U.S. Farm Dilemma: The Global Bad News Is Wrong

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America's farmers entered the 1980's feeling more prosperous and secure than at any time in modern history. They had just survived a furious onslaught of new farm technology, which helped to cut the proportion of farmers in the U.S. population to less than 4 percent. Overseas demand for food was being stimulated by economic growth. World trade in agricultural commodities had increased by some 10 million metric tons per year through the 1970's, and the United States had received most of the new business. Land values rose 50 percent in real terms during the decade.

If any farmers still had doubts about their future, the *Global 2000 Report* (*1*), which was presented to President Carter in 1980 and which was based on the best projections of the U.S. government, predicted that world demand for food would increase vastly in the next 20 years, that real food prices would double, and that developed countries would have to supply most of the increase (*1*). Conservationists immediately expressed concern about the tremendous pressure this food demand would put on the world's cropland. Some even suggested that resulting deforestation and erosion might alter world climate. Improved farm technology looked like a slender hope; yield increases were tapering off and higher oil prices threatened to expose our dependence on petrochemical-based fertilizers and pesticides.

Today, just 5 years later, the world of the American farmer lies in disarray, with mounting surpluses, heavy farm debt, and massive farm subsidy costs. Demand for U.S. farm products is weak, land values are down, and farm policy seems to be at a dead end.

Yet the long-term need for food is as critical as ever. The population continues to increase. Erosion and deforestation are still being reported. The worst famine in Africa's history has caused thousands of deaths and has malnourished millions.

The Bad News Is Wrong

The bad news for the American farmer is that the global bad news is wrong. The world is not on the brink of famine or ecological disaster brought on by desperate food needs. According to the Food and Agricultural Organization, world agricultural output rose 25 percent between 1972 and 1982 to reach an all-time high. Farm output in less-developed countries (LDC's) rose 33 percent. Compared to an increase of only 18 percent in developed countries (DC's), where markets were already saturated. Per capita food production rose 16 percent in South America and 10 percent in Asia. Equally important, the annual rate of growth in farm output in LDC's has been rising—from 2.7 percent in the early 1970's to 3.3 percent in 1977–1982. (The *Global 2000 Report* projected an overall farm productivity growth of 2.2 percent, with most of it in the developed countries.) The growth rate in the LDC's would have been even higher if the averages had not been skewed by some dismal farm policy failures in countries with good agricultural resources, especially in sub-Saharan Africa.

The improved performance by farmers in LDC's is basically due to improved technology and stronger incentives to use it. The wheat and rice varieties of the Green Revolution are legend; genetics has gone on to produce the world's first hybrid wheat, cotton, rice, and rapeseed (*2*). Triticale, a hybrid of wheat and rye, outyields other cereals by 250 percent under certain unfavorable conditions. There are new sorghums for Africa that may have Green Revolution potential (*3*). Farmers in LDC's are also benefiting from better pest control technology, such as new low-volume pesticides and small electrostatic sprayers (*4*). Fertilizer use in LDC's has doubled and fertilizer production has tripled (*5*). LDC's tripled their real spending for farm research in the 1970's (*6*), and a global network of internationally funded farm research centers has been established with promising results.

Even Africa has the technology to double its crop yields and drought-proof its food supplies. The fact that this technology has not been more widely applied represents both a tragedy and an indictment of the farm and food policies followed by the African nations themselves.

The farm and food policies of the Third World are improving, however, prodded by population growth and, ironically, by the sharp declines in external financing for Third World governments. For the first time, the Third World is focusing on productivity rather than spending. The LDC's are also learning from the successful experiences of such nations as China and Malaysia. All of this is good news for the hungry of the world, but it will not ease the pressure on U.S. farmers.

Summary. World agricultural production is at an all-time high and is climbing fast, especially in the developing countries. Even Africa has ample land and technology to feed its population, given more effective national policies. Higher agricultural output has been stimulated primarily by new technology, but also by investments and improved government policies. Constraints such as cropland shortage, soil erosion, and higher oil prices have been readily surmounted. High-technology agriculture has even overcome some major "systems breaks." Thus U.S. farmers will continue to face commercial surpluses of farm products in world markets in the years ahead.

