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Reading 9
Agriculture and Economic Development

Economic growth was previously defined as a "sustained rise in the level of consumption or real income per person." **Economic development**, a broader concept, relates to progress along a wide spectrum of technological, economic, social, and cultural dimensions. Thus it is much more difficult to characterize a country in terms of development than it is to characterize it in terms of growth. In many respects, India is a highly developed low income country, whereas the United States is an underdeveloped high-income country.

One index of development is the extent to which an economy can free its resources from the production of basic food and fiber requirements. In a society in which a high proportion of resources must be devoted to meeting basic subsistence requirements, most people are engaged in the production of food and fiber for themselves and for their neighbors. They do not have the time, the ability, or the tools to produce other goods and services. In a highly developed economy, only a small proportion of the population is engaged in agriculture, agricultural productivity is relatively high, and most of the working population is engaged in the production of other goods and services.

The processes by which a nation achieves the transition from a low to a high level of productivity and income are still poorly understood. It is clear that rapid industrial development is difficult to achieve without the support of a progressive rural economy. And it is equally true that a highly productive agricultural sector is easier to achieve when it is part of a rapidly growing urban industrial economy. Most countries of the world continue to be characterized by low productivity and income in rural and urban areas alike. The significance of the problem of agricultural development was dramatized when Professor Theodore W. Schultz of the University of Chicago was awarded the Nobel Prize in economics in 1979 for his contributions to a better understanding of agricultural and economic development (Fig. 1).

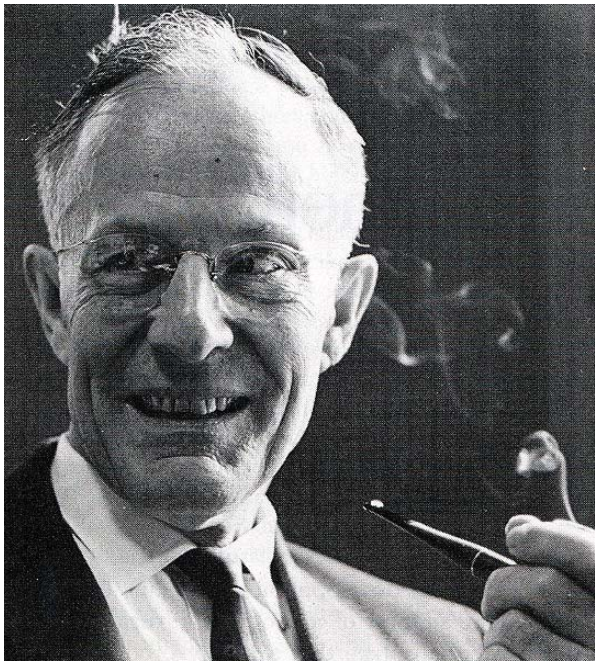


Fig. 1. In 1979 Professor Theodore W. Schultz of the University of Chicago received the Nobel Prize in economics for his contributions to a better understanding of agricultural and economic development. Research by Professor Schultz demonstrated the high personal and social returns on investment in the education and health of rural people and the importance of providing farmers with new and more productive inputs and technologies.

There are 4 ways in which the agricultural sector can contribute to national economic development.

1. Most essential, it can provide the food and fiber necessary for an expanding population that is growing in income and wealth.
2. It can release workers needed for the production of nonagricultural goods and services.
3. It can serve as a market for nonfarm goods

and services, thus providing a stimulus for expansion of employment and output in the nonfarm sector.

4. It can provide a source of capital that can be invested in improved productive facilities in the rest of the economy.

A progressive urban industrial economy contributes, in turn, to the rapid development of agriculture by expanding the markets for agricultural products; by supplying the farm machinery, chemical fertilizers, and so on, that raise the level of agricultural technology; by expanding productive employment opportunities for workers released from agriculture by technological change; and by making possible improvements in the quality of rural life by raising standards of consumption both in urban and in rural areas.

The net effect of this dynamic interaction between the agricultural and nonagricultural sectors in a developing economy is the complete transformation of the agricultural sector. Indeed, the term agriculture itself may have little meaning for the modern food and fiber industries that are in the process of emerging from the economic and technological revolution now occurring in the United States.

AGRICULTURAL DEVELOPMENT UNDER LABOR SCARCITY: THE UNITED STATES

From the time of the Plymouth and Jamestown settlements until the closing years of the 19th century, the encounter with the frontier represented a dominant theme in American agricultural development. This encounter created an opportunity for the evolution of an agriculture based on an abundance of land and a relative scarcity of labor. This, in turn, stimulated the development of an agricultural technology that was primarily directed toward achieving gains in labor productivity rather than gains in land productivity.

Since the closing of the frontier, in the last quarter of the 19th century, the encounter with an increasingly dominant urban industrial sector has emerged as a major theme in American agricultural development. By 1880, nonagricultural employment exceeded agricultural employment. By 1929, manufacturing employment alone exceeded agricultural employment. By 1970, agricultural employment was less than total unemployment in the United States (Table 1).

We can best visualize the interactions between the farm and the nonfarm sectors that led to this fundamental restructuring of the American economy by looking in turn at each of 3 sets of market relations:

Table 1. Employment by sector in the United States, 1880–1978, and projections to 1985 (in thousands of workers)[1]

Year	Agriculture	Total nonagriculture	Manufacturing	Unemployment
1880	8,585	8,807	NA	NA
1929	10,450	37,180	10,534	1,550
1950	7,160	51,760	15,241	3,288
1970	3,462	75,165	19,369	4,088
1978	3,380	87,763	20,332	6,012
1985 (est)	2,300	100,504	22,597	3,309

[1]Before 1950, data include people of age 14 and older; after 1950, data include people of age 16 and older.

1. The product market, through which the output of the agricultural sector is transmitted to the nonfarm sector and through which incomes are generated in the farm sector.
2. The input markets, through which move the manufactured inputs, equipment, and capital used in agricultural production.
3. The labor market, through which labor is allocated between the agricultural and nonagricultural sectors and among firms in each sector.

The Product Market

Throughout most of American economic history, the product market the market for things farmers sell represented the primary link between the farm and the nonfarm sectors of the economy. It was the dominant channel through which international shifts in the terms of trade, national fluctuations in non-farm income, and local variations in nonfarm demand were channeled into the agricultural sector.

In most low income countries, in which a substantial share of increases in income per capita are devoted to dietary improvement, the product market is still the main link between the peasant and the urban industrial sector of the economy. As income per person rises, consumption of agricultural products expands less rapidly (Table 2). At the highest income levels, there may be almost no additional food consumed as income continues to rise. In the United States, the declining response in consumption of food and fiber to increases in nonfarm income has almost eliminated the commodity market effects of growth in economic activity in the nonfarm sector.

In addition, agricultural trade and commodity policies have been designed that partially insulate the prices of agricultural commodities, particularly crop prices, from normal trade and market fluctuations (Chapters 24 and 25).

As a result of these changes, the rate of growth of domestic demand for food and fiber products in the U.S. economy now barely exceeds the rate of population growth. Opportunities for growth in U.S. agricultural output have become increasingly dependent on the growth of export demand and on food aid to the developing countries (Chapter 25).

Technological change in agricultural production has been accompanied by institutional changes in the product markets that link the agricultural sector to the urban industrial sector. The production of some products has become essentially industrialized. Broiler "factories" have almost entirely replaced farm production of poultry meat. Commercial production of fruits and veg-

Table 2. Comparison of growth of demand for agricultural commodities, at different stages of development (hypothetical cases).

