7.1 Sustainable Resource Use and Global Food Security

The notion of food security has expanded in recent years from a relatively static focus on food availability to one that recognizes longer-term concerns about access and resources. At the same time, economists have been working to incorporate changes in the quality and quantity of natural and other resources into measures of national income and wealth. A review of trends in global and regional food production, population growth, and resource use helps illustrate the relationship between sustainable resource use and food security, and indicates the continuing importance of the role that U.S. agriculture will play in meeting these goals in the 21st century.

Contents

Resources and Food Security

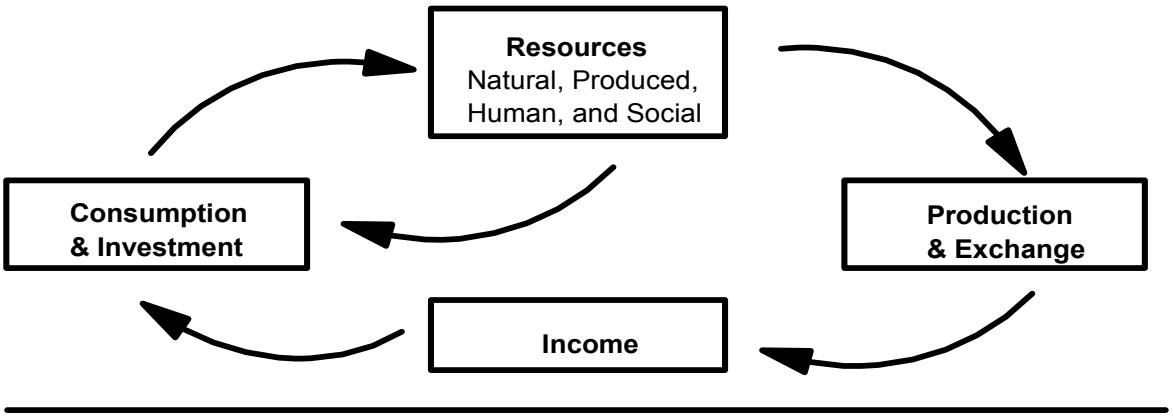
Sustainable resource use refers to a pattern of resource use that meets the needs of the present without compromising the ability to meet the needs of the future (World Commission on Environment and Development, 1987; Hrubovcak, Vasavada, and Aldy, 1999). Food security is among the most basic of these needs, and agriculture is one of the most important of the activities by which resources are used to achieve food security (see "Glossary"). U.S. agriculture is central to this relationship. The U.S. currently produces about a third of the world's coarse grain, half of its soybeans, and accounts for about two thirds of world trade in those commodities (as well as a third of world trade in wheat) -- numbers that are projected to remain steady over the next decade (ERS, 1998). The U.S. has also accounted for about half of world food aid in cereals in recent years (FAO, 1999). The issue of sustainability will be considered in greater depth after a review of concepts and trends in resource use and food security.

Food security is generally defined in terms of "access by all people at all times to sufficient food for an active and healthy life "(World Bank, 1986; World Food Summit, 1996). This understanding derives in large part from the work of 1998 Nobel Laureate Amartya Sen's work on entitlement and hunger. Sen (1981) argued effectively that an individual's access to food may come from trade or from other means in addition to food production. As a result, shortfalls in production are neither necessary nor sufficient for hunger, which can result also from a variety of other factors, including changes in income, employment, food prices, or the provision of safety nets. This understanding represents a significant advance over earlier definitions that focused on global food availability, yet careful consideration of food security requires moving beyond even access to food, and recognizing the choices that households and regions face when incomes fall short (Dasgupta, 1993). Low incomes force tradeoffs between meeting current consumption needs and protecting the resources needed to meet consumption and other needs over the longer term.

Resources can be classified in a variety of ways. Natural resources (e.g. land and water), produced resources (e.g. roads and factories), and human resources (e.g. skilled and unskilled labor) are generally recognized, if not always easy to measure. Social resources are comprised of the institutions and cultural patterns on which functioning societies are based (Serageldin, 1996). Resources are critical to food security because they determine the ways in which individuals, households, and countries gain access to food through production and exchange. These relationships are illustrated in the right-hand side of figure 7.1.1. Resources are also related to food security in a second significant way. Once individuals or groups have engaged in production and exchange, they can allocate the resulting income, along with their remaining stock of resources, to consumption and investment. Consumption and investment in turn affect the quality and quantity of the human and other resources that are available in subsequent periods. Consumption and investment can be viewed as alternative forms of expenditure on resources, where consumption in the form of food intake represents the most basic form of investment in human resources. These concepts are illustrated in the left-hand side of figure 7.1.1.

Recognizing the tradeoff between consumption and investment in other resources is particularly important in poor countries and households, where small increases or decreases in the level of consumption can have large effects on health and nutritional status. Proximity to a minimum consumption threshold highlights the tradeoff between alternative forms of investment that poor households may face. Specifically, households with

Figure 7.1.1 The role of resources in food security



Source: Maxwell and Wiebe (1999).

insufficient income may be forced to choose which forms of investment will be curtailed, and thus which types of resources will be degraded or depleted over time. For example, resource-poor households may be forced to cultivate their land intensively, even degrading it over time, in order to generate enough income to avoid undernourishment in the short run (Perrings, 1989; Mink, 1993). Alternatively, they may accept a certain degree of undernourishment rather than deplete their natural or produced resources. In fact, while simplistic notions of food security imply that the former strategy would be preferred, evidence (e.g. Sen, 1981) suggests that many resource-poor households choose the latter.