Constraints Less Severe Than Expected

The constraints that were expected to limit food production during the 1980's and 1990's have been far less severe than almost anyone foresaw.

Cropland. One of the most obvious constraints is cropland. Most of the world's best and most accessible cropland is already in use. [Some nations, such as the Sudan, Zimbabwe, and Thailand, still have large areas of uncropped

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arable land, but much of it is far from consumer markets and lacks a transportation infrastructure (*8*).] Man still cannot create new land. However, many developments now under way have the same effect:

- New corn varieties are ready to double yields for small farmers in Central America and West Africa (*7*). New high-yielding varieties are raising the output of wheat, sorghum, cassava, peanuts, and most other crops.
- Irrigation has been expanding. Most of this is in the form of highly efficient, small-scale wells. Turkey, however, is building dams to irrigate 7 million hectares in the upper Euphrates Valley—an area equal to all the cropland in Nebraska.
- Wet areas are being drained. West Africa may become self-sufficient in rice production by shifting from upland to swamp rice production (this will require ditches, dikes, and disease control efforts) (*9*).
- Brazil is opening up 50 million hectares of acid soils on the Cerrado plateau; lime and phosphate make the area productive and competitive (*10*).
- New ways are being found to farm the world's 300 million hectares of black, sticky vertisol soils, which occur principally in India, Australia, and the Sudan) (*11*). Much of this land was not cropped at all in the past; some is now being triple-cropped.
- Australia has developed the "ley" system for farming its semiarid land. An annual legume crop is substituted for the normal fallow year, sharply increasing the forage supply and fixing enough nitrogen to raise cereal yields in the ensuing year 15 to 30 percent. Overall, the ley system increases the productivity of dry lands 30 to 40 percent. Spain, Portugal, and the North African countries are trying to adapt similar farming systems to their millions of semiarid hectares. The systems require sophisticated management, but the long-term prospects are good.
- Argentina, which has huge tracts of prime land oriented to pasturing beef cattle, is gradually shifting to more intensive cropping of grains and oilseeds. The government last year abolished a 25 percent tax on nitrogen imports, and nitrogen use jumped 54 percent. Since 1980 the grain exports of Argentina have been increasing by about 1 million tons per year (*12*), and average yields of hybrid sunflower varieties have recently increased 25 percent (*13*).
- Peru has raised its rice production by 40 percent in each of the past 2 years with a new upland variety that tolerates the aluminum toxicity of the soils in the western Amazon Basin (*14*).
- Even the United States has been draining, terracing, and irrigating land and making other investments that add to our cropland base.

Erosion. Soil erosion has been both less severe and less detrimental to the world's crop yields than many expected. Conservation tillage and minimum tillage techniques have spread rapidly in many countries. Perhaps one-third of the Corn Belt is currently farmed with some form of conservation tillage (*15*), probably including most of the land at serious risk. The University of Minnesota Soil Science Department recently concluded that current rates of soil erosion, extended over the next 100 years, would cause irreplaceable losses in Corn Belt yields of less than 8 percent. Such losses would not be negligible, but seem certain to be dwarfed as we find even better conservation methods and improved production technologies over the next century.

Much of the world's cropland has a more serious erosion problem than the Corn Belt, of course. But raising the productivity of the best land relieves the pressure on fragile land. Steep and rocky land in New England and West Virginia has been relegated to pastures and forestry. Investments in drainage, land leveling, contour cultivation, and tree planting have made cropping safer on other land. The moldboard plow is disappearing from many farming regions.

In the developing world the productive potential of the best land has not been fully realized. Africa has the worst erosion problem in the world, yet plants a relatively small fraction of its arable land to crops in any given year. Traditional bush fallow periods range from 6 to 20 years. Population growth is now forcing shorter fallow periods, sharply increasing erosion rates. Most of Africa's food production takes place on millions of tiny subsistence farms with no fertilizer and seeds that are the horticultural equivalent of Indian corn. Overgrazing has been encouraged by communal landholding and by traditions that give status to owners of larger herds of undernourished animals. A new sorghum hybrid has been developed in the Sudan that triples the yields of traditional varieties in much of East Africa and that is much more drought-resistant (*16*). A new sorghum for the drier conditions of the Sahel apparently can double cereal yields there (*3*). The International Potato Research Center has achieved test yields as high as 50 metric tons per hectare in Ethiopia—but few people in that poor country know what a potato is.

