Effect of pollution on Agriculture

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Abstract

Developing means of farming and agriculture is the reason humans live in the world they do today. It is a necessary means of survival, without which there would be famines all over the world. For thousands of years, agricultural was a natural process that did not harm the land it was done on. In fact, farmers were able to pass down their land for many generations and it would still be fertile as ever. However, modern agricultural practices have started the process of agricultural pollution. This process causes the degradation of the ecosystem, land, and environment due to the modern-day by-products of agriculture. No single cause can be attributed to the widespread agricultural pollution we face today. Agriculture is a complex activity in which the growth of crops and livestock have to be balanced perfectly. The process of agricultural pollution stems from the many stages their growth goes through.

Recent research on the agricultural impacts of climate change has primarily focused on the roles of temperature and precipitation. These studies show that India has already been negatively affected by recent climate trends. However, anthropogenic climate changes are a result of both global emissions of long-lived greenhouse gases (LLGHGs) and other short-lived climate pollutants (SLCPs). Two potent SLCPs, tropospheric ozone and black carbon, have direct effects on crop yields beyond their indirect effects through climate; emissions of black carbon and ozone precursors have risen dramatically in India over the past three decades. For most of our history, humans were hunters and gatherers. We fished in the ocean, hunted on land, and collected wild-growing fruits, seeds, and plants. Modern agriculture was born just 12,000 years ago, when we began to grow wild wheat and barley in the Fertile Crescent of the Middle East and Mediterranean basin, and to tend to the first rice paddies in swamps in China. Agriculture transformed our way of life, giving us more consistent food supplies, allowing the growth of civilizations, and supporting an exponential boom in human population.

Here, to our knowledge for the first time, we present results of the combined effects of climate change and the direct effects of SLCPs on wheat and rice yields in India from 1980 to 2010. Our statistical model suggests that, averaged over India, yields in 2010 were up to 36% lower for wheat than they otherwise would have been, absent climate and pollutant emissions trends, with some densely populated states experiencing 50% relative yield losses. [Our point estimates for rice (−20%) are similarly large, but not statistically significant.] Upper-bound estimates suggest that an overwhelming fraction (90%) of these losses is due to the direct effects of SLCPs. Gains from addressing regional air pollution could thus counter expected future yield losses resulting from direct climate change effects of LLGHGs.

Keywords: climate impacts , ozone , aerosols , agriculture , India

Introduction

Rural India is experiencing not only a decline in its rate of growth as well as share of population in the total, but also a decline in its contribution to national GDP. Figure 2 shows that the total contribution of agriculture sector to total GDP of India is declining significantly. For instance, in 1981 the contribution of agriculture to GDP was 36 % but it declined to 14 % in 2015. On the other hand, the limited urban GDP data currently available in the public domain shows that the share of urban sector's contribution to total GDP has increased significantly over time, i.e. from 38 % in 1970-71 to 52 % in 2004-05. Agriculture sector in India is majorly dependent on monsoon which is often unpredictable; therefore it is has been characterized by disguised and seasonal unemployment. The decline in employment opportunities in the agriculture and lower productivity level are the major reasons for the decline in the share of agriculture sector to total GDP. On the same logic, it could be construed that the increasing share of industry and service has also lead to the decline in the share of agriculture in GDP.

In 1900, worldwide, there were 6.7 rural dwellers to each urban dweller; now there is less than one and projections suggest close to three urban dwellers to two rural dwellers by 2025. This has been underpinned by the rapid growth in the world economy and in the proportion of gross world product and of the economically active population working in industry and services (since most industrial and service enterprises are in urban areas). Globally, agricultural production has managed to meet the demands from a rapid growth in the proportion of the workforce not producing food and rapid changes in food demands towards more energy- and greenhouse gas emissionintensive food. However, hundreds of millions of urban dwellers face under-nutrition today, although this is far more related to their lack of income than to a lack of capacity to produce food. There is a very large urban population worldwide with incomes so low that their health and nutritional status are at risk from any staple food price rise—as became evident with the rising hunger among urban populations after the food price rises in 2007 and the first half of 2008 (Cohen & Garrett 2009). Much is made of the fact that in 2008, the world's urban population exceeded its rural population for the first time.