Levels of development	Percentage of population in agriculture	Annual rate of population growth	Annual rate of income growth	Income elasticity of demand	Annual rate of growth in demand[1]
Very low income	70	2.0	.5	1.0	2.5
Low income	60	3.0	1.0	.9	3.9
Medium income	50	3.0	3.0	.6	4.8
High income	25	2.0	4.0	.5	4.0
Very High income	10	1.0	3.0	.2	1.6
Highest income	5	0.1	2.0	.1	0.3

[1]The total annual rate of growth in demand is the sum of the population effect and the income effect. The income effect is calculated by multiplying the income elasticity of demand by the rate of income growth.

etables has become highly concentrated. As a result of technological and organizational changes in processing, transportation, and distribution, regional specialization in the production of fruit, vegetables, and animal products has reduced the impact of local urban industrial development on the demand for locally produced farm products. Milk, protected by a series of local market trade barriers, remains a major exception to this generalization.

These developments in the farm sector have been accompanied by the replacement of small-scale retail stores served by local wholesalers with large chain-store distribution systems served by integrated wholesale and retail operations. There is an increasing tendency for these large distributing organizations to establish direct linkage with the large specialized fruit and vegetable producers, poultry producers, and livestock feeders, and to bypass traditional marketing channels.

This type of development has not yet had any substantial impact on the major agricultural commodities, such as wheat, cotton, corn, and soybeans, nor on most hog and beef production. But the emergence of highway truck transportation as a major competitor with the railways in the hauling of bulk agricultural commodities has eliminated many of the older terminal markets.

The Markets for Purchased Inputs

The markets for manufactured capital equipment and current inputs have become increasingly important in transmitting the effects of changes in the nonfarm sector to the agricultural sector. Much of the new agricultural technology is embodied in the form of new capital equipment or more efficient fertilizers, insecticides, and other manufactured inputs. In 1870, the typical American farm was still a subsistence unit, with inputs purchased from the nonfarm sector amounting to less than 3% of the value of farm production. By 1900, nonfarm inputs still amounted to only 7%. But by the late 1970s, they accounted for approximately 40% of the value of farm production.

The use of purchased inputs has been closely related to developments in the labor market. The demand for labor, resulting from rapid urban-industrial development, reinforced the economic pressure for substitution of capital equipment for labor in American agriculture at precisely that period when the frontier was disappearing as a major factor in agricultural development, It was during this period that the tractor, 1st functioning as the source of motive power for formerly horse-drawn equipment, and later as the power unit around which new equipment was designed, became the symbol of technological change, both in U.S. agriculture and around the world.

The rapid growth of labor productivity in U.S. agriculture was not, at first, accompanied by parallel changes in land productivity. Grain yield per hectare in American agriculture remained essentially unchanged from the end of the Civil War in the 1860s until well into the twentieth century (Table 3). By the mid 1920s, however, the production of fertilizer and other agricultural chemicals was beginning to be reflected in higher yields. Higher yield potentials were also emerging as a result of the application of advances in genetics to plant breeding by scientists in the Land Grant College system and the U.S. Department of Agriculture.

This emergence of a new chemical and biological technology in U.S. agriculture in the 1920s was itself the product of a long sequence of institutional developments. As early as 1862, the U.S. Congress passed legislation granting public lands to the states, to be used for the "support and maintenance of at least 1 college where the leading object shall be...to teach such branches of learning as are related to agriculture and the mechanic arts." It was not until 1887, however, that an act was passed that established agricultural experiment stations in each state, usually at the land grant" colleges.

By the mid-1920s, substantial progress in agricultural research, embodied in crops, produc-

tion practices, and other forms of new knowledge, was beginning to flow from the agricultural education and research system to the farmer via the newly organized federal-state extension service. Hybrid corn was a particularly dramatic product of this research.

The combination of rapid advance in biological research plus the high volume of relatively inexpensive agricultural chemicals created a new dimension in agricultural productivity in U.S. agriculture. Land productivity, which had experienced no real growth between 1900 and 1925, rose by 1.4% per year for the period 1925–1950, by 2.5% per year between 1950 and 1965, and by 0.8% per year between 1965 and 1979. This higher output per hectare combined with continued mechanization to produce a rate of growth in labor productivity of 6.6% per year between 1950 and 1965 and by 4.8% per year between 1965 and 1979 (Table 4).

The Labor Market

The labor market has become an increasingly important channel of interaction between the farm and the nonfarm sectors. Technical and economic developments have made it increasingly profitable to substitute inputs purchased from the industrial sector for farm labor. Between 1950 and 1965, the slow growth in domestic demand for farm products, the insulation of domestic markets

Table 3. Acreages, yields, and production of grains in the United States.

Period	Acreage (millions)	Production (million tonnes)	Yield (tonnes/acre)	Indexes (1880–1889 = 100)		
				Acreage	Production	Yield
1880–1889	135.0	72.2	0.535	100	100	100
1890–1899	162.8	86.8	0.533	121	120	100
1900–1909	185.2	103.5	0.559	137	143	104
1910–1919	208.1	111.2	0.534	154	154	100
1920–1929	218.2	120.2	0.551	160	169	103
1930–1939	219.6	102.8	0.468	163	142	87
1940–1949	212.5	134.7	0.634	157	187	119
1950–1959	187.9	143.3	0.762	139	198	142
1960–1964	160.7	176.7	1.099	119	244	205
1965–1969	152.9	215.3	1.408	113	298	263
1970–1974	155.0	223.9	1.445	115	310	270
1975–1979	173.0	282.4	1.632	128	391	307

Table 4. Annual average rates of change (percent per year) in total outputs, inputs, and productivity in United States agriculture, 1870–1979.

Item	1870–1900	1900–1925	1925–1950	1950–1965	1965–1979
Farm output	2.9	0.9	1.6	1.7	2.1
Total inputs	1.9	1.1	0.2	-0.4	0.3
Total productivity	1.0	-0.2	1.3	2.2	1.3
Labor inputs[1]	1.6	0.5	-1.7	-4.8	-3.8
Labor productivity	1.3	0.4	3.3	6.6	6.0
Land inputs[2]	3.1	0.8	0.1	-0.9	0.9
Land productivity	-0.2	0.0	1.4	2.6	1.2

[1]Number of workers, 1870–1910; hours of labor, 1910–1971.

[2]Cropland used for crops, including crop failure and cultivated summer fallow.

from changes in demand in other countries through import restrictions and export subsidies, and the rapid growth in labor productivity combined to place most of the burden of balancing the rate of growth in agricultural output with the rate of growth in demand for agricultural products on the labor market.

With the demand for agricultural output expanding at less than 2% per year and labor productivity rising by about 6% per year, the burden of adjustment in the labor market was extremely heavy. It was particularly difficult in the low-income agricultural regions in which local nonfarm employment did not expand fast enough to absorb both the excess agricultural labor force and the new entrants to the labor force from rural areas.

Between 1940 and 1960, the annual net emigration of farm people averaged close to 1 million people (Fig. 2). During this same period, annual average employment on farms declined from 11 million to 7 million workers. Between 1960 and 1980, farm employment declined by another 3 million workers—to just under 4 million. There is today, however, a better balance between the size of the farm population and the availability of farm and nonfarm employment in rural areas than in the past. The incomes of farm families, which averaged less than 60% of the incomes of nonfarm families in the 1950s, are, when cost-of-living differences are considered, close to parity with nonfarm incomes (Table 5).

One of the more surprising developments in the agricultural-labor market is the rise in the number of hired farm workers since 1970. The average annual employment of farm workers rose from 1.17 million in 1970 to approximately 1.25 million in 1980, while employment of operator and family labor declined from 4.5 million to less than 4 million.