In general, consumption that is maintained at sufficient levels only by irreversible degradation or depletion of natural, produced, and/or social resources will not be sustainable, and can hardly be described as part of a food-secure livelihood strategy in the long run. Likewise protection of natural and other resources that is achieved only at the expense of necessary consumption levels, and thus minimum standards of human health, will not be

sustainable in the long run either. This is why it is necessary to consider resource use and food security together.

Global Trends in Food Availability and Access

Two centuries after the publication of Malthus' *Essay on the Principle of Population*, the world's population has increased sixfold and continues to grow. Yet food production has more than kept pace in recent decades, increasing in per capita terms by 0.9 percent annually on a global scale, and even faster in China, India, and other populous developing countries (figure 7.1.2). Malthus clearly underestimated the potential for increased food production as demand increased. Nevertheless, production figures alone conceal important trends in access to food, which is equally important in determining food security.

Shapouri and Rosen (1999) estimate the amount of food available (i.e. production plus commercial imports) and the amount of food needed to maintain two alternative consumption levels for 67 low-income countries. The "status-quo food gap"is defined as the difference between the amount of food available in a given year and average per capita consumption levels for 1996-98 in each country. The "nutritional food gap" is defined as the difference between the amount of food available in a given year and the amount needed to meet minimum recommended nutritional requirements in each country. Shapouri and Rosen project that the total "status-quo food gap" will grow from 13 million tons in 1999 to 17 million tons in 2009, and that the total "nutritional food gap" will grow from 15 million tons in 1999 to 23 million tons in 2009, primarily in Sub-Saharan Africa and Asia.

Among the factors contributing to these growing food gaps are low yields for food crops (table 7.1.1), which limit production's role in meeting food needs. Sub-Saharan African yields for cereals (1 ton per hectare), roots and tubers (8 tons per hectare), and pulses (0.5 tons per hectare) are well below world (and even developing-country) averages, due to low levels of fertilizer application, lags in the development and adoption of Green Revolution technologies, and other factors. Food availability, as measured by kilocalories of dietary energy available per person per day, is also lowest in sub-Saharan Africa (at 2,150 kilocalories per person per day). While yields and availability are higher in South Asia, access to food remains limited by lower per-capita incomes (at $380 per year) and by the larger share of the population (43 percent) that lives in poverty. Low incomes limit poor countries' ability to compensate for production shortfalls through commercial imports. The consequences of the resulting food gaps are evident in indicators of consumption in developing countries. While data are scarce, an estimated 43 percent of Sub-Saharan Africa's people are chronically undernourished, compared with 22 percent in South Asia and 12-16 percent in other developing areas (Pinstrup-Andersen and Pandya-Lorch, 1999). The greatest numbers of chronically undernourished people live in Asia.

Food production, access, and consumption are important components of current food security, but it is also essential to consider the longer-term interactions between food security and sustainable resource use. Recognizing the urgency of immediate consumption concerns, it is not surprising that gross savings rates in Sub-Saharan Africa are less than half those in the East Asia & Pacific region (table 7.1.1). Low savings rates may reflect the short-term priority of consumption over investment in other resources, but they may also conceal depletion of natural and other resources that are critical to food security over the long term. The gross savings rates reported in table 7.1.1, calculated as GNP minus public and private consumption (World Bank, 1997b), do not reflect changes in the stocks of many natural, human, and other resources that are associated with sustainability and food security, ranging from deforestation and carbon dioxide emissions to institutional decline and malnutrition-related disease.

