The U.S. Agricultural System and Global Markets

2

Far-reaching changes in technology, domestic and global markets, and organizational structure have had a profound impact on the U.S. agricultural system. Within the new framework that has evolved, agricultural output, marketing decisions, and farmers' incomes are tied ever more tightly to global markets and market prices. The traditional beacons of domestic demand and government farm programs, which farmers looked to for guidance on what to plant, how to market, and what to export, are steadily being replaced by market signals—signals that emanate from many different countries and filter through markets located in urban areas like New York, Chicago, Memphis, and Kansas City.

The structure of farms has changed as well. Six million farms produced the nation's food during World War II, but now, a commercial agricultural sector of less than one million farms accounts for more than 95 percent of all farm output. Another million or so part-time farming operations add to agricultural supplies, although the operators of these farms earn more from work they do off the farm than from farming itself. Together, higher farm incomes on commercial farms and more off-farm income on part-time farms have raised farm household incomes to the national average of all U.S. households. The improved economic status of farm households has helped to stabilize the farming sector, slowing the loss of individual farms and helping more farms to stay solvent.

As technological, economic, and social forces have combined to increase the average size of farms, farm output has increased. As output has grown—as domestic surpluses have become the norm, and budget costs for disposing of stocks a major concern—

public debate over adequate food supplies has been supplanted by concerns about food quality, human nutrition, food safety, environmental protection, and the development of a sustainable agricultural system. In this new paradigm, farm tillage methods have changed and the environmentally unfriendly moldboard plow has largely disappeared; fertilizer and pesticides have been monitored more closely for their impacts on water quality as well as crop output; and biotechnology has been hailed as an evolving technology that can potentially improve productivity as well as enhance food quality, food safety, and environmental quality.

Faced with new demands from consumers, farmers have devised new marketing arrangements to better match farm output with consumer needs. Contract production and vertical integration (in the first instance, producing goods according to strict contractual stipulations; in the second, putting functions such as production, marketing, and retailing all under one roof) have become crucial to agricultural production, lowering economic risk and improving quality control. Simultaneously, developments in other countries have broadened the composition of their agricultural imports, expanding markets for U.S. value-added food items (a category that includes processed grains, fruits, vegetables, and meat). As U.S. exports of bulk commodities (mostly raw grains) slumped in the early 1980s, exports of value-added foodstuffs continued to grow, offsetting some of the loss in export earnings. Even though exports of U.S. value-added foods expanded, however, total global trade in these items expanded faster—which means that the United States, relatively speaking, has been losing ground in global food markets.

Part of the problem is the United States' emphasis on bulk commodities, a legacy of current farm programs that originated in the 1930s. These programs result in multiple subsidies, first for producing bulk commodities, and then for disposing of them in export markets. Substantial budget savings and greater efficiency could come from gradually phasing out incentives for producing bulk commodities, and allowing farmers to respond more appropriately to expanding global markets. Another useful change would be to redirect current market research efforts. Approximately 60 percent of all food and agricultural research expenditures is directed to animal and crop production; less than 5 percent is spent on researching international and domestic markets. As global markets continue to change, more research on changing trends in food trade, and their implications for U.S. agriculture, is essential.

With farm incomes higher, and with global markets now boosting demand for U.S. agricultural products (especially value-added food exports), the nation has an opportunity and, some would argue, the government an obligation to formulate new policies for U.S. agriculture. As a foundation for developing future legislative options, this chapter examines in detail the state of the U.S. agricultural system, its evolution over the past few decades, and its operation in the current economic and technological climate.

THE AGRICULTURAL PRODUCTION SYSTEM

U.S. agriculture has undergone tremendous changes in the course of this century. Gone are the days of the Great Depression, with its low prices and incomes. Gone are the days of World War II, when more farm output was deemed a national priority. Gone are the post-war decades of agricultural adjustment, when surpluses burdened markets and farm numbers sometimes fell more in a single year than they now fall in a decade. Today, agricultural productivity is impressive, resources are concentrated on larger farms although part-time farming is widely practiced, and farm household incomes have improved considerably. Despite the changes, agriculture remains an industry of enormous diversity, in terms of geography, production systems and practices, and in terms of income levels and asset values.

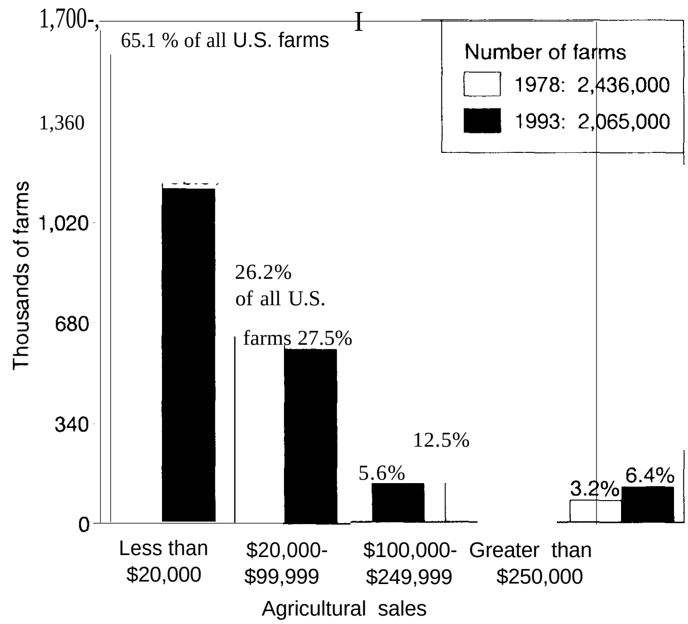
Commercial Farms and Agricultural Output

The structure of the U.S. agricultural sector has been streamlined substantially over the past few years, as a consequence of four key factors. First, technology in the form of mechanization allowed individual farmers to handle more acres of land, while new technology in the form of higher yielding seed varieties and pesticides increased output and lowered real commodity prices. Second, lower real prices cut into the incomes of farmers who were unable to produce more, leading some of them to seek jobs off the farm and others to retire. In both instances, other farmers generally took over their land. Third, farmers learned to manage their land better; and fourth, job opportunities off the farm grew. Slowly, the six million farms that existed during World War II became two million farms by 1994.[1]

The decline in farm numbers reflects the loss of more small, part-time operations (those selling less than $20,000 worth of output) than larger commercial farming operations.[2] In 1978, some 1.6 million farms sold less than $20,000 worth of output. Most were part-time operations. By 1993, the number of such farms had fallen to 1.1 million, a loss of 500,000 farms over 15 years (figure 2-1). In this same period, the number of farms selling more than $20,000 worth of output actually increased, rising from 908,000 farms to 960,000 farms (22).

As the total number of farms declined, the shares of output accounted for by commercial and part-time farms changed. Part-time farms (under $20,000 worth of sales) accounted for 7.5 percent of all farm output in 1978 and 6.2 percent in 1993 (figure 2-2). Intermediate-size farms-farms selling between $20,000 and $100,000 worth of output—also lost in terms of share of production: they accounted for 30 percent of farm output in 1978 and 17 percent in 1993. Larger farms-those

FIGURE 2-1: Number of Farms by Size of Sales



SOURCE: U.S. Department of Agriculture, Economic Research Service (EC IFS 13-1), Economic Indicators of the Farm Sector, *National Financial Summary* 1993

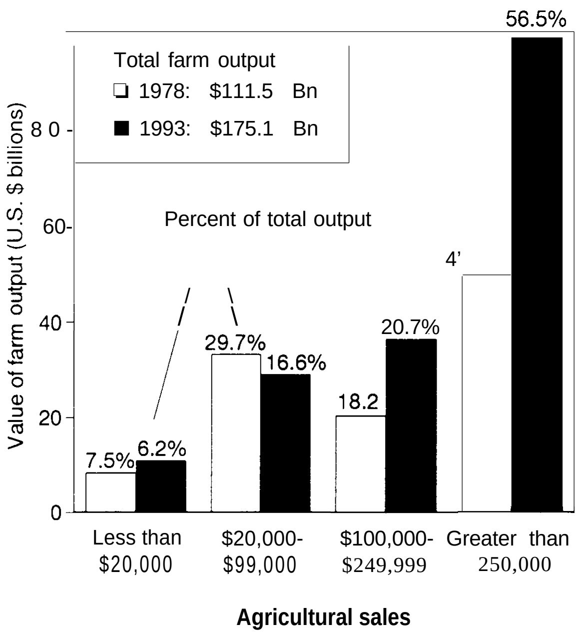
selling more than $100,000 but less than $250,000 worth of output annually—increased their share of total farm output from 18 percent in 1978 to 21 percent in 1993. Farms selling more than $250,000 worth of output each year also increased their share of total farm output. Although they represent only 6 percent of all farms, these enterprises now account for 57 percent of all farm output, up from 45 percent in 1978.

The fact that only two million farms, or more accurately one million commercial farms, can sat-

[1]The number of farm varies according to whose estimate is used. The 1992 Census of Agriculture counted 1,925,000 farms, but excluded farms currently in the Conservation Reserve program (CRP) and farms producing Christmas trees. Horse farms were included. The U.S Department of Agriculture's (USDA) estimate of farm numbers for 1992 is 2,094,000, a figure that includes CRP farms and Christmas tree farms, but excludes horse farms. The USDA estimate for 1994 is 2,044,000 farms.

[2]The definition of what constitutes a commercial farm varies by region and type of farm, as does the definition of what constitutes a part-time farm. Some farms with large sales probably are managed by operators who also manages off-farm enterprises and considers the farm enterprise as less than full-time employment. Alternatively, some farms with less than $20,000 of sales may engage the operator full time. For this study, we have arbitrarily divided farms into part-time (under $20,000 in sales) and commercial (more than $20,000 in sales) farms.

FIGURE 2-2: Farm Output by Farm Size



SOURCE U S Department of Agriculture, Economic Research Service (EC IFS 13-1), Economic Indicators of the Farm Sector, *Nationai Financial Summary 1993.*

isfy the nation's food and fiber needs is the result of large increases in land and labor productivity. Technical advances such as hybrid seeds, irrigation, fertilizer, and pesticides have raised crop yields and reduced the number of acres needed to satisfy agricultural markets. Larger machines can cover more acres and lower the amount of labor required, thus reducing the number of farmers needed. But that is not the whole story. Insect-resistant storage bins and chemicals to control rodents have reduced storage losses, and feed conversion rates for animal production have risen sharply, decreasing the amount of feedstuffs needed to produce meat. As yields and feed conversion rates went up and storage losses went down, farmers needed fewer acres to grow grain. As the sizes of machines increased and their numbers declined, fewer farmers were required to feed and clothe the expanding U.S. population, which grew by some 55 million people between 1970 and 1994. Even though export markets nearly doubled in volume over this period, crop production capacity still outdistanced markets, leaving on average some 55 million acres idle each year between 1984 and 1993.