Hired farm workers remain the most disadvantaged group of American workers.[1] They have less protection than other workers from arbitrary action by employers and they receive fewer employment related benefits when they are out of work. A fundamental limitation in achieving legislation to improve the position of farm workers is that they are not organized to reflect their own economic interests. Organization of farm workers is more difficult than organization of industrial workers because of the seasonal nature of much farm work and the casual attachment of many farm workers to the agricultural labor force. It is also difficult because of the weak legal protection that is given to organization efforts on the part of farm workers. Farm-operator interests are represented through general farm organizations, through commodity organizations, and through cooperatives. The neglect of the problems of hired farm workers in America is in particularly striking contrast to the attention that has been given to the economic problems of farm operators.

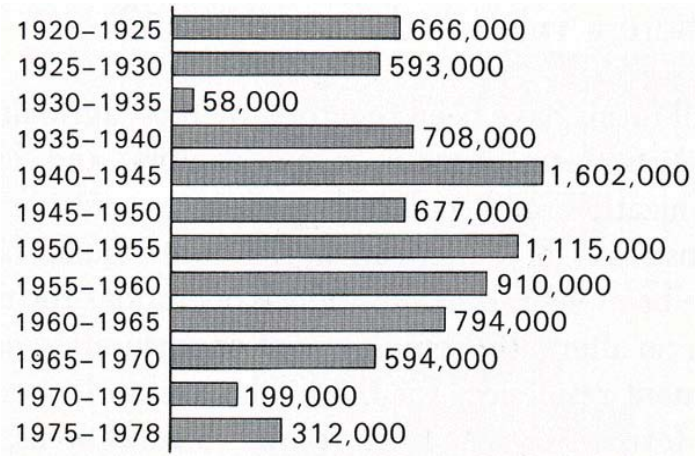


Fig. 2. Annual net emigration from the farm population. [From 1979 Handbook of Agricultural Charts (USDA/ESCS Agriculture Handbook 561), 1979.]

Structural Change

The agricultural-development policies of the United States have been uniquely successful in meeting national farm-output and productivity objectives. These poli-

[1]See Stephen H. Sosnick, *Hired Hands: Seasonal Farm Workers in the United Stated* (Santa Barbara: McNally and Loftin, 1978).

cies have been less successful in meeting the income objectives of all of the families who are engaged in the production of agricultural commodities. One observer has pointed out that "behavior of rural people, their representatives and their institutions implies a materialistic bias in favor of plants, land, and animals and against people." Although this is perhaps overdrawn, it is true that the policies of the past were designed primarily to solve technological and commodity problems rather than to solve the income problems of rural people and the development problems of rural areas.

It can be argued that this was a valid choice at the time these policies were established. It was important for U.S. economic development that the agricultural sector achieve sufficiently high rates of output and productivity growth to meet national requirements for food and fiber and at the same time to release substantial numbers of farm workers for nonfarm employment.

In spite of the productivity of American farms and the prosperity of the families that account for most of the nation's food and fiber production, there has been a growing unease about the role of rural people and of rural communities. In March 1979, in a speech at a Farmers Union convention in Kansas City, Secretary of Agriculture Bob Bergland suggested that the United States engage in a national dialogue about the future structure of American agriculture.[2]

Three issues have been of particular concern to American farm people and to rural communities:

1. Who will control agricultural production in the future?
2. Is there a role for the small farm?
3. What is the future of rural communities?

In the following sections we discuss these 3 issues.

Who will control agricultural production?

Agricultural production has been increasingly concentrated. The number of farms has declined from a peak of nearly 7 million in the 1930s to 2.7 million in the late 1970s. These numbers are somewhat misleading. A farm is defined somewhat unrealistically in the official statistics as any place with annual sales of $1000 or more.

In 1978, 82% of farm sales were accounted for by the 577,000 farms with sales of more than $40,000. The share of sales accounted for by the 50,000 largest farms rose from 23% in 1967 to 36% in 1977. It is not difficult to anticipate that by the year 2000 close to two-thirds of farm sales could be accounted for by the 50,000 largest farms and 80% by the 100,000 largest farms.

Who will own the 100,000 farms that will account for most of U.S. farm output in the future? Will they be family farms or will they be owned by agribusiness firms that integrate production, processing, and marketing activities? It seems quite clear that, unless remedial action is taken, an increasing share of the production on specialized farms engaged, for example, in cattle feeding and poultry production, fruit and vegetable production, nursery and greenhouse plant production, and sugarcane produc-

Table 5. Mean income of farm and nonfarm families by race and origin, United States, 1977.

Mean income	All families	White	Black	Spanish origin
Total	16,100	16,729	10,791	12,565
Nonfarm	16,168	16,811	10,846	12,579
Farm	14,111	14,496	6,531	NA

[2]The USDA has produced a series of reports to serve as background for the discussion of structural issues. See U.S. Department of Agriculture, *Structural Issues of American Agriculture* (Washington, D.C.: USDA/ESCS Agricultural Economic Report 438, 1979).

tion will be corporate farms, Family farms will probably continue to dominate in the more diversified farming systems and in the production of soybeans, food and feed grains, dairy products, and pork. Even in these areas, however, many family farms may incorporate in order to facilitate the intergeneration transfer of resources.

The rapid inflation of land prices in the 1970s is another factor that has led to a concentration of land ownership. Prices for agricultural land more than doubled in the decade between 1970 and 1980. The combination of larger farm size and higher prices for land and other assets has made it more difficult for young people to get started in farming without substantial family backing. This has led to a concern that the ownership of farmland may become increasingly concentrated in the hands of the wealthy that rural America will be owned by a class of hereditary landed proprietors and by integrated corporate enterprises.

An important issue for the future will be whether changes should be made in the tax laws and the inheritance laws that would reduce the incentives for farmland ownership by those who are not operating farmers.

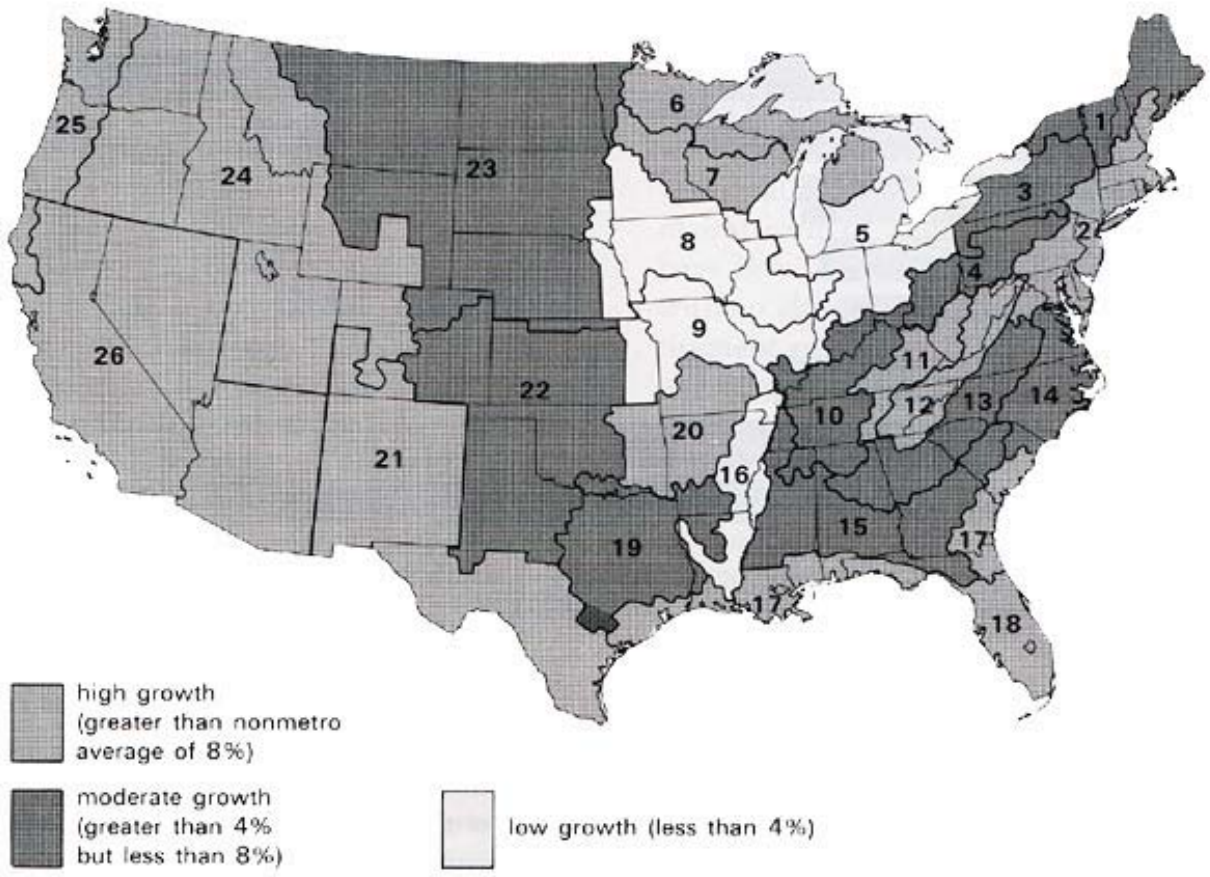
Is there a role for the small farm?

