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Intensive farming may ease climate change

To many people, modern agriculture, with its industrial-scale farms and reliance on petroleum-based fertilizers, may seem a necessary evil — one that has fed a growing human population while causing untold damage to the environment. But the alternative may be worse, concludes a Stanford University study: a less-productive agricultural system would destroy even more wild land, drive up greenhouse-gas emissions and wreak havoc on biodiversity. The study's results suggest that further agricultural intensification will play a critical part in addressing global warming.

P. WHITAKER/REUTERS

Modern farming practices have led to reduced carbon dioxide emissions.

In the study, researchers modelled the world as we know it, complete with the 'green revolution' and modern agricultural practices, and two alternative realities in which crop yields were kept at the levels of decades ago. Published on 14 June, the results show that increased greenhouse-gas emissions resulting from intensive farming are more than offset by the effects of land preservation, which keeps carbon sequestered in native soils, savannahs and forests (J. A. Burney *et al. Proc. Natl Acad. Sci. USA* doi:10.1073/pnas.0914216107; 2010).

"In the beginning, we weren't even sure whether the carbon savings from land use would outweigh the increased agricultural emissions," says David Lobell, an agricultural scientist at Stanford University in California and a co-author on the study. After all, the fertilizers used in intensive farming increase emissions of greenhouse gases. All told, agriculture was responsible for 10–12% of global anthropogenic emissions in 2005.

Yet the balance turns out to be favourable, says Lobell, "and the carbon savings are quite large". All other things being equal, the researchers found that agricultural advances between 1961 and 2005 spared a portion of land larger than Russia from development and reduced emissions by the equivalent of 590 gigatonnes of carbon dioxide — roughly a third of the total emitted since the start of the Industrial Revolution.

The notion that increasing crop yields preserves forests and other native lands dates back to the father of the green revolution, the late US plant scientist Norman Borlaug, and is known as the Borlaug hypothesis. Lobell's team attempted to quantify that effect and to calculate the resulting reduction in greenhouse-gas emissions.

Between 1961 and 2005, the global population increased by 111%, from 3.1 billion to 6.5 billion, but agricultural yields went up by 135% over the same period, according to the researchers. As a result, global cropland increased by just 27%, from 960 million to around 1.2 billion hectares.

To work out how much land would be required to feed today's world using yesterday's technology, the researchers froze agricultural yields at 1961 levels and then allowed population and living standards to increase apace. Although emissions from fertilizer use were lower than in the real-world scenario, the amount of land required to grow food expanded by nearly 1.8 billion hectares. In a second scenario, both the yields and the standard of living were fixed at 1961 levels; the effects in terms of agricultural-land conversion and greenhouse-gas emissions were roughly half those of the first scenario but were still higher than actual impacts in the real-world analysis (see 'Greenhouse-gas emissions').

Finally, the team analysed the nearly US$1.2-trillion investment in agricultural research and development since 1961. Averaged over the study period, investments in agricultural yields reduced carbon emissions at a cost of around $4 per tonne of carbon dioxide equivalent, less than a quarter of the going price for emissions permits under Europe's carbon-trading scheme.

The environmental benefits will accrue if yields continue to increase, say researchers. Last year, for example, a team from the Joint Global Change Research Institute in College Park, Maryland, analysed land-use scenarios and found that increasing yields could reduce emissions as much as could energy technologies such as wind and solar (M. Wise *et al. Science* 324, 1183–1186; 2009).

"Above all, this study underscores the purpose of agricultural research funding, especially in developing countries," says Andrew Balmford, a conservation scientist at the University of Cambridge, UK. Unless the world sees a second green revolution, some 1.5 billion to 2 billion additional hectares will need to be put into production by 2050 to feed a growing population, according to an ongoing analysis by David Tilman, an ecologist at the University of Minnesota in St Paul. Fortunately, there is plenty of cleared land that is underperforming and massive potential for boosting yields in developing countries, Tilman says. "If we want to save the Earth, we have to feed the world," Tilman adds. "And it's these poorest countries that have the most to contribute." ■

Jeff Tollefson

GREENHOUSE-GAS EMISSIONS

A comparison of two model worlds with the real world suggests that intensive farming has actually mitigated total carbon emissions from agriculture (SOL, standard of living)