Oil prices. Oil prices are constraining agriculture much less severely than was expected as recently as 1981. Real oil prices have already dropped one-third from their peak and may well decline further. More efficient techniques are being developed for such energy needs as crop drying. Low-volume pesticides are effective in applications of less than 100 grams per hectare. The prices of petrochemical-based fertilizers never rose as much as oil prices because of relatively cheap natural gas produced in association with oil. Fertilizer is often the most attractive market outlet for such gas. Indonesia has increased its annual production of fertilizer from a few thousand tons to 1.2 million tons in the past decade, and is using most of it on its own crops. Such major oil producers as Iran and Nigeria are still flaring off large quantities of gas (although Nigeria is now building one medium-sized plant).

Running Out of Farm Science?

The pessimists assumed that the major discoveries which could sharply increase world agricultural output had already been made. Superficially, there was some justification for accepting this premise. Productivity gains in the United States and other developed countries had slowed in the late 1970's. However, progress in agricultural science has always been somewhat erratic. Over the longer term agricultural science has always moved forward in tandem with other areas of research.

Ongoing research throughout the world has produced a host of new developments that raise agricultural potential:

- The first genetically engineered vaccines. One prevents a major form of malaria, the other is the first fully safe weapon against foot-and-mouth disease (*17*). Both vaccines are made from the protein coatings of the disease organism, which triggers the immune reaction without risk of infection.
- The first viral insecticide, which attacks only the *Heliothis* genus of insects (corn earworm, tomato hornworm, tobacco budworm, soybean podworm) (*18*). The spores of the virus remain in the field after the worms have been killed, and attack any succeeding generations.
- A weed, *Stylosanthes capitata*, turned into a high-yielding forage legume for the huge acid savannas of Latin America (*19*). The plant outyields the

best previous forage crops in the region by 25 percent.

- Isoacids, a new class of feed additives for dairy cows. They increase bacterial action and protein synthesis in bovine stomachs, raising milk production or reducing feed requirements. The product is already being test-marketed.
- Embryo transplant operations to boost the genetic impact of top-quality dairy cows. The cows are given fertility drugs to induce multiple ovulation, and the fertilized eggs are then transplanted into the ovaries of average cows for gestation. The supercow can thus produce dozens of calves per year instead of just one. Thousands of such operations are now being performed each year.
- Short-season hybrids that have extended corn production 250 miles nearer to the earth's poles in the past decade (*20*). The grain is now being grown as far north as central Manitoba. East Germany has developed a corn hybrid and plans to shift its hog feed from imported shelled corn to a domestically produced mix of corn and cobs (*21*).
- The first practical hybrids for wheat, rice, and cotton. Hybrid alfalfa and rapeseed are at the field test stage. Triticale has recently outyielded the best wheats under difficult conditions, such as cool temperatures and acid soils (*22*).
- A system of agricultural research institutions for the Third World. The Consultative Group on International Agricultural Research (CGIAR) now has 14 research centers attacking farm production constraints. These centers produced the original dwarf wheat and rice varieties that launched the Green Revolution. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in Hyderabad, India, produced the potential breakthrough varieties of sorghum for Africa. The International Institute for Tropical Agriculture (IITA), at Ibadan, Nigeria, has produced a cassava that resists several endemic diseases, and thus outyields current varieties by three to five times. New peanut varieties from ICRISAT under test in India and Africa show yields several times greater than those of current varieties. The International Laboratory for Research on Animal Diseases (ILRAD), in Nairobi, Kenya, plans to launch a new vaccination program against Africa's tick-borne East Coast cattle fever within the next year. The International Center for Tropical Agriculture (CIAT), in Cali, Colombia, has produced varieties that double bean yields in Latin America. The International Maize and Wheat Center (CIMMYT), in Mexico City, has new white corn varieties that could nearly double yields in Central America and West Africa. The International Board for Plant Genetic Resources (IBPGR), in Rome, is preserving species. IITA is experimenting with alley cropping for African food production. The International Livestock Center for Africa (ILCA), in Ethiopia, is designing new farming systems that could sharply increase food production in Ethiopia's famine-wracked highlands. The latest miracle rice from the International Rice Research Institute (IRRI), in the Philippines, needs only two-thirds as much nitrogen and one-tenth as much pest protection as previous high-yielding varieties.
- Biotechnology, which may ultimately add more to farm productivity than any other development. Biotechnology has already produced the foot-and-mouth disease vaccine and high-fructose corn syrup. In the offing are such possibilities as ammonia-producing soil bacteria that farmers can plant to fertilize their crops, the first plant protein that is nutritionally complete for humans, crops with more built-in drought and pest resistance, and animals with better fat-to-lean ratios.