Small farms have been regarded by most agricultural scientists, farm-program administrators, and farm organization and political leaders as outside the mainstream of American agriculture. Small farms have been viewed as subsistence operations for those with no alternative employment opportunities; as retirement residences for those who are no longer active farmers or who have retired to rural areas; and as a source of part-time employment or income supplementation for persons employed in nonagricultural occupations. The information presented in Fig. 3 supports the view that, for small farmers as a group, income from farming accounts for a relatively small share of total income.

There has been a growing commitment to the idea that small farms ought to have a larger role in contemporary agriculture. The Rural Development Act of 1972 and the Food and Agriculture Act of 1977 included provisions for research and extension directed to the agricultural-production problems of small farmers. A number of pilot programs, such as the Texas Intensified Farm Planning Program and the Missouri Small Farm Program, have been started by the state extension services.

Others have been started with the help of private philanthropic foundations, In Mississippi and Alabama, 2 programs modeled on the Israeli *moshav* farm-cooperative concept have been started. Each farm involves 1200 acres and 40 farm families. The projects, which are initially heavily subsidized both from public and from private sources, are managed by a Small Farm Development Corporation. Such programs tend to be rather controversial. One newspaper that objected to the assistance provided by the USDA ran the following headline: “Government Will Establish Collective Farms under the Guise of Family Farm Development.”

The most active support for the strengthening of small-farm agriculture comes from what is often referred to as the “alternative-agriculture” movement. The alternative-agriculture movement emphasizes both technological and social alternatives to the dominant trends in U.S. agricultural and rural development over the last fifty years. In the area of technology, it emphasizes organic approaches to maintaining and improving soil fertility. Alternatives to the intensive use of pesticides are stressed. Less capital-intensive systems of crop production are employed. At the social level, smallness, self-sufficiency, decentralization, and the development of the rural community and culture are emphasized.[3]



1. Northern New England–St. Lawrence
2. Northeastern metropolitan belt
3. Mohawk Valley and New York–Pennsylvania border
4. Northern Appalachian coal fields
5. Lower Great Lakes industrial
6. Upper Great Lakes
7. Dairy belt
8. Central corn belt
9. Southern corn belt
10. Southern interior uplands
11. Southern Appalachian coal fields
12. Blue Ridge, Great Smokies, and Great Valley
13. Southern piedmont
14. Coastal plain tobacco and peanut belt
15. Old coastal plain cotton belt
16. Mississippi delta
17. Gulf of Mexico and South Atlantic coast
18. Florida peninsula
19. East Texas and adjoining coastal plain
20. Ozark-Ouachita uplands
21. Rio Grande
22. Southern great plains
23. Northern great plains
24. Rocky mountains, Idaho-Utah valleys, and Columbia Basin
25. North Pacific coast (including Alaska)
26. Southwest (including Hawaii)

Fig. 4. Nonmetropolitan population change by economic subregion, 1970–1976. [From 1979 Handbook of Agricultural Charts (USDA/ESCS Agriculture Handbook 561), 1979.]

[3]For a useful introduction to the philosophy of alternative agriculture, see Wendell Berry, *The Unsettling of America: Culture and Agriculture* (New York: Avon Books, 1977).

What is the future of the rural community?

During the 1970s, there has clearly been a reversal of the long-term trends in population in many rural areas (Fig. 4). The nonmetropolitan areas of the southern Appalachians, the Ozark Uplands, and the upper Midwest that had lost population in the 1950s and 1960s were among the regions with the most rapid population growth in the 1970s. Improvements in the health and education services in rural communities have made them more attractive places to live. Decentralization of employment opportunities have made them more attractive places to work. And the new preference for rural living has resulted in a more positive view of the advantages of rural life.

As the population of rural areas has expanded, the nonagricultural character of the rural economy and the rural community has become more pronounced. As a result, economic-development and community-development programs must address the needs of the entire rural and small-town population if they are to have any chance of success. The need to respond to expanding needs for improvements in the quality of education, to meet the health and housing needs of the elderly, and to provide for water, sanitation, and fire-protection services is placing increasing pressure on the capacities of voluntary community agencies and local governments.

A major challenge that faces rural communities is how to respond to the opportunities and pressures for growth without losing the very qualities that have led to a preference for rural life by farm people and other rural residents.

THE DEVELOPMENT OF A LABOR-INTENSIVE AGRICULTURAL SYSTEM: JAPAN

Japan was the 1st Asian country to succeed in bringing about a striking transformation in the productivity of its agriculture. In contrast to the United States, agricultural development in Japan occurred within a framework of increasing labor intensity. The average size of the Japanese farm was approximately 1 hectare (2.2 acres) in 1878 and 0.8 hectare (1.7 acres) in 1962.

In many respects, the Japanese experience was the outcome of factors peculiar to the Japanese environment. Japan is an island economy, and social institutions had been cultivated and refined over generations to permit an efficient balance between population and a limited resource base.

Despite other differences, at the time of the "takeoff", Japanese agricultural development was similar in many respects to that of other countries in Asia-a traditional agriculture characterized by small scale subsistence farms dominated by a hierarchical social structure. The level of productivity in Japanese agriculture prior to the Meiji Restoration (1868), as measured by yields per hectare or per person, were probably only slightly higher than the levels of productivity that persist today throughout the rest of Asia (Fig. 5)

The remarkable feature of the Japanese agricultural transformation, and the feature that makes it of special interest in the rest of Asia today, is that it took place within a traditional framework of small scale agriculture. Although the average farm was declining in size, the average rice yield rose from 1.8 metric tons per hectare (1868 to 1882) to 4.0 metric tons in the late 1950s and 5.8 metric tons in the mid 1970s.

During this development, Japanese agriculture went through 4 phases (Table 6):

1. A period of rapid growth lasting from approximately the time of the Meiji Restoration (1868) until the end of World War I.
2. A period of slower growth lasting from the end of World War I through World War II.
3. A new period of rapid growth, starting almost immediately after the end of World War II and continuing to the mid 1960s.
4. A period of slower growth since the mid 1960s.

Productivity Growth From Intensification of Traditional Agriculture, 1870–1920

The rapid increase in Japanese agricultural productivity between 1870 and 1920 was due to the diffusion of the superior practices already in use in Japanese traditional agriculture combined with the limited adoption of Western methods, primarily soil and fertilizer science adopted from Germany.