Economic Status of Farm Households

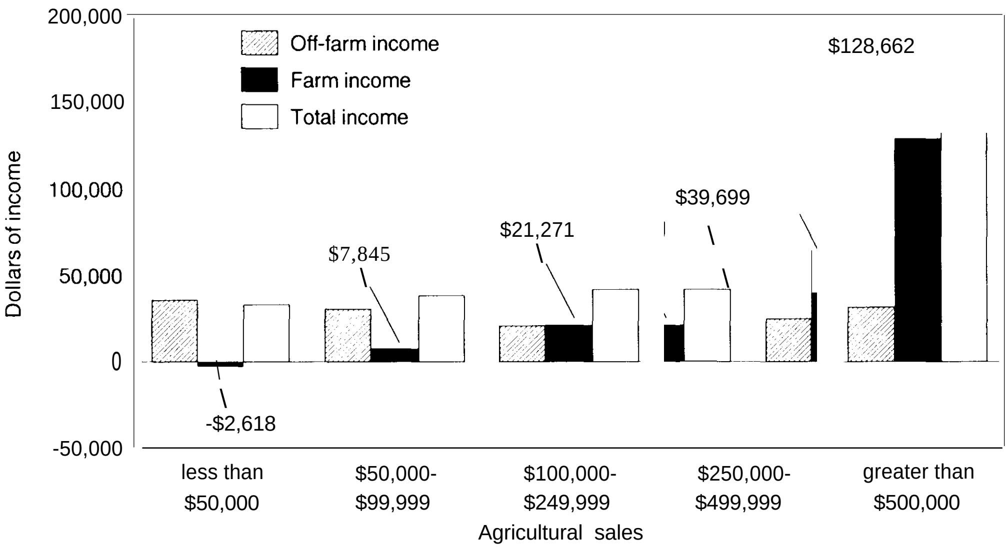
As the farm sector restructured itself, household income on both commercial and part-time farms rose significantly. Incomes rose on commercial farms as farming activities expanded and lowered per-unit costs of production on larger sales; and incomes rose on part-time farms as well, as family members found more work off the farm. The combination of higher farm incomes on commercial farms and higher off-farm incomes on part-time farms raised average incomes of all farm households. In 1993, for example, the U.S. Department of Agriculture (USDA) reported that average farm household income, from all sources, totaled $42,911 (22). For the same year, the Bureau of the Census reported that the average U.S. household had an income of $40,885 (29).

The data in figure 2-3 illustrate that farmhousehold incomes vary by farm size—and that the source of their incomes also varies. Generally, as farm size increases, farm income increases. For example, the amount of net farm income rises to $7,845 for farms selling between $50,000 and $99,999 worth of products annually, and reaches more than $128,000 on farms selling more than $500,000 worth of products annually. The essence of the farm situation today is that smaller farms earn most of their income off the farm, and actually lose money on their agricultural activities; larger farms make money from both their agricultural activities and employment off the farm.[3]

The low income from farming operations shown in figure 2-3 for intermediate-size farms ($50,000 to $99,999 worth of sales) leads many analysts to conclude that farm financial problems

[3]All farm income statistics cited are net of all expenses, including depreciation.

FIGURE 2-3: Farm Household Income 1993



SOURCE: U.S. Department of Agriculture, Economic Research Service (ECIFS 13-1), Economic Indicators of the Farm Sector: *National Financial Summary, 1993*

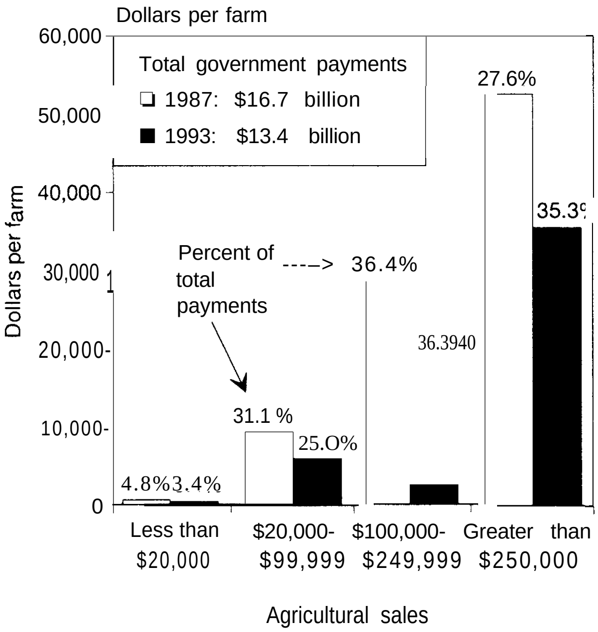
are concentrated primarily on this size farm. However, when income from sources off the farm is taken into account, these intermediate-size farms averaged household incomes of $38,309 in 1993, slightly under the average income of all U.S. households of $40,885 (29). As averages, both figures can hide wide variations in income. The data suggest, however, that when off-farm income is included in farm household income calculations, farms households are faring about as well as nonfarm households.

Variations in farm household income also result from differences in other organizational characteristics of farms. An important difference relates to borrowed capital. Some farms use large amounts of borrowed capital and have large interest payments. Others operate without borrowed capital and have low interest costs. Overall, the farming industry has a very low debt-to-asset ratio, averaging 16 percent in 1993 (15). Large farms (those with sales exceeding a half million dollars annually), have debt-to-asset ratios exceeding 25 percent (22); smaller farms have debt-to-asset ratios that range as low as 11 percent. However, as figure 2-3 indicates, the income of larger farms is much greater and it follows that debt repayment capacity is also larger.

Another measure of farm diversity is the rate of return on assets used in the farm business. Although large farms have high debt-to-asset ratios, those same farms have high rates of return on owned assets. For example, farms selling more than a million dollars of output annually have average rates of return of 25 percent according to one land grant university study (10). As farm size decreases, the rate of return declines to around 10 percent for farms selling between $100,000 and **$250,000** worth of products, and is negative for farms selling less than $40,000 worth of products annually.

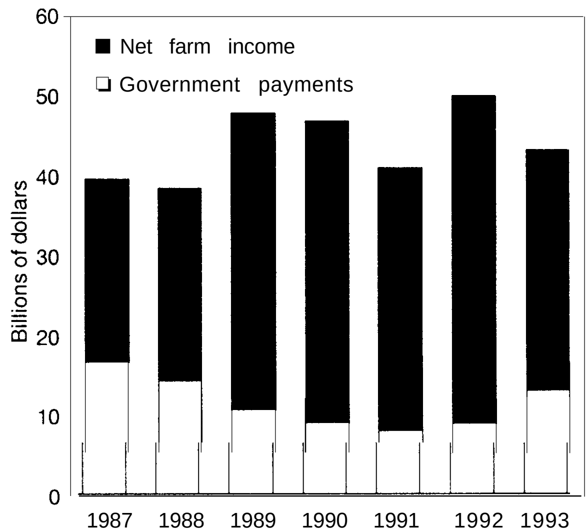
Government payments to farms also vary greatly, depending on farm size. Figure 2-4 divides farms into four size groups and shows the average payments to each group for 1987 and 1993. Direct payments made to farmers reached a high of $16.7 billion in 1987 and declined to $13.4 billion in 1992. The distribution of payments followed patterns of production with smaller farms receiving a

FIGURE 2-4: Government Payments by Farm Size



SOURCE: U S Department of Agriculture, Economic Research Service (EC IFS 13-1), Economic Indicators of the Farm Sector, *Nationai Financial Summary, 1993*

FIGURE 2-5: Net Farm Income and Government Payments



SOURCE: U.S. Department of Agriculture, Economic Research Service (EC IFS 13-1), Economic Indicators of the Farm Sector, *National Financial Summary 1993*

smaller share and larger farms receiving a larger share. Farms with sales under $20,000 annually received 4.8 percent ($593 per farm) of all direct payments in 1987 and 3.4 percent ($458 per farm) in 1993 (figure 2-4). Farms with sales of more than $250,000 received 28 percent ($52,557 per farm) in 1987 and 35 percent ($35,579 per farm) in 1993. Payments varied between these figures for farms with sales of more than $20,000 but less than $250,000 annually.[4]

The decline in direct government payments between 1987 and 1993 had little effect on net farm income. As figure 2-5 illustrates, net farm income was $39.7 billion in 1987 and $43.4 billion in 1993. The $3.3 billion drop in direct government payments between 1987 and 1993 was offset by a $33.2 billion increase in cash receipts and a $29.3 billion increase in cash expenses. The difference, *$3.9 billion,* covered the *$3.3* billion drop in payments, and contributed $0.6 billion of the $3.7 billion increase in net farm income. About half of the $33.2 billion increase in cash receipts was due to a rise in farm exports, which increasedby$14.1 billion between 1987 and 1993. The remainder was accounted for by increased domestic consumption, including more industrial uses of agricultural products and increased livestock sales.

Size and Diversity

Although individual farms may have undergone many changes in past years, the size and diversity of U.S. agriculture as a whole have remained the same. There are 2.3 billion acres (3,594,000 square miles) of open land outside the nation's cities—land that stretches from the irrigated valleys of California to the tile-drained lands of northern Iowa, from the windswept plains of western Kan-

[4]The European Union reports similar distributions of characteristics among its farms. See chapter 6.

