India is an intensively cultivated breadbasket where Green Revolution innovations in crop breeding led to high-input, high-yielding rice-wheat agriculture. That crop combination, in addition to government provision of free electricity to rural areas, drove high rates of groundwater pumping and overdraft.

Subsequent policy to limit dry-season irrigation led to a narrower window between rice harvest and wheat planting, which inadvertently contributed to large-scale crop residue burning as a way to quickly prepare fields for wheat.

At peak burning periods, agriculture burning contributes around 30% of fine particulate matter in New Delhi, the capital, where it causes respiratory harm, contributes to climate change, and disproportionately affects the poor who are less able to take adaptive measures. Technical solutions have been developed

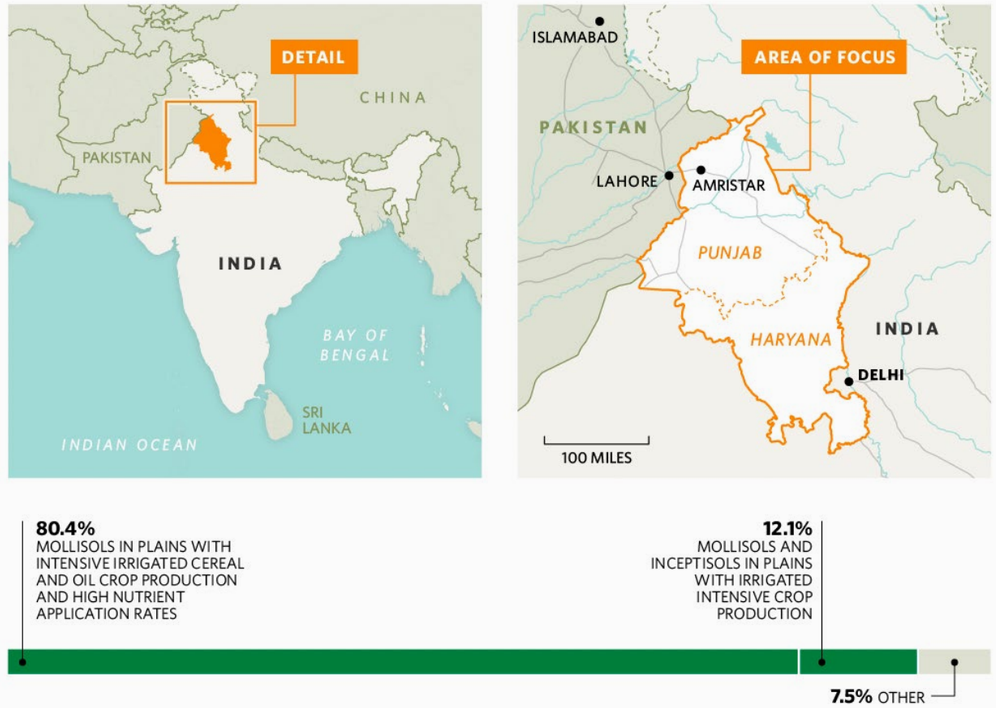

Figure 1. Map of Punjab-Haryana foodscape[47]. The bars represent the most extensive foodscape classes within the foodscape. The color of bars indicates the intensity groups corresponding to those classes: intensive production dominant (dark green). The other category includes the classes that each made up <5% of the foodscape area.

to enable seeding wheat without burning rice residue, but these technologies have not been adopted as widely as necessary despite public investment.

The Punjab-Haryana foodscape demonstrates the potential pitfalls of narrowly focused policies that can lead to unintended consequences. Policies aimed at limiting water depletion ultimately created another problem: poor air quality in New Delhi. Lasting solutions to both water depletion and poor air quality here require combined and complementary approaches, including nature-based solutions for managing farms without the need for burning.

Adoption of nature-based and other relevant solutions can be accelerated by providing a clear context for aligning public policy and economic incentives around multiple outcomes, including crop production, air quality, and water security.