The basic agricultural policy of the new Meiji Government, established in 1868, developed around the ideas of Lord Iwakura, who visited North America and Europe in 1871 and 1873. Iwakura's visits were followed by tours made by other Japanese officials, and western agricultural experts were invited to Japan. At first, most of these experts came from the United States and England. Later, experts from Germany were invited. The Japanese officials who returned to Japan from western countries stressed the need for raising the level of Japanese agriculture to that of the West by adopting western-style extensive farming in place of small-scale intensive farming. It became apparent, however, that instead of the large-scale farm-management techniques developed in North America and England, the knowledge and techniques of Germany, particularly the new

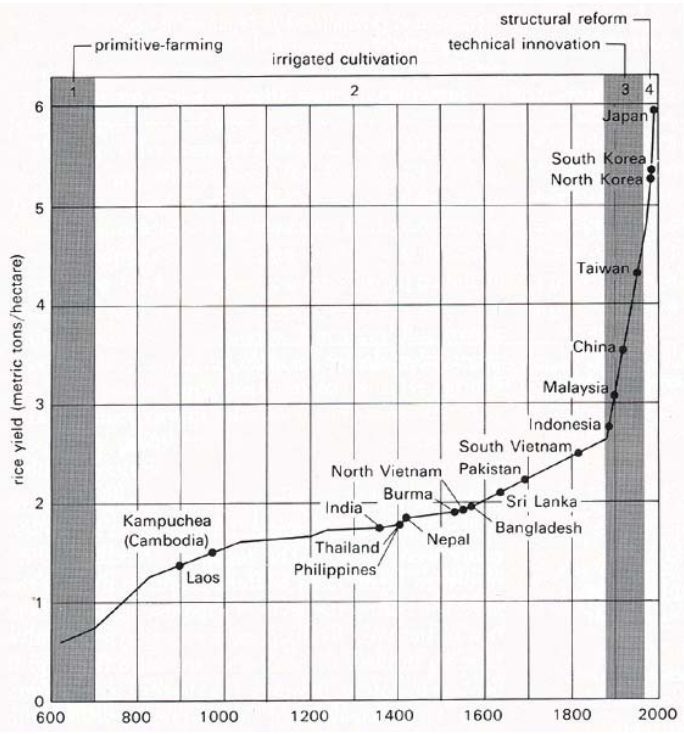


Fig. 5. Current rice yields (rough rice) in selected countries related to Japan's historical trend. Intensification of farming on land now being farmed is the other way to grow more food. This means moving farming in developing regions to higher stages of development, in effect recapitulating the historic progression exemplified here by the case of Japan. Typical rice yields in Japan increased (black curve) as Japanese agriculture moved from the traditional stage through the advent of irrigation to scientific agriculture and finally to structural transformation. Current yields in most Asian countries, where less than 50% of the rice land is cultivated, place them still in second stage, as plotted. [From W.D. Hopper, "The Development of Agriculture in Developing Countries." Copyright © 1976 by Scientific American, Inc. All rights reserved.]

Table 6. Annual average change in total outputs, inputs, and productivity in Japanese agriculture, 1880–1975.

Item	1880–1920	1920–1935	1935–1955	1955–1965	1965–1975
Farm output	1.8	0.9	0.6	3.6	1.4
Total inputs	0.5	0.5	1.2	0.7	-
Total productivity	1.3	0.4	-0.6	2.9	-
Labor inputs	-0.3	-0.2	0.6	-3.0	-3.6
Labor productivity	2.1	1.1	0.0	6.6	5.0
Land inputs	0.6	0.1	-0.1	0.1	-0.7
Land productivity	1.2	0.8	0.7	3.5	2.1

knowledge of soils and fertilizers, would become more realistic and practical in application to the small-scale Japanese agriculture. Only in the northern island of Hokkaido did extensive farming based on livestock production and western-style "horse mechanization" find a permanent home.

In 1887, a new agricultural policy was adopted that shifted emphasis away from introducing western farming methods to bolstering traditional farming methods. There were 3 major elements in this new policy:

1. Selection and diffusion of high-yielding cultivars of rice
2. The establishment of a fertilizer-consuming agriculture
3. Introduction and diffusion of new cultural practices and implements

These 3 policies were closely interrelated. The new rice cultivars selected were those that responded well to nitrogen fertilizer. Such cultural practices as deep plowing, double cropping, straight-row planting, revision of field layouts, irrigation and drainage, and others were also oriented toward obtaining a favorable response from increased fertilization. Table 7 traces the evolution of the use of fertilizer in one Japanese prefecture from 1877 to 1957.

These policies were effective for several reasons. Over the preceding 300 years of the Tokugawa period, agricultural techniques had been slowly improving, but the restraints of the feudal system had suppressed the diffusion of new techniques. Under the feudal system, peasants were bound to their land and not allowed to leave their villages except for religious pilgrimages. Nor were they free to choose which crops to plant or which cultivars to sow. The feudal lords were anxious to raise agricultural productivity in their own territories, but they frequently prohibited the transfer of techniques or cultivars outside their bounds. It is even recorded that 1 village placed a guard at its border to prevent a variety of seed selected in the village from being taken out.

A 2nd factor in the success of the Meiji agricultural policy was the pattern of investment in agricultural education by the government. Agricultural schools were organized as early as 1876. An agricultural experiment station and seed breeding station was established in 1877 10 years before the U.S. Congress passed the Hatch Act, which established experiment stations in each state. By 1900, Japan had developed a number of national research institutions as well as a network of experiment stations at the prefectural level.

Initially, the most successful "veteran farmers" were used to carry improved techniques to other farmers in their own and in other prefectures. By 1893, 11 years before the establishment of the federal-state extension service in the United States, the prefectural experiment stations were given responsibility for formal extension activity.

Thus the prefectural experiment stations became extension centers for the dissemination of new knowledge to associations of village farmers. Failure to adopt improved technologies was frequently punished by fines or arrest. This obviously created a somewhat different level of receptivity than the county agents in the United States faced when they began their work in 1914.

Stagnation of Traditional Agriculture, 1920–1946

Shortly after World War I, Japan appeared to have reached the limit of agricultural development that could be attained by using traditional methods. The rate of growth of agricultural output declined. Food shortages developed in the face of a growing urban population. Whereas agriculture had been a major source of support for Japan's industrial revolution during the Meiji era, it now became a depressed area in the economy. The land-tenure system placed increased burdens on the tenants and dampened incentives to produce.

A number of significant changes took place during this period. Agricultural land develop-

Table 7. Changes in application of fertilizers in Kanaya-Machi, Shizuoka prefecture, Japan, 1877–1977.