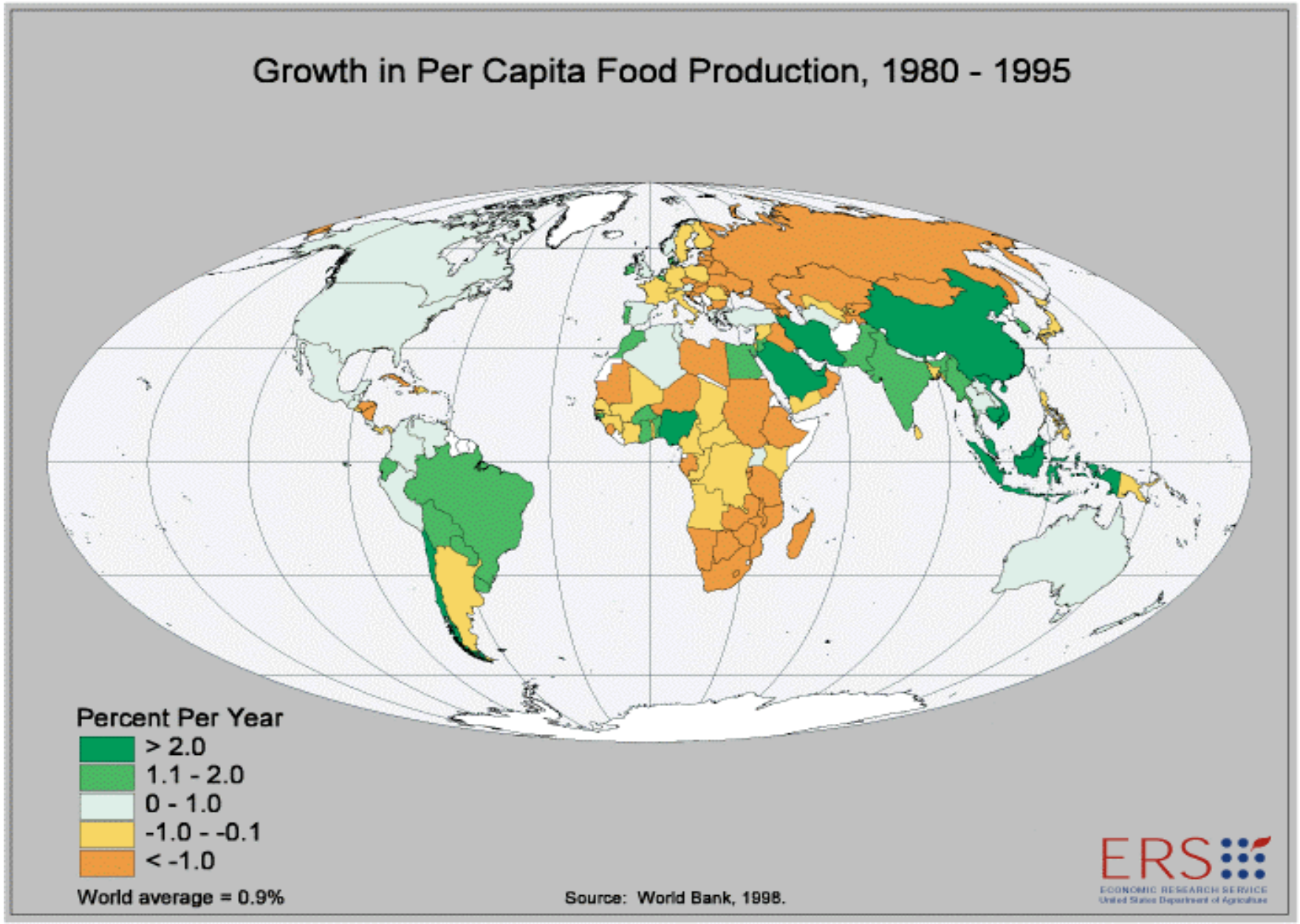

Growth in Per Capita Food Production, 1980 - 1995
Percent Per Year
> 2.0
1.1 - 2.0
0 - 1.0
-1.0 - -0.1
< -1.0
World average = 0.9%
Source: World Bank, 1998.
ERS
ECONOMIC RESEARCH SERVICE
United States Department of Agriculture

Figure 7.1.2

Table 7.1.1 Selected indicators of food availability and access

Indicator	Low- & Middle-Income Economies							High-Income Economies		World
	Sub-Saharan Africa	East Asia & Pacific	South Asia	Europe & Central Asia	Middle East & North Africa	Latin America & Caribbean	All	US	All	
Production										
Cereals yields (*tons/hectare, 1997*)	1.0	4.2	2.3	2.1	1.9	2.7	2.6	5.3	3.3	2.9
Roots & tubers yields (*tons/hectare, 1996*)	8.0	11.0	15.3	12.7	na	11.6	11.6	na	17.6	13.0
Pulses yields (*tons/hectare, 1996*)	0.5	0.9	0.6	1.4	na	0.7	0.7	na	1.6	0.8
Availability										
Dietary energy supply (*kcal/person/day, 1994-96*)	2,150	2,740	2,360	2,850	2,990	2,780	na	3,620	3,340	2,720
Income										
GNP per capita ($/capita, 1997)	510	970	380	2,310	2,070	3,940	1,250	29,080	25,890	5,180
Poverty (*% living on < $1/day, 1993*)	39	26	43	na	4	24	29	na	na	na
Consumption & investment										
Undernourishment (*% chronically undernourished, 1990-92*)	43	16	22	na	12	15	21	na	na	na
Gross savings (*% of GDP, 1997*)	17	38	18	21	25	20	25	16	22	23
Genuine savings (*% of GNP, 1993*)	-1	21	6	na	-2	6	9	na	14	na

Notes: na = not available. Gross savings are calculated as GNP minus public and private consumption, while genuine savings are adjusted to account for depletion of natural resources and damages caused by pollution (World Bank, 1997b).
Sources: USDA, ERS, based on FAO (1997 and undated), Pinstrup-Andersen and Pandya-Lorch (1999), World Bank (1997a, 1997b, 1998, and 1999a).

Economists have begun trying to better incorporate such changes in resource stocks into measures of national income (Hrubovcak, LeBlanc, and Eakin, 1995; World Bank, 1997b). For example, adjusting estimates of savings to reflect changes in the value of natural and human resources yields the "genuine savings" data presented in table 7.1.1. World Bank estimates, admittedly limited by constraints of data availability and quality, indicate that genuine savings rates in Sub-Saharan Africa and the Middle East & North Africa are negative (as they have been for the past several decades), while rates in East Asia & the Pacific are high and rising (World Bank, 1997b). These trends suggest the need to look beyond short-term indicators of food availability and access to explore the longer-term links between food security and resource use.

Global Resource Trends

In general, resource priorities change as economies evolve. In low-income economies, priority is typically given to issues related to the management of natural resources for poverty alleviation and food security (UNEP, 1997). As economies grow, priority may shift to include resource problems associated with industrialization and urbanization, such as air and water quality and the treatment and disposal of waste. While analysis of local and national resource-use and food-security decisions requires disaggregated data, broader patterns are revealed in regional data reported by the World Bank and other sources. Selected data from these sources illustrate some of the resources and processes depicted in figure 7.1.1.

Natural resources

About 11 percent of global land area is considered arable land (i.e. land in temporary or permanent crops), ranging from 5 percent in the Middle East & North Africa to 43 percent in South Asia (table 7.1.2). Arable land per capita ranges from 0.1 hectare in East Asia & the Pacific to 0.7 hectares in the U.S. In recent decades, agricultural land area has increased at 0.3 percent annually worldwide, and as high as 1.3 percent annually in Latin America & the Caribbean.

