We can cut carbon emissions by one third by replacing fossil fuels with renewable energy sources for electricity and heat production." –Lester R. Brown, Janet Larsen, Jonathan G. Dorn, and Frances Moore, *Time for Plan B: Cutting Carbon Emissions 80 Percent by 2020*

Books

Eco-Economy: Building an Economy for the Earth

Lester R. Brown

Chapter 7. Feeding Everyone Well: Raising Cropland Productivity

In a world where there is little new land to plow, raising the productivity of existing cropland is the key to feeding the 80 million people added each year. It is also essential for protecting the earth's ecosystem. If farmers had not been able to nearly triple land productivity since 1950, it would have been necessary to clear half of the world's remaining forestland for food production.

There are at least three ways of raising cropland productivity: raise the yield per crop, increase the number of crops per year through multiple cropping, and get more out of the existing harvest by "processing" crop residues through ruminants to produce meat and milk.

Raising world cropland productivity is becoming progressively more difficult. Over the last century or so, plant breeders dramatically boosted the genetic yield potential of wheat, rice, and corn—the leading grains. At the heart of this effort was an increase in the share of the plant's photosynthate, the product of photosynthesis, going to the seed. While the originally domesticated wheats did not use much more than 20 percent of their photosynthate to produce seed, today's highly productive varieties devote half or more to seed formation. The theoretical upper limit is estimated at 60 percent since the plant's roots, stem, and leaves also require photosynthate.[17]

Realizing the genetic potential of the new seeds depends on alleviating any nutrient or moisture constraints on yields. Fertilizers are designed to remove the limits imposed by nutrient deficiencies. As cities have grown over the past century, there has been a massive disruption of the nutrient cycle, making it more difficult to return the nutrients in human waste to the land, and leaving the world ever more dependent on fertilizer. In earlier times, when food was produced and consumed locally, nutrients were automatically recycled back onto the land in the form of livestock and human waste. But as cities developed, as the world shifted from a subsistence economy to a market economy, and as international trade expanded, farmers offset the growinsg loss of nutrients with fertilizer.

As world fertilizer use climbed from 14 million tons in 1950 to 141 million tons in 2000, in some countries it began to press against the physiological limits of plants to absorb nutrients. In response, fertilizer use has leveled off in the United States, Western Europe, Japan, and now possibly China. In these countries, applying additional nutrients has little effect on production. Some parts of the world, such as the Indian subcontinent and Latin America, can still profitably use additional fertilizer. But for the world as a whole, the rapid growth in fertilizer use—the engine that helped triple the world grain harvest since 1950—is now history.[18]

Where fertilizer use is excessive, nutrient runoff into rivers and oceans can lead to algal blooms that then use up all available oxygen in the water as the algae decompose, creating dead zones with no sea life. Food output on land is expanding in part at the expense of that from the oceans.[19]

The accumulation of nitrates in underground water supplies in Western Europe led to European Union regulations to restrict fertilizer use. In Denmark, farmers are required to compile an annual nitrogen balance for the application and crop use of nitrogen. If this balance, submitted to the government each year, shows excessive runoff, farmers can be fined. The state of Iowa, concerned about nitrogen in underground water, levied a tax on fertilizer to discourage its excessive use.[20]

Just as fertilizer removes nutrient constraints on production, irrigation can remove moisture constraints, enabling plants to realize their full genetic potential. In some cases, irrigation simply boosts land productivity, but in others it permits dry season cropping or an expansion of cropping onto arid land.

While the world as a whole has nearly tripled land productivity since 1950, some countries have done even better. Over the last half-century, China, France, the United Kingdom, and Mexico have quadrupled wheat yield per hectare. India has nearly done the same. And the United States has quadrupled its corn yield.[21]

For several decades scientists generated a steady flow of new technologies designed to raise land productivity, but this flow is now ebbing. In some countries, farmers are now literally looking over the shoulder of scientists at agricultural experiment stations. In countries where yields have already tripled or quadrupled, it is becoming difficult for farmers to continue raising yields. For example, wheat yields in the United States have increased little since 1983. Rice yields in Japan have risen little since 1984.[22]

Even some developing countries are now experiencing a plateauing of grain yields. Between 1961 and 1977, rice yields in South Korea increased nearly 60 percent, but during the quarter-century since they have risen by only 1 percent. Similarly, wheat yields in Mexico climbed from 0.9 tons per hectare in 1950 to 4.4 tons in 1982, a rise of nearly fivefold. Since then there has been little change. (See Figure 7-1.) As the rise in land productivity levels off in more and more countries, expanding global grain output will become progressively more difficult.[23]

Over the last half-century, the world's farmers nearly tripled land productivity, but now future gains in productivity are more difficult to come by. Farmers managed to double the 1950 grain yield of 1 ton per hectare by 1982, when they surpassed 2 tons. By 2000 they were at 2.8 tons, close to a tripling of the 1950 yield. But the rise in yields is slowing.[24]

Raising crop yields is primarily a biological challenge, not unlike increasing athletic performances. Somewhere in antiquity, someone ran a mile in less than six minutes. Well before the first modern-day Olympics, held in 1896, runners were covering a mile in under five minutes. In 1954, Roger Bannister broke the four-minute barrier. A half-century has passed since then, but no one talks about running a three-minute mile. We have reached the point where cutting another minute from our mile time may be physiologically impossible.[25]

We are faced with a similar situation with grain yields. For the world's farmers, going from an average of 1 ton per hectare to

2 was easy. Getting from 2 tons to nearly 3, where we are now, was much more difficult. For the world to move from 3 to 4 tons per hectare may be almost as difficult as going from a four-minute to a three-minute mile. If so, family planners will be under a lot of pressure to slow population growth.

