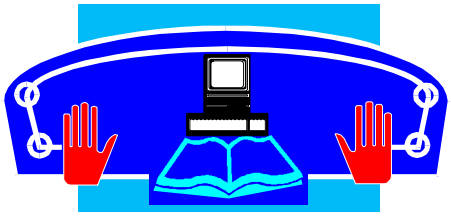

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Sustainable Agricultural Development And The Environment - Towards An Optimal Solution

Type of Study: Policy Material/related
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Date of Report: 1994
Author: Bill Anderson
Catalogue Number: 1-1-19

Sustainable Agricultural Development and the Environment: Toward an Optimal Solution

Bill Anderson

October 1994

SUSTAINABLE AGRICULTURAL DEVELOPMENT AND THE ENVIRONMENT
TOWARD AN OPTIMAL SOLUTION

A REPORT ON GLOBAL RESOURCE USE ISSUES

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CANADIAN INTERNATIONAL DEVELOPMENT AGENCY "

Funding support for the printing of this report is gratefully acknowledged from:

Agricultural institute of Canada
Ottawa, Ontario
October 1994

Table of Contents

Table of Contents (cent'd)

CHAPTER 1: THE CONTEXT FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT

INTRODUCTION

We live in a world in which:

- the population is about to double again reaching roughly 1() billion by 2040;
- billions of underfed citizens in poor countries have already begun to raise their incomes and to upgrade their diets: and
- environmental concerns argue more and more strongly against clearing and ploughing more land tor food production.

To meet the world's demand for food, protein and environmentai protection, the global food system in 2040" will have to produce three times as much as it does now -- most of it from the same farmland and water used today. [1]

In short, countries must pursue the goals of sustainable agriculture and sustainable agricultural development (defined below).

Whether the world can meet the growing demand for more and better food at an acceptable or "sustainable" environmental cost depends on many variables.

Among the most important are:

- decisions on agricultural policy;
- the extent to which farmers adopt better practices for managing agricultural land: and
- the extent to which countries invest in agricultural research and development.

"Sustainable Agriculture" vs. "Sustainable Agricultural Development"

These terms. which appear throughout this paper, are very different concepts. Sustainable agriculture is based on policies and practices that acknowledge environmental concerns, instead of focusing primarily on growth. production and distribution considerations. Sustainable agriculture is appropriate for countries or groups of countries, such as the European Community (EC). that have already achieved high growth and production and have developed sophisticated distribution systems. However, growth, production and distribution have occurred at great environmental cost (discussed later in Chapter 2) -- a cost that is no longer acceptable. Therefore. the EC needs "sustainable agriculture, " which places environmental priorities ahead of increases in productivity.

On the other hand. in many countries. such as Bangladesh. agriculture must expand (i.e., develop): distribution must improve and, at the same time, environmental concerns must be addressed. In essence. Bangladesh needs "sustainable agricultural development" -- agriculture that increases output and improves distribution in a way that can be sustained.

The rest of this introductory chapter briefly discusses the relationship among sustainable agricultural development, economic development and the environment. This discussion provides a context for subsequent chapters. which explore the issues of agricultural policy, land management, research and development (R&D) and technology transfer.

AGRICULTURE, ECONOMIC DEVELOPMENT AND THE ENVIRONMENT

our discussion under this heading emphasizes that sustainable agricultural development, economic development and the health of the environment are inextricably linked. This link flows from three assumptions:

- Most of the world's poor live in rural areas and depend on agriculture for their livelihood. Therefore. agriculture is the main avenue through which they can emerge from poverty, improve their standard of living and develop their self-reliance.
- Poverty leads to practices that are incompatible with sustainable agricultural development. and which work against sustainable development in

the larger sense. In other words. poverty is hard on the environment.

- Population will virtually double to 10 billion by 2040.[2] Agricultural policies and practices must change (become "sustainable") if we are to meet the increased demand for food without causing serious harm to the environment.

Figure 1: Rural Population in Africa, Asia and the Americas

	1990 **Population (millions)**	**1990 Percent Rural**	**Population Rural (millions)**
Africa	642	66.1	424
South America	296	24.9	74
Asia	3.113	65.6	2.042
Central America	151	-H)	60
Total	4.202	62	2. (>00

Source: *World Resources 1992/93 - A Guide to the Global Environment:* Column A: p. 246; Column B: p. 264.

The Need to Attack Rural Poverty

Figure 1 shows that most of the world's poor lived in rural areas in 1990.

Currently, there are 2.6 billion rural inhabitants of low-income countries. They account for 77 percent of the world's 1.2 billion people living in absolute poverty. Most of these people are small entrepreneurs engaged in agriculture.

organizations involved in reducing Third World poverty and promoting development generally agree that reducing poverty is a top priority in many poor countries. The World Bank, the Asian Development Bank and CIDA are all on record to this effect. However. not all agree on the best way to reduce global poverty. Some -- including influential strategists at the World Bank -- suggest that the poor are a marginal group in need of welfare provision. While it is true that the Bank is now iending more for health and education, many of its programs designed to heip the poor are essentially welfare safety nets -- not a way of lifting people out of poverty. In Ethiopia, for example, the Bank has promoted food coupons as a way of cushioning the poor from the effect of lifting state food subsidies. This may satisfy city dwellers, but aid workers argue that. in Africa, where most of the poor are small farmers who often live in remote areas, the poor do not need handouts. Instead. they need heip in taking advantage of the new incentives provided by the Bank's market-freeing reforms. [3]

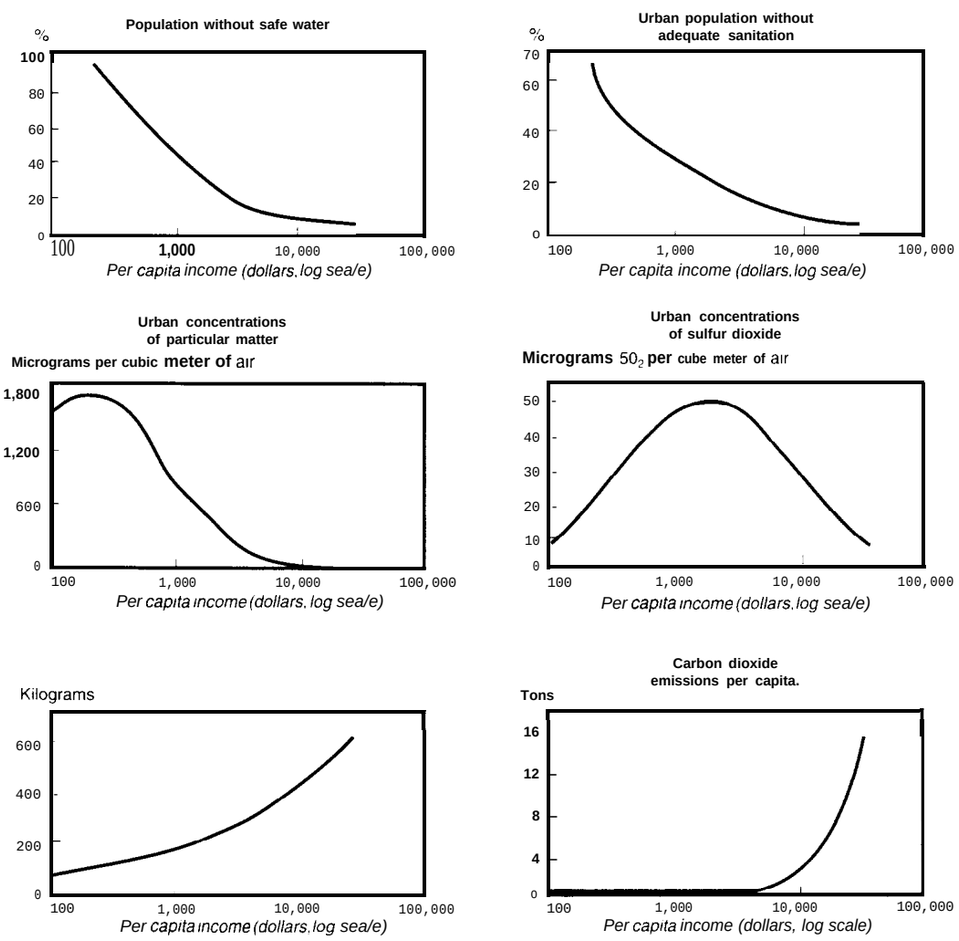
Bell, Hazell and Slade (1982) provide hard evidence that agricultural technology can help alleviate rural poverty. They studied the combined effect of an irrigation project anti the use of high-yielding varieties of rice in the Muda River region 01 Malaysia over the period 1967 to 1974. In that time, the technology's direct benefits meant that the average per capita income in the region covered by the study ",. increased by 70 pm-cent when measured in constant prices. Land-owning households gained relatively more, but landless paddv workers aiso increased their real per capita incomes by 97 percent, despite a shift to mechanization for land preparation. " The same study aiso made the point that the "indirect benefits were skewed in favour 01 the non-farm households in the region. many of which were already well off."[4] The essential point here is that, although the indirect benefits of agricultural growth [lowing from the use of agricultural technology may not necessarily improve the relative (distribution of income within the rural areas. they can have major effects on alleviating poverty in the absolute sense.

