

Governments can curb over-fertilization

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The China-Kazakhstan border from space: The border between the two countries is defined by land use policy. Credit: NASA Earth Observatory

Many countries could be using less nitrogen fertilizer in their agriculture without compromising their crop yields, as an international research team headed up by ETH scientists David Wüpper and Robert Finger are demonstrating.

The world is awash with nitrogen. In agriculture, nitrogen is used as a fertilizer to increase output, but this causes one of the biggest environmental problems of our time. Nitrogen pollution has detrimental

effects on water and soil and is also harmful to human and animal health. What's more, when the air or rain carry nitrogen into unfertilised habitats, such as bogs or forests, it causes a decline in natural biodiversity.

National governments have it within their power to curb the problem. What is required are national and international policies that steer the global food system towards higher yields and a much lower environmental impact. However, research to date has barely touched on the extent to which countries actually influence their nitrogen pollution and their [crop yields](#).

Quantifying countries' overall impact

Now, ETH researchers David Wüpper and Robert Finger from the Chair of Agricultural Economics and Policy have joined forces with other international authors to investigate for the first time the overall impact of almost every country in the world on their nitrogen pollution and crop yields. The results of their study were recently published in the journal *Nature Food*.

In this publication, the researchers show that countries do in fact have a major impact, especially on levels of nitrogen pollution. In fact, countries' impact on pollution is often multiple times greater than their effect on crop yields.

Curbing use without compromising yield

In many countries much greater use of nitrogen fertilizer has only marginally reduced their yield gap—the difference between potential yield and the actual yield achieved. Overall, when individual countries attempt to close the yield gap by 1 percent, this is associated with a 35

percent rise in nitrogen pollution on a global scale. In other words, some countries are using enormous amounts of fertilizer but achieve very little in the way of additional yield. This leads the researchers to conclude that many countries could curb their fertilizer use without seeing yield reductions.

In their study, they also identified the factors that explain overall nitrogen use and pollution relative to their crop yields. Key factors include the quality of institutions, the degree of economic development and the size of the population, for example, but also the share of agriculture in the country's total economy.

Another major factor that influences a country's nitrogen pollution is direct state subsidies to reduce the cost of nitrogen fertilizer. However, indirect subsidies and policy measures that affect the price of agricultural products in relation to fertilizer costs also play a role, as do regulations and laws, farmer training, technology and even trade structures.

Evaluating global nitrogen and yield data

One example of how country-specific factors influence nitrogen pollution can be seen at the border between Kazakhstan and China, a region that is naturally dry with sparse vegetation. Satellite images show that on the Chinese side the vegetation is lush and green right up to the border, but on the Kazakh side it changes abruptly and becomes less green. This points to the presence of irrigation and ample amounts of nitrogen fertilizer on the Chinese side.

"Such a marked difference in the vegetation can't be a natural phenomenon," says Wüpper, lead author of the study. "This example illustrates that the country in which the fields are located is a decisive factor for yield and nitrogen pollution," he explains. "However, it would

be possible for China to achieve a similar yield with significantly less nitrogen pollution."

Also Switzerland is hardly a poster child for nitrogen pollution levels. Like other European countries, but considerably more, it continues to apply nitrogen fertilizer in great volumes that are too much for the crops to fully absorb. The surplus ends up in streams, lakes and other ecosystems.

"Agriculture in Switzerland is very intensive," Wüpper says. He explains that this has a direct impact on nitrogen pollution, not least because the fodder that Swiss animals eat comes from abroad. However, the manure produced by the livestock is spread on Swiss soil, where it contributes to the levels of nitrogen pollution.

Economic instruments are one policy option

"Overall, however, there's an uneven balance in the distribution of fertilizer resources around the globe," the researchers say to sum up. While Switzerland has an oversupply, other regions of the world don't have enough. In parts of sub-Saharan Africa, for example, farmers underuse nitrogen fertilizer. However, if they were to increase their use of nitrogen fertilizer only marginally, they would be able to significantly increase their yields. Mitigating this global fertilizer imbalance would enable yields to be considerably increased in some places and [pollution](#) to be greatly reduced in others.

One way to achieve this would be to adjust the cost of nitrogen fertilizer. In countries where too much is used, the cost of fertilizer should go up, e.g. by introducing a nitrogen tax, or by other policy instruments and adjustments. Conversely, in countries in which too little nitrogen fertilizer is used, the price should go down, e.g. by introducing a nitrogen subsidy, or by other policy instruments and adjustments.

Another approach involves changes on farms themselves. Government and industry could offer farmers incentives to make their crop production more environmentally friendly. They could, for example, promote certain production processes that increase the efficiency of nitrogen use. Moreover, farmers who use less nitrogen and consequently have to contend with lower yields could receive financial compensation from the state.

Huge potential in precision farming

New technologies could also increase [nitrogen](#) efficiency. "We're talking about what's known as precision agriculture, a concept in which fertilizer is applied only where it is actually needed. This can increase the efficiency of use and reduce environmental problems without decreasing output," Finger explains.

"But consumption can also make a big difference," Wüpper adds. He points out that one-third of all food produced goes to waste, intensifying [nitrogen pollution](#) and environmental damage. "If we cut down on food waste, we reduce environmental problems, too," he says. A much meat-reduced diet also helps to cut back excess levels of fertilizer because if farmers produce less meat, less manure ends up on the fields.

More information: David Wuepper et al. Countries influence the trade-off between crop yields and nitrogen pollution, *Nature Food* (2020). [DOI: 10.1038/s43016-020-00185-6](https://doi.org/10.1038/s43016-020-00185-6)

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