This increase often represents expansion of cultivation onto marginal lands, such as those with shallow soils or steep slopes. Permanent pasture has remained relatively constant in area, indicating that the majority of the net increase in cropland area has occurred ultimately at the expense of areas formerly under forest or woodland cover. Deforestation has occurred most rapidly, in percentage terms, in East Asia & the Pacific and in Latin America & the Caribbean. Nationally protected areas have increased relatively rapidly in recent decades, although it is difficult to assess the true effectiveness of such protection. Based on projected growth in cereal demand and yields, Rosegrant, Ringler, and Gerpacio (1999) argue that land conversion will slow in the next two decades, and that area constraints will not threaten global food supplies in the forseeable future. Based on assessment of agroecological zones, food needs, and technological development and adoption potential, Alexandratos and Bruinsma (1999) also conclude that projected increases in agricultural land area are only a small proportion of total unused land with rainfed crop production potential. Others caution that land conversion continues at high levels in some regions, such as Sub-Saharan Africa, and raise concerns about future production constraints in those areas (Houghton, 1994).

Even if the rate of land conversion for agriculture slows in the coming decades, land already used for agricultural production is also subject to increasingly intensive production. This can lead to degradation via nutrient depletion, soil erosion, and other processes in the absence of appropriate management practices. For example, Bumb and Baanante (1996) report that in many countries of Sub-Saharan Africa, soil nutrients are removed at rates 3 to 4 times those of nutrient replenishment, while Lal (1995) estimates that soil erosion has reduced crop yields in Sub-Saharan Africa, relative to what they would have been otherwise, by about 6 percent. Crosson (1997) counters that erosion-induced on-site productivity losses are actually quite low on a global scale, averaging less than 0.5 percent per year, although concern may still be justified where soil erosion has significant off-site effects, as well as in particular areas where soil losses are higher. Scherr and Yadav (1996) identify a number of such "hot spots" where land degradation poses a significant threat due to soil erosion, nutrient depletion, deforestation, salinization, and other processes. Based on the global assessment by Oldeman, Hakkeling, and Sombroek (1991), they report that degradation of agricultural land and permanent pasture is most extensive in Africa (65 percent and 31 percent, respectively), while degradation of forest and woodland is most extensive in Asia (27 percent). Recent reviews indicate that land degradation can have significant on-site and off-site impacts on income and environmental quality in any areas, even if it does not threaten global food supply (Scherr, 1999; Pagiola, 1999).

Water is abundant globally but scarce in many regions (UNEP, 1997). Only 7 percent of annually renewable freshwater is withdrawn from rivers and aquifers worldwide each year (World Bank, 1992). Increased withdrawals are difficult, however, because most of the remainder is lost to evaporation or flooding, or is distributed unequally relative to population or across seasons (Rosegrant, 1997). In contrast to land resources, Rosegrant, Ringler, and Gerpacio (1999) argue that rapid growth in water demand, in combination with the high cost of developing new water sources, could threaten future growth in food production. Agriculture currently accounts for 87 percent of water withdrawals for 87 percent of water withdrawals in low- and middle-income regions, 47 percent in the high-income economies, and 72 percent worldwide (Rosegrant, Ringler, and

Table 7.1.2 Selected indicators of natural resources

Indicator	Low- & Middle-Income Economies							High-Income Economies		World
	Sub-Saharan Africa	East Asia & Pacific	South Asia	Europe & Central Asia	Middle East & North Africa	Latin America & Caribbean	All	US	All	
Arable land (*hectares per capita, 1996*)	0.3	0.1	0.2	0.6	0.2	0.3	0.2	0.7	0.4	0.2
Freshwater (*renewable, 1000 cubic meters per capita, 1996*)	7.8	5.1	3.0	11.4	0.9	22.0	7.0	9.3	9.4	7.3
for agriculture (*% of annual withdrawals, various years*)	85	84	95	52	84	77	80	42	40	68
Land use (*% of total land area)*										
Arable land (*1996*)	6	12	43	12	5	7	10	19	12	11
Permanent pasture (*1994*)	34	34	10	16	26	29	27	26	24	26
Forest (*1995*)	17	24	16	36	1	45	26	23	21	25
Nationally protected areas (*1996*)	6	7	5	3	2	7	5	13	11	7
Land use change (*annual % change in area)*										
Arable land (*1965-89*)	0.7	0.3	0.2	0.1	0.1	1.3	0.5	0.2	0.2	0.3
Permanent pasture (*1965-89*)	0.0	-0.2	-0.4	-0.0	0.0	0.5	0.1	-0.2	-0.1	0.0
Forest (*1965-89*)	-0.4	-0.7	0.3	0.2	0.2	-0.5	-0.4	-0.2	-0.1	-0.2
Nationally protected areas (*1972-90*)	1.9	14.0	10.7	7.3	6.9	8.0	5.6	na	7.1	6.3

Note: na = not available.
Sources: USDA, ERS, based on FAO (1997), World Bank (1992, 1995, 1997a, 1998, and 1999a).

Gerpacio, 1999). Analysis by the International Water Management Institute (IWMI) indicates that world requirements for the development of additional water supplies (primarily for irrigation) may grow by as much as 57 percent by 2025, although improved irrigation effectiveness can reduce this growth by about half (Seckler et al., 1998). Seckler et al. note that "in a growing number of countries and regions of the world, *water has become the single most important constraint to increased food production"* (p. 16; emphasis in original), but water constraints have not yet been incorporated in global food production models (such as those of the World Bank, FAO, or IFPRI).

