

Human Appropriation of the World's Food Supply

- Is the world food supply keeping pace with population growth?
- What are the means of increasing the world's food supply?
- How much can we increase the world's food supply?
- What are the limits to the world's food supply?

Introduction

World population is projected to continue increasing well into the next century. Can global food production be increased to provide for the coming population expansion? Because many people are malnourished today, it will be necessary to increase current levels of food production more than proportional to population growth, so as to provide most humans with an adequate diet.

Whether food supply can keep pace with an expanding human population is an old question. In 1798, Thomas R. Malthus predicted that population growth would outstrip food supply, causing great human suffering. In the early 1960s, most nations were self-sufficient in food, but alarm about a rapidly growing population (~2% annually) caused many to echo Malthus' prediction. Then, the Green Revolution (high-yield crops and energy intensive agriculture) brought about remarkable increases in crop production. World grain output expanded by a factor of 2.6 from the 1950s to the 1980s. Today, per capita production has now slowed and appears to be declining.

To increase food production, we can farm more land, or we can increase the yield from each unit of land. The future lies in increasing yields. Humans are appropriating an ever-larger fraction of the world's productive capacity.

The Availability of Productive Land

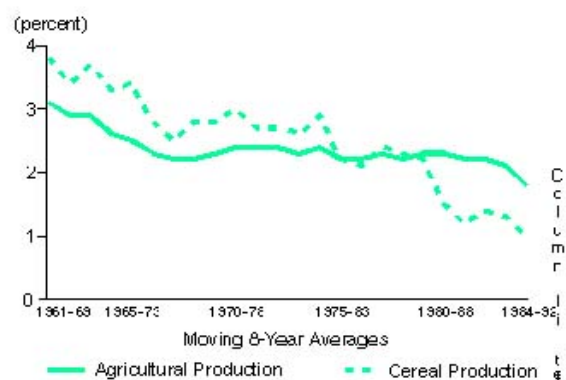
Of the world's total land area of 150 million km² (16 X the area of the US), much is not suitable for agriculture. Arable land comprises 10% of the total. Permanent crops are 1%; meadows and pastures, 24%; forest and woodland, 31%. The remaining 34% is land surface that supports little or no vegetation: Antarctica, deserts, mine sites, urban areas. Nearly all of the world's productive land is already exploited. Most of the unexploited land is either too steep, too wet, too dry or too cold for agriculture. In Asia, nearly 80% of potentially arable land is now under cultivation.

Some parts of the Earth's land surface are much more productive than others. Most of the "good bits" have been in agriculture for a long time. Some of the remaining land surface, such as tropical rain forest, is highly productive under native vegetation (hence not much use for feeding people), and, at least with the farming methods of today, not very productive when converted to agriculture. In fact, cropland per capita is declining world-wide, as agricultural land is degraded, or urbanized. Increasing the yields from available farmland appears to be the key to increased food production.

The Green Revolution

In the 1960s, the efforts of agriculture scientists began to be realized in increased crop production in many areas of the world, especially Asia. Selective plant breeding produced high yielding varieties of rice and other crops, particularly maize, sorghum, and wheat. These high yield varieties (HYVs) performed best under high applications of fertilizer, and also required more expenditure for pesticides, irrigation, farm machinery, etc. Rice is a particular success story, and as the leading cereal crop, helps to pull the world yield rates upwards. Soybean production also has climbed dramatically overall, and stayed somewhat ahead of population growth.

Fig. 1: Growth Rates of World Agriculture Production and World Cereals Production, 1961-



The overall consequence is that per capita food production has contradicted the doom-sayers of the 1960s: during the greatest episode of population growth in human history, food supply per capita grew. Note that Asia did better than the world average, while Africa did worse. The Green Revolution's great success with rice explains the former; lack of success with breeding new arid-land crop varieties, combined with a large dose of political instability, explain Africa's worsening condition. Per capita grain production in Africa is down 12% since 1981 and down 22% since 1967. Some 20 years ago, Africa produced food equal to what it consumed; today it produces only 80% of what it consumes.

Fig. 2: Trends in World Food Production, 1961-94

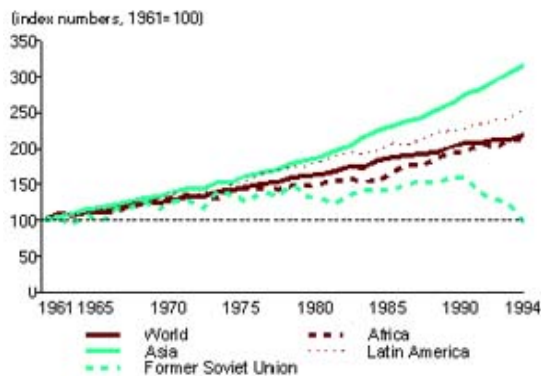
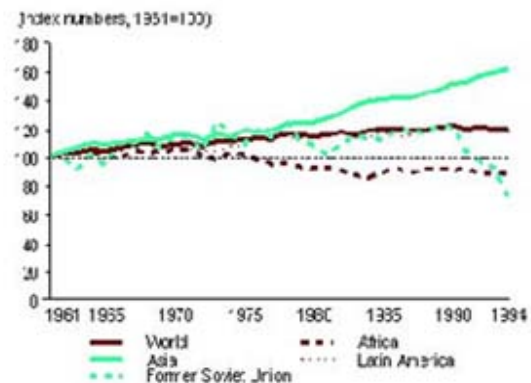