Given the large numbers of poor (many of whom are women, as noted below) who are, in effect, small farmers, it would seem that the key to improving heir economic status and increasing their self-reliance lies in improving agricultural productivity.

Agriculture and Gender Issues

Agricultural development and the economic well-being of millions of rural women are virtually inseparable. At least 80 pm-cent of the women in the less-developed countries (LDCs) live in rural areas and depend completely on agriculture for their Livelihood. j In fact, a larger proportion of women than men are engaged in agriculture: women are the agricultural decision makers, and they and their families benefit directly from agricultural development programs and assistance. But thus far, rural women have not had enough ready access to agricultural technology and programs in the LDCs. This fact may account for the low growth of agricultural production in many of these countries. However, where women farmers have participated in projects such as the CIDA-funded CARDI Sheep Production and Marketing project in the Eastern Caribbean, results have been positive. Clearly, agricultural development programs anti aid should acknowledge the critical role rural women in LDCs can play in promoting sustainable agriculture.

Figure 2: Environmental Indicators at Different Country Income Levels



[a] Emissions are from fossil fuels.
Source: *World Development Report, 1992.*

Poverty and the Environment

Poverty and environmental degradation are closely linked. This linkage is especially apparent in rural areas of the LDCs, where poor families often live at basic subsistence levels. Meeting their needs for the bare essentials may prompt them to "mine" natural resources. For example, they may overcut to obtain firewood, fail to replace soil nutrients and overgraze pastures. In other words, what the rural poor in many LDCs must do to subsist is not consistent with sustainable agricultural practices, and it degrades the environment.

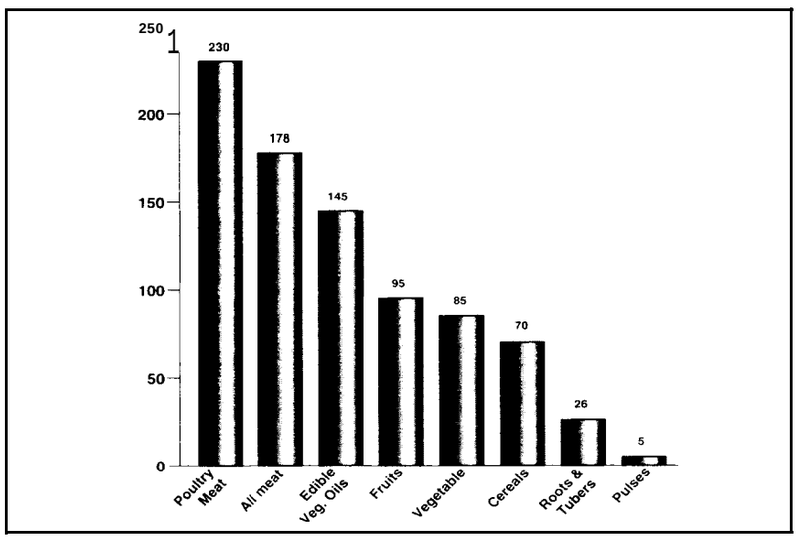
As Figure 2 illustrates, data from the *World Development Report*, 199.2 show that urban environmental conditions deteriorate as incomes decline, according to four of six indicators.

Conversely, environmental conditions improve as incomes rise. If this is the case, and given that most of the world's poor in low-income countries are rural and engaged in subsistence agriculture, it seems reasonable to conclude that anything that can be done to increase their income should benefit the environment. Any success in meeting the global environmental challenge and improving economic development will depend heavily on their role or lack of it.

Coping with Growth: The Need for Sustainable Agricultural Development

As noted earlier, the world's population is expected to double by about 2040." However, it is evident that the demand for food will *triple* by 2040: "... if the world's people are to have a nutritionally adequate diet, world food output must at least triple over the next half century, given the likely population increases" *(James Gustave Speth, UNDP Administrator, in* his Sir *John Crawford Memorial lecture to the annual CGIAR meeting)*

Figure 3: Asian Production of Selected Food Crops
1970- 1989 (percent increase}



Source: FAO Agrostat 1991

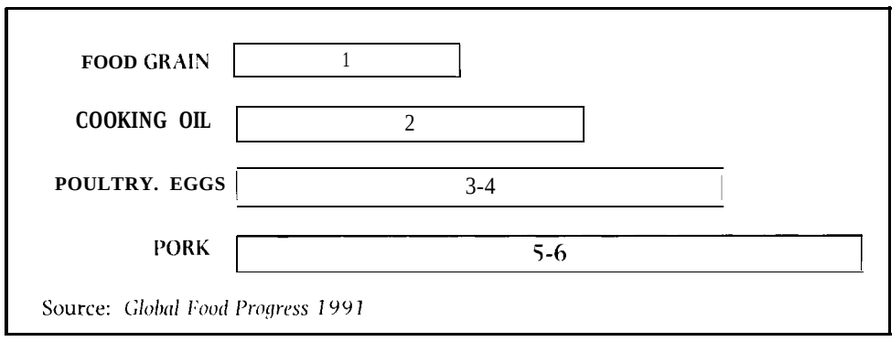
Population growth will account for only part of the increase in demand for food. The rest will occur as a result of more disposable income in the LDCs. This is best illustrated by Figure 3, where the switch in consumer preference is evident.

GNP per capita for all LDCs is forecast to grow about 3.5 percent annually to 2040,[6] a growth rate that implies a doubling of per capita incomes every 20 years. Even a lower rate of growth will dramatically alter the composition of the mix of commodities purchased.