A Systems Break?

With productivity trends now so strongly positive, pessimistic arguments center on the possibility of "systems breaks"—sudden, sharp changes in external variables that affect agricultural success. In fact, however, high-technology farming has demonstrated tremendous capacity to adjust to sharp economic and environmental changes. It successfully overcame the oil crisis and its attendant escalation in fertilizer prices. It has surmounted the banning of the early persistent pesticides and their broad side-effects, such as the buildup of insect resistance.

Irrigation helps to drought-proof India and Bangladesh. Sudan's new sorghum seeds, in a year so dry that local varieties failed completely, yielded more than the local varieties do in a good year. Dams and drainage cut flood risks and convert swamps to cropland where necessary.

Technology can also broaden the range of production possibilities: Florida's most frost-prone citrus groves are going out of production; imports of frozen juice from Brazil now fill the gap when Florida's crop is hit, and the high prices that used to make the frost risk worthwhile no longer occur.

Neither drought in the Corn Belt nor massive crop failure in the Soviet Union nor the most severe drought in Africa's modern history have produced actual shortages of food in the world (although there have been regional shortages, complicated by transportation difficulties). Most significant, high-technology agriculture is producing more food per capita nearly everywhere in the world, despite the most rapid rates of growth in population and food demand in history.

High-technology agriculture could probably even take a significant degree of change in global climate in stride. Farmers already successfully cope with annual and seasonal weather variability that has far more impact on crop production than would even a major global cooling or warming trend. Any climatic change in the foreseeable future is likely to have only a moderate net effect on world cereal production, with some countries being helped and others hurt, but with the world retaining ample productive capability (*23*). Moreover, past changes in world climate have come over periods of centuries—ample time for breeding programs to adapt plants and animals to the new conditions. (There is no solid evidence that a global climatic change is taking place. Meteorologists say that, while overgrazing and deforestation play a part in the drought cycle of the Sahel, the broader African drought of 1983 and 1984 was too large to have been produced by human activities on the continent; rather, the drought was caused by a severe Southern Oscillation, a periodic global weather phenomenon that has often produced African droughts in the past.)

Famine in the Midst of Plenty

Africa's famine proves only that population growth has pushed traditional African agriculture to the limits of its productivity, even in good years. Any drought there now means hunger. The inevitable next drought will mean more deaths unless African agriculture can be modernized.

Fortunately for Africa, much of the technology for modernization is already available. New varieties of corn, sorghum, peanuts, and cassava are raising yield potentials from the Sahel to Zimbabwe. New farming systems promise help for Ethiopia and Nigeria. Improved pest control and new varieties are raising West African yields of cowpeas tenfold (*7*). A leguminous tree native to Central America (*Leucaena leucocephala*) is well adapted to many arid parts of Africa; it can be planted for timber and erosion control and is very effective in alley cropping, in which the roots of these trees planted in rows fix nitrogen for food crops planted between them (*24*).

Improved seeds are relatively cheap, and so are moderate levels of fertilization and pest protection for most farmers getting efficient off-farm support. Farmers increasingly use them because they cut per-unit production costs and raise the productivity of land and labor. Tree planting and improved crop rotations may cost nothing except some family labor. Desperately poor farmers become less desperately poor by using such improved methods.