Less attention has been given to two other transitions: around 1980, the economically active population employed in industry and services exceeded that employed in the primary sector (agriculture, forestry, mining and fishing); and around 1940, the economic value generated by industry and services exceeded that generated by the primary sector (Satterthwaite 2007). Today, agriculture provides the livelihoods for around one-third of the world's labour force and generates 2 –3% of global value added— although this is misleading in that a significant proportion of industry and services are related to the production, processing, distribution and sale of food, and other agricultural products. In addition, the figure might be higher if the value of food produced by rural and urban dwellers for their own consumption is taken into account. UN projections suggest that the world's urban population will grow by more than a billion people between 2010 and 2025, while the rural population will hardly grow at all (United Nations 2008). It is likely that the proportion of the global population not producing food will continue to grow, as will the number of middle and upper income consumers whose dietary choices are more energy- and greenhouse gas emission-intensive (and often more land-intensive) and where such changes in demand also bring major changes in agriculture and in the supply chain.

Two key demographic changes currently under way and likely to continue in the next few decades are the decline in population growth rates and the ageing of the population. An ageing population in wealthier nations may produce more people that want to and can live in 'rural' areas, but this is best understood not as deurbanization but as the urbanization of rural areas; most such people will also cluster around urban centres with advanced medical services and other services that they want and value.

Objective:

This paper aims to explore the harmful impact of pollution on agriculture

Air pollution on Agricluture

On the ozone side, chamber, open-top, and other field experiments have resulted in hundreds of dose–response relationships for individual crop cultivars over a range of agro-ecological zones and ozone concentrations (15–18). These dose–response relationships have been used to estimate global and regional crop loss in individual years, as well as into the future under different emissions scenarios (11, 19–24). These studies show large ozone impacts: one estimated that global crop loss caused by surface ozone in the year 2000 reached over 79 million metric tons ($11 billion) (21). In this report, we attempt to harmonize the existing research on climate and pollution impacts on agriculture. We do this by bringing SLCP emissions into a statistical analysis of historical yield data in India for both rice (predominantly rainy season) and wheat (dry season).

By explicitly including pollution variables along with climate variables in our analysis, we provide upper-bound estimates of direct SLCP impacts on yields. Linking SLCP Emissions to Crop Yield Impacts Although conceptually simple, this quantification of SLCP impacts on crop growth is complicated by: (i) the lack of nearsurface BC or ozone concentrations over the Indian subcontinent, (ii) coemmission and mixing of BC with other aerosol precursors and species, and (iii) the nonlinear nature of tropospheric ozone formation. Each of these is discussed briefly below and in greater detail in the SI Text.

Emissions Inventories

No long-run records of surface concentrations for BC and ozone exist for India; the best proxy for these pollutant concentrations is therefore an emissions inventory of aerosols and ozone precursor compounds (e.g., refs. 25 and 26). Although not equivalent, emissions of pollutants are nevertheless related to their ambient surface concentrations (e.g., refs. 27–30). Moreover, although crop impacts depend on concentrations, emissions are ultimately the policy-relevant variables; establishment of the link between emissions (as opposed to concentrations) and yields is therefore desirable. The difficulty in this emissions-based approach is then in how to construct emissions variables that can adequately serve as proxies for the basic chemistry and physics governing ozone formation and aerosol radiative impacts.