The increase in disposable income will trigger a sharp increase in demand for food because, in many developing countries, more than half of any increase

in disposable income is spent on more or higher-quality food. Foods such as cooking oil. meat. eggs and fresh produce will be in particular demand. In a study of economic changes in village households in India over a 10-year period. *Hazell and Ramasamy* found, for all household groups analyzed. "...an improvement in the mix of commodities and services purchased towards more luxurious items: more livestock and horticultural products and vegetable oils..."; In Asia. this trend appears to have been in progress since the 1970s.

Figure 4: Relative Agricultural Resources per Calorie



Source: *Global Food Progress 1991*

Notes: Conversions shown above are indicative: technologically advanced livestock operations. commonplace in Canada, now achieve conversion rates of less than 3:1. Diets with less dependence on grains are healthier, but require more resources to produce and are subsequently more expensive.

Given the projected increase in demand for food, the challenge becomes one of achieving a secure supply of food at acceptable (sustainable) environmental cost.

The Need for More Productivity

It' agriculture is to produce **enough** food to meet demand, it will be essential to produce much more of it and to produce it differently. Demands on farm resources will be affected not only by population growth but also by change in diet. spurred by rise in disposable income. It takes several times more farm resources to produce a calorie of energy derived from vegetable oil. milk, meat. eggs, poultry or pork than it does to produce the same calorie from carbohydrate-based cereal grains (Figure 4).

So-called "luxury" foods form a large and growing portion of the world's grain consumption. reflecting dietary change in countries as poor as India.

The expansion of global cropped area has almost stopped in recent years (Figure 5).

Figure 5: Global Land Use
(Billion Hectares)

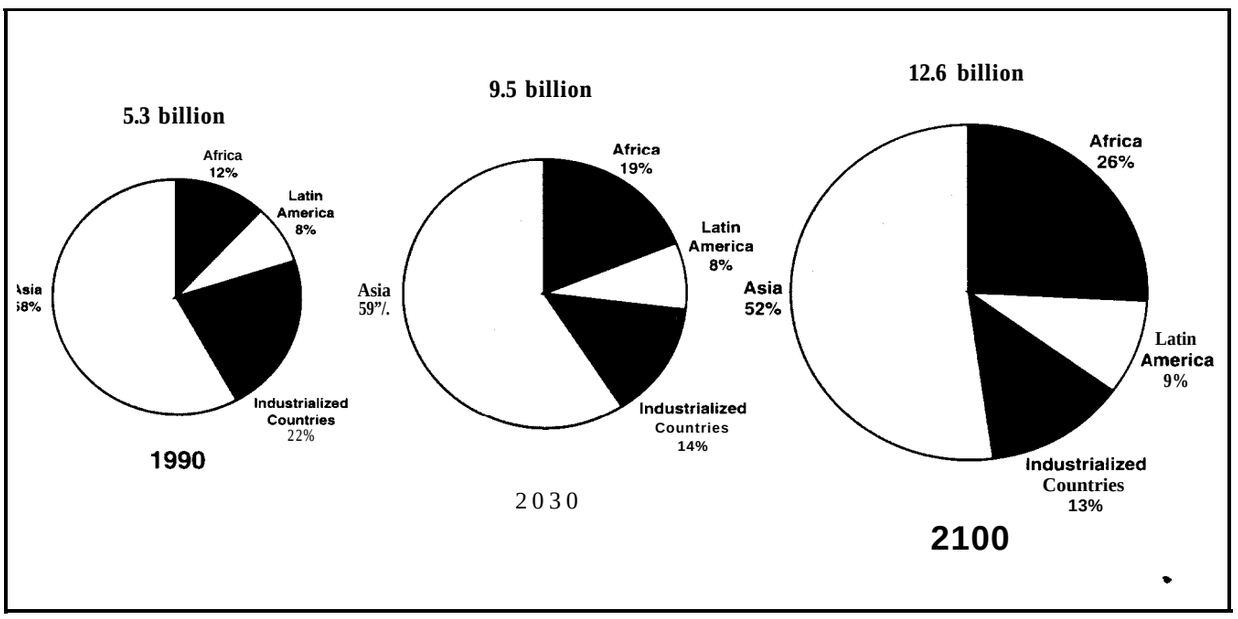
	1975	1980	1985	1990
Total land area	13.08	13.08	13.08	13.08
Arable & permanent Crops comprised of:	1.39	1.42	1.43	1.44
arable land	1.30	1.33	1.34	1.35
permanent crop	0.09	0.09	0.09	0.09
permanent pasture	3.31	3.33	3.37	3.40
forest and woodland	4.17	4.10	4.06	4.03
other land	4.20	4.23	4.23	4.21

Source: *FAO Production Yearbook 1991*

Accordingly, the developing countries will depend more and more on better productivity from existing cropland to meet their food needs. But any gains in productivity must be achieved with much more emphasis on the health of the environment. The environmental damage (now an acknowledged fact) that has accompanied the great increase in agricultural production in the EC must be curtailed. In the LDCs, sustainable agricultural development principles must prevail.

Population control, while vital, is no solution to the growing global food demand. Despite progress in lowering fertility rates, the major population growths will occur (Figure 6) in low-income countries.

Figure 6: Projected World Population by Region, 1990, 2030 and 2100, Central Scenario



Source: International Institute of Applied Systems Analysis (IIASA) as quoted in "The Future of World Population" by Wolfgang Lutz. Population Bulletin #49. July 1994.

Therefore, given the reality of a growing demand, the **key** to ensuring adequate global food supplies in the next 50 years lies with investments in sustainable agricultural development. Failure to address the present challenge of producing more, but producing it at acceptable environmental cost, will reduce the long-term development prospects for many LDCs.

THE OUTLOOK FOR AGRICULTURE IN THE 21ST CENTURY

Key Changes

In the next 100 years, we can expect the world's farmers to practise the same basic form of agriculture as they do today. However, four major changes will be necessary:

- Agriculture in the 2 1st century must rely even more on new knowledge. Much of this new knowledge will be aimed at helping tropical farmers overcome their traditional disadvantages of heat. drought and crop-destroying pests,

- The agriculture of the future must be safer for the environment. Pesticides and integrated pest-control methods must be developed that have even fewer side-effects than the low-volume, narrow-impact, pest-specific and rapidly degrading pesticides used widely today. Many of these new pest controls could be made possible by biotechnology and integrated pest-management technologies.[8]

- New conservation techniques, such as conservation tillage. zero tillage and inter-cropping, will have to be widely instituted to reduce soil erosion.

- Higher yields from the world's best farmland will be required to reduce the economic incentive to destroy forests (including the world's rain forests) in order to create more cropland.

These changes are synonymous with "sustainable agricultural development" and "sustainable development" in the broader sense.

The following chapters highlight key areas of the policies, practices and new knowledge associated with the realities of agriculture in the next century.

ENDNOTES: CHAPTER 1

1. "High-Yield Agriculture: Saving Both People and Environment" by Denis Avery, Director, Global Food Issues, Hudson Institute, Indianapolis, Speech given to Canadian Crop Protection Institute, Toronto, September 21. 1992.

2. Author notes that a global population of 1() billion would be reached by 2040 by the scenario shown in Figure 6 from 1990-2030 followed by annual growth of only ().5 percent between 2030-2040.

3. *The* Economist, October 30.1993, p. 50.

4. Hazell and Ramasamy. The *Green* Revolution *Reconsidered: The Impact of High-Yielding Rice* Varieties *in* South *India* (Baltimore: Johns Hopkins [University Press, 199 1), pp. 2 and 3.

