INTERRELATIONSHIPS BETWEEN THE ENVIRONMENT AND FOOD PRODUCTION

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Contents

Summary

Food has to be extracted from the natural environment of land, water, climate, flora, fauna, solar energy, fossil fuels, and other natural resources needed for the production of crops, livestock, and the like essential for adequate diets. These requisites for food production must be provided by the Earth's materially closed, finite, and nongrowing ecosystem with a limited throughput of solar energy. The interrelationships between the natural environment and food supplies were apparent for nearly everyone in agrarian societies, but in urban-industrial ones they are often forgotten. All human activities depend ultimately on complex interactions among ecological and social systems. The ecological limits to the expansion of food production cannot be deduced by a reductionist analysis of particular components of ecological life-support systems, such as agricultural land, forests, fresh water, biodiversity, or climate, for example. This is because of the numerous positive and negative feedback at all levels among these components, along with socioeconomic systems that would have to be taken into account.

This short article attempts to speculate about a few of the interrelationships among environmental constraints, social institutions, policies, food production, and food security (access to food for a healthy life by all people at all times).

At the global level there seems to be ample potentially arable land available so that a shortage of land per se would not be a major constraint for meeting increased demands for food, accompanying projected increases in world population and income levels during the twenty-first century. This would be the case even if we assume there would be no spectacular new technological breakthroughs in food production and no radical changes in relative prices. The same appears to be true at national levels for most countries if one assumes continued access to international markets for food, agricultural inputs, and other goods and services.

Arable land, however, is only one component of the complex ecological systems upon which all food production ultimately depends. Land without water is useless for food production. At the global level, ample fresh water is available to meet growing demands for food. Using water rationally for sustainable development, however, implies major socioeconomic reforms both in the international system and within countries. International rules and practices regulating access to water and protection of its quality will have to become more equitable and sustainable. Reforms in social relations and in patterns of production and consumption in both developed and in developing countries are required. Improved technologies in water use and pollution abatement could help, but there are no simplistic technological solutions to impending fresh water shortages that could constrain food production in many regions.

It appears highly improbable, however, that global environmental limits to increasing food production would be a principal limiting factor for achieving food security within a more sustainable development pattern. Human societies seem more likely to disintegrate in the flames of social conflict associated with growing inequalities than by their having reached environmental limits to the production of adequate food supplies. The costs implied in reforming international policies and institutions to be more conducive for sustainable development must be borne primarily by the rich countries and by rich elites in poor ones. The rich, however, can probably only be persuaded to adjust after their own internal contradictions become intolerable. Growing pressures of increasingly organized groups of the hitherto excluded poor could help as could appealing to the longer-term self interests of the rich, but they are unlikely to be sufficient. The key issue is one of mobilizing the social forces willing and able to bring about the policy and institutional reforms required to make development more socially and ecologically sustainable.

1. Introduction

Food security means access to food for a healthy life by all people at all times. The widely accepted international goal of sustainable development implies food security as an indispensable component. Access to adequate food implies its equitable distribution. It also presupposes its availability that in turn requires its sustainable production. Food has to be extracted from the natural environment of land, water, climate, flora, fauna, solar energy, fossil fuels, and other natural resources needed for the production of crops, livestock, and the like essential for adequate diets (see *Rural Resources and Feeding Folk Fully*). These requisites for food production must be provided by the Earth's materially closed, finite, and nongrowing ecosystem with a limited throughput of solar energy.

There is great uncertainty about where the global environmental limits to growth in food supplies may lie, but they undeniably exist. Nonetheless, global environmental limits to increasing food production have never been approached and probably never will be. Instead, chronic hunger and famines affecting particular social groups in specific countries and localities will be aggravated by environmental stress. Social conflicts fostered in part by growing inequalities in the control and use of resources of all kinds will continue to be the most imminent obstacles for achieving food security. The interactions between social and ecological systems at all levels from local to global should be the principal focus of inquiry for guiding policy, and not the potential global limits (see *Projections of Global Carrying Capacity*).

A large and growing proportion of the world's six billion and still expanding numbers of food consumers are only indirectly involved in dealing with the environmental constraints faced daily by most food producers. Moreover, inadequate access to enough food for a healthy life for about one-fifth of the world's population is principally determined by social institutions and by the policies of public and private social actors, not by actual or potential environmental limits to food production. This short article attempts to speculate about a few of the interrelationships among environmental constraints, social institutions, policies, food production, and food security.

2. Urbanization, Population Growth, and Technological Changes

During most of the hundreds of millennia since *Homo sapiens* is believed to have evolved as a distinct species, human societies fed themselves primarily by hunting and gathering They were directly dependent on the natural environment for their food. While they sometimes depleted local food supplies, they affected the wider natural environment only marginally (see *Historical Origins of Agriculture*). Livestock raising and the selection and cultivation of food crops seem to have appeared independently at various times in widely separate geographic regions during only the last 10 000 years (see *Forests and Grasslands as Cradles for Agriculture*). Neolithic farming gave rise to permanent settlements and eventually to hierarchical urban-centered societies. Some of these early settlements grew into large empires that were able to provide access to food for ruling élites and substantial urban populations through extraction of food surpluses from their subjects through plunder, tributes, and trade. The vast majority of their peoples, however, remained directly dependent for their livelihoods on food production. Their efforts were constrained by their environment, their technologies, and their social relations. In agrarian societies, the interrelationships between the natural environment and food supplies continued to be apparent for nearly everyone.