Fig. 3: Trends in per capita Food Production, 1961-94



From the perspectives of feeding a growing population, the Green Revolution was a smashing success. Lurking behind this success story, however, are some disturbing issues:

- Planting with identical HYV's reduces genetic diversity and increases vulnerability to pests, necessitating heavy use of pesticides.
- Agriculture makes heavy use of fresh water.
- High dependency on technology.
- Questionable sustainability.

Towards Improved Agriculture

Continued improvements in agricultural practices and land management, hopefully will allow us to both increase yields and minimize some of the negative effects of agriculture. Some areas that hold much promise include: better pest management, water-conserving irrigation, conservation tillage, and development of new crops through breeding or genetic modification.

The use of pesticides multiplied by a factor of 32 between 1950 and 1986, with developing countries now accounting for a quarter of the world's pesticide use. However, inappropriate and excessive use can cause contamination of both food and environment and, in some cases, damage the health of farmers. Pesticides also kill the natural enemies of pests, allowing them to multiply; meanwhile the number of pest species with resistance to pesticides has increased from a handful 50 years ago to over 700 now.

Crops and foods can be produced using recombinant DNA techniques which enhance their agronomic potential, nutritional characteristics, or one or more features of pest protection (insect and viruses) and tolerance to herbicides. More than 40 such transgenic crop varieties have been cleared through the federal review process. New varieties of plants are being developed using genes from wild varieties with inbuilt disease resistance. Genes from the wild have been used to protect Brazil's coffee plantations; while a Mexican wild maize confers resistance to seven major diseases. According to the American Medical Association, these foods are "substantially equivalent to their conventional counterparts," and no long-term side effects have yet been detected.

While it is difficult to estimate the gains in food production that we may obtain from exploring new crop species, this could make a large contribution. Ninety percent of the world's food is derived from just 15 plant and 8 animal species. Wheat, rice, maize (corn), millet, and sorghum provide nearly all (70%) the food energy

percentage, and up to 60% of all protein consumed by the world's people. Cereal grains are humanity's major food, contributing more than two-thirds of the world production of edible dry matter and half of the world's protein.

What Fraction of the World's Net Primary Productivity do Humans Appropriate

On land, one species, *Homo sapiens*, commands about 40% of the total terrestrial NPP. This has probably never occurred before in earth's history. Human "carrying capacity" on earth is hard to estimate, because it depends upon affluence of a population and the technology supporting that population. But at present levels of affluence and technology, a population 50 to 100% larger than we have today would push our use of terrestrial NPP to well over 50% of the available production, and the attending degradation of ecosystems on earth (e.g., air and water pollution) would be of major concern.

The Food and Agriculture Organization of the United Nations (FAO) has published a study on the food production outlook through the year 2010. The FAO forecasts that production increases can, in fact, accommodate effective demand and rising world population, although malnutrition will become an increasing problem in developing countries. It is also assumed that continuing substantial investments in agricultural research are essential.

Summary

- The expectation that population growth will outrun its food supply has a long history. Surprisingly, from the 1950s to the 1990s, which experienced the most dramatic increase in human population ever, per capita world food production increased.
- The Green Revolution - high-yield varieties of cereal crops - resulted in enormous increases in yield per hectare. However, environmental costs are high.
- Most arable land already is farmed, and the land area under agriculture had slightly declined. Improved agricultural methods that increase yields while minimizing environmental impacts hold the greatest promise for increasing world food supplies.
- At present, humans use or co-opt a substantial fraction of the world's terrestrial net primary production, raising doubts about our ability to greatly increase food supply to humans.

Suggested Readings:

- Kindall, Henry W. and David Pimentel. 1994. ["Constraints on the Expansion of the Global Food Supply"](#). *Ambio*, Vol . 23, No. 3. Royal Swedish Academy of Sciences.
- ["Food Production: Have yields stopped rising?"](#) World Resources Institute's Sustainable Development Information Service
- ["Agriculture and Genetic Diversity."](#) World Resources Institute.
- Agricultural Biotechnology Information Center [Home Page](#) (U.S. Department of Agriculture)
- "The Ecological Risks and Benefits of Genetically Engineered Plants." *Science* (290), 15 Dec 2000.