TABLE 2-1: Total Land Area Land in Farms and Land Used for Crops

	Millions of acres				
Year	Total land area	Total land in farms	Land available for crops	Land planted to crops	Land harvested for crops
1970	2,264	1,063	384	333	289
1975	2,264	1,059	369	367	330
1980	2,264	1,038	382	382	342
1985	2,265	1,012	403	372	334
1990	2,265	987	403	341	310
1992	2,265	980	395	340	308
1993	2,265	978	391	332	299
1994	2,265	975	389	340	311

SOURCE: U.S. Department of Agriculture, Economic Research Service, *Agricultural Resources,* Situation and Outlook Report, AR-30, May 1993 and personal communications.

sas to the rolling pastures of Vermont and Maine. Across this vast expanse of land, farms accounted for 43 percent, or 975 million acres, in 1994. Yet these 975 million acres reflect a drop of over 85 million acres in farmland since 1970 (table 2-l). The downward trend in land available for farming was of widespread concern during the 1970s, as rising world food needs generated fears that science and technology would not provide sufficient output to offset the loss of cropland. But that concern slowly dissipated in the 1980s as production levels continued to rise, commodity exports declined, and large acreages of cropland again had to be idled under government farm programs.

Despite a decline in the amount of land in farms, land available for crops actually increased after 1975, rising from 369 million to over 400 million acres in 1985 before declining to 389 million acres in 1994. The increase came about as farmers plowed up grass and other types of noncropland and planted it with crops. Much of this expansion occurred in the 1970s, as an export boom increased economic returns. Some 30 million acres were added to the cropland base during this period (table 2-1). The expansion did not exhaust the supply of available acres. A 1975 study found that 111 million acres of land could be converted to crop production (27). A second study completed in 1977 found even more land, 127 million acres (28). However, this figure reflected a decline from the previous decade: in 1967, USDA's *Conservation Needs Inventory* had reported that 265 million acres could be converted (8). None of the studies specified what kinds of market prices would induce farmers to move more of these acres into crop production.

More important than land in farms, or even acreage available for crops, is the amount of land actually harvested. This measure of productive capacity varies more than land used for farms or land available for crops: it rises in good economic times (e.g., the 1970s) and falls in bad ones (the 1980s). By 1994, harvested acreage was down 30 million acres from what it had been in 1980. Many of these acres were drawn out of production by government-sponsored land retirement programs. In 1993, annual and long term land retirement programs removed over 56 million acres of cropland from cropping (table 2-2) while land harvested for crops was down 43 million from 1980. The 13-million-acre differential between the reduction in acreage harvested and the amount of acreage under government programs included land in the Conservation Reserve Program (CRP)[5] that had

[5]The CRP was authorized by the Food Security Act of 1985. It was intended to remove at least 45 million acres of erosion-prone land from production, and ensure that these acres would be used to plant grass or trees. More information on the CRP is provided in chapter 4.

TABLE 2-2: Federal Acreage Reduction Programs, 1975 – 1993

	Millions of acres idled, by commodity					
	Wheat	Feed grains	Cotton	Rice	Other	Total
Annual programs						
1980	0	0	0	0	0	0
1985	71	18,8	3.6	1,2	0	307
1990	75	171	2.0	1.0	0	27,7
1993	4,6	13,3	1.3	0.6	0	19.9
Conservation reserve program						
1980	0	0	0	0	0	0
1985	0	0	0	0	0	0
1986	0.6	0.6	0.1	0	0.7	2.0
1990	10,3	10,2	1,3	0	12.1	33.9
1993	109	11,0	1,4	0	13,2	36.5
Total acres idled						
1980	0	0	0	0	0	0
1985	7.1	18,1	3.6	1,2	0.7	30.7
1990	17.8	27.3	3.3	1,0	12,1	61.6
1993	15.5	24,3	2.7	0.6	13,2	56.4

SOURCE: U.S. Department of Agriculture, Economic Research *Service, Agricultural Resources,* Situation and Outlook Report, AR-32, October 1993

not been previously planted with program crops, and other acres that are often called slippage (i.e., cropland that might not have been planted if acreage reduction programs had not been in place). Examples include cropland pasture that went into the CRP, and areas around the edge of fields or along streams where tillage is difficult and the risk of machinery accidents is high.

Wheat and feed grains account for most of the acres removed from crop production by land retirement programs. In 1993, for example, 15.5 million acres of wheat land and 24.3 million acres of feed grain land were placed under government acreage reduction programs. An additional 3.3 million came from cotton and rice land. The total land idled was 56 million acres: 36 million acres in the CRP and 20 million acres in annual programs for wheat, feed grains, and other crops. The CRP retired almost equal amounts of wheat and feed grain acres: 10.9 million acres of wheat and 11.0 million acres of feed grains. Of widespread interest is what will happen to CRP acres when the 10-year contracts under which land is idled begin to expire in early 1996.

TECHNOLOGY AND MANAGEMENT PRACTICES

Acres idled under government programs are one important source of potential farm output. Another is technology. Technological innovation has played a significant role in transforming agriculture in the past, and still promises to have major impacts on the U.S. agricultural system. The transition from horsepower to mechanical power (1920 to 1950) boosted the productive capacity of agriculture even as farm labor requirements decreased dramatically. From 1950 to 1980, agricultural productivity rose further as irrigation, tillage practices, chemical fertilizers, and pesticides helped farmers to increase yields. Changed in how these technologies are used, which have been prevalent in the past decade, are discussed below.

■ Irrigation Water Use

Like the idled acres under government programs, irrigated cropland is of interest from an environmental standpoint. Irrigation can lead to so-called “intensive” farming: with a plentiful water supply, a fanner may use more fertilizer and other chemicals to get correspondingly higher levels of output. As fertilizer and pesticide use increases, the danger of runoff and seepage into underground waters and aquifers also increases.

Despite such problems, and the expense associated with its development, irrigation remains a key agricultural technology. In specialty crop production, irrigation is an insurance policy, protecting high-value crops against drought. In some instances, it also improves quality. Marketing specialists from the McDonald's Corp. recently pointed out that:

> Potatoes, particularly the type valued for the ubiquitous French fry, require more irrigation water, fertilizer and other chemicals than do many other crops. These requirements for potato growing have significant effects on production and management requirements (6).

With irrigation, the fast-food industry has the size and quality of potato that satisfies consumer demand for French fries. Without irrigation, it might have to develop other varieties.

The positive characteristics of irrigation led to a sharp increase in irrigated acres during the boom years of the 1970s. Compared with 39 million acres irrigated in 1969, some 50 million acres were irrigated by 1978 (table 2-3). Much of the additional output from the increased acreage went to overseas markets. When exports declined in the 1980s and farm income declined, the number of irrigated acres dropped, settling at 46 million acres in 1987. Subsequent improvements in agricultural markets led to another expansion in irrigated land, to 53 million acres in 1993. At that point, water for irrigation accounted for 81 percent of all fresh water used in the United States (18).

Along with the rise in the total number of acres irrigated, total water use for irrigation increased steadily during the 1970s. After 1980, water use for irrigation stabilized, reflecting fewer acres irrigated and a decline in per-acre use, from 2.09 ft / acre in 1970 to 1.80 ft/acre in 1993. New irrigation techniques helped farm operators find more efficient ways of using irrigation water—a trend that bodes well for the growing water demands of cities and instream uses. (See chapter 4.)

USDA, ARS

Irrigation scheduling and uniform distribution are key factors in improving irrigation management and reducing agrichemical losses. Shown here is a center pivot irrigation system that provides water for nearly 270 acres of corn.

■ Tillage Methods

Along with using irrigation water more efficiently, farmers have found new ways to till their cropland. In some instances, the motivation to use new tillage methods is economic: these practices can lower production costs for many farmers (2). In other cases, the incentive is eligibility for farm program payments. Under the Food Security Act of 1985, commonly known as the 1985 farm bill, farmers with land especially prone to erosion were required to have a conservation plan in place for their farms by January 1, 1995, or possibly lose

TABLE 2-3: Irrigated Acreage by Regions of the U.S., 1975-1993

Region	Millions of acres				
	1869	1978	1987	1900	1993
Atlantic seaboard	1.8	2.9	3.0	3.4	3.4
Corn belt & lake states	0.5	1.4	2.0	2,2	2.7
Northern plains	4.6	8.8	8.7	9.8	10.6
Delta states	1.9	2.7	3.7	4.6	5.4
Southern Ppains	7.4	7.5	4.7	5.5	5.3
Mountain	12.8	14.8	13.3	14.6	14.5
Pacific	10.0	12.0	10.8	11.4	10.8
Total	39.1	50.4	46.4	51.6	52.8

SOURCE:U.S. Department of Agriculture, Economic Research Service, *Agricultural Resources,* Situation and Outlook Report, AR-30, May 1993;

program benefits. Through 1992, loss of farm program payments for violations of conservation provisions (often called Sodbuster provisions) had been relatively small: $6.4 million on 129,000 acres (18). However, as late as 1993, a total of 55 million acres out of the 148 million acres designated by the Soil Conservation Service (SCS) as "highly erodible" were subject to a conservation plan that was not fully applied or not yet certified. Another seven million acres were not under any conservation plan, either because producers had not requested such a plan from SCS or had not accepted a proposed conservation plan (18). These numbers suggest that up to 62 million acres might have been ineligible for program payments on January 1,1995, when conservation plans were required.

Conservation tillage provides many advantages for farmers and the environment. It is being adopted by more farmers each year

One way for farmers to meet conservation requirements and maintain their eligibility for farm program payments is by adopting "conservation tillage" practices. (For an explanation of conservation tillage, see box 2-1.) Corn and soybeans, two crops that leave land susceptible to wind and water erosion, illustrate the rapid rate of adoption. Twenty-one percent of corn acres were farmed using conservation tillage in 1988 and 39 percent in 1992 (table 2-4). Soybean production went from 16 percent using conservation tillage in 1988 to 37 percent in 1992. Wheat has shown a smaller increase. Nineteen percent of the 1988 wheat crop was produced with minimum tillage, and 25 percent in 1992. One explanation for conservation tillage's apparent lack of popularity in the wheat sector is that wheat growers have long used fallow systems that maximize moisture retention. The new tillage systems are similar to those already used by wheat growers (with the exception of no till, and production of wheat using the no-till method has increased). For rice and cotton, the major change has been the substitution of other conventional tillage methods for methods that used the moldboard plow. Use of the moldboard plow in cotton decreased by half between 1988 and 1992. The moldboard plow had not been widely used in rice production for sometime, but even in this sector farmers are using it less. National sales of new moldboard plows consequently dropped from 60,543 in 1974 to only 1,382 in

BOX 2-1: Conservation Tillage

Conservation tillage is defined as any tillage and planting system that (a) leaves at least 30 percent of the planted soil surface covered by residue to reduce soil erosion by water, or (b) leaves at least 1,000 pounds of residue per acre during critical periods when soil erosion by wind is a primary concern. Two key factors influencing the amount of crop residue are the type of crop previously harvested and the type of tillage operations carried out before and during planting. There are three types of conservation tillage practices:

1. No Till, The soil is left undisturbed from harvest to planting, except for nutrient injections. Seeds are planted in a narrow bed or slot created by coulters, row cleaners, disk openers, in-row chisels, or roto-tillers. Cultivation may be used for emergency weed control.
2. Ridge Till. The soil is left undisturbed from harvest to planting, except for nutrient injection. Seeds are planted in abed prepared on ridgeswith sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between the ridges. Weeds are controlled with herbicides and/or by cultivation. The ridges are rebuilt during cultivation.
3. Mulch TiIl. The soil is broken before planting with tillage tools such as chisels, field cultivators, disks, sweeps, or blades. Weeds are controlled with herbicides and/or by cultivation.