5. United Nations. Women's World Trend and Statistics. 1970-1990.

6. "Evolution of Japan's Strategy on Global Agricultural Development," International Development Centre of Japan. August 30, 1993, projecting growth in GNP per capita in developing countries, 1990-2040. Discussion paper.

7. Hazell and Ramasamy, op. cit., p. 55

8. Avery, Denis T., *Global* Food Progress *1991* (Indianapolis Hudson Institute), p. 228.

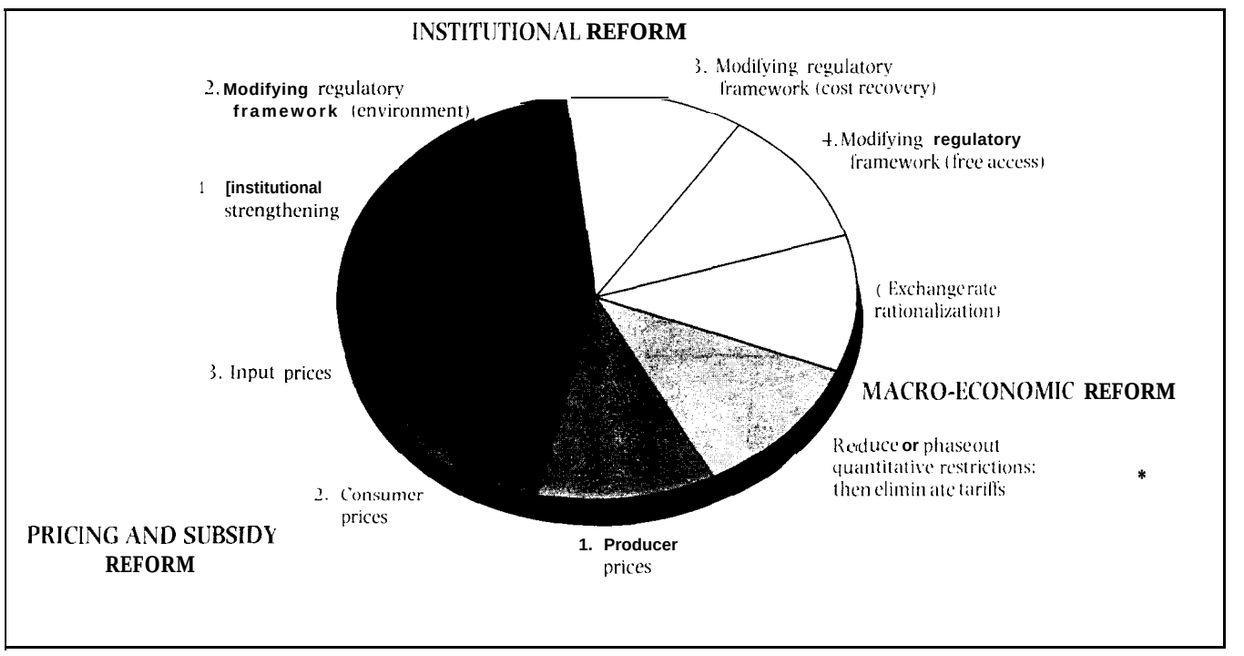
CHAPTER 2: AGRICULTURAL POLICY

INTRODUCTION

There are three broad categories 01 agricultural policy reform. each of which has an important impact on the ability of the agriculture sector to deliver sustainable agricultural development. These categories. illustrated in Figure 7 below, are: (i) institutional reform for the sector: (ii) pricing and subsidy reform: and (iii) macro-economic reform.

This chapter highlights four policy areas that governments must address if the world is to meet the growing demand for food over the next 50 years. The four areas are: agricultural protectionism: land ownership and property rights: technology transfer: and investment in the agricultural infrastructure.

Figure 7: Elements of Agricultural Policy Reform



Essentially, many of the current food "shortages" in, for example. African LDCs result not so much from actual shortages as from bad national policies. Wars, climate, weak distribution systems. and lack 01 agricultural R&D contribute to the problem, but the role of misguided policy is significant.

The most dramatic problems for African farmers have resulted from mistakes of their own governments. Many governments have overvalued their currency exchange rates and instituted controlled and artificially low food prices.

These policies have benefited or "appeased" the politically volatile urban population at the expense of the less vocal and politically visible rural population. Compounding the problem are government monopolies in the farm-support system and a lack 01 foreign exchange to purchase key inputs to agricultural production and to create an "agricultural infrastructure" (we pp. 1 9-20).

Industrialization vs. Agricultural Development Policy: The African Example

Many African nations received their independence in the only decade in world history in which agriculture was not regarded as the most important building block for economic growth. [1] It is not surprising, therefore. that faulty agricultural policy formed in the 1960s has hindered the economies of many African and other developing countries - given the close links between agriculture and economic development.

During that decade. governments advanced policies that stressed industrial growth rather than agricultural development. These policies were based on the theory that emerging economies could tax their farmers for the capital needed to leapfrog directly into modern industrialism.

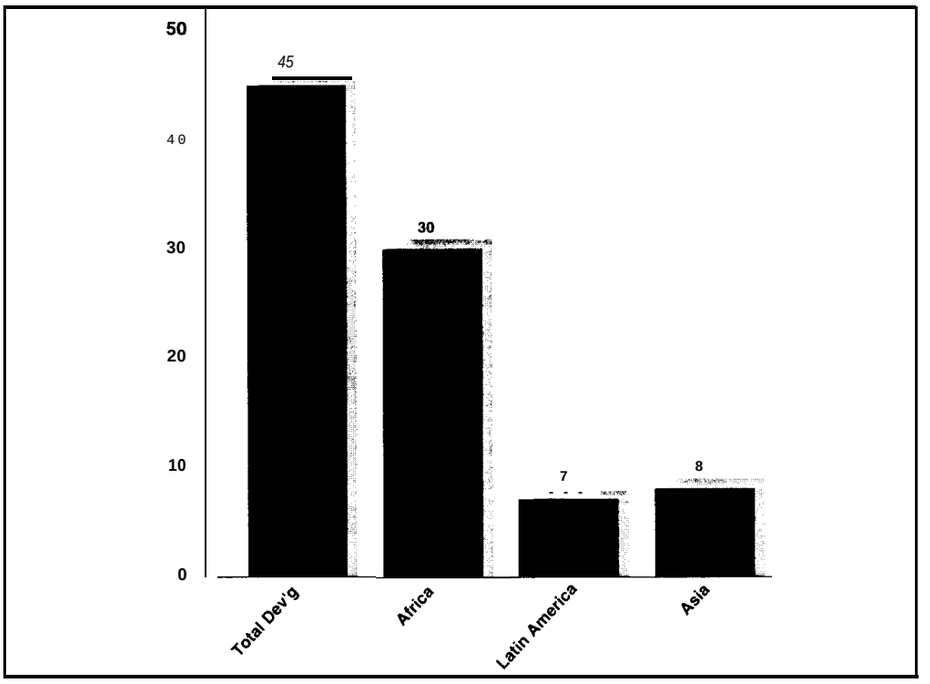
Unfortunately, the new theory ignored certain important realities: If African farmers are taxed instead of rewarded for producing, they simply retreat to the traditional subsistence agriculture that they and their forebears have engaged in for generations. In the absence of locally produced food, the urban population came to depend increasingly on food from foreign donors. The theory also ignored the fact that if 70 to 90 percent of a country's population consists of farmers who earn no money from selling their products in the cities. there will be no domestic market for the products of the new urban industries.