Black Carbon

The direct impacts of BC on radiation and crop growth are straightforward: BC is an absorbing aerosol that reduces both direct and diffuse light available to plants, and—all else equal— should therefore lower yields. However, this effect is difficult to isolate because BC is usually coemitted or mixes in the atmosphere with other scattering aerosols to create compound particles of varying radiative properties (31). Scattering aerosols also reduce total surface radiation but increase the diffuse fraction; research has shown that plants are often able to more efficiently use diffuse light for photosynthesis (32). Two earlier studies found no significant impact of total surface radiation on rice yields (4, 14). The models in these studies made no distinction between direct and diffuse light, and may have found no effect because the overall reduction in total surface radiation was offset by an enhanced fraction of diffuse radiation. The studies also examined only kharif (rainy season) rice, where expected aerosol impact would be lower. As with BC, no long-run records exist for the main scattering aerosols: organic carbon (OC) and sulfates. (The main sources of BC in India are domestic biofuels—wood, dung, and crop residues for cooking—and fossil fuels. Biomass burning is also the main source of OC emissions, whereas sulfates are formed from gas-to-particle conversion of sulfur dioxide, SO2, a main component of coal-fired power plant emissions. Average growing season surface radiation (total = direct + diffuse) for the main wheat- and rice-producing states in India over the past three decades.

S5 and S6 (data are from ref. 33). This dramatic surface dimming of 7–10% is attributed (6, 34) to increased aerosol emissions in the region; total BC+SO2 emissions and reduction in total surface radiation are correlated with R2 = 0.44. Recent research indicates that the net radiative forcing of OC (once thought to be pure scattering) is in reality close to zero (31), and that the relative abundance of BC and sulfates is the main determinant of overall aerosol radiative forcing (35). We therefore include BC and SO2 emissions (as the main precursor for sulfate aerosols) in our model, and omit OC.

Ozone Tropospheric ozone (O3) formation depends on the presence of methane, carbon monoxide, or volatile organic compounds (VOCs) and nitrogen oxides (NOx = NO + NO2). [We use NOx and nonmethane VOCs (NMVOCs) in our analysis because CO and methane (CH4) contribute predominantly to background ozone levels.] At low NOx concentrations, increasing levels of NOx and, to a lesser extent NMVOCs, result in higher ozone concentrations. At high NOx concentrations, increased NOx can conversely result in net titration of ozone out of the atmosphere, bringing overall levels down (with changes in NMVOC concentrations having little impact). The determinant of these two NOx “regimes” is the ratio of summed VOCs (weighted by reactivity) to NOx (36). Our model therefore includes NOx, NMVOCs, and the NMVOC:NOx ratio.

Livestock Water Pollution

Cows, pigs, chickens, and turkeys do what all other animals do: poop. In 2012 livestock and poultry grown in the largest CAFOs in the United States produced 369 million tons of manure, or almost 13 times the waste of the entire U.S. population, according to an analysis of USDA figures done by Food & Water Watch. All of that farm animal waste needs to go somewhere. But CAFOs don’t treat animal waste in the same way we treat human waste, by sending it to a wastewater treatment plant via a municipal sewer system.

Instead, this waste is disposed of by spreading it, untreated, on land. Operators are supposed to apply only the amount that crops can use, but in reality, there is often too much manure—so it is applied beyond the ground’s natural absorption rate, leading to runoff into water sources. To make matters worse, before it is applied it to land, the manure usually sits on-site in vast manure lagoons that can grow to the size of a football field. The lagoons contain a toxic stew of antibiotics residue, chemicals, and bacteria decomposing the waste, a medley that can take on a sickly hue. They’re often unlined and are prone to overflows, leaks, and spills, often causing the contents to leach into the soil and groundwater. (Big storms, like Hurricane Florence, which devastated North Carolina’s coast, make wide-scale spills and contamination more likely.) And once this mixture, chock-full of phosphorus and nitrogen, gets into a water body, it causes a cascading reaction called eutrophication, or the destructive overgrowth of algae.

Similar problems arise with poultry waste, which is mostly dry litter, a combination of the birds’ bedding materials (such as shavings), their feces, and loose feathers, which is stored in exposed, giant mounds. Because chicken manure contains a higher percentage of phosphorus than other animal manure, it’s also prone to harming waterways with phosphorus runoff.