Another critical component of natural resources is the earth's atmosphere, a global resource that is being modified by human activities on an unprecedented scale (IPCC, 1990). Most notable are emissions of carbon dioxide from the combustion of fossil fuels, which are associated with global warming and its possible effects on the location, productivity, and variability of agricultural production. Given the potential for farmers to adapt over time, global warming is not expected to constitute a threat to food production on a global scale, although some resource-poor regions, particularly those in tropical latitudes, may suffer reductions in food availability and access (Darwin et al., 1995; Schimmelpfennig et al., 1996).

Genetic resources share characteristics of both natural and produced resources, and are discussed in chapter 3.2 of this report. Additional information on U.S. land and water resources and global climate is provided in sections 1 and 2 and chapter 7.2.

Produced resources

Agricultural intensification in the form of increased use of produced inputs may involve both costs (in terms of environmental quality) and benefits (in terms of increased production, which may in turn alleviate pressure to convert additional land to agricultural use). The balance between these costs and benefits varies from region to region with levels of intensification. South Asia has the highest proportion of cropland irrigated (37 percent), while the East Asia & Pacific region applies fertilizer most intensively (235 kilograms per hectare of arable land) (table 7.1.3). Sub-Saharan Africa lags in irrigation (4 percent of cropland), fertilizer use (14 kilograms per arable hectare), and agricultural mechanization (0.2 tractors per arable hectare). Per-capita energy use varies by a factor of 4 from Sub-Saharan Africa and South Asia to the low- and middle-income economies of Europe & Central Asia. The latter use energy at about half the level of the high-income economies. Even more dramatic are differences in the share of energy derived from fuelwood and charcoal, ranging from one percent in the low- and middle-income economies of the Middle East & North Africa to 26 percent in South Asia and 47 percent in Sub-Saharan Africa. Different patterns of energy use contribute to different forms of resource degradation. Fuelwood and charcoal burning may contribute to deforestation, for example, while fossil fuel combustion releases carbon dioxide and other gases and solids that may affect climate.

Human resources

World population was 5.9 billion in 1998, about half of it located in Asia (table 7.1.4), and reached 6 billion in 1999 (United Nations, 1999). Annual population growth rates are among the highest in the low-income regions of sub-Saharan Africa (2.6 percent) and South Asia (1.9 percent), but vary widely across low- and middle-income economies, from 0.1 percent in Europe & Central Asia to 2.1 percentin the Middle East & North Africa. Global population growth has slowed more than previously expected, from an average of 1.6 percent per year over the period 1980-1997 to 1.3 percent per year in 1999, due to declining fertility and also to increased mortality from HIV/AIDS (United Nations, 1999). Urban populations are growing particularly rapidly, especially in Sub-Saharan Africa, East Asia & the Pacific, and the Middle East & North Africa. Nevertheless the bulk of the labor force in the most heavily populated regions (i.e. Asia and Sub-Saharan Africa) remains in agriculture, suggesting the importance of improved agricultural performance to simultaneously increase rural incomes and urban food supplies.

Given limitations on land and water supplies for agriculture, growth in yields and other measures of productivity will be an increasingly important source of future growth in agricultural production. Labor productivity in agriculture has grown by 1.9 percent per year since 1980 in South Asia and by 2.5 percent per year in Latin America and the Caribbean, but has fallen by 1.0 percent annually in sub-Saharan Africa over the same period (World Bank, 1998). Additional information on changes in technology and agricultural productivity is presented in section 5.

Poverty and the burden of malnutrition-related disease are relatively high in Sub-Saharan Africa and South Asia, while life expectancy and adult literacy rates are relatively low (table 7.1.4). Similar patterns are evident in child stunting (low height for age) and wasting (low weight for height) (World Bank, 1993). The levels of these indicators are consequences of continuing pressure on natural and other resources in these regions. Through their impact on labor productivity, they are also potential causes of continuing pressure on natural and other resources (Dasgupta, 1993; Mink, 1993).

Social resources.

In contrast to natural resources (e.g. land and water), produced resources (e.g. roads and factories), and human resources (e.g. skilled and unskilled labor), social resources are comprised of the institutions and cultural

Table 7.1.3 Selected indicators of produced resources

Indicator	Low- & Middle-Income Economies							High-Income Economies		World
	Sub-Saharan Africa	East Asia & Pacific	South Asia	Europe & Central Asia	Middle East & North Africa	Latin America & Caribbean	All	US	All	
Irrigation (*% of cropland, 1994-96*)	4	10	37	10	31	11	19	12	3	17
Fertilizer consumption (*kg per arable hectare, 1997*)	14	235	100	35	68	81	90	114	126	99
Mechanization (*tractors per arable hectare, 1994-96*)	0.2	0.6	0.8	1.7	1.2	1.1	1.0	2.7	4.4	1.9
Energy use (*tons of oil equivalent/capita, 1996*)	0.7	0.9	0.4	2.7	1.2	1.2	1.0	8.1	5.3	1.7
Fuelwood and charcoal (*% of total energy used, 1996*)	47	12	26	2	1	16	12	4	3	7

Note: na = not available.
Sources: USDA, ERS, based on FAO (1997), World Bank (2000, 1998, and 1999a).