In fact, most of Africa's new industries were aimed at a largely non-existent domestic market. They were intended to reduce imports, rather than produce goods for export, which would have spurred export-led economic growth. In essence, the capital taken from the farmers to develop the new industries was largely wasted. [2]

Food Security

Today's relative complacency regarding the global food situation is largely based on the observation that present global harvests are at least adequate to supply everyone in the world. This observation has limitations.

Figure 8: Food Insecurity by country 1988-90

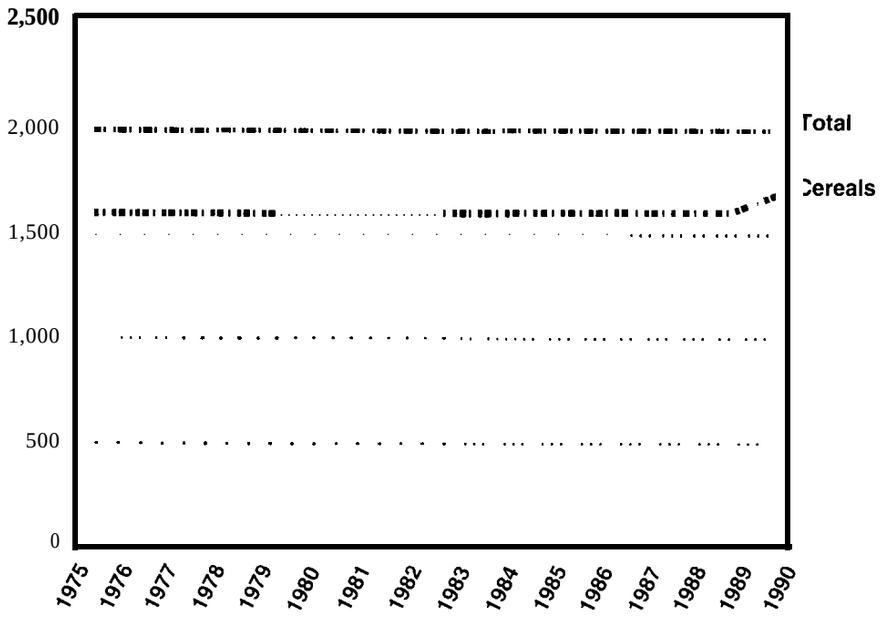


Source: *Human* Development Report *1994*. pp. 154, 155.

- Global food supply snot particularly well distributed. This is unlikely to change in the short-run -- with or without food aid, which accounts for less than 1 percent of global cereal consumption. Many low income countries are calorie insecure. In 1988-90 there were still over 40 countries with average food availability below minimum requirements based on the United Nations minimum nutrition] standard (Figure 8). In some 70 countries, according to *State of the World Population 1* 993, per capita food production dropped in the 1980s.

- Food insecure countries can take little comfort from statistics showing the present adequacy of global food supplies. [n future, they are most unlikely to adopt an economic development strategy that rests on the assumption that unused arable land somewhere in Africa would provide their domestic food needs in the 2 1st century. For the most part, countries will strive to provide in large measure their own food resources. however capable they may be to do so. Satisfying the caloric requirements 01' the global population is, furthermore, only part of the solution. Bangladesh. for example (Figure 9). is almost calorie self-sufficient, yet the quality of the diet is marginal and has not significantly improved in overall quality from 1975, largely due to its over-dependence on one source -- in this case, rice. Their diet desperately needs nutrients from a broader range of food commodities.

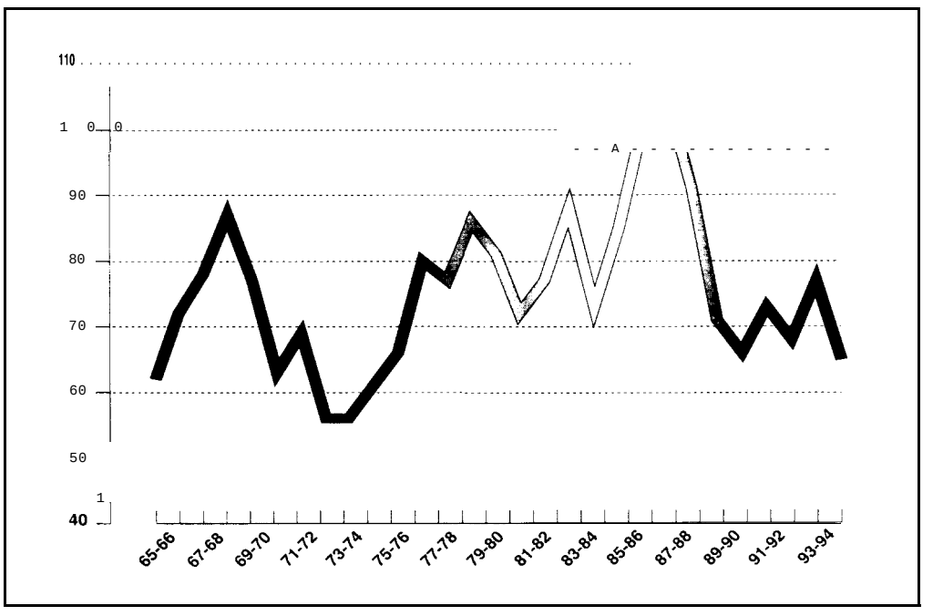
Figure 9: Dietary Energy Supply
(Kcals/Caput/day) Bangladesh



Source: *Second Report on the World Nutrition Situation. volume II. United Nations.* March 1993)

- The present situation as reflected by global stocks is not much different than the 1970s. One has to conclude that even in the bleakest period of 1973-74, there were stocks in excess of 5-0 days 01 consumption, as compared to 67 days at the end of 1993 (Figure lo). However, the situation in 1973-74 triggered a worldwide panic that let to steeply rising cereal prices.

Figure 10: Total Grain Ending Stocks Expressed in Days of Use'



* Wheat. Coarse Grains & Rice.
Source: B. White, Canadian Wheat Board.

- While there has been remarkable progress in bringing nutrition to the developing world in the last 20 years. the food requirements will need to triple in the next 50 years. It is evident that the number of adequately nourished (as defined by the global population less the number of malnourished) has grown by roughly 1.6 billion or 80 million a year in the last 20 years. As a result of population growth. shrinking cropped area, increased purchasing power, and changing tastes, food deficits in Asia are projected to grow from 30 million tons in 1982-88 to about 1 ()() million tons in 2005" (Figure 11).

The viewpoint that food security is not a food production problem. but an income or purchasing power problem is easily one of the most destructive simplifications in the international development. Most poor people in poor countries live in rural areas, and the principal means of raising their incomes can only be through increasing agricultural production, with the resulting chain reaction of increasing employment in and out of agriculture. The rural poor can increase their incomes through production of nonfarm goods and services and high-value agricultural commodities. However. the effective demand for those goods and services must come from rising farm incomes.

Figure 11: Food Demand-Supply Projection ('000 ton)

	1982-88	2005
Wheat	-36.376	-44,433
Paddy	4.361	3.512
Corn	-16,811	-56,353
Other cereals	-3.957	-6.831
Root	22.964	17,222
Pulse	-403	-3.787
Total	**-30,222**	**-97.694**

Source: *ADB/IFPRI. Food Supply. Demand. and Trade in Asia.*

Malnutrition and Agricultural Development

The causes of malnutrition in LDCs are often related to a lack of policies that promote agricultural and rural development. Without such development, food security becomes an elusive goal, and malnutrition often results. While the world as a whole may be eating better than ever before. there remain nutritional problems of immense proportion, particularly in the world's low-income, high-population nations that lack food self-reliance. The nutritional problems arc clearly more prevalent in regions with low per capita income (2) and a lack of general economic development (Figure 1 2).