Animal Agriculture Pollution

For most of history, meat was considered a luxury. But as disposable income has risen in the past century, so too has our demand for and consumption of meat, milk, and eggs. Between 1961 and 2014, meat consumption around the globe nearly doubled, from an average of 50 pounds per person each year to 95 pounds. Americans consume much higher amounts: roughly 133 pounds of red meat and poultry per person annually, according to the U.S. Department of Agriculture (USDA). Here's why feeding, slaughtering, and transporting billions of animals each year in businesses officially known as concentrated animal feeding operations, or CAFOs, is environmentally costly.

Livestock Air Pollution

Livestock and their manure pollute our air, too: Manure management alone accounts for 14 percent of all agricultural greenhouse gas emissions in the U.S. Manure emits ammonia, which combines with other air pollutants, like nitrogen oxides and sulfates, to create tiny (and deadly) solid particles. We humans then inhale these particles, which can cause heart and lung disease and are said to account fort least 3.3 million deaths each year globally. Additionally, hog waste in particular has been called out by people living near CAFOs for its foul smell.

Antibiotic resistance

The widespread use of antibiotics in meat production in animals that are not sick is contributing to the public health crisis of antibiotic resistance. Two-thirds of antibiotics important to human medicine in the U.S. are sold for use in livestock, not people. The regular use of these drugs in the food and water of farm animals to (poorly) help them survive the often crowded, unsanitary, and stressful conditions on CAFOs contributes to the rise and proliferation of antibiotic-resistant bacteria. These bacteria can then spread from CAFOs via air and water, including water used to irrigate crops, and can end up in animal waste used to fertilize crops. Contaminated meat and farmworkers' clothing and shoes can also spread these antibiotic-resistant bacteria into our communities. Resistant bacteria can even "teach" other bacteria resistance, and this process can take place anywhere bacteria are found, including in our homes and guts. The exposure of workers and farm-adjacent communities is particularly high.

Antibiotic-resistant bacteria are among the gravest health threats we face today. It's estimated that up to 162,000 people die per year in the United States as a result of antibiotic-resistant infections—that's more people than are killed in all types of accidents, and more than double the annual deaths from opioid overdoses—making it the third-leading cause of death in the United States, behind heart disease and cancer. And public health officials warn that the crisis will only get worse if we continue misusing and overusing these drugs.

Nutrient Runoff

The climate impacts alone are enough of a reason to wean ourselves off synthetic fertilizers, but these chemicals have another major environmental downside: nutrient runoff. Runoff occurs when nutrient-rich material like fertilizer or manure, chock-full of nitrogen and phosphorous, makes its way into nearby rivers, oceans, and lakes, wreaking havoc on our freshwater and marine ecosystems. Heavy rains can trigger runoff, as can soil erosion. Here's how it works: An excess of nutrients in a water system causes an overgrowth of algae. As algae then die off, aerobic bacteria decompose them, consuming oxygen in the process and starving other marine life. Algae overgrowth can also block sunlight, disrupting the ecosystem below that relies on the sun for energy.

The results can be dramatic: Nutrient runoff decimated the once-thriving Chesapeake Bay, killing off large numbers of the estuary's fish and shellfish. Each summer, high levels of manure and fertilizer from the Mississippi River make their way into the Gulf of Mexico, causing a recurring "dead zone" thousands of kilometers wide. And in recent years, persistent algal blooms, like red tides that produce toxins, have devastated coastal communities in Florida, staying long past their typical seasons and killing marine life en masse.

Chemical Pesticides

Farmers routinely use pesticides—herbicides, insecticides, rodenticides, and fungicides—to keep away any unwanted weeds, insects, rodents, and fungi. But these toxic chemicals have serious side-effects. These chemicals can cause many chronic diseases such as endocrine (hormone) and neurological disorders and cancer. Because of their still-developing bodies, children are especially vulnerable to exposure and face the worst health impacts. Some of the most toxic pesticides, like chlorpyrifos, have been linked to developmental delays, lower IQs, and learning disabilities.