ABOUT THE FOODSCAPE

The Punjab-Haryana foodscape is an important breadbasket for India. The majority of this landscape is cultivated; 84% of Punjab is cropland compared to a national average of 40%. In most of the foodscape, irrigated rice and wheat are grown back-to-back.

Crop Residue Management TNC India / truck hauling recently harvested rice husk to market, Ludhiana, India
© TNC India

In the past, there was a greater diversity of crops and traditional crop varieties that were well suited to environmental and soil conditions. Crops that have declined in the area include maize, pearl millet, sorghum, lentils, peas, sugarcane, peanut, mung bean, barley, rapeseed, mustard, and sunflower. Part of the reason for this decline has been demand from the Food Corporation of India, India's national food distribution system, which targets high-yielding paddy rice varieties to provide affordable staples throughout India. Some farms produce a higher quality basmati rice for local consumers able to afford a higher-end product and for international export.

CHALLENGES

The Punjab-Haryana foodscape faces severe groundwater shortages. Free electricity provided by the state government to rural areas enabled widespread pumping of groundwater to irrigate rice and wheat in semi-arid zones. Because both water and electricity are free to farmers, there is little economic incentive to limit water extraction. Yet groundwater in this region is declining by over 70 cm per year.[38]

State governments responded to groundwater depletion by enacting policies to limit water use. The states of Punjab and Haryana adopted a Preservation of Subsoil Water Act in 2009. In the Punjab, the act's approach to conserving groundwater was to mandate delayed planting of rice to correspond with the onset of the monsoon season. During the monsoon evapotranspiration of water from crops is lower and less irrigation is required.

Rice is harvested, and soon thereafter wheat is planted. Farmers who plant rice to coincide with monsoon rains have only 10–20 days to get wheat planted. This narrower window created a need for quick approaches to crop residue management, which led to a sharp increase in crop residue burning. Approximately 60% of the crop residue from high-yielding variety of rice is burned, however, because basmati is harvested manually and its straw can be used for fodder, which means it is cut lower to the ground during the harvesting process.

The period of crop residue burning overlaps with seasonal winds that carry the particulate matter from Punjab-Haryana foodscape to New Delhi where it then contributes considerably to the total fine particulate matter shrouding the city causing air pollution during the burning season.[39] During peak air pollution periods, particulate matter levels in New Delhi can be more than 10 times India's National Ambient Air Quality Standard. The government of the greater New Delhi area has taken policy measures to address short-term spikes, such as closing schools and high-polluting industries during peak emissions periods.

Ability to adapt to emissions is not equal among households. Wealthier households increasingly leave the city during peak periods and purchase air purifiers. Individuals who work outdoors or who cannot afford filters or leaving the city therefore experience the greatest impact of air pollution. One immediate opportunity to reduce burning is technology and equipment that allows for direct seeding of wheat into rice stubble (the Happy Seeder). The federal government provided $240 million in subsidies for these crop-residue management technologies.

Because cooperatives, rather than single farmers, receive a higher subsidy rate, the subsidies create an opportunity for entrepreneurs to develop service provider models where they enable use of these tools at a fee per area. Unfortunately, demand has been low with some machines operating at only 20% of capacity. Part of the reason for low demand is that it requires farmers to make changes to irrigation and nutrient management practices. It also conflicts with cultural preference for seeding into a clean field.

BENEFITS AND VALUE OF NATURE-BASED SOLUTIONS IN THE PUNJAB-HARYANA FOODSCAPE

In addition to aligning incentives around the use of technologies such as the Happy Seeder, another opportunity to reduce burning is to incentivize crop diversification away from the high-yielding rice varieties that contribute the most to burning (FIGURE 2). In addition to lowering burning, more diverse crops can decrease irrigation needs and increase nutritional diversity.[40]

The simplest crop diversification strategy is to convert a portion of high-yielding rice to basmati rice. This crop change can be combined with other agronomic practices that reduce water use, such as direct seeding of rice and composting of crop residue. Together, these actions could increase farm net revenue by around $1,000 per year, though initial costs of transition would be about one-third of current farm revenue and therefore require new sources of capital or redirection of current subsidies and investments (Supplementary Material, Archetype A).[1]