Accordingly, the "right" agricultural policies aimed at strengthening agricultural and rural development, as discussed in the rest of this chapter, could contribute much to reducing malnutrition -- one of the most common (and costly in human terms) symptoms of weak economics.

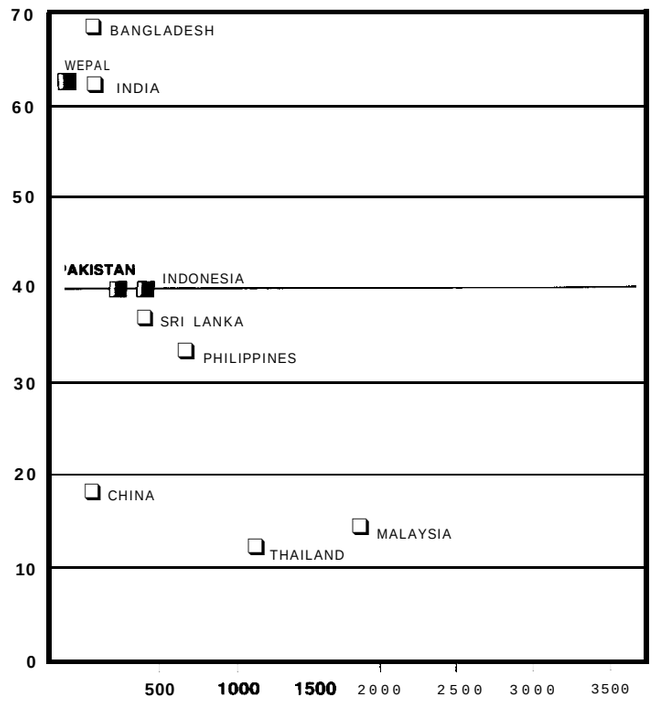
POLICY AREA ONE: GATT AND THE PROTECTIONIST ISSUE

This section discusses two opposing agricultural policy directions. one is protectionist anti emphasizes "national food self-sufficiency" (often achieved at great economic and environmental cost). The other is trade-oriented and acknowledges the concept of "comparative advantage." i.e.. that some countries may be able to produce an agricultural product more efficiently than another.

Efficiency or National Self-Sufficiency?

The world is at a critical juncture in agricultural trade. During the next 15 years. major investments will be required to meet the food and diet aspirations of huge populations emerging in low- and middle-income countries.

Figure 12: Percent Underweight Preschool Children -- 1980s



GNP per capita (constant U.S. dollar).
Source: *Second* Report on *the World* Nutrition Situation, ***Vol.*** 2, March 1993.

The world is deciding now where its agricultural production investments for the next century will be made. The key decision is whether to pursue protectionist policies and national food self-sufficiency models (the current norm), or to shift toward a less protective, trade-oriented agriculture. The trade-oriented model based on global "comparative advantage" (see pp. 15 and 16 for an explanation of this concept) has been enormously successful for non-farm goods and services and, since the formation of the General Agreement on Tariffs and Trade (GATT), the world has moved in that direction. But the potential benefits for its farmers and food buyers under a similar trade regime have been ignored. Instead, food self-sufficiency models have prevailed. The reason is that virtually every country today considers food imports as a waste of foreign exchange and a lost opportunity for its domestic agriculture. The protectionist model is radically different from the competitive, low-tariff trading model that has evolved for world manufacturing since 1950.[3]

Quotas, Tariffs and Non-Tariff Barriers: The Attendant Problems *

Article XI **2(c)** of GATT permits import quotas wherever agricultural imports would adversely affect domestic programs for controlling supply. This Article allows countries (developed and less-developed alike) to severely distort agricultural trade if they wish to do so. One of the Uruguay Round proposals was to foster trade by eliminating non-tariff barriers such as quotas, which limit imports of commodities to a set level. Beyond that level, imports cease, no matter how competitive a supplier in another country may be.

The Uruguay Round was concluded in December 1993 and, as a result, the prospects for freer agricultural trade appear brighter, However, efficient agricultural producers will continue to suffer under quota systems for as long as quotas persist, whether they grow wheat in Canada, apples in Washington State, rice in Thailand or sugar in the Philippines.

Taxpayers around the world will pay a heavy price for quotas through higher grocery bills, higher taxes or both.

Producers in developing countries who need cash flow to help their economies grow lose billions of dollars annually because of the agricultural and trade policies of their own countries. For example, it is estimated that if developing countries were to give up taxing their own farmers and invest in rural infrastructure instead, the annual gains could approach $50 billion by 2000.[4] (The growth in food exports from LDCs has expanded in recent decades, but not nearly to the extent it would have under free trade.)

Europe's Common Agricultural Policy (CAP)

Assistance to agriculture and rural development in the EC has been implemented through CAP since the mid- 1960s. The objectives of CAP were to increase production and to provide market unity within the EC. Market unity bars any restrictions on trade between member states and requires a uniform agricultural price for the entire community. Each spring, the EC's 12 agricultural ministers fixed guaranteed prices. which have generally been above world market prices. To protect against cheap imports, EC countries imposed tariffs on non-EC products, ensuring their sale at guaranteed prices.

The Financial Costs of CAP

Swedish analysts claim that consumer food costs in Sweden could be cut in half simply by eliminating CAP farm subsidies and import barriers. The savings would be equivalent to a 1() percent pay raise for the average worker. [5]

In recent years, price distortions have significantly influenced what farmers have chosen to produce in the EC and other industrialized countries. For example, price policies in the EC have encouraged production of maize and sugar beets and discouraged production of pulses (peas, beans and lentils) and root crops. Meanwhile. relatively inexpensive imports of sugar from efficient producers in the Third World are excluded. Similarly, in pig and poultry production. farmers are using expensive, home-grown feed cereals from EC sources rather than low-price feeds from outside. Accordingly, consumers in the EC pay more for these products, and LDC producers lack a market for what they can produce more cheaply.

Protectionist regimes such as CAP reward production inefficiencies. In contrast, freer agricultural trade policies discourage them. For example, if Country A produces sugar more cheaply and efficiently than Country B does. Country B will eventually be eliminated as a sugar producer in the absence of protectionist measures. Consumers in both countries will also enjoy a lower price for this commodity.

In the 1980s, other countries, notably the United States, began to counter the export subsidies of others with export subsidies of their own. In so doing. they made the cost of maintaining subsidies sharply more expensive for all governments.

Finally, farm subsidies have another undesirable side-effect: Considerable evidence exists that subsidies encourage the concentration of land ownership in the hands of larger-scale farm operators.

The Environmental Cost of Food Self-Sufficiency

As the figures above indicate, agricultural protectionism and policies that favour food self-sufficiency are costly in dollar terms. Clearly, the world's economies have suffered from the higher costs of inefficiently produced food. However. these policies are also costly in environmental terms.

The pursuit of food self-sufficiency witnessed throughout the world in recent years has often been counterproductive to the extent that the environment suffers from attempts to grow crops on unstable land. Accordingly. environmental considerations offer good reasons for moving away from the policies of food self-sufficiency for all nations.