Other types of tillage and planting systems that leave less than 30 percent of the soil's surface covered by residue may meet erosion control goals with or without other supporting conservation practices (for Instance, strip-cropping, contouring, or terracing).

SOURCE: USDA/ERS, May 1993, p 31

1991, reflecting a dramatic change in less than two decades (14,15).

As the use of conservation tillage has increased, horsepower requirements on farms have changed. Annual sales of large tractors (those with more than 99 hp) peaked in 1990 at 22,800 units and declined 11 percent by 1994 (table 2-5). Sales of extra-large, four-wheel-drive tractors dropped sharply. Sales of smaller tractors were more stable.

Conservation tillage uses less fuel as well as less horsepower. Gasoline use on farms has declined strikingly, from 2.9 billion gallons in 1981 to 1.6 billion gallons in 1992. Diesel fuel use declined slightly, and the use of liquid petroleum gas was cut by a full 40 percent (17). Even though some of the reduction may be attributed to more efficient and increased amounts of custom services, the clear inference is that conservation tillage has reduced the amount of fuel used on farms. The effect on labor use has been less dramatic. Total hours of contract and hired labor used on farms declined about 8 percent between 1981 and 1991. Taken together, lower fuel use and decreased labor requirements resulted in lower production costs. One Ohio study estimated that a shift to no-till methods reduced production costs by $20 per acre, compared with the costs of conventional tillage practices. The same study found that substituting a chisel plow for a moldboard plow reduced production costs by $8 per acre (2).

■ Fertilizer and Pesticide Use

Applications of fertilizer declined after 1981, as farm programs drew land out of production and weaker markets reduced farm incomes. In 1983, when planted acreage was reduced by nearly 50 million acres in an attempt to lower stockpiles, fertilizer use dropped nearly 25 percent. Fertilizer applications increased again in 1984, but not to previous highs, as crop acreages expanded to offset the effects of a drought in 1983 and government programs. These lower usage levels reflect a sharp reversal of earlier trends. Total use rose from 7.5 million nutrient tons in 1960 to

TABLE 2-4: Tillage Systems Used in Crop Production, 1988 to 1992

Crop and tillage system	1988	1989	1990	1991	1992
Corn (million acres)	53.2	57.9	58.8	60.4	62.9
No till (percent)	7	5	9	10	12
Ridge-till	*	*	*	*	2
Mulch-till	14	17	18	20	25
Conv/wo/mbd plow[a]	20	59	57	55	49
Conv/w/mbd plow[b]	20	19	17	15	12
Soybeans (million acre)	48.8	50.9	48.2	49,2	48,6
No till (percent)	4	6	7	10	14
Ridge-till	*	*	*	*	1
Mulch-till	12	16	18	21	22
Conv/wo/mbd plow	62	58	57	55	53
Conv/w/mbd plow	22	20	18	14	10
Wheat (mill Ion acres)	45,1	54.3	59.1	50.7	56.5
No till (percent)	1	1	3	3	4
Mulch-till	18	21	19	21	21
Conv/wo/mbd plow	66	65	67	66	65
Conv/w/mbd plow	15	13	11	10	10
Rice (million acres)	2.1	2.1	1.8	1,9	2.0
No till (percent)	*	*	1	2	1
Mulch-till	2	*	3	4	4
Conv/wo/mbd plow	96	97	96	94	95
Conv/w/mbd plow	2	1	1	*	*
Cotton (million acres)	9.7	8.4	9.7	10.9	1 0 2
No till (percent)	*	*	1	1	*
Mulch-till	*	*	1	1	*
Conv/wo/mbd plow	72	84	84	76	88
Conv/w/mbd plow	28	15	14	21	12

[a]Conventional without moldboard plow

[b]Conventional with moldboard plow

*Included in no-till for these years

SOURCE: U.S. Department of Agriculture, Economic Research *Service, Agricultural Resources,* Situation and Outlook Report, AR-29, February 1993

TABLE 2-5: Numbers of Tractors Purchased, 1966-1994, by Size and Type

Year	40-99 hp	>99 hp	4-wheel drive	Total tractors sold
1986	**30,800**	14,300	2,000	47,100
1987	**30,700**	15,900	1,700	48,300
1988	**33,100**	16,100	2,700	51,900
1989	**35,000**	20,600	4,100	59,700
1990	**38,400**	22,800	5,100	66,300
1991	**33,900**	20,100	4,100	58,100
1992	**34,600**	15,700	2,700	53$000
1993	**35,500**	19,000	3,300	57,800
1994	**39.100**	20,400	3,700	63,200

SOURCE: U.S. Department of Agriculture, Economic Research Service,*ARE/ Updates Farm Machinery, No.* 1, 1995

TABLE 2-6: Fertilizer Use in the United States, 1960-1993

	Millions nutrient tons			
Year	Nitrogen	Phosphate	Potash	Total
1960	2.7	2.6	2.2	7.5
1970	7,5	4,6	4.0	17.2
1980	11,4	5,4	6.2	23.1
1985	11,5	4,7	5.6	21.7
1990	11.1	4 3	5.2	20.6
1991	11,3	4 2	5.0	20.5
1992	11,4	4,2	5.0	20.6
1993	na	na	na	19,8

SOURCE U S Department of Agriculture, Economic Research Service, *Fertilizer Use and Trade,* March 1993

16.1 million tons in 1970, and continued upward thereafter, reaching a high of 23.1 million tons in 1980 (table 2-6). By 1993, however, fertilizer applications totaled 19.8 million short tons, down 14.3 percent from 1980.

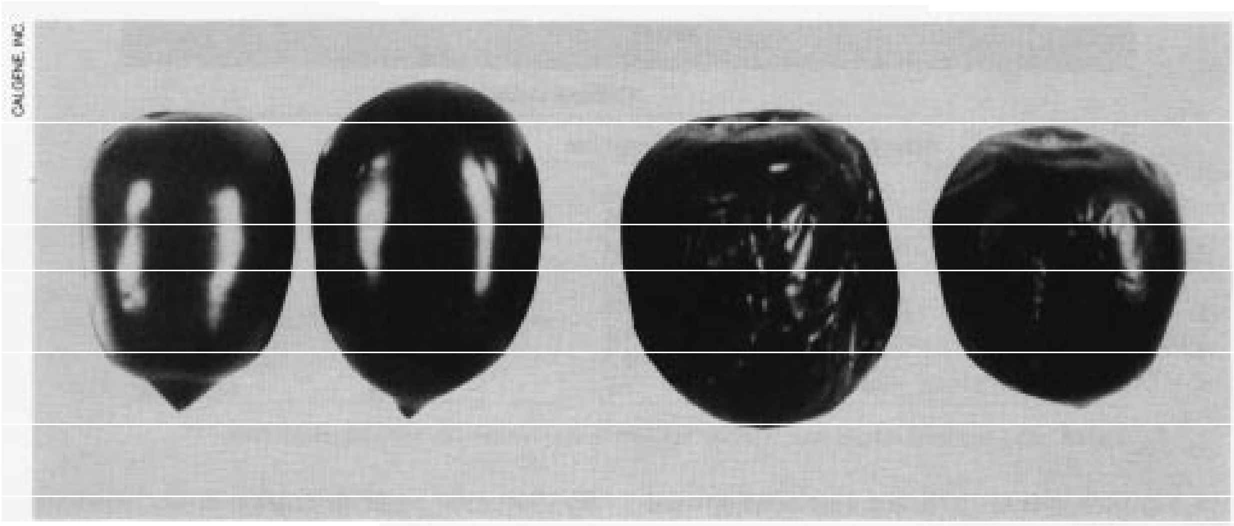
The dip in fertilizer use to below 20 million tons in 1993 may have been a temporary phenomenon, reflecting that year heavy rains and flooding. What may be more permanent is the pressure on growers to reduce all kinds of chemical use in farming. Concerns over environmental impacts have subjected all agricultural chemicals to new and more intense scrutiny. (See chapter 4.) Coupled with intense cost pressures that force growers to reduce inputs wherever possible, all chemical use has stabilized or fallen.

The pattern of pesticide use mirrors that of fertilizer use: rising sharply in the 1970s, peaking in the early 1980s, and dropping sharply thereafter. By 1990, total pesticide use was down 13 percent from the record set in 1982 (table 2-7). Pesticide use declined in 1993 by an estimated 3 percent (17). Trends in use of individual pesticides have varied. Herbicide use expanded rapidly in the 1960s and 1970s, peaked in 1982 and then eased downward. Insecticide use was relatively steady from 1964 through 1976 and then dropped off sharply. Fungicide use was relatively stable throughout the period. Corn production accounted for the greatest percentage of pesticides used in U.S. agricultural production (43 percent in 1992), in part because corn is planted on more acres than any other crop. Soybean production accounted for 12 percent of pesticide use; cotton, for 10 percent; and potatoes, for 7 percent. Wheat, grain sorghum, and rice accounted for about 3 percent each; peanuts and citrus fruits, for 2.5 percent each.