The most serious constraints on African agriculture are those imposed by the national policies of African nations. Most of these nations achieved independence in the 1960's, when the popular development model argued that LDC's could skip agricultural development and move straight into modern industrialism. Even the countries that were able to export industrial products, however, were soon spending most of their new earnings to import food for growing urban populations. Ghana nearly destroyed one of the continent's most productive export agricultures with low prices and state-run farms. Tanzania forcibly gathered its small family farmers into collectivized villages, where their productivity sagged. Ethiopia's tiny agricultural research station 10 years ago produced improved varieties of wheat and sorghum; with a little fertilizer, they were capable of doubling yields on the small highland farms. The Mengistu government sent the seeds and fertilizer to its new state farms, where yields with the new inputs were lower than those at the peasant farms without them.

Only recently have African governments begun to recognize the need for agricultural research and farmer incentives. African agriculture is likely to make significant strides in the next decade, partly because Africans are learning from past mistakes and partly because they no longer have the financial backing to continue making them.

Declining Advantage of U.S. Cropland

American farmers have long believed that an important part of their competitive advantage lay in the nation's superior cropland and climate. Those factors now mean less because technology and investment are rapidly diminishing production constraints on other land in other countries.

Because of the advent of short-season corn, corn-growing potential can be expanded in Asia, Europe, and Latin America; even the Soviet Union is trying again to expand its corn production. The European Economic Community has greatly increased its output of rapeseed, sunflower seed, and field peas and other legume crops in order to displace soybean meal in its livestock feeds. Saudi Arabia produced 130,000 metric tons of wheat in 1975, and in 1985 is expected to produce 2.3 million metric tons. High wheat prices have turned the Saudi desert green. Palm oil production is rapidly expanding in the Pacific Rim to compete with soybean oil. Cassava from Asia competes with corn for the feed market. Sweden has a new seed treatment that makes wheat more winter-hardy, and already has its own grain surplus.

Agricultural output is becoming less a function of natural factors and more a function of the degree to which cost-effective technology is utilized. High land values today no longer mean farm prosperity; rather, like expensive machinery or chemicals, they just mean high production costs.

The real competitive advantages of U.S. farmers today lie in their high output per farmer and in the scientific and industrial infrastructure that supports them. The United States has the best-trained farm managers in the world—vitally important when a modern commercial farmer has to master a broad range of scientific, engineering, and business skills.

U.S. farmers also get exceptional support from off the farm. When export markets for feedstuffs expanded rapidly in the 1970's, the United States already had farm-to-market roads, railroads, farm equipment manufacturers, and food processors able to handle large volumes efficiently. The government had grain inspection and grading services with worldwide reputations. Agribusiness radically increased investment in unit trains, barges, and export elevators. (Canada and Argentina are still trying to get their export-handling capacity up to their farming potential—a decade after the opportunity appeared.) The United States also has outstanding research institutions, both government and private, to produce new technology.

These advantages will continue to be critically important, because world farm export markets will be fiercely competitive in the next decade. Production in LDC's is increasing rapidly because of technology, experience, and the need to feed populations and to service debts. This output is not only displacing imports but is producing some export competition as well. China, for example, is suddenly exporting cotton and corn.

Some middle-income countries, like Brazil and Argentina, are also under strong debt pressures to maximize their export potential. Others are doing it just to achieve economic growth for their swelling populations.

Finally, most of the DC's still maintain farm subsidy programs that stimulate additional farm output. The most significant of these is in the European Economic Community, which has increased the tax base for its farm subsidies by 40 percent in the last year and which will take Spain and Portugal into membership in 1986. Wheat yields in the community increased 23 percent in 1984, field pea harvests in France have jumped 50 percent in 2 years, and farm productivity in Spain could readily increase by one-third in the next few years.

Outlook for the U.S. Farmer

In the longer term, population increases and economic growth will increase the overall market for farm products. Protein foods will continue to increase their importance in international trade. New products will emerge—just as the soybean emerged to profitably occupy 50 million hectares of cropland. The agricultures that meet these emerging demands are headed for higher productivity, increasing affluence, and broader opportunity, but they are also headed for more competition.

The U.S. farmer is in an awkward position to compete for this long-term market growth. The strength of the dollar has raised U.S. farm price supports in recent years by perhaps 35 percent above the levels Congress thought it was establishing. This has provided a profit umbrella for competing farmers all over the world. (It may be technically impossible to effectively administer dollar-denominated price supports in today's world of volatile exchange rates.)