Since becoming widespread in the past century, pesticides are routinely detected in 90 percent of our streams and rivers. And we Americans now have an average of 43 different pesticides in our blood, circulating to all the organs and systems in our bodies where they can cause adverse health effects. Farmworkers are particularly susceptible to exposure, coming into contact with pesticides when spraying fields, inhaling pesticide "drift," and exposing their families via contamination on their clothing. Rural residents in general may be exposed to contaminated water, air, and food.

Aside from being bad for human health, pesticides are also bad for pollinators. The populations of insects like the iconic monarch butterfly and native bees like the rusty patched bumble bee have plummeted in recent decades, due in part to these ubiquitous toxins. But under pressure from pesticide manufacturers and industry lobbyists, governments are often slow to ban or even limit these products' use. Instead they choose to pass off the risk to consumers, rural communities, and agricultural workers.

If we're going to stave off the worst effects of climate change, we must tackle the oversize carbon pollution footprint of meat. An NRDC analysis showed that in 2014, beef alone was responsible for 34 percent of all food-related greenhouse gas emissions in the United States.

Enteric Fermentation

It’s a fancy name for a not-so-fancy phenomenon: cow burps and gas. Enteric fermentation is part of the digestive process of ruminant animals like cows, sheep, and goats. Gut microbes decompose and ferment fibrous food, like grass, producing methane , which has about 30 times the planet-warming power of carbon. Those emissions add up: Enteric fermentation is the largest source of greenhouse gas emissions in agricultural production, contributing roughly 164 million metric tons of carbon dioxide-equivalent emissions.

India's unsustainable demand for crops

The states surrounding Delhi are known collectively as the "grain bowl" of India after the agricultural sector underwent a green revolution in the 1960s, leading to a dramatic increase in rice and wheat productivity. In Haryana alone, 80% of the almost 5 million hectares of land is now under cultivation, producing over 13 million tons of grain per year.

But as production grew, the sector could not keep up with an increasing demand for labor, with farmers eventually abandoning hand harvesting in favor of less labor-intensive methods such as the combine harvester.

Unlike manual harvesting techniques however, combine harvesters leave behind rice stubble, which prevents machines from sowing wheat seeds. With as little as 10 days between rice harvesting season and the sowing of wheat, farmers often turn to stubble burning to quickly remove the remaining rice crop residue. With one ton of residue containing 4-6 kg of nitrogen, 1-2 kg of phosphorus, and 15-20 kg of potassium, CIMMYT's research has shown that residue burning not only releases toxic gases into the air, but also reduces soil nutrition and therefore crop yields.CIMMYT studies show that agricultural productivity can be improved with the use of happy seeders and super sms machines by between 10 and 15%, by reducing labor costs and time and allowing nutrients from the crop residue to be recycled back into the soil. Dr Jat sees it as a win-win situation: "On one side you are increasing your productivity with the happy seeder," he says, "And on the other you are saving your resources.”

Reducing Industrial Agriculture Pollution

By 2050 the global population will hit nearly 10 billion. Can we feed all these people without overtaxing our natural resources or destroying the planet in the process? It’s possible, but we’ll have to make significant shifts in the way we grow, raise, and eat food. Here are some steps we can all take; even small changes can be very meaningful:

- Eat more plant-based foods.
- Minimize consumption of red meat, our most carbon-intensive food.
- When choosing among restaurants, consider their records on antibiotic use in their meat supply (check out NRDC’s restaurant scorecards).
- When you buy animal products, buy products from animals raised without the regular use of medically important antibiotics