TABLE 2-7: Estimated Quantities of Pesticides Applied to U.S. Crops, Selected Years 1964-1992

	Quantities applied to crops (1,000 pounds)				
Years	Herbicides	Insecticides	Fungicides	Other pesticides	Total pesticides
1964	54,884	128,167	21,715	27,983	232,750
1966	87,351	121,717	21,660	24,233	254,961
1971	198,949	137,808	30,906	31,565	399,228
1976	368,422	135,920	29,546	31,072	564,960
1982	464,596	84,793	27,519	35,417	612,325
1990	376,363	56,617	31,632	68,958	533,571
1991	368,269	51,055	33,117	80,900	533,341
1992	387,126	56,837	34,242	85,657	563,863

SOURCE: USDA/ERS, Unpublished Data, May 1994



Genetically engineered tomatoes, approved by the FDA in 1994 (left), and control (right) 3 weeks after harvest.

The decline in pesticide use between 1982 and 1992 may continue. Public and government pressure on agricultural producers to work in greater harmony with nature—that is, to practice "sustainable agriculture''-already has induced many to change their farming practices, as noted above. With regard to such inputs as fertilizers and pesticides, the overuse that characterized the farming of decades past was called into question during the economic downturn of the 1980s. Upon close examination, reduced levels of inputs often were found to offer lower costs with little or no loss in yields. In addition, a generation of new and more effective pesticides has helped lower usage levels (although not necessarily costs). As future farm prices and incomes remain uncertain, especially on smaller and moderate-size farms, input use will, in all likelihood, be monitored closely to hold down production costs.

■ A New Generation of Technology

Change certainly has taken place in how current technologies are used. But change is also taking place in the types of technologies that will be used in the future. Today, U.S. agriculture is on the threshold of a new era: the biotechnology and information technology era. Technologies that have just been introduced, or are in the final stages of development, have the potential to increase agricultural productivity, enhance the environment, and improve food safety and quality. Some of the major technologies that will be influential in the future are outlined below.

■ Biotechnology

Biotechnology, broadly defined, includes any technique that uses living organisms or processes to make or modify products, improve plants or animals, or to develop microorganisms for specific uses (12). It relies on two powerful molecular genetic tools: recombinant deoxyribonucleic acid (rDNA); and cell fusion technologies. Using these tools, scientists can isolate, clone, and study the structure of an individual gene, as well as explore the gene's function. Such knowledge allows scientists to exercise unprecedented control over biological systems, leading to significant improvements in agricultural plants and animals.

Some of the new technologies are or will soon be on the market. For example, in early 1994, the U.S. Food and Drug Administration (FDA) approved the first genetically engineered tomato, which has an extremely long shelf life and a better flavor than many tomatoes currently available to consumers. The tomato may be harvested ripe for full flavor, shipped without refrigeration, and delivered fresh to supermarket shelves without the standard ethylene "gas" treatment.

Genetic engineering allows scientists to breed plants that have greater resistance to disease, insects, and weeds, and can withstand environmental stresses such as cold, drought, and frost. It also allows them to develop value-added products from agricultural commodities; and to improve their understanding of plant resistance and of the interactions among plants, pests, and biological control agents in the agro-ecosystem.

Insect Control

Traditional breeding programs have produced, and will continue to produce, insect-resistant or insect-tolerant varieties of crops. However, the tools of biotechnology can be used to selectively engineer plants for this trait. For example, genetic coding for bacterial Bacillus thuringiensis (Bt) toxin has been cloned and inserted into plants.[6] Transgenic plants producing Bt toxins are expected to be commercially available by the mid to late 1990s.

Weed Control

Improved understanding of how herbicides work is helping scientists to design herbicides that destroy some plants (e.g., weeds) but have no effect on others (e.g., crops). In addition, genetic engineering is being used to develop crops that have some resistance to herbicides. The frost herbicide-tolerant crops are expected to be commercially available by the mid-1990s.

Disease Control

Biotechnology techniques are being employed to determine how pathogenic organisms cause disease and to engineer plants that can better resist disease. Genetically engineered plants that resist certain viruses are expected to be commercially available by the mid- 1990s. In animal agriculture, biotechnology has the potential to improve feed efficiency, reduce losses from disease, and increase the ability of all livestock to reproduce successfully. Advances focusing on growth promotants, reproductive technologies, and animal health will play a major role in enhancing the efficiency of animal agriculture and the quality of its products.

Growth Promotants

Genetic engineering techniques are being used to produce new products such as a new class of protein hormones called somatotropins. In late 1993, the FDA approved the first of these compounds, bovine somatotropin (bST), which increases milk production in lactating cows. Although the efficacy of the product ultimately relies on the management ability of the producer, average increases in milk volume of about 12 percent are expected.

Another growth promotant, porcine somatotropin (pST), is expected to be approved for use in the near future. Pigs that are given pST show increases in average daily weight gains of approximately 10 to 20 percent, improved feed efficiency of 15 to 35 percent, decreased fat tissue of as much as 50 to 80 percent, and concurrently increased protein deposits of as much as 50 percent. The quality of their meat is not adversely affected.

Tomato plants that show one -stripped by caterpillar and one not. The plant not stripped contains the Bacillus thuringienis toxin gene.

[6] Bt is a spore-forming bacterium that produces insecticidal proteins. Different strains of Bt produce proteins toxic to different insects. Through biotechnology insecticidal genes from different Bt strains have been incorporated into other organisms, including plants, which then produce the corresponding Bt toxin.

TERRY ETHERTON, PENNSYLVANIA STATE UNIV.

Comparison of pork loins that show the effect of pigs treated with porcine somatotropin (pST). The loin-eye area of the loin treated with pST is 8 square inches; the control is 4.5 square inches.

Animal Reproduction Technologies

The field of animal reproduction is undergoing a scientific revolution. In the cattle industry, for example, it has become possible to induce genetically superior females to shed large numbers of eggs; and to fertilize these eggs in vitro with the sperm of genetically superior males. Each resulting embryo can be sexed (i.e., preselect the sex of the embryo) and split to produce multiple copies of the original embryo. Each of the new embryos can then be frozen for later use, or transferred to a recipient cow. The cow carries the embryo to term and gives birth to a live calf. It maybe possible in the near future to sex the sperm rather than the embryo, or to create more copies of each embryo than is currently possible.

USDA, ARS

Animal physiologist prepares embryo for microscopic examination before implanting it into an animal.

Animal Health Technologies

Biotechnology is rapidly acquiring a prominent place in veterinary medical research. New vaccines include those created by deleting or inactivating the genes in a pathogen that cause disease. The first gene-deletion viral vaccine to be approved and released for commercial use was the pseudo-rabies virus vaccine for hogs.

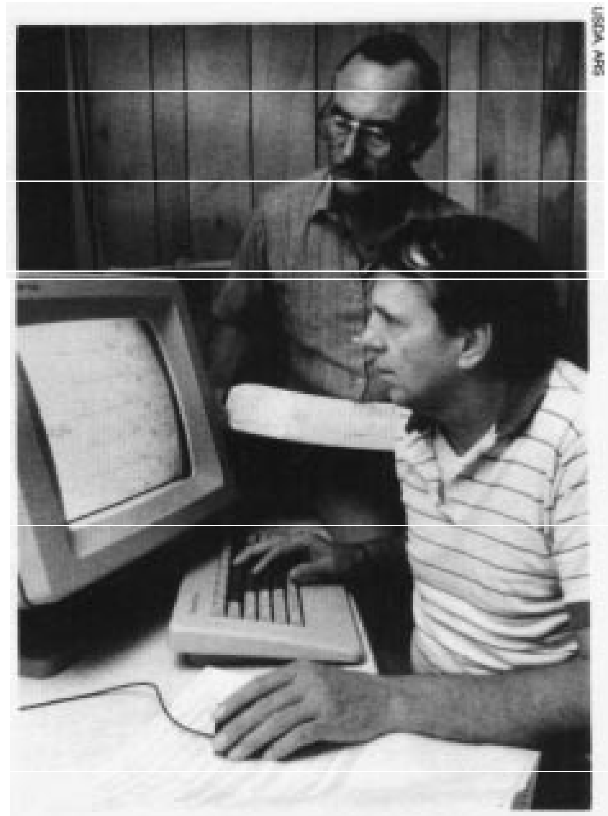
■ Advanced Computer Technologies

Since the Industrial Revolution, agricultural systems have intensified, and agricultural productivity has grown significantly with farm size. Labor-saving devices on farms have increased output per worker many times over, and advances in understanding and applying biological principles have boosted agricultural yields significantly. As production has increased, however, managing a farm has becomes a more challenging and complex job. Even today, many farmers make decisions with less than full information, and many agricultural systems are poorly managed (12).

Advanced computer technologies can make for more effective agricultural management. Computer technologies can provide managers with the ability to determine systematically the best decision, rather than arrive at decisions in an ad hoc fashion. For example, a farmer deciding whether to plant a specific crop on a specific field can weigh the profitability of the crop, as well as overall farm needs (e.g., nutritional requirements for livestock). The decision will have an impact on land sustainability, and will determine whether certain pest-control strategies should or should not be used. Improved access to information can also help farmers to monitor their progress more effectively. Keeping better track of animals' growth rates, for instance, can allow a farmer to detect diseases earlier.

The primary application of computer technology by the mid to late 1990s will be so-called expert systems (i.e., computer programs that actually solve problems, based on information given to them). Such systems are currently being developed, and farmers will have a cadre of them to diagnose diseases and to evaluate production performance. These systems generally will not be integrated with one another: each will consider only one aspect of a problem. Integrated systems that solve production problems while considering economic and environmental consequences will not be available until the latter part of the decade.

Electronic sensors are already playing an important role in agriculture. Sensors are being used for improving operations in crop production by machine guidance systems, applying pesticides and fertilizers more accurately, and improving the management of irrigation water to conserve there-source and reduce production costs. Current research focuses not only on developing methods of monitoring crop growth that can be used with computer models for improving day-to-day crop management and strategic planning, but also on developing sensors for assessing crop maturity and fruit location as a basis for mechanical harvesting. Sensors and satellite technology are currently used to monitor weather and field conditions for crop management. Expert systems help farmers to interpret these data and suggest appropriate management strategies for irrigation, fertilizer, or pesticide treatments.



Farmer and consultant examine data from a expert system that has diagnosed a crop disease on his farm and provided the specific remedy based on the unique characteristics of his farm.