The U.S. share of world farm export markets has dropped significantly, in part because of our long-term policy of storing surpluses rather than selling them. In the past several years, the payment-in-kind (PIK) program cut U.S. production, further encouraging competitors. Grain can now be imported into the United States more cheaply than it can be bought here, while the annual cost of U.S. farm programs has soared from less than $1 billion to about $15 billion per year.

The current mechanisms of the General Agreement on Tariffs and Trade are weak and ill-suited to defending free trade for farmers. Renouncing farm exports, however, would mean renouncing export earnings—recently about 25 percent of U.S. farm income. This would cost hundreds of thousands of jobs on U.S. farms and in farm-related industries, while worsening the U.S. balance of trade and weakening economic growth.

The U.S. farm policy of the future must be geared to competing for buyers who have more alternative sources of supply than ever—their own agricultures, competing agricultures all over the globe, and more synthetics and substitutes. This means that our policies must be designed to reduce costs per unit and to provide farmers with the latest technology. Strong efforts are also needed to lower trade barriers; this will not only be good for U.S. farmers but will help the world to benefit from fuller utilization of global comparative advantages. Researchers need to look at farmland not only in the traditional sense but also as a potential source of biomass and the various kinds of complex chemical feedstocks that could be produced from genetically engineered plant life.

One thing seems certain: the price supports, land diversion, and storage programs that have dominated U.S. farm policy for the past 50 years work against the U.S. farmer in a world of high technology and rising productivity.

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RESEARCH ARTICLE

X-ray Structure of the Major Adduct of the Anticancer Drug Cisplatin with DNA: *cis*-[Pt(NH_3)$_2${d(pGpG)}]

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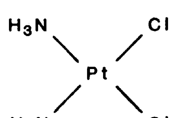
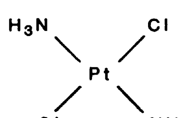
cis-Diamminedichloroplatinum(II), *cis*-DDP or cisplatin, is a clinically important anticancer drug, being especially effective for the management of testicular, ovarian, and head and neck cancers (*1, 2*).



cis-DDP
(cisplatin)



trans-DDP

It is one of the most widely used antitumor drugs at the present time. The *trans* isomer, *trans*-DDP, is inactive. Considerable evidence points to DNA as being the main target of cisplatin in the tumor cell (*3*). Attention has therefore focused on the nature of, and the differences between, adducts formed by *cis*- and *trans*-DDP with DNA. By using a variety of enzymatic mapping techniques, we and others have shown (*4*) that the most common binding mode of *cis*-DDP with DNA involves loss of two chloride ions and formation of two Pt-N bonds to the N(7) atoms of two adjacent guanosine nucleosides on the same strand. For stereochemical reasons, this intrastrand d(GpG) cross-link cannot be formed by *trans*-DDP. Much structural information about the adduct of *cis*-DDP with synthetic oligodeoxynucleotides has been garnered through nuclear magnetic resonance (NMR) spectroscopic investigations (*5, 6*). In addition, recent molecular mechanics calculations on *cis*-[Pt(NH_3)$_2${d(GpG)}] adducts in two oligonucleotide duplexes and two single-stranded oligomers have provided theoretical insight about the structure (*7*).

Conspicuously lacking thus far has been structurally definitive single crystal x-ray diffraction information about *cis*-DDP bound to DNA. In attempts to model the binding of the *cis*-{Pt(NH_3)$_2$}$^{2+}$ fragment to d(GpG), more than a dozen x-ray structural studies have been made on amine complexes of platinum bound to two 6-oxopurine bases, nucleosides, or nucleotides (*8, 9*); however, no oligodeoxynucleotide adduct has yet been crystallographically characterized. Three studies have been directed toward establishing the nature of cisplatin binding to nucleic acids by diffusing the drug into crystals of a B-DNA dodecamer (*10*) or into phenylalanine transfer RNA ($tRNA^{Phe}$) (*11, 12*). In all cases, high resolution information was precluded either by low or multiple occupancy (or both) of platinum binding sites in the crystal lattice or by the failure

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