Year	Major fertilizer	Rice		Barley		Tea	
		Plains	Mountains	Plains	Mountains	Plains	Mountains
1877	Natural organics	Grass	Grass	Night soil	Unknown	Soybean meal, shrimp	Unknown
1887							
1897	Green manure and organic by-products	Grass, compost, soybean and fish meal	Grass, compost, soybean and fish meal	Night soil, compost, soybean meal, superphosphate	Night soil, compost	Soybean meal, shrimp, organic mixes	
1907		Grass, compost, soybean and rapeseed meal, spent distillery mash, green soybean	Grass, soybean and rapeseed meal, seaweed	Night soil, compost, soybean meal, superphosphate	Night soil, compost, superphosphate	Night soil, shrimp, organic mixes, soybean meal, green soybean	
1917		Grass, compost, soybean and rapeseed meal, sodium nitrate, ammoniated superphosphate	Grass, soybean and rapeseed meal, ammonium sulfate, superphosphate	Night soil, compost, superphosphate, soybean meal, ammonium sulfate	Night soil, compost, superphosphate	Night soil, meal, organic mixes, shrimp	Soybean and fish meal
1927	Chemical	Grass, compost, fish meal, ammonium sulfate, sodium nitrate, mixed	Grass, compost, night soil, organic mixed fertilizers, superphosphate, ammonium sulfate, sodium nitrate	Night soil, compost, meal, ammonium sulfate, superphosphate, mixed	Night soil, compost, meal, ammonium sulfate, superphosphate, mixed	Night soil, meal, green soybean, organic mixes	Grass, organic mixes, superphosphate, ammonium sulfate
1937		Compost, fish meal, ammonium sulfate, superphosphate, potassium chloride, calcium cyanamide ammonium phosphate, mixed	Grass, compost, wood ash, night soil, ammonium sulfate, calcium cyanamide, superphosphate, potassium chloride, mixed	Night soil, compost, ammonium sulfate, superphosphate	Night soil, compost, ammonium sulfate, superphosphate, mixed	Superphosphate, ammonium sulfate, mixed	Rapeseed meal, grass, ammonium sulfate, mixed
1947		Rapeseed meal, ammonium sulfate, calcium cyanamide, potassium chloride, fused phosphate, mixed	Night soil, compost, ammonium sulfate, potassium chloride, urea, fused phosphate, mixed	Night soil, compost, potassium chloride, ammonium sulfate, calcium cyanamide, mixed	Night soil, compost, ammonium sulfate, superphosphate, mixed	Grass, ammonium sulfate, calcium cyanamide, mixed	Fish and rapeseed meal, ammonium sulfate, calcium cyanamide, urea, mixed
1957		High synthetic, low synthetic compound, calcium cyanamide (granular, dust), calcium cyanamide compound, potassium phosphate ammonium mixed, special compound for rice seedling bed, silic calcium, ammonium chloride, magnesium lime, mixed, urea intermixed compound, ammonium potassium compound[1]		Low synthetic compound	None grown	Superphosphate of lime, fused phosphate, potassium chloride, potassium sulfate, low synthetic compound, high synthetic compound, organic matter intermixed compound, multiphosphate, phosphate potassium ammonium mixed, phosphate ammonium nitrate, potassium mixed, magnesium lime, fish meal, seed cake, chicken droppings, ground bonemeal, ground composts[1]	
1977							

[1]The distinction between plains and mountains has tended to disappear as a result of continued modernization.

ment was pushed into marginal areas. Farmers began to shift their production away from rice into the even more labor-intensive livestock production, silkworm raising (sericulture), and fruit and vegetable production. The shift away from rice was partly in response to the lowering of prices that resulted from the importation of rice from Formosa (Taiwan) and Korea.

The rapid shift of farm workers from agricultural to nonagricultural employment during the period was not sufficient to reduce the size of the agricultural labor force. Farm employment did decline, however, from roughly 40% of the labor force at the beginning of the period to less than 20% by the beginning of World War II.

By the beginning of World War II, Japanese agriculture was again beginning to experience rapid economic growth. During the war, however, agriculture suffered from shortages of labor and materials. Availability of commercial fertilizer dropped sharply. The yield of rice fell in 1945 to only about 70% of the prewar level.

The Modernization of Japanese Agriculture

Following World War II Japanese agriculture experienced a new burst of productivity. 2 factors appeared to have been particularly important.

1. The increased incentive to produce, which resulted from the land reform of 1947–1950.
2. The backlog of modern technology resulting from the increased sophistication of experiment-station research and the increased industrial capacity that emerged from World War II.

The postwar land reform represented the culmination of land improvement that began during the Meiji restoration rather than any sharp break with the past. All farmland owned by absentee landlords and all farmland leased by resident landlords in excess of 4 hectares was appropriated by the government and sold to the actual tenants. About 2 million hectares, approximately 80% of the tenant-cultivated land, was acquired by tenant farmers. The result was a major improvement in incentives to adopt new technology and increase production (Table 6).

The change in agricultural technology since World War II can be illustrated by the following. The new rice cultivars being planted in Japan today are the result of experiment station breeding programs designed to produce high yielding, disease resistant varieties that respond well to fertilization. This is in contrast to the basis of selection that prevailed during the Meiji period, when the best cultivars were selected from the many already in existence. The new breeding programs, however, did not depart in their objective from that of the older selection programs. The varietal improvements and associated cultural practices continued to be directed toward the development of a “fertilizer consuming rice culture.”

The increased capacity of Japanese industry to produce fertilizers and other agricultural chemicals has complemented this traditional objective. There has, however, been 1 major change. As a result of Japan’s continued rapid industrial development, the agricultural labor force began to decline in the 1950s. Agricultural wage rates have risen. Small scale mechanization, including the use of power sprayers and dusters and the use of electric motors and internal combustion engines for threshing and pumping irrigation water, has expanded rapidly. Most striking of all has been the rapid small scale mechanization of plowing and other field operations. The use of mechanized equipment for field operations was trivial before World War II, but by 1960 there were half a million small tractors or cultivators in use. By the 1970s, this small scale equipment was being replaced by larger land preparation and tillage equipment.

A major problem of structural reform in Japanese agriculture is how to increase the size of

the farm operating unit in an equitable manner. Programs of assistance for land consolidation and cooperative use of farm equipment have been implemented. The Farmers' Pension Fund is authorized to purchase agricultural land from older farmers and sell it to farmers who want to enlarge their farms. The fund can also assist in financing the purchase of land from retiring farmers.

The Significance of Japanese Agricultural Development

This history of Japanese agricultural development illustrates how the agricultural sector of the economy was able to fulfill its traditional role in the strategy of overall development. Japanese agriculture, in the course of its transformation, was able to earn foreign exchange, to provide savings and investment for a developing urban industrial sector, and to supply raw materials and foodstuffs for the rest of the economy.

Most significant of all, this was achieved within a system of small scale, labor intensive farming made possible by placing greater emphasis upon the "biological revolution" than upon the "mechanical revolution." In the next several decades, as the Japanese agricultural labor force declines, it seems likely that Japanese agriculture will successfully complement the "biological revolution" of the last 100 years with a "mechanical revolution," leading to a fully modern system of agriculture. The Japanese example, with its initial stress on the "biological revolution," represents a more valid model for many of the developing economies than the United States model.

THE TAKE OFF THAT FAILED: ARGENTINA

Agricultural development in Argentina presents an interesting contrast to both the United States and Japan. Like the United States, Canada, and Australia, Argentina developed, during the 19th century, an agricultural system based on an abundance of land and a relative scarcity of labor. By the late 1920s, Argentina ranked among the leading countries in the world with respect to income per capita. Its prosperity was based on an economic system that involved:

- Exportation of agricultural raw materials, particularly food and feed grains, oil crops, and meat and wool
- Importation of manufactured capital equipment and consumer goods

The disorganization of international markets during the world depression of the 1930s and during World War II impressed upon Argentina's policy-makers the desirability of developing a more diversified economy. Industrialization became a major policy goal.

In an effort to increase the foreign exchange earnings needed to finance industrialization, Argentina established a government monopoly to handle the export of primary commodities. The monopoly paid low prices to Argentina's agricultural producers and attempted to bargain for the highest possible prices for the export commodities on world markets. The prices received by Argentine farmers were kept far below world market prices. This was equivalent to a heavy tax on agricultural production.

The effect was to dampen incentives either to produce or to export agricultural commodities. Agricultural production increased by less than 10% between the periods 1945–1949 and 1959–1961. Argentina's share of world exports of a number of major agricultural commodities declined sharply from prewar levels (Table 8). This weakened Argentina's capacity to import. By the mid 1950s, imports of capital goods needed for industrialization had dropped below prewar levels.

The lack of price incentives might have been partially offset if Argentina had given support to technological change in agriculture by building agricultural research and extension programs in a manner comparable to the United States and Japan. Even today, however, Argentina has only a

relatively weak agricultural research and extension establishment. Corn yields remain relatively low compared to those of the United States and a number of other countries.