Pursuit of this goal is clearly incompatible with sustainable agriculture. Again, using the EC example, subsidies associated with CAP have produced serious environmental consequences, particularly in terms of soil and surface water degradation. In essence, although CAP has been a technological success, it has also been an environmental failure. in the LDCs. subsidy programs produce their own environmental side-effects. one of the most prevalent is the accelerated degradation of soil and water which occurs as a result of programs that encourage mono-cropping on fragile lands.

A better model is essential if the world is to produce enough food to meet the rise in demand in the next

50 years without causing an environmental catastrophe. The environmentally sensible course of action is to push to end protectionist agricultural subsidies, which threaten further environmental degradation around the globe. The conclusion of the Uruguay Round of GATT in December 1993 is an important step in that direction that will at least partly resolve the subsidy problem over time.

Alternatives to Protectionism

At the other end of the spectrum from protectionist policies aimed at food self-sufficiency are those that emphasize efficient, trade-oriented agriculture.

"Food Self-Sufficiency" and "Food Self-Reliance"

As noted above, under food self-sufficiency, a nation's agricultural policy is aimed at producing as much food as possible within its borders, Imports are avoided, even when imports would be less expensive than foodstuffs produced at home. On the other hand, *food* ***self-rdianu*** is a concept based on the fact that some countries enjoy a "comparative advantage" in producing particular agricultural products. A country with a policy of food self-reliance would likely import a product from another country if that country enjoyed a comparative cost advantage in producing it. The self-reliant country would also institute policies that encourage the growing of crops at home if a comparative cost advantage existed. [t would export these crops to earn foreign exchange to pay for importing necessary food that it could not produce efficiently itself.

Measuring Comparative Advantage

Comparative costs in agriculture vary enormously. One variable that influences comparative advantage in producing a given product is the value of land. (Infrastructure and transport costs are also important variables, but these tend to be reflected in land values.) Japanese farm costs may be the highest in the world. with ordinary rice land selling at $ 50,000 per acre and up. Cropland in the EC can cost $ 15,000 per acre, while U.S. Corn Belt land can be bought for $1,500" per acre.[9] High-quality Canadian prairie land is priced much lower.

All 01 these variables affect the cost of producing a unit of a given commodity relative to that of the competition. However. comparative advantage does not take into account certain other costs, such as the stress on natural resources, as ideally it should. If, for example. Country A and Country 13 can produce a ton of wheat for the same cost per ton, but one country degrades soil and water to a greater degree to do so. the rules of sustainability tell us that production should be concentrated in Country A. Canada. for example, produces wheat for about the same cost per ton as a number of its competitors, but it uses lower levels of chemical inputs than many.

The Future of Agricultural Protectionism

The current trend in most countries is away from price support and production payments. Food demand (i.e.. the market for food)islargely saturated in these countries. They also have severe deficit problems. which make it difficult to continue spending money on expensive price support programs. The more affluent countries are indeed moving away from trade barriers. as are the "Asian tigers" -- Singapore, Hong Kong, Thailand, Malaysia. Taiwan and Korea. However. they are doing so very slowly. Most of the "Asian tigers" are land-poor and carry out much of their agriculture on deficient, thin or sloping soils, which are susceptible to degradation. But although they have little agricultural land. these nations are financially well positioned for agricultural trade liberalization and should be opening their doors more widely.; A more open, efficiency-oriented trade regime -- in both the organization tor Economic Cooperation and Development (OECD) and developing countries -- will be critical to satisfying the world's emerging food needs.

As was pointed out earlier, protectionism and food self-sufficiency policies have been expensiveinterms of financial and environmental costs. The key to shifting agricultural policy toward promoting a more efficient. environmentally sustainable model for food production lies with the GATT negotiations. GATT rules must change to guarantee a free flow of agricultural imports and exports into and out 01 the Newly Industrialized Countries (NICs). Agreeing to such a change in the rules will represent a major, long-term change in policy on the part of these countries. Rules and policies that support food self-reliance and freer trade -- as opposed to food self-sufficiency -- will help to solve the problem of meeting the demand for food in the next 50 years.

The relatively low growth in the consumption 01 key foods (grain, meats, vegetable oils and dairy products) projected for the More Developed Countries (MDCs). along with their capacity to produce more. suggests that the MDCs could continue to make up any shortfall in the world's supply of these commodities. Accordingly, some of the pressure to produce them would be taken off the agricultural resource base of the LDCs. which would reduce the strain on the environment and lessen the degradation 01 soil and surface waters. However, in order for the MDCs to be able to supply enough grain. two conditions would have to exist: First. a strong capacity to produce grain would be essential: second. the international trading system would have to become freer than it is at present, and many LDCs would have to be willing to accept a certain level of dependence on agricultural imports.

POLICY AREA TWO: LAND OWNERSHIP AND PROPERTY RIGHTS

Introduction

This section examines how land ownership policies affect the productivity of land and either promote or work against a sense of stewardship over the land.

Throughout the world. property rights for land represent a large part of people's wealth. In the United States, they account for more than 40 percent of family assets. In most developing countries, about 70 percent of family assets consists of land.[8] Yet most property rights in these countries are not protected by formal titles -- (hat is, they are "informal." We believe that policies that formalize property rights and strengthen land ownership in the LDCs would contribute significantly to increasing agricultural productivity. At the same time. they would provide an incentive for farmers to move toward more sustainable agricultural methods. anti to see the land as something to be protected, rather than exploited for immediate gain.

Key Benefits of Formal Property Rights

The Incentive to Improve the Land

When people have formal title to land. they feel that it is under their legal control anti they therefore have the incentive to invest in and improve it. In Peru. for example, investment in property has tended to increase nine fold when squatters obtain formal title to their homes. In Costa Rica. tanners who are formally titled have much higher incomes than those who are not. Formalized title also enables farmers and others to obtain credit.

Environmental Implications

When formal title is available to provide security and tenure. planning horizons are longer and. therefore, the incentive to protect land, water and forest is present. Investments to improve the soil. reduce erosion and control the accumulation of rubbish are more likely to be made. However. when ownership is uncertain, there is a tendency to "mine" the land by maximizing its short-run production at the expense of preserving its long-term value. Crops, such as trees can benefit the environment, but they are simply not planted because they require a number 01' years before they (urn a profit.

Collectivism and Communal Management

Attempts have been made to put land into the hands of the rural poor on a collective basis. in Latin America, for example, large tracts of land have been expropriated and given to poor farmers as part of collectivism agrarian reform. But formal title was lacking. In most cases. these ret'orms failed to create satisfactory market economics. not only because farmers proceeded to break up the collective units into small informal land holdings. but also because the individual rights to land were neither recognized nor formalized.

However. many natural resources, including pastures, have ken successfully managed communally in some LDCs. A compelling reason to support community resource management is its importance for the poor. In the absence of formal title. common property management is often all that separates the landless and land-poor- from destitution. The *World Development Report. 1992* noted a study carried out in India by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The study showed that common property resources accounted for between 14 anti 23 percent 01' the income of poor households in seven states, and that grazing or communally owned lands accounted for more than 84 percent of fodder for the livestock of the rural poor.

It appears that retaining some community control over land ownership curbs the proliferation of rural landlessness -- at least in those countries where community control is officially supported.

So far. most efforts to formalize title to land in many LDCs and thus bring it into the market economy have failed. What stand in the way of the formalization of land ownership are the legal systems and the bureaucracies in many of these countries. Until property formalization is put at the top of the developing world's agenda, the long-run prospects for economic development will be limited.