DOMESTIC MARKETING TRENDS

Beyond the farm gate, the process of turning farm commodities into finished food products also has changed. Fresh fruits and vegetables that once were picked in the fields and transported to packing sheds and then to market are now packed in the field and transported directly to retail markets. Milk that once was shipped to local processing plants is now refrigerated and shipped to urban processing centers. Chickens that once were grown in small flocks on farms for supplemental income are now raised in specialized broiler facili-

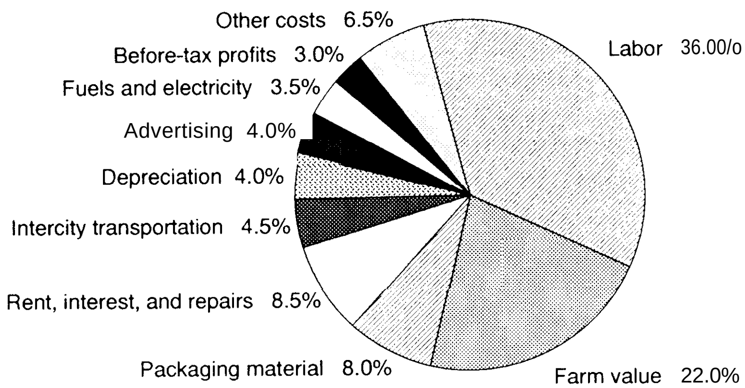
The combination of sensors, global positioning systems and expert systems allow site-specific programs to be developed such **as** *for crop nutrient management.*

ties and processed by the hundreds of thousands daily. Small comer grocery stores that were once the mainstays of families throughout America have slowly lost ground to large supermarkets—and supermarkets have in turn lost some ground to specialized stores catering to health food aficionados, the elderly, or other niche markets.

The economic components of the food chain have also changed. Processing and retailing costs now account for 78 percent of the nation's food bill (and farm value 22 percent). Of that 78 percent, labor costs make up 36 percent; packaging materials, 8 percent; intercity transportation, 5 percent; fuel and electricity, 4 percent; and corporate profits, 3 percent. Other costs, such as interest, depreciation, and advertising, account for the remaining 22 percent (20) (figure 2-6). In return for the added processing and marketing costs they pay, consumers are able to spend less time preparing food and more time doing other things, including eating out in restaurants. Restaurant meals accounted for 45 percent of all food dollars spent in 1992, a substantial increase from the 25 percent spent in 1954 (3).

New ways of organizing food production in the United States are being introduced at a relatively rapid rate, spurred by high rates of return on capital, declining levels of economic protection from government farm programs, and other forces. These trends have the potential to change marketing practices for a wide range of crop and livestock production. This section focuses on some specific marketing methods that are already widely used in agricultural production.

FIGURE 2-6: Economic Components of Food $: 1993



Total 1983 costs: $217.5 billion
Total 1993 costs: $382.1 billion

SOURCE: U.S. Department of Agriculture, Economic Research Service, *Food Cost Review,* 1993, Agricultural Economic Report No 696, Washington, DC, August 1994

Contract Production and Vertical Integration

As consumer demand for high-quality agricultural products has increased, agricultural marketing has moved more toward coordinating production methods and final market demand. As a result, more farmers are working under contract to processors—that is, they produce specialty crops and some types of livestock according to the terms of a written agreement. Similarly, vertical integration (which means that a single firm handles the different functions of production, processing, marketing, and retailing) is becoming more and more common in agriculture, accounting for a larger share of processed vegetables, fresh vegetables, and potatoes (table 2-8). Production for sale into open markets, where the producer delivers the product to a middleman who then moves it to the ultimate consumer, is less the rule.

Vertical production and contract production are becoming more prevalent in animal agriculture. Turkey production, like broiler production, involves more contract production and less production for open markets. Production of eggs and even sheep and lambs is following suit. Large-scale, integrated operations for hog production are replacing traditional corn-hog production. Alan Barkema of the Federal Reserve Bank in Kansas City reports that "from 1980 to 1990, the percentage of the nation's hog production under contract or vertical integration doubled to about 10 percent." He notes that other estimates place this share as high as 16 percent in 1991 (4). Notably bucking the trend is cattle feeding—a lower percentage of output involved contracts and vertical integration in 1990 than in 1970.

Field crops continue to be sold mostly through open markets, although contractual arrangements are accounting for a larger share of food and feed crops. No figures are available for oilseeds, but the trend is likely to be similar to that for other field crops. Michael Cook, an economist with the University of Missouri, offers four explanations for this growing phenomenon in grain markets:

> First, consumers have become more discriminating buyers not only of grain products, but of all products including grain and oilseed-based items. Second, biological, mechanical, and chemical technology is beginning to permeate the grain related industries, permitting participants to evaluate risks and consumer needs in greater depth. Third, the demand for organizational forms that minimize the information

TABLE 2-8: Farm Products Marketed Through Contracts, Integrated Ownership, and Open Markets in 1970 and 1990

	Form of marketing					
	Contracts		Vertical integration		Open markets	
Commodity	1970	1990	1970	1990	1970	1990
Field crops						
Food grains	2	7	1	1	97	92
Feed grains	1	7	1	1	98	92
Cotton	11	12	1	1	88	87
Specialty crops						
Processed vegetables	85	83	10	15	5	2
Fresh vegetables	21	25	30	40	49	35
Potatoes	45	55	25	40	70	95
Citrus	55	65	30	35	15	0
Other fruit	20	40	20	25	40	65
Livestock						
Broilers	92	92	7	8	1	0
Turkeys	60	65	12	28	28	7
Hatching eggs	70	70	30	30	0	0
Market eggs	35	43	20	50	45	7
Manufactured milk	25	25	1	1	74	74
Hogs	1	18	1	3	98	79
Fed cattle	18	12	7	4	75	84
Sheep/lambs	7	7	12	33	81	60

SOURCE: Patrick M O'Brien, "Implications for Public Policy, " in National Planning Association, *Food and Agricultural Markets: The Quiet Revolution,* Lyle P. Shertz and Lynn M Daft (eds.), Washington, DC, 1994, p 301

search and monitoring costs of operating in a more segmented and higher technology marketplace is increasing. Fourth, an over expansion in physical assets with few alternative uses created financial burdens on many participants that required better risk-management tools (5).

Cook concludes that agricultural markets are moving toward two markets: one a market in which grain and oilseeds will be traded for traditional purposes, like livestock feed or industrial uses, and a second in which commodities are purchased for specialized uses such as food processing, pharmaceutical uses, and cosmetic applications. Cook titles the former a "commodities" market and the latter a "products" market.

▮ Industrial Uses of Farm Commodities

In addition to consumer demand for quality, industrial demand for farm commodities is encouraging shifts to contract farming. To keep production lines running smoothly, industrial firms require a steady, uniform supply of raw materials. When agriculture becomes the source of raw materials, its greater variability in quality and quantity must be addressed. Generally, this can be done through contractual arrangements between growers and industrial firms that ensure uniformity in, and constant supplies of, a material. Such arrangements are even more likely to be employed if the industrial crop in question is new and grown on relatively small acreages, as many industrial crops are.

Although some analysts forecast a rosy future for industrial crops, the expansion starts from a small base, which limits the overall impact on demand. In 1991, an OTA report concluded that "[l]arge-scale replacement of U.S. fuel use or primary chemical feedstocks would require significant acreage for crop production. However, economics do not favor these developments at the current time" (11). The president of the American Farm Bureau Federation touted the virtues of industrial crops three years later—but also was careful to couch his remarks in terms of the future, not the present:

> Alternative uses of major farm commodities are attracting attention (for example, ink made from soybeans). Improvements will lead to greater use, eventually requiring 100 million bushels of soybeans to meet annual demand. Corn growers eagerly promote ethanol use because it adds 20 cents to their pockets for every bushel of corn sold. Ethanol, packing materials, and other industrial uses of corn could require 850 million bushels a year. Paints, fiberboard and medicines could also contain farm products. Many more alternative uses will occur and will contribute to a farmer's income (7).

Retail Food Marketing Changes

As the nation's population gradually ages, as two-income families have less time to prepare food at home, and as nutrition and food safety become ever more important to consumers, retailers are providing a constant stream of new products, new forms of packaging, and new market outlets. The elderly, for example, want food products that meet special dietary needs. Working parents want foods that can be prepared quickly but are nutritious, and health-conscious consumers want foods that are low in fat and high in energy. The retailers' response can be seen in more salad bars in full-line food stores, and more take-out sections in gourmet food stores, to cite only two examples. As Barkema has observed, "consumers are becoming more discriminating, requiring the food industry to design its products more carefully" (4).

In 1991, Senauer, Asp, and Kinsey pointed out that "[s]ome consumers are willing to pay a premium for products such as free-range chickens, natural beef raised without antibiotics or hormones, or wild game meat that is raised for sale" (9). With consumers willing to pay, processors have established contracts with growers that ensure that supplies of specialty items will be available. In the 1980s, these items translated into big business. Senauer, Asp, and Kinsey, estimate that sales of organic products—that is, products grown without chemical pesticides or synthetic fertilizer and distributed without artificial preservatives or dyes—amounted "to over $3 billion annually."

GLOBAL MARKETING TRENDS

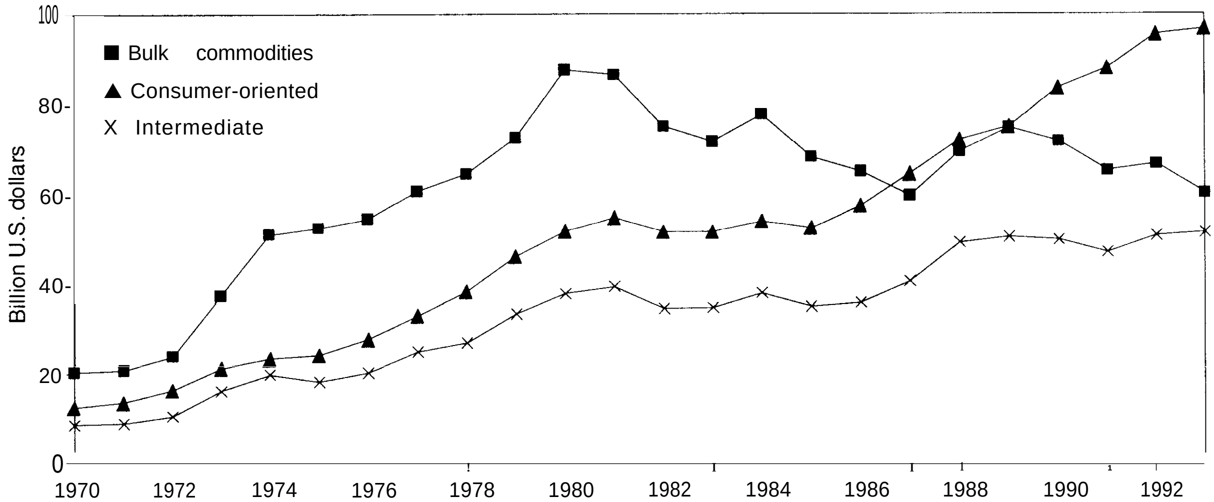
Global markets for agricultural goods are changing as much as domestic markets. On the one hand, certain developing countries have applied new agricultural technologies that have improved their crop yields, increased their degree of self-sufficiency, and decreased their need for imports.[7] On the other hand, international trade agreements have helped to open up international agricultural markets and increase exports. Following the Tokyo Round of the General Agreement on Tariffs and Trade (GATT), which ended in 1979, negotiations to expand trade in food products continued, and were ultimately successful. Another strong force pushing expanded global food trade has been the economic prowess of Pacific Rim countries. As they have modernized and expanded their economies, and as their trade surpluses have grown, these countries have gradually opened their markets to imports of semiprocessed and retail-ready food products.