For the world as a whole, the rise in land productivity has slowed markedly since 1990. From 1950 until then, world grain yield per hectare rose 2.1 percent a year. Between 1990 and 2000, however, the annual gain was only 1.1 percent. (See Table 7-2.)

Biotechnology is often cited as a potential source of higher yields, but although biotechnologists have been engineering new plant varieties for two decades, they have yet to produce a single variety of wheat, rice, or corn that can dramatically raise yields. The reason is that conventional plant breeders had already done most of the things they could think of to raise grain yields. Biotechnology's contributions are more likely to come in developing crop varieties that reduce insecticide use, are more drought-tolerant, or are more salt-tolerant. If genetic engineers can breed salt-tolerant varieties, it would alleviate water shortages. Perhaps the largest question hanging over the future of biotechnology is the possible long-term environmental and human health effects of using genetically modified crops.

Land productivity can also be raised by increasing the number of crops per year, where temperature and soil moisture permit. In China, for instance, double cropping winter wheat and corn is widespread, enabling farmers in the North China Plain to harvest two high-yielding grain crops each year. In northern India, the double cropping of winter wheat and summer rice is now commonplace, a key to sustaining India's population of 1 billion. Argentina and the United States both double crop winter wheat with a summer crop of soybeans.[26]

Although the United States occupies a latitude similar to that of China, double cropping is not nearly as common, partly because until recently farmers' eligibility for government support prices depended on restricting the area planted, which discouraged multiple cropping. While there was surplus land, there was little reason to seriously consider double cropping or to develop the technologies that would facilitate it.

At present, roughly 10 percent of the 30-million-hectare U.S. soybean crop is double-cropped with winter wheat. If world food supplies tighten, this area could be expanded substantially, providing a strategic assist in increasing the food supply.[27]

Raising cropland productivity is the key to saving the world's remaining forests. If the world's farmers cannot raise land productivity enough to satisfy the future growth in demand for food, then further clearing of forests for agriculture will be unavoidable.

Table 7-2. Gains in World Grain Yield Per Hectare, 1950-2000

Year	**Yield Per Hectare**[1]	**Annual Increase**
	(tons)	(percent)
1950	1.06	
1990	2.47	2.1
2000	2.75	1.1

[1] Yield for 1990 is three-year average.
Source: USDA, Production, Supply, and Districution, electronic database, Washington, DC, updated May 2001.

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ENDNOTES:

17. Percent photosynthate to seed from L.T. Evans, Crop Evolution, Adaptation and Yield (Cambridge: Cambridge University Press, 1993), pp. 242-44; theoretical upper limit from Thomas R. Sinclair, "Options for Sustaining and Increasing the Limiting Yield-Plateaus of Grain Crops," paper prepared for the 1998 Symposium on World Food Security, Kyoto, Japan (Washington, DC: USDA Agricultural Research Service, September 1998), p. 14.

18. Fertilizer usage numbers based on series from FAO, Fertilizer Yearbook (Rome: various years), and on Kim Gay Soh and Michel Prud'homme, Fertilizer Consumption Report: World and Regional Overview and Country Reports (Paris: International Fertilizer Industry Association (IFA), December 2000).

19. Tom Horton and Heather Dewar, "Feeding the World, Poisoning the Planet," Baltimore Sun, 24 September 2000.

20. European Union from M. Prud'homme and K.G. Soh, Short Term Prospects for World Agriculture and Fertilizer Use (Paris: IFA, November 2000), p. 9; International Institute for Sustainable Development, "Iowa's 1987 Groundwater Protection Act," iisd1.iisd.ca/greenbud/iowa.htm, viewed 1 August 2001.

21. Sandra Postel, "Redesigning Irrigated Agriculture," in Lester Brown et al., State of the World 2000 (New York: W.W. Norton & Company, 2000), p. 40.

22. USDA, op. cit. note 1.

23. Yields and Figure 7-1 from ibid.

24. Ibid.

25. "The 1896 Olympics: Ancient Greece," http://www.olympicwebsite.com/ancientgames.htm, viewed 1 August 2001; Gerald Holland, "Roger Bannister: Sportsman of the Year," Sports Illustrated, 3 January 1955.

26. Double-cropping information for China from W. Hunter Colby, Frederick W. Crook, and Shwu-Eng H. Webb, Agricultural Statistics of the People's Republic of China, 1949-90 (Washington, DC: USDA, ERS National Agricultural Statistics Service (ERS-NASS), December 1992), p. 48; Praduman Kumar et al., "Sustainability of Rice-Wheat Based Cropping Systems in India: Socio-Economic and Policy Issues," Economic and Political Weekly, 26 September 1998, p. A-152-58; Argentina information from USDA, ERS, "Commodity Spotlight," Agricultural Outlook, September 2000, p. 6.

27. Conservation Technology Information Center (CTIC), "Conservation Tillage Survey Data: Crop Residue Management 1998," CTIC Core 4 Conservation Web site, http://www.ctic.purdue.edu/Core4/CT/CT.html, updated 19 May 2000.

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