The emergence and rapid expansion from its origins in Western Europe of capitalist commercial and industrial modes of production during the last five centuries has resulted in a global food system and nearly 200 national food systems being superimposed on a myriad of what were initially largely self-provisioning local ones. At the beginning of the twenty-first century, only about half the world's population is directly engaged in agriculture (including forestry and fisheries). In industrial countries this proportion averages less than 10%, and in many of them less than 3%. Agriculture employs more than half the workforce on average in developing countries, varying from less than one-fifth of the total in a few of them to the vast majority in most.

Population growth during the last four centuries has been spectacular. Global numbers of people are estimated to have been only about half a billion in the early seventeenth century, to have doubled to about one billion by the beginning of the nineteenth century, to have doubled again to 2 billion by the early twentieth century and to have reached 6 billion by the twentieth century's end, implying a twelvefold increase during the past 400 years. Most current population growth is taking place in the world's poorer countries (see *World Demography and Food Supply* and *Projections of Global Carrying Capacity*).

Global rates of increase have slowed so that the UN's latest medium-level projections now forecast a global increase to about 9 billion people by the mid-twenty-first century and an eventual stabilization at nearly 10 billion by the twenty-first century's end. Demand for food has increased much more rapidly than population, as higher income consumers have tended to eat more animal products and other higher cost foods (see Regional and *Cultural Differences in Nutrition*).

Repeated warnings during the past two centuries that humankind's food supplies would soon reach their limits, however, have turned out to be mistaken. More than two centuries ago, Malthus predicted that limits to global food supplies would check population growth and keep living levels for most of the world's inhabitants at subsistence levels. He is now remembered principally for his erroneous assumptions. On the contrary, global food supplies on average have continued to increase more rapidly than has population, and food has become relatively cheaper where average per capita incomes rose. His thesis enjoys enduring popularity among the better-off, however, in part because of its intuitive plausibility and in part because it blames hunger primarily on the irresponsible reproductive behavior of the poor rather than on the social institutions and policies generating their poverty.

New technologies in food production, such as the use of chemical fertilizers, pesticides, and herbicides, improved high-yield varieties of food crops, and the use of mechanical energy derived principally from fossil fuels, have been accompanied by spectacular increases in agricultural productivity. Outputs of food and other farm products per unit of land and per person employed in agriculture increased substantially during the twentieth century in much of the world. New forms of social organization accompanied increased international trade in food and agricultural inputs.

These changes in turn were facilitated by cheaper and more rapid transport and communications. Recurrent unmarketable food surpluses in several countries have frequently depressed food prices in domestic and world markets, contributing to the impoverishment of low-income food producers. This widespread paradox of hunger for many low-income groups in the midst of plenty suggests a predominant role of social relationships and public policies in determining food security.

All human activities depend ultimately on complex interactions among ecological and social systems. The ecological limits to the expansion of food production cannot be deduced by a reductionist analysis of particular components of ecological life-support systems, such as agricultural land, forests, fresh water, biodiversity, or climate, for example. This is because the numerous positive and negative feedbacks at all levels

among the environmental and socioeconomic components of food systems would have to be taken into account. In practice, limiting factors on expansion of food production may be reached long before or well after those indicated by the analysis of the potential availability of each component. It depends, of course, on particular contexts.

3. Interrelationships between the Environment, Human Societies, and Food Production

A few of the overlapping interrelationships among the environment, human societies, and food production are briefly mentioned below. They illustrate many of the ambiguities, complexities, and uncertainties involved. Analyses at the global level have to be linked with those of national food systems and with those in subnational ecosystems and local communities. Projections concerning food production and the environment need to be embedded in analyses of socioeconomic, ecological, and political contexts and processes at local, national, transnational, and global levels. Otherwise, results are much too abstract to provide useful insights about purposeful courses of action (policies) that relevant social actors (stakeholders) might take to improve food security. Such holistic analyses are complicated by the fact that the environment, production systems, and food security are all social constructs subject to diverse and conflicting interpretations.

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Biographical Sketch

The late **Solon L. Barraclough**, Ph.D., completed his undergraduate and graduate study at Harvard University (Ph.D. in 1950). He was a former Director of the UN Research Institute for Social Development (UNRISD) in Geneva. Prior to that he worked on agrarian reform policy for FAO. He spent many years in South and Central America. During much of this time he was director of agrarian reform research and training programs in Chile and Mexico. He also directed the Inter-American Committee for Agricultural Development studies on land tenure and development in nine Latin American countries and was Adjunct Professor of Agricultural Economics at Cornell University. He was author of numerous books in English and Spanish, including *Economic Analysis of Farm Forest Operating Units, Agrarian Structure in Latin America, An End to Hunger? The Social Origins of Food Strategies,* and (together with Krishna B.Ghimire) *Forests and Livelihoods: The Social Dynamics of Deforestation in Developing Countries*. After his retirement he continued to work as Senior Consultant for UNRISD, and for several international bodies and NGOs.
Solon Barraclough passed away in 2002.