Table 7.1.4 Selected indicators of human resources

Indicator	Low- & Middle-Income Economies							High-Income Economies		World
	Sub-Saharan Africa	East Asia & Pacific	South Asia	Europe & Central Asia	Middle East & North Africa	Latin America & Caribbean	All	US	All	
Population (*millions, 1998*)	627	1,817	1,305	475	286	502	5,011	270	886	5,897
Population growth (*annual % change, 1997*)	2.6	1.1	1.9	0.1	2.1	1.6	1.5	0.9	0.6	1.4
Urban population growth (*annual % change, 1980-97*)	4.9	4.2	3.3	1.7	4.0	2.7	3.3	1.2	0.8	2.5
Labor force in agriculture (*% of total labor force, 1990*)	68	69	63	23	35	25	58	3	6	49
Adult literacy (*%, 1995*)	57	83	49	na	61	87	70	na	na	na
Life expectancy (*years, 1998*)	50	69	62	69	68	70	65	77	78	67
Disease burden (*disability-adjusted life years lost due to malnutrition-related causes, per 1,000 population, 1990*)	87	9	52	2	29	19	na	na	1	28

Note: na = not available.
Sources: USDA, ERS, based on World Bank (2000, 1993, 1997a, 1998, and 1999a).

patterns on which functioning societies are based (Serageldin, 1996). The line between social and human resources becomes difficult (and perhaps unnecessary) to draw, as social indicators include factors that affect political and economic activity, as well as indicators associated with the provision of public goods and services such as health and education.

Indicators of social resources are important for food security in two basic ways. First, along with natural, produced, and human resources, they are important in determining the potential for future economic growth and income generation, and thus the ability to command sufficient access to food. And second, they reflect the ability of society to compensate its members when they experience shortfalls in production, availability, or access to food. Health expenditures (both public and private) are lowest in South Asia region, at $16 per capita

(table 7.1.5). Access to clean water is lowest in Sub-Saharan Africa, while South Asia suffers the lowest access to sanitation services. Male enrollment in primary education is near complete everywhere except in Sub-Saharan Africa, but female enrollment lags, particularly in South Asia and in the Middle East and North Africa.

Another important social indicator is the State's performance in relation to political and economic participation. The World Bank's "democracy index" is an ordinal ranking based on a variety of indicators described in the 1997 *World Development Report* (World Bank, 1997a, p. 112), and ranges from a low in the Middle East & North Africa to a high (relative to other low- and middle-income economies) in Latin America & the Caribbean (table 7.1.5). The *Report* also reports results from a survey of businesspeople on obstacles to economic activity. Property rights and corruption were identified as the principal obstacles in Sub-Saharan Africa and in Latin America & the Caribbean, while taxes were identified as the principal obstacle in Europe & Central Asia. (Infrastructure was identified as the principal constraint in South Asia and the Middle East & North Africa.) Although data are scarce, conflict is also increasingly being recognized as a critical factor in preventing political and economic participation in general, and in threatening food security in particular (de Soysa and Gleditsch, 1999; Messer, Cohen, and D'Costa, 1998).

Finally, knowledge has been recognized as an economic resource (whether classified as a human resource or a social resource) since at least the time of Theodore Schultz's Nobel Prize-winning research in the 1950s and 1960s (e.g. Schultz, 1964; Wiebe and Crosson, 1999). Knowledge is embodied in people and technology as well as in the laws, social norms, and public and private institutions that help markets function properly (World Bank, 1999b). Recent trends in global spending on agricultural research, particularly in public spending, raise concerns that future investment in knowledge may prove insufficient to address the needs of developing countries. For example, investments through the Consultative Group for International Agricultural Research (CGIAR) have stagnated after increasing rapidly in the 1970s and 1980s (Alston, Pardey, and Roseboom, 1997). Per-capita expenditures on research and development vary widely across regions, more so even than does income, heightening concerns about future agricultural performance (World Bank, 1999b).

Implications for Sustainability and Global Food Security

The data presented earlier in this chapter provide only a general sense of the ways in which resource indicators supplement indicators of food availability and access to provide a longer-term perspective on global food security. Taken together, they suggest room for both optimism and concern about prospects for sustainable resource use and food security. Sub-Saharan Africa fares worst of all regions in terms of crop yields, dietary energy supply, and undernourishment. Yet sub-Saharan Africa has more arable land per person, and uses proportionately less of it, than do the densely population regions of Asia. While sub-Saharan Africa has considerable potential to raise yields and incomes through increased use of conventional inputs, such as fertilizer, even more fundamental constraints are posed by the lack of physical infrastructure and institutional stability. Similar constraints, though less severe, limit agricultural production and incomes in the low- and middle-income economies of Europe and Central Asia. In terms of natural resources, land constraints may be less critical in most regions than are limits on the availability and distribution of water. At an even more general level, institutional constraints have proven at least as difficult to overcome as have natural resource limits or technological challenges. As a result, regional concerns about access to food remain warranted even while global trends in production and availability appear promising.

Because of the close and reciprocal links between access to resources and access to food, it is difficult to devise a uniquely satisfactory scheme for distinguishing resource categories, let alone comparing them. Likewise, just