Value-Added Food Trade

The impact of all these changes can be seen in the changing composition of global food trade. The higher yielding crops grown in developing countries lowered imports and reduced trade in bulk commodities. Higher incomes and lower trade barriers brought more trade in intermediate and

[7] Bangladesh exemplified the trend, with high-yielding varieties (HYV) used for 1.6 percent of all wheat planted in 1967-68 and 95.9 percent in 1982-83. In India, 4.2 percent of all wheat planted used HYV in 1966-67 and 76.0 percent in 1983-84. China increased from 10.1 percent HYV in 1980 to 34.2 percent in 1984, an amazing increase in such a short period (1).

FIGURE 2-7: World Agricultural Trade by Type



SOURCE: U.S. Department of Agriculture, Foreign Agricultural Service, *Desk Reference Guide to U.S. Agricultural Trade,* Agricultural Handbook *No 683,* revised April 1994

consumer-oriented food products.[8] The shift began in the early 1980s, at the same time that U.S. exports of bulk commodities began to decline. Initially, the prevailing explanation for declining exports of bulk commodities was that higher price supports in the 1981 farm bill, along with a stronger dollar and a weak global economy, made U.S. commodities uncompetitive in global markets. As global trade continued to shift toward more value--added trade (i.e., trade in both intermediate and consumer-oriented products) and less bulk commodity trade, the explanation began to change. B y 1989, the USDA's Foreign Agricultural Service (FAS) reported that:

> During the 1980s, growth in world trade was greatest in consumer-oriented products, which grew by around 3 percent, or $3.7 billion a year, compared to less than 1 percent a year for both bulk and intermediate products.

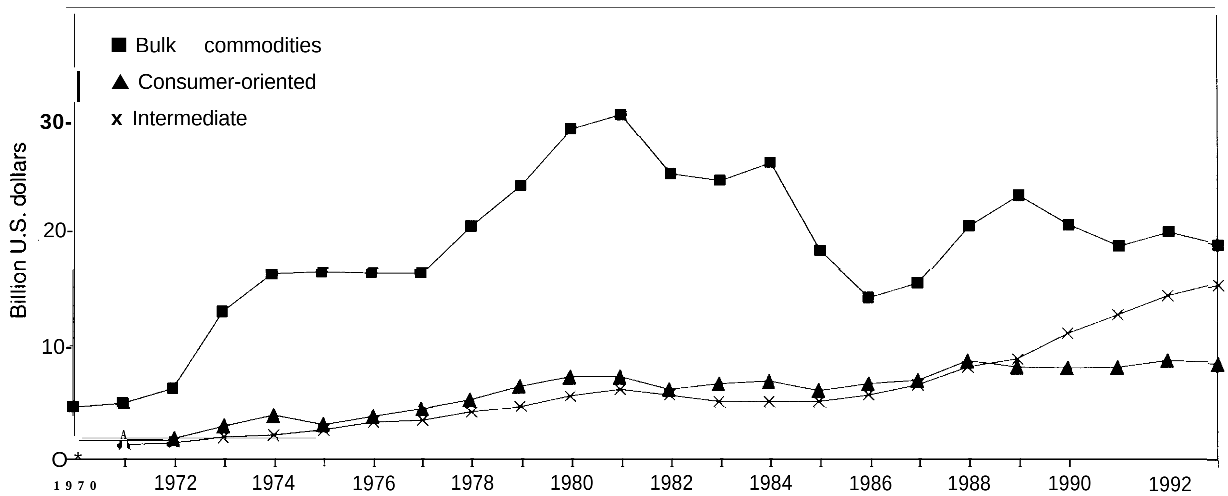
The report noted that:

> Increases in demand were most concentrated in meats, horticultural products, dairy products, beverages and pre-packaged food preparations (23).

What was unclear in the early 1980s was that expanding demand for value-added food items was changing the overall composition of world food trade. The share of global food trade accounted for by consumer-oriented food products rose 12 percentage points between 1980 and 1990, from 30 to 42 percent, and the share accounted for by intermediate food products increased 3 percentage points, from 21 to 24 percent. The share accounted for by bulk commodities fell by 15 percentage points, from 49 percent to 34 percent. (For more recent trends, see figure 2-7.) A small portion of the increased trade in consumer-oriented

[8] Bulk commodities are products that have not been processed, such as wheat, corn, rice, soybeans, and unmanufactured tobacco. Intermediate products are semiprocessed products, such as wheat flour, oilseed meal, vegetable oil, hides and skins, animal fats, wool, and refined sugar. Consumer-oriented products are end products that require little or no additional processing for consumption, such as fresh and processed horticultural products, fresh and processed meats, dairy products, table eggs, and bakery products.

FIGURE 2-8: U.S. Agricultural Exports by Type



SOURCE: U.S. Department of Agriculture, Foreign Agricultural Service, Desk *Reference Guide to U S Agricultural Trade,* Agricultural Handbook *No 683,* revised April 1994

and processed food products, especially the increase in meat exports, involved the use of bulk commodities (feed for cattle, for example). But that increase was not nearly large enough to offset the loss of U.S. bulk commodity exports. As U.S. crop production continued to rise during the 1980s and bulk commodity exports declined (figure 2-8), commodity prices received by farmers fell, decreasing farm income and expanding acreage diversion programs.

In an attempt to discourage further stockpile growth, the United States implemented a Payment-in-Kind (PIK) program in 1983 to reduce crop acreage, using excess stocks to pay farmers to lower production. That reduction in crop acreage, coupled with an extremely severe drought in the Midwestern grain belt, cut grain output by nearly 40 percent in 1983. The return of favorable weather in 1984 meant that surpluses built up again, however, and led to the implementation in 1985 of the Export Enhancement Program (EEP). EEP was designed to stem the losses incurred in global markets and used stocks as payments to exporters for meeting foreign competition. Neither PIK nor EEP, or even a weaker dollar and large export subsidies, changed the global trend toward more trade in processed and consumer-oriented food products. By 1993, global trade in these types of products was up $45 billion over 1980. U.S. exports of these items also increased, rising by $10.0 billion between 1980 and 1993 (23).

Bulk Commodity Trade

Although value-added food trade has risen sharply since 1985, trade in bulk commodities has, as noted above, weakened. Global trade in bulk commodities totaled $87.5 billion in 1980 and fell to $71.6 billion in 1990 (23). While traders and others remained optimistic about long-term prospects, the decline in bulk commodity trade continued, falling to $60.2 billion in 1993. Meanwhile, trade in processed and consumer-oriented food products rose from $89.5 billion in 1980 to $133.2 billion in 1990. With economic recovery under way, global trade in processed and retail food products reached $148 billion in 1993.

The new trends in global food trade should have been familiar to the U.S. food industry, be-

TABLE 2-9: Value of U.S. Agricultural Exports, by Commodity Groups, Fiscal Years 1950-1992

(million dollars)

Fiscal year	Grains & products	Oilseeds and products	Animals products	Fruits, nuts and products	Vegetables and products	Cotton and tobacco
1950	**1,268**	**212**	**301**	**123**	**103**	**1,214**
1955	**1,178**	**410**	**405**	**230**	**143**	**761**
1960	**1,802**	**628**	**429**	**270**	**172**	**1,287**
1965	2,441	1,094	527	323	213	982
1970	2,464	1,676	765	401	500	914
1975	11,230	4,852	1,704	805	1,049	1,938
1980	18,261	9,811	3,757	2,087	2,170	4,382
1985	13,285	6,195	4,075	1,886	2,204	3,555
1990	15,672	6,125	6,610	3,116	4,617	4,079
1992	13,858	7,156	7,756	3,940	5,944	3,763
1993	14,104	7,210	7,781	3,831	6,695	2,969

SOURCE U S Department of Agriculture, *Agricultural Statistics,* U.S. Government Printing Office, Washington, DC, 1981, p 564-565 and 1993, p 474-475, U S Department of Agriculture, Economic Research Service, *Foreign Agricultural Trade of the United States* (FATUS), April 1994

cause they mirrored earlier patterns in U.S. food expenditures. In the 1950s and 1960s, U.S. families began purchasing more and more ready-to-eat food products, cutting back on purchases of flour, potatoes, and other ingredients for homemade food. Two-income families could, and did, spend even more on ready-to-eat food items. The same economic trends led to more food consumption outside the home, in restaurants and fast-food establishments. These same trends are reflected in world food trade: trade in processed and consumer-oriented food products has increased, and bulk commodity shipments have declined. One result is more jobs in food- processing industries, just as more food consumption outside the home led to more jobs in restaurants and fast-food establishments.

Global trade in bulk commodities obviously will not disappear, any more than domestic use of bulk commodities disappeared. The issue instead is one of growth, and adapting to new trends in global markets. Adapting is difficult for the United States, for various reasons. Bulk commodities were at the heart of the U.S. agricultural export boom of the 1970s, and the value of grain exports more than quintupled over the decade (table 2-9). Exports of oilseed crops and products also rose. But as global markets for bulk commodities shrank in the 1980s, U.S. exports of grain and oilseeds declined as well. Other items became the driving force behind export expansion, even as traditional farm programs continued to encourage production of bulk commodities. Animal product exports doubled between 1980 and 1993. Similarly, exports of fruits and nuts nearly doubled, and exports of vegetables more than tripled.