Thus the heavy taxation of Argentina's agricultural technology killed the goose that laid the golden eggs that were expected to pay for the program of industrialization. Today Argentina's income per capita ranks her either as one of the less prosperous developed nations or one of the more prosperous developing nations, rather than in the position among world leaders that she held in the 1920s.

Argentina's heavy taxation of agricultural exports, in such a way as to reduce directly the prices received by farmers, was in sharp contrast to the policies adopted by the Japanese during the last 3rd of the 19th century. Japan successfully utilized the export earnings from tea and silk to finance industrialization. Distortion of production incentives was avoided by using a heavy land tax to raise revenue from agriculture instead of directly interfering with prices. The favorable prices for silk and tea were allowed to act as incentives to produce supplies for export, and the land tax, which was not affected by the level of production, was used to finance industrialization.

During the 1970s, there were some indications that Argentina was beginning to adopt policies that would provide greater incentives for agricultural production. The response of agricultural production and exports to these greater incentives has, however, been obscured by the extremely high rates of inflation in Argentina.

DEVELOPMENT IMPERATIVES

There are numerous examples of situations in which rapid progress in agricultural development did not lead to sustained economic growth because of the absence of other elements critical to the process of development. Many examples of this type can be drawn from the former colonial economies. The Dutch experience in Java is particularly striking. The Dutch were remarkably successful in their efforts to develop improved crop varieties and cultural practices for a number of tropical export crops. The Agricultural Research Institutes that they developed at Bogor were among the best in the world.

The colonial system was not, however, successful in developing the capacity of the Javanese population. The result was a dual economy that provided high incomes for the expatriate owners and employees who ran the plantation and for the firms that handled the export commodities.

Table 8. Share of Argentine exports in world exports of selected commodities (expressed as percentages).

Commodity	1934–1938	1959–1962	1968–1970	1975–1977
Wheat and wheat flour	19.3	5.5	4.6	5.2
Corn	64.0	18.5	14.2	7.3
Greasy wool	11.7	9.9	5.8	5.6
Degreased wool		13.9	13.8	11.6
Linseed and linseed oil[1]	67.6	49.3	29.3	23.5
Linseed, cake and meal	NA	71.6	59.5	55.2
Sunflower seed and its oil[1]	NA	14.1	5.3	4.9
Sunflower seed, cake and meal	NA	95.2	75.0	74.4
All fresh, chilled, frozen meat	39.7	17.5	11.8	5.4

[1]It has been assumed that three tons of linseed and sunflower seed are equivalent to one ton of linseed oil and sunflower-seed oil.

Production of food for local consumption continued to be produced by traditional methods by the local population. Gains in productivity per hectare were absorbed by population growth with no rise in the standard of living of the indigenous population.

The same pattern was repeated, although perhaps not as strikingly, in India, in the Philippines, and in many other former colonial economies in Asia and Africa.

Successful economic development involves a complex of technological, economic, and cultural changes. Rapid productivity changes in agriculture are becoming an increasingly essential component in this complex. In the past, countries like the United Kingdom, the United States, and Australia were able to achieve rising incomes in advance of growth and land productivity (Fig. 6). The United Kingdom was able to postpone the yield takeoff because it was more profitable to capitalize on its early technological lead by exporting manufactured goods and importing foodstuffs and raw materials. The United States and Australia, because of a relatively favorable ratio of land resources to labor, were able to concentrate on achieving rapid growth of labor productivity prior to emphasis on land productivity.

Japan's experience in generating an income takeoff and a yield takeoff at the same time is unique. This is clearly the optimum pattern for most of the presently developing countries, particularly those that already have a high population relative to land resources. For many of the developing countries, particularly those that are unable to limit the rate of population growth, it may be necessary for a yield takeoff to precede an income takeoff.

Important as yield increases are, they are but one of a number of closely, interrelated factors involved in agricultural development, The development of the countries studied in this chapter-the United States, Japan, and Argentina-illustrates the workings of 5 "essentials" and 5 accelerators."

The 5 essentials are:

1. New farm technology
2. Availability of purchasable inputs
3. Markets for products
4. Transportation
5. Incentives for agricultural producers

The adequacy of these five determine the possibilities of agricultural development. They are like the parts of a wheel (Fig. 7); none is useful without the others.

The accelerators are those factors that, although not absolutely essential for agricultural growth, can contribute to speeding up the rate of growth once the essentials are met. The 5 accelerators are:

1. Education
2. Production credit
3. Effective farm organizations or associations
4. Improving or expanding the land base
5. Effective agricultural planning

There can and will be some growth in agricultural productivity wherever all of the

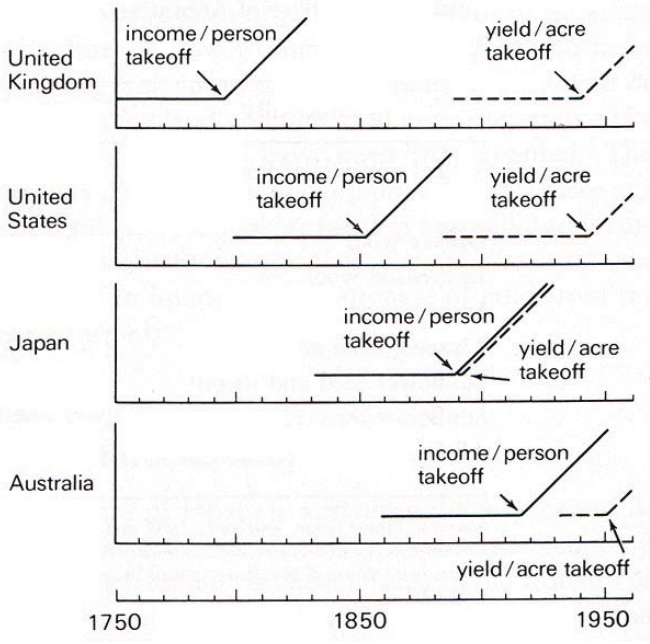


Fig. 6. Take-off dates for income per person and yield per acre in selected countries. [After Brown, Increasing World Food Output (USDA Foreign Agricultural Economics Report 25), 1965.]

essentials are present, but without all of them there will be none. The situation is different with the accelerators. Each of them is important but none are indispensable. But in many countries it is necessary that agricultural development proceed as rapidly as possible. Recent studies have documented that investment in agricultural research often gives returns 5 to 10 times higher than conventional returns on capital investment. By placing emphasis on the accelerators, as well as on the essentials, the pace of progress can be accelerated and the return on the investment in the essentials can be raised.

DEVELOPMENT CONSTRAINTS

It is conventional to emphasize the social and economic gains brought about by agricultural development. These gains have been substantial. In short, productivity growth in agriculture has been an essential component of the total development process.

The harmful effects of agricultural development are frequently ignored. They are primarily of 2 types.

- 1st, there is the environmental stress that occurs as a by product of productivity growth.
- 2nd, there is the social stress resulting from inequities in the partitioning of the costs and benefits of agricultural development.

Environmental Stress

The environmental damages caused by productivity growth were discussed in Chapters 5, 24, and 27. They are largely the by products of the increases in intensity of cropping systems associated with the use of insecticides and herbicides, and of nitrogen and phosphate fertilizers, and of the processing of agricultural and forest products. Concern has also been expressed about the loss of genetic diversity in crops that have been bred for high yields and about the effects of deforestation on climate and on oxygen production.

These social costs have not been adequately reflected in most calculations of the economic returns from investment in research or in trends in output per unit of input (Table 4 and Table 6). There can be no question that the problems of environmental congestion and pollution, both from agricultural and from industrial sources, have reached serious dimensions in specific localities and regions. The casual use and diffusion of certain materials, such as chlorinated hydrocarbons, pose a serious threat to environmental stability, public health, and economic activity.