Table 7.1.5 Selected indicators of social resources

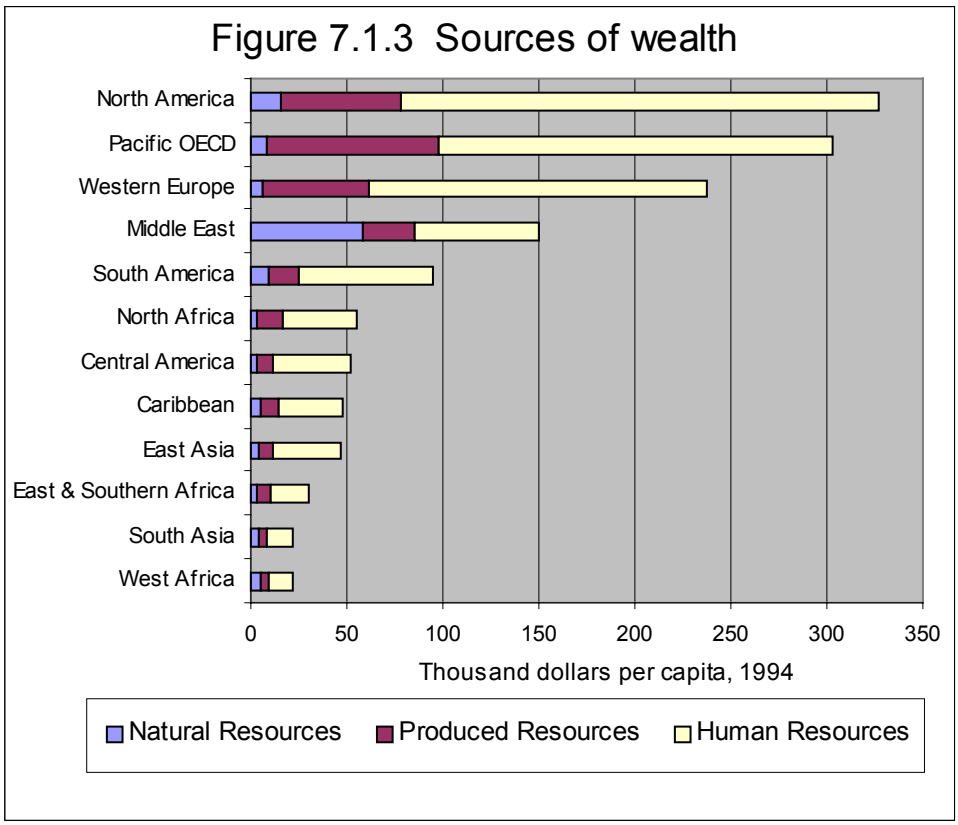
Indicator	Low- & Middle-Income Economies							High-Income Economies		World
	Sub-Saharan Africa	East Asia & Pacific	South Asia	Europe & Central Asia	Middle East & North Africa	Latin America & Caribbean	All	US	All	
Health expenditures (*$/capita/year, 1990-97*)	34	46	16	144	89	274	61	4,093	2,485	502
Water supply (*% of population with access, 1996*)	47	77	81	90	70	75	75	73	96	75
Sanitation (*% of population with access, 1990*)	35	85	15	85	59	69	na	85	86	60
Female primary education (net % of age group enrolled, 1997)	na	99	70	99	84	93	86	100	100	88
Male primary education (net *% of age group enrolled, 1997*)	na	99	83	100	91	95	91	100	100	92
Democracy index (*rank, 1994; least democratic = 1*)	2	na	3	4	1	5	na	na	6	na
Obstacles to economic activity (*rank, 1997; worst = 1*)										
Property rights/corruption	1	na	3	3	2	1	na	na	5	na
Taxes	2	na	2	1	3	5	na	na	1	na

Note: na = not available.
Sources: USDA, ERS, based on World Bank (2000, 1993, 1997a, and 1999a).

as measures of food availability and access are insufficient to capture the notion of food security, it is impossible to equate any one resource indicator (or even any one resource category) with the notion of food security as a whole. In fact, food security is indicated not just by the quality of human resources, but rather by the extent and composition of all resources to which individuals, households, and countries have access.

One promising approach in the search for more sophisticated measures of the relationship between resources and food security is to move beyond conventional quantity measures of individual resources, such as total land area (which is subject to wide variations in land quality), towards measures that reflect both the quality and quantity of multiple resources simultaneously. As noted previously, economists have begun trying to better incorporate changes in resource stocks into measures of national income and wealth. Recently the World Bank has estimated the contributions of different resource categories to wealth (figure 7.1.3). Agricultural land accounts for most of the value of natural resources in most areas (Dixon and Hamilton, 1996). The share of total wealth represented by human resources is consistently high across regions, between 60 and 80 percent everywhere except in the Middle East, although total wealth varies widely. Estimates of genuine savings rates, which reflect changes in the value of human and natural resources as well as produced resources, also vary widely (table 7.1.1). Low genuine savings rates indicate the potential for deepening food security problems in some areas, particularly in Sub-Saharan Africa.

Such estimates are admittedly preliminary, but they offer interesting parallels between the analysis of resources and the analysis of food security. Just as the concept of food security has evolved in recent years from a relatively static focus on food availability to incorporate longer-term concerns about access, so has interest grown in developing economic and environmental indicators that move beyond current income to reflect longer-term changes in the quality and quantity of natural and other resources. While these two processes emerged from different concerns that were traditionally viewed as conflicting -- the former primarily with



hunger at the household and local levels, the latter largely with environmental degradation at the national and global levels -- they are closely related.

Specifically, both represent components of an integrated problem in resource management, in which natural, produced, human, and social resources can be used in various ways to achieve a variety of objectives, including food security (World Bank, 1997b). At the core of this problem is the concept of sustainability. Serageldin (1996) distinguishes degrees of sustainability based on the extent to which resources are seen as substitutes or complements to one another. "Strong sustainability" requires the maintenance of each kind of resource intact, based on the assumption that resource categories are complements rather than substitutes. By contrast, "weak sustainability" maintains the total value of resources, regardless of its composition, implying that resource categories are substitutes rather than complements, and that individual resources (and even resource categories) can be depleted without threatening wealth as a whole.