The impact of the shift away from bulk commodities was dramatic. By 1993, bulk commodities made up 44 percent of the value of U.S. agricultural exports, compared with 70 percent in 1980; intermediate products such as soybean meal made up 20 percent, compared with 17 percent in 1980; and consumer-oriented products accounted for 36 percent, compared with 13 percent a decade earlier (23). In little more than a decade, consumer-oriented products had more than doubled their share of U.S. agricultural exports, rising from 13 to 36 percent. On a global scale, consumer-oriented food products had gone from 29 to 46 percent. In 1993, the United States was about where world markets were in 1983, relative to consumer-oriented exports. To catch up and remain the world leader in food and agricultural trade, the United States may need to rethink its farm programs and its export expansion programs. Otherwise, it will likely remain behind the times in global food markets.

Global Marketing Shifts

One geographical area that has been central to the growth of consumer food exports is the Pacific Rim. Japan and Taiwan, along with Hong Kong and Korea, are among the top 10 markets for consumer-oriented food exports—and exports to these countries are growing rapidly. Red meat exports to Japan increased 83 percent between 1988 and 1993. Poultry exports to Hong Kong more than tripled. Exports of fresh tree fruits to Taiwan more than doubled, and exports of these items to Malaysia increased by 50 percent (26).

As development has proceeded, Asian countries have become more prominent players in the international trade arena. Asia replaced Europe as the leading regional market for U.S. farm products as early as 1979 (23). One-third of all agricultural exports went to Asia at that time. The Asian share has continued to increase and reached 37 percent in 1993. In describing the evolution of this trade, a 1994 USDA report noted that:

> Asians have begun to incorporate more Western-style food into their diets. This, in turn, has led to a surge in demand for Western-style consumer-ready goods in Asia. Increases in demand have been most marked for beef, horticultural products, beverages, and pre-packaged foods. Both U.S. beef and poultry meat exports to Asia posted record levels in fiscal 1993. Fueled by a burgeoning demand for a diversity of tastes, U.S. sales of snack food, dairy products, fresh vegetables, and tree nuts to Asia also reached all-time highs (23).

Asian nations are not the only ones increasing imports of food items. Canadian importers are exploiting new opportunities under the U.S.-Canada Free Trade Agreement (FTA) and importing large amounts of food products, a phenomenon that has made Canada the world's largest importer of U.S. food products. Mexico is also increasing food product imports and ranks third, after second-place Japan, as an importer of U.S. food products. Other countries in the top 10 include Hong Kong, Germany, the United Kingdom, South Korea, Taiwan, France, and the Netherlands.

The expansion of trade in food products has had a positive effect on the nation's trade balance. Some of the processed items shipped, however, are tradeoffs for bulk commodities. Exports of corn and red meat to Japan provide a good illustration. Total shipments of red meat to Japan increased steadily and reached $3.1 billion in 1993, a full 83 percent above the value of red-meat shipments made in 1988 (26). Japanese corn imports totaled 16 million metric tons in 1993, the same amount as five years earlier (25). The Japanese case is not unique. According to the February 1994 issue of the USDA's FAS grain circular (24):

> After expanding at about 5 percent annually throughout the 1960s and 1970s, the growth rate for corn utilization outside the U.S. fell dramatically in the 1980s. If China and other major corn exporting countries are excluded, corn utilization in the remaining countries only increased a net 6.7 mmt [million metric tons] from marketing year 1980/81 to 1993/94, a rate of about 0.2 percent annually. Over the same period, U.S. corn utilization expanded 37.7 mmt, a rate of about 2.3 percent annually.

Slow growth rates were not alone in hurting bulk commodity exports. Another USDA grain circular (25) noted that Latin America is importing more wheat and now accounts for 15 percent of world trade in wheat, but that "U.S. wheat has become relatively uncompetitive." In this instance, both the European Union (EU) and Argentina have successfully replaced the United States as a supplier of wheat to Latin America.

Although drought or some other unforeseen event could lead to rapid growth in bulk commodities almost overnight, as the 1970s demonstrated, the availability of supplies from other exporting countries suggests that the likelihood of permanent increases is low. Planning public policy around such an expectation does not appear to be very realistic.

Alternatively, the probability of further growth in consumer food exports appears higher, and planning public policy to take advantage of that growth seems more promising. What is evident on the basis of past trends is that some change in policy is needed. The United States had a 23 percent share of global food and agricultural trade from 1980 to 1984, but only 20 percent in 1992. Over the same period, the EU took advantage of the shift toward processed food products and increased its share of world food trade from 14 percent in the years 1980 to 1984, to 19 percent in 1992 (23). Even though the United States has increased its consumer food exports, world markets have grown even faster. The ultimate outcome: other countries have absorbed a more-than-proportional share of world food markets, and the United States has been losing out.

THE U.S. DILEMMA

Part of the U.S. dilemma with regard to agricultural exports has been the aforementioned slow growth in world markets for bulk commodities, as well as fierce competition from the EU and other food-exporting countries. But part of the reason for the declining market share may be ascribed to the United States' overemphasis on bulk commodities. Price supports and deficiency payments for wheat, rice, cotton, and feed grains prevent the United States from taking maximum advantage of opportunities to export intermediate products such as soybean meal and wheat flour. While global trade in semiprocessed products increased by $13.5 billion between 1980 and 1993, U.S. exports of oilseed products dropped, from $9.8 billion to $8.3 billion (13,15). U.S. soybean acreage also declined, from 68 million acres harvested in 1980 to 57 million acres in 1993 (13,15). Despite changes in the 1990 farm bill designed to free up more program acres for soybean production, soy bean plantings continued to lag. Apparently, support payments for planting other crops are more important than planting more soybeans, no matter how many acres are available for doing so.

Like global trade in intermediate agricultural products, global trade in consumer-oriented food products also rose dramatically between 1980 and 1993, by $45 billion. U.S. exports of these items increased, by $10 billion—but mostly in response to the efforts of private firms. Government promotion programs continued to focus on exporting excess supplies of wheat, feed grains, and other price-supported bulk commodities. With budgets already limited, there were few funds left over to promote exports of processed and retail-ready food items. Farm legislation may also act as a constraint. Examples include the legislative prohibition on planting of fruits and vegetable crops on flex acres and the administrative regulation against grazing and haying of CRP acres. Both prevent more production of items that are in growing demand in global markets.

RESEARCH AND DEVELOPMENT

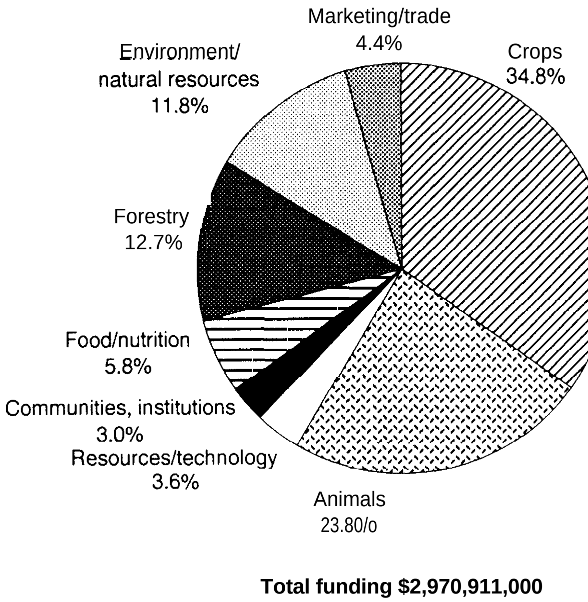
The task of providing information to the public on trends in international agricultural trade falls to government agencies and the agricultural research community. The challenges vary from reporting events in individual countries that will shape trade in the coming year to assessing trade agreements that will influence the patterns of food exports and imports for coming decades. On the commercial side, the task includes monitoring trends in food consumption, along with changes in government regulations, to anticipate new marketing opportunities. On the economic front, the task includes following trends in earnings and assessing where trade patterns are likely to change.

Achievements in these research areas contrasts sharply with achievements in research on food production. On the technological side of agriculture, the nation has benefited from a long stream of scientific breakthroughs that raised agricultural output and lowered the real cost of food and fiber. Although such technological breakthroughs were newsworthy achievements in earlier decades, most are greeted today with little fanfare. Their lack of visibility does not, however, mean that they are unimportant, or that food costs are absorbing a larger share of national income. In as recent a period as 1983 to 1992, the percent of disposable personal income spent on food in the United States declined on average from 13.0 percent to 10.6 percent—a truly remarkable achievement, considering that food purchases consist more of processed and ready-to eat items than they have before (15).

One explanation for the different level of research achievements can be found in the budgetary resources devoted to food production and agricultural trade. In 1993, the nation devoted $3.0 billion to agricultural research through federal and state research institutions (16). As shown in figure 2-9, the allocation of these funds heavily favored crop and livestock production. Research on crops received 34.8 percent of the total funds, while research on animals received 23.8 percent. Both far outdistanced funding on international and domestic markets, which accounted for 4.8 percent of total research funds. Research expenditures on people and institutions accounted for even less: 3.0 percent of the total, or $88,353,000 of federal funds. With the Uruguay Round Agreement (URA) implemented this year, and the new World Trade Organization (WTO) in place, opportunities for expanded trade (and the adjustments to the agriculture sector they may bring) may justify more investment in examining changing international markets and their impact on U.S. agriculture.

Food consumption trends in other countries differ from trends in the United States. As a mature industrial nation with a population structure to match, U.S. food demand is relatively stable. Many of the countries that will be responsible for shaping the composition of future global trade in food products, however, are at a different stage of development, with different income levels and different responses to changes in incomes, food prices, and availability of new food products. For the United States to become proficient at marketing food in these countries, it must become more knowledgeable about their internal conditions, about food tastes and taboos, and about cultural habits that shape food consumption. In essence, the United States must learn more about the differences among countries and shape marketing programs to match other countries' needs rather than our own. This will be a major challenge for the research community, as well as the business community, in coming years.

FIGURE 2-9: Agricultural Research Funding 1993



SOURCE: U.S. Department of Agriculture, Cooperative States Research Service, Inventory of Agricultural Research, Fiscal Year 1993 Washington, DC, 1993.

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