Recent debate on environmental policy has tended to polarize around 2 alternatives. One is the antigrowth movement. It is founded on the view that the relation between people and the environment is so delicate that the effects of economic growth on the natural world may seriously impair the capacity of the earth to support life. The ca-

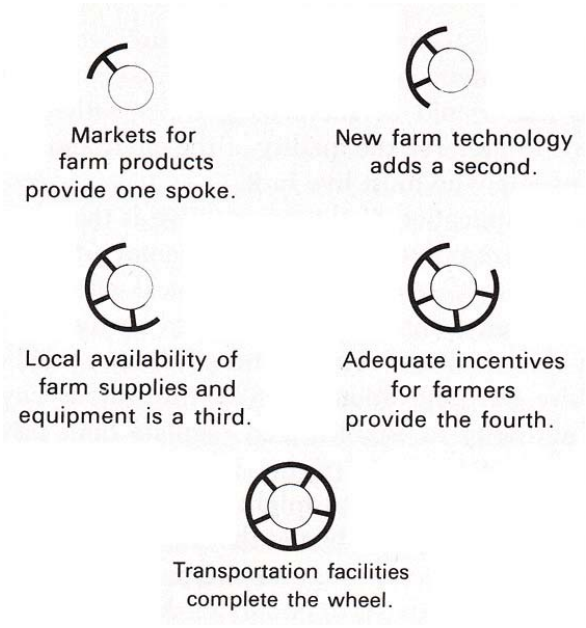


Fig. 7. The five essentials for agricultural development are like the parts of a wheel. [After A.T. Mosher, Getting Agriculture Moving: Essentials for Development and Modernization. Praeger, 1966.]

pacity of the ecosystem to sustain production and to absorb the byproducts of productive activity is regarded as finite; the limits to growth are being approached exponentially; and the conclusion is that, if present growth trends continue, the world will face ecological disaster within a matter of decades.

An alternative view is that scientific and technical effort can be redirected to permit the reduction of environmental stress and the continued acceleration of the performance of the ecosystem.

In the past, the capacity of the environment to absorb pollutants or residues seemed to be infinite. Consequently the tendency was to bias the direction of technical change toward excessive production of residues. This process has been clearly apparent in agriculture. Although one effect of the agricultural commodity programs has been to make the use of land in agricultural production "expensive" by restricting its use, at the same time, the ability of the environment to absorb the residues from crop and livestock production has been assumed to be limitless. As a result, in the development of agricultural innovations in the United States, too much emphasis has been placed on the development of land substitutes—plant nutrients, plant protection chemicals, crop cultivars, and management systems that reflected the overvaluation of land and the undervaluation of the social consequences of the absorption or disposal of the residues from agricultural production processes. It also seems apparent that these biases in resource pricing have led to underinvestment in scientific and technological efforts directed toward those pest management and soil management systems that would be more compatible with current efforts to preserve the quality of the environment for the people who must live in it.

The implication of this perspective is that the appropriate response to the environmental crises is the redirection of scientific and technical effort to reduce the environmental stress caused by the production of agricultural commodities. This move will also require the innovation of social institutions having the authority to establish and regulate both private and public property rights in environmental resources. One possibility might be the establishment of private firms or public authorities with appropriate incentives to manage environmental resources. Another alternative is to design market or marketlike mechanisms to direct the production and use of environmental commodities and services.

The basic limitation of the 1st, or "crisis," approach to environmental stress is that too much preoccupation with the threat of ultimate disaster diverts attention from the efforts needed for solution of the problems that are of immediate concern. The skills attained in scientific, technical, and institutional innovation required to solve the more immediate, if less dramatic, problems will add to our capacity to solve the more distant, through more dramatic, problems as they emerge.

Social Stress

Agricultural and economic development places great stress on the social systems as well as on the ecosystem. Technological change widens the options available to a society. It makes available to society new income streams that can be used to support a wide range of individual and social objectives. Economic units, such as firms, households, and public agencies, are engaged in a continuous struggle to capture or internalize the new income streams resulting from economic growth and to avoid the costs associated with growth. The broader society is simultaneously engaged in a struggle to force the economic units to bear the costs of growth and to diffuse or externalize the benefits.

In agriculture, the socialization of much of agricultural research, particularly the research leading to advances in biological technology, is an example of public sector institutional innova-

tion designed to realize for society the potential gains from advances in agricultural technology. The political and legislative history of farm price programs, from the mid 1920s to the present, can be viewed as a struggle between agricultural producers and society in general regarding the partitioning of the new income streams between agricultural producers and consumers.

The gains from agricultural development are also distributed unequally among the several social classes engaged in agricultural production. For example, when the benefits of technical change are computed, usually little consideration is given to the losses undergone by displaced workers. In a study of the returns from the invention, development, and use of the tomato harvester in the United States, it was found that the social returns, assuming that workers would be compensated for their loss of jobs, were several orders of magnitude below the level of returns when such losses are not included.[4] Effective social institutions to facilitate such compensation are not available. Therefore, the adoption of the tomato harvester provided a net gain to society but also imposed substantial uncompensated losses on workers. Part of this gain, then, was actually a subsidy to the producers by the workers.

In the United States, the effects of such displacement are often of relatively short duration because of the capacity of economic growth in other sectors of the economy to absorb the labor displaced by technological change in the agricultural sector. Where the capacity to absorb displaced workers does not exist, the intensity of the sociopolitical struggle over the partitioning of gains the new income streams resulting from agricultural development may be quite intense.

Some of the conflict is between land owners, tenants, and landless laborers over the distribution of the increase in farm income. Some is between the rural and urban sectors regarding how much of the gains will be transferred to urban workers in the form of lower prices. There is a struggle between the private and public sectors concerning control of the uses of the growth "dividends." Also, within the public sector, the "military" and the "development" bureaucracies frequently struggle over the uses of new resources available to the public sector. The effects of agricultural development, and of economic development generally, max, be to generate more social tension than the political systems of many countries seem able to absorb.

A viable sociopolitical environment is essential for the successful solution of the problems of environmental stress accompanying economic growth. The evolution of a viable sociopolitical system, capable of introducing institutional innovations that effectively allocate the gains of growth among classes and sectors, is fundamental to the development process.

SCIENCE, TECHNOLOGY, AND AGRICULTURAL PROGRESS

This book has given major attention to the scientific and technological foundations that underlie the creation of new agricultural practices. New technology, particularly new crop production technology resulting in higher yields, is 1 of the 5 essentials for agricultural progress.

The foundation of biological science on which this new crop production technology rests is becoming increasingly sophisticated. It requires greater depth in the training of biological and agricultural scientists in their respective disciplines. If the new agricultural technology is to exert an impact on agricultural production, increasing sophistication is also required in the agribusiness and public sectors of the economy, since these sectors organize and make available to agricultural producers the other 4 essentials—purchasable inputs, markets, transportation, and incentives.

[4]Andrew Schmitz aod David Seckler, "Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester," American Journal of Agricultural Economics, vol. 52, no. 4, p. 569–577, 1970.

It is also true that the biological and agricultural scientists who develop the new science and technology can make the greatest contribution to agricultural progress if they can achieve a broad understanding of the process of agricultural development itself. Agricultural progress depends not only on the specialized skills of a wide variety of persons engaged in many occupations and activities in each country attempting to develop its agriculture but also on an understanding of the nature of agricultural development. Such understanding is needed not only by agricultural scientists, educators, planners, and administrators but by legislators, editors, merchants, bankers, and many others.

For this reason the scope of this book is considerably wider than the typical introduction to a field of science. It provides a broad international and interdisciplinary orientation to the problems of crop science and production. There are, however, many chapters that remain unwritten or incomplete. Their completion will depend on the potential scientists, educators, farmers, and citizens who will be organizing and carrying out the agricultural development efforts of the future.

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