Serageldin (1996) proposes a "sensible" middle approach that requires both the maintenance of total wealth and concern with the composition of wealth, recognizing that different resource categories are both substitutes and complements, and that critical levels of each category should be defined and maintained. Such a definition parallels evolving definitions of food (and livelihood) security, which increasingly recognize the need to meet both food and non-food requirements in order to sustain human and other resources over time. In its shared attention to critical thresholds, tradeoffs, and sustainability over the long term, the convergence between these areas of research offers promise for improved understanding of the relationship between sustainable resource use and food security in the future.

Implications for Resource Use in the United States

The U.S. has historically been a major global supplier of food, in terms of both food aid and commercial exports. We noted earlier that Shapouri and Rosen (1999) project that food aid needs will increase by 40-50 percent over the next decade, and that the U.S. has accounted for about half of world food aid in cereals in recent years (FAO, 1999). With regard to commercial trade, ERS (1998) projects a slight rise in the U.S. share of world coarse grain trade over the next decade (although the magnitude of this increase will depend on the performance of the countries of Eastern Europe and the Former Soviet Union). The International Food Policy Research Institute (IFPRI) projects that changes in population, income, and urbanization will cause net cereal imports by developing countries to nearly double by 2020, to 192 million tons, and that about 60 percent of these imports will come from the U.S. (Pinstrup-Andersen, Pandya-Lorch, and Rosegrant, 1999). As a result of these and other factors, USDA projects that U.S. acreage planted to eight major field crops (grains, soybeans, and cotton) will rise by about 5 percent (about 12 million acres) over the next decade, after a slight decline in the shorter term due to the lingering effects of the Asian economic crisis (USDA, 1999).

Trends such as these indicate that pressure on land and related resources in the U.S. will continue into the forseeable future, but increased resource degradation does not necessarily follow. Over the past two decades, U.S. agricultural productivity growth has accelerated while soil erosion has declined, groundwater depletion has slowed, surface water quality has improved, and agriculture has become a net supplier of wetlands -- due in part to changes in technology and to agricultural and environmental policies and programs implemented in the 1970s and 1980s (Hrubovcak, Vasavada, and Aldy, 1999). These challenges and accomplishments underscore the importance of continued policy measures to protect highly erodible soils, wetlands, agricultural lands vulnerable to urban encroachment, and other environmentally sensitive lands. Such resources, and the policies used to protect them, are described in detail in sections 1, 2, 3, and 6 of this report.

Other Challenges to Sustainable Resource Use and Global Food Security

Improving our understanding of the relationship between sustainable resource use and global food security requires recognition of the reality that global food and resource-related processes are driven ultimately by the choices made by individual decisionmakers who clear land, draw water, plant crops, and raise livestock to meet their own goals. These choices are influenced in turn by the ways in which property rights and institutional systems structure markets to balance the interests of individual decisionmakers with those of the public, both locally and globally, and both in the short term as well as over the longer term.

Without stable institutions, markets are unlikely to offer sufficient incentives for investment in the productive and sustainable use of natural and other resources. It is notable that per capita food production has fallen most markedly in recent decades in two relatively land-abundant but institutionally turbulent regions: sub-Saharan Africa and the countries of the former Soviet Union (figure 7.1.2).

Without the appropriate institutional setting, markets are also unlikely to offer incentives for the protection of resources for which property rights may be imperfectly defined or enforced -- whether on a local scale, such as grazing lands traditionally managed under a common-property regime that has subsequently disintegrated, or on a global scale, such as the earth's atmosphere (Dasgupta and Mäler, 1994; Wiebe & Meinzen-Dick, 1998). Where tenure systems are absent or have ceased to function properly, development of well-defined and carefully enforced institutional arrangements will be necessary (but not sufficient) for sustainable resource use.

Finally, the efficiency with which resources are used to meet food security and environmental goals over the long term will depend not only on the performance of markets and other institutions but also on improvements in productivity, on the protection and appropriate use of genetic diversity, and on other dimensions of the global agricultural economy that are addressed elsewhere in this report.

Lead Author: Keith Wiebe (202-694-5529, kdwiebe@ers.usda.gov). Contributor: Kelly Day-Rubenstein.

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Glossary

Food access refers to the ability of individuals or groups of people to acquire food, whether through production or exchange.
Food availability refers to the total amount of food available globally, nationally, or regionally, through production and trade, without regard to the ability of individuals to acquire food.
Food gap refers to the difference between food needs and food available in a country through production and commercial imports:
Status quo food gap refers to the amount of food needed, given a country's production and commercial imports, to maintain per capita consumption at average historic levels.
Nutritional food gap refers to the amount of food needed, given a country's production and commercial imports, to maintain per capita consumption at minimum recommended nutritional requirements.
Food security is generally defined in terms of access by all people at all times to sufficient food for an active and healthy life.
Resources are the factors used in the production and distribution of goods and services:
Natural resources include land, water, climate, and biological resources.
Produced resources include roads, factories, communications networks, and other physical infrastructure.
Human resources include skilled and unskilled labor.
Social resources include the social, legal, and political institutions on which functioning societies are based.
Sustainability refers to a pattern of resource use that meets the needs of the present without compromising the ability to meet the needs of the future:.
Weak sustainability maintains the total value of resources, regardless of its composition, implying that resource categories are substitutes rather than complements, and that individual resources (and even resource categories) can be depleted without threatening wealth as a whole.
Strong sustainability requires the maintenance of each kind of resource intact, based on the assumption that resource categories are complements rather than substitutes.
Medium sustainability requires both the maintenance of total wealth and concern with the composition of wealth, recognizing that different resource categories are both substitutes and complements, and that critical levels of each category should be defined and maintained.