Because assured income through rice-wheat procurement systems creates such a strong economic signal for the continued production of high-yielding rice, cecause assured income through rice-wheat procurement systems creates such a strong economic signal for the continued production of high-yielding rice, a shift in governmental procurement policies could be a step towards incentivizing crop diversification Going further, policies could jointly target crop production, water availability, and human health (air quality). Overall, short-term solutions—such as shifting from traditional high-yielding variety of rice to basmati rice—could produce more than $900 million in net benefits per year over the whole foodscape. Off-farm benefits would be more than $700 million (FIGURE 2).

Over the longer term, there can be further diversification to crops that were traditionally grown in the region — pulses, legumes, other cereals — and perennials. This could provide similar revenue increases to basmati rice, and many of these other crops are also well adapted to drought stress. The addition of perennial woody vegetation would also increase carbon storage.

[38] Vatta, K. Sustainability of Groundwater Use in Punjab Agriculture: Issues and Options. in *Natural Resource Management: Ecological Perspectives* (eds. Peshin, R. & Dhawan, A. K.) 19–30 (Springer International Publishing, 2019). doi:10.1007/978-3-319-99768-1_2.
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AGGREGATION OF ARCHETYPES TO THE FOODSCAPE LEVEL

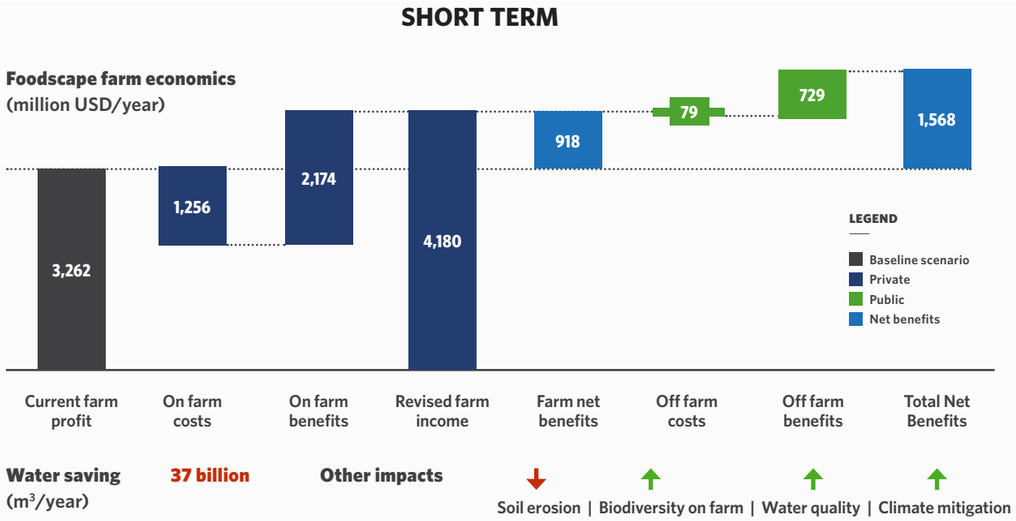

Figure 2. Summary of economic analyses for the Punjab-Haryana foodscape. **Disaggregated costs & benefits toward $1210 million net benefits from several farm archetypes:** Starting with baseline current farm profits (grey, far left), the diagram shows proposed future on farm benefits and costs (dark blue), totaling farm net benefits of $965 million (light blue, middle). Additional public off farm benefits and costs (light green) added to and subtracted from farm net benefits equals $1210 million total net benefits (light blue, far right). Other impacts are qualitative assessments of other ecosystem service benefits, except for water savings which was quantified. See Supplementary Material for a description of methods.[1]

This is a case study excerpted from the report *Foodscapes: Toward Food System Transition*. Please access the entire global report at nature.org/foodscapes.

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