- When possible, opt for organic, especially with the fruits and vegetables known to carry the highest amounts of pesticides like strawberries, spinach, and apples.
- Plan meals in advance and serve small portions to prevent food waste, a significant contributor of greenhouse gases. Nearly 40 percent of food in America goes uneaten, a remarkable waste of resources.
- Don't trash food scraps. Bring leftovers home from restaurants, and freeze what you won't eat right away. Any vegetable odds and ends can go into a home or community compost.
- Support local farmers practicing more sustainable growing methods by buying from a neighborhood market. Get to know the farmers, ask about their soil and livestock management practices, and let them know you appreciate their efforts.
- Buy "ugly" produce. Food waste happens at every level of the supply chain—including on the farm itself. Edible produce is frequently left unharvested because there's simply no market for it. (Think tiny apples, misshapen carrots, or too much of any one crop.) Though farm-level food waste is the least destructive kind (as resources have not been expended on packing and shipping), we can still do our part by telling local farmers directly that we're willing to purchase imperfect produce, which could help shape future harvesting practices.
- Buy in bulk to limit your packaging consumption.
- Start a "plant forward" initiative in your community and build meals around your favorite vegetables instead of meats.
- Grow your own food, without chemicals. You'll have a better understanding of regenerative farming and will be able to reward yourself with organic, in-season produce.
- Pay attention to farm policy and be vocal in your support of pro-environment practices. While the solutions for reducing nutrient pollution are plentiful, our system of food and farm policies is not set up to give farmers incentives to use the best practices. In fact, farm policy is often a barrier to practices that regenerate the land. You can make a difference by reading up on farm policy in the news and petitioning your government representatives to do the following: support conservation and climate-friendly farming, ban harmful pesticides, reduce the use of medically important antibiotics in meat and poultry production, improve the crop insurance program, invest in research to help farmers transition away from chemical agriculture to more ecological practices like organic and regenerative farming, and enforce stricter rules on the disposal of manure from CAFOs.

Conclusion

The paper shows that in the non-monsoon (non-flood) periods, which may account for all but 2 months of a year, agricultural diffuse pollution sources seem to have no impact on stream water quality. During these periods flows are low to minimal and pollution is dominated by the in-stream uses, sullage waters of rural communities and point discharges from urban/industrial sources, if any. Pollution due to agricultural return waters, either as wash-off or as seepage, appears to be rare during the 8–10 fair weather months. However, surface wash-off of pollutants from agricultural sources becomes the dominant factor during flood flows, and seepage/drainage from agricultural fields/soils continues to pollute streams for a month or two after the monsoons are over.

Application of chemical fertilizers and pesticides (or any other agricultural chemicals) in India is still low compared to developed countries, and while eutrophication due to high levels of washed-off nutrients is observed in rural ponds and other stagnant bodies of water receiving agricultural drainage, and excessive pesticide residuals are often reported for vegetables, fodder, milk, etc., monitoring of streams and rivers does not show any significant pollution due to nutrients or pesticides from agricultural diffuse pollution during fair weather months. High nitrate concentrations have been reported in groundwater and in many areas, such as

Punjab and Haryana, these can often be linked directly to diffuse agricultural sources. The major problem of agricultural diffuse pollution appears to be the heavy silt loads, along with large quantities of dissolved salts, nutrients, organics and even heavy metals and bacterial contaminants washed off during floods. The silt tends to clog up the flow channel to further encourage seasonal floodplain agriculture. This results in a vicious circle, which degrades the channel, increases flood-damage and is undesirable from ecological and sustainability points of view.

High concentrations of salts and nutrients encourage growth of weeds and macrophytes after the floods have passed. The presence of organics, heavy metals and bacterial contamination renders the streamwater unfit for in-stream use or abstraction. With the introduction of intensive agriculture and adoption of modern farming techniques involving the application of much irrigation water and agricultural chemicals, the problems caused by diffuse agricultural pollution are bound to grow. Routine pollution control methods of discharge permits (or consent letters), EIAs or environmental audits, and normal enforcement measures by regulatory agencies are not likely to work for control of such pollution. Using the example of a small river in central India, Paisuni (Mandakini), the paper brings out the nature of the problems, and suggests a possible management approach.

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