POLICY AREA THREE: TECHNOLOGY TRANSFER

Introduction

Another key to managing agricultural resources is to develop policies that facilitate transferring agricultural technologies to the typical peasant farmer in the LDCs. The technologies exist, but the challenge is to put them into the hands of small farmers, many of whom are illiterate. In most instances, the performance of the public sector extension service in meeting this challenge has been disappointing: the lack of success has occurred at the expense of the economy and the environment. Accordingly, new organizational approaches must be developed that involve, to a large extent, non-governmental organizations (NGOs) and private sector companies.

This section illustrates the task for policy makers vis-à-vis technology transfer, and the need to educate farmers in low-income countries about the proper use of technology. Getting more farmers to understand and adopt technology that leads to environmentally sustainable practices is a key step in solving agriculture's environmental problems. These practices must also be compatible with the goals of *economic sustainability.*

Reaching the Small Farmer

To some extent [however inadequately). small farmers are being exposed to new technologies that help them to generate more income. For example, *Barker and Herd (1978*) used data from several Asian countries to demonstrate that small farmers were adopting high-yield varieties (HYVs) at a rate that did not differ significantly from that of large farmers. This was the case even in villages with marked inequalities in land distribution. Nevertheless. contacting small farmers and showing them the potential benefits of technologies and methods such as integrated pest management and soil conservation remain difficult tasks in many LDCS. Such technologies are better for the environment, but they are often information-intensive: farmers must be trained to use them if they are to be effective. Many farmers cannot read and do not have access to radios in many LDCs. Therefore, the conventional training methods of the developed countries must be adapted and delivered through more appropriate channels. The alternative to these methods is well-trained and motivated extensionists who are equipped to carry out the necessary one-on-one confidence-building sessions with farmers. Unfortunately. this rarely occurs in cash-strapped LDCs.

CIDA is active in extension in a number of these countries, but more must be done to help the small farmer, as shown below.

The Need to Train Small Farmers in New Technology

Farming will remain dominant in the LDCs because it is the livelihood for hundreds of millions of people in these countries. Therefore. it is essential to ensure that small farmers receive the training in new (or existing) agricultural technology, and that they are motivated to use it. Generally, the large farmers receive the help they need to adopt new practices. However. small farmers generally do not. The following example demonstrates how a lack of knowledge can affect the small farmer.

The *1992 World Development Report* cited a study that pointed out how rising health concerns in the United States about pesticide residues negatively affected small farmers in Guatemala. Donors had encouraged Guatemala to expand non-traditional food exports. At about the same time (in 1987). the United States adopted more stringent regulations regarding pesticide residues in domestic and imported fruits and vegetables. Although about 95 percent of the large growers in Guatemala received technical assistance on pesticide use. only 5 percent of the small farmers and no small independent growers received any help. Because of a lack of knowledge. small growers applied three times as much pesticide as was necessary. mainly because they sprayed randomly rather than

when pests were present, Few small growers knew about the need to leave an adequate interval between spraying and harvesting. As a result, many small farmers found that exporters refused to work with them because their harvests were unacceptable for export.

Small independent surplus-producing farmers need special help if efficient farmers are to benefit from export growth. This help is especially needed in countries, like Bangladesh, that have strong export aspirations and millions of small farmers. most of whom are illiterate.

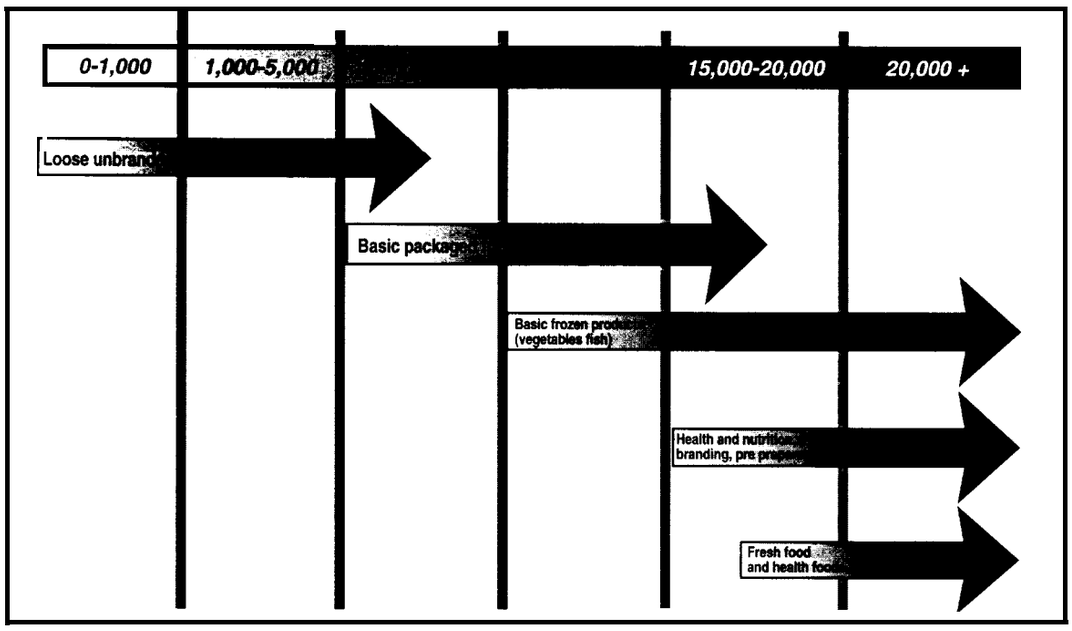
Policies that encourage the transfer and proper use of technology are especially important because they lead to more productive farming practices. which can also alleviate many environmental concerns, such as soil degradation. erosion and water contamination. Chapter 3 of this paper discusses these and other issues, along with some of the "sustainable" land-management technologies available to address them.

POLICY AREA FOUR: INVESTMENT IN THE **AGRICULTURAL INFRASTRUCTURE**

One of the important prerequisites to meeting the global demand for food in the next century is an adequate agricultural infrastructure in developing countries. By "agricultural infrastructure, " we refer to irrigation systems and the facilities needed to transport, process, store and distribute agricultural products. Along with R&D. a country's roads, railroads, storage bins and processing plants can play a key role in controlling post-harvest losses. Reducing these losses by 25 percent (a reasonable goal) is equivalent to raising yields by 25 percent in developing countries.

Developing such an infrastructure requires capital. To do so will require a combination of foreign direct investment (FDI). domestic investment and donor investment. Half the FDI in Third World countries since 1989 has been channelled into five countries -- China, Argentina, Thailand. Malaysia and Mexico --

Figure 13: Trigger Points
(GDP per persons $)



Source: Unilever.
The Economist. ***December, 1993.***

A strong linkage exists between the demand for processed food and rising **GDP (Gross** Domestic Product): as illustrated above an increase in GDP per person must precede an increased demand for processed food, The trigger points estimate the income levels at which demand changes.

which means that. for most of the Third World. FDI is meagre or non-existent. The other 94 LDCS with populations of more than 1 million must depend more on donors and their own limited capital to carry out projects that will contribute to economic development.

Many LDCS have much to gain by instituting policies aimed at improving their investment climate -- as Malaysia and a few others have done, Such improvements are needed because FDI (or the lack of it) will play an increasingly important role in developing parts of the agricultural infrastructure, such as food-processing plants, in the LDCs. over the next 50 years. many of the cash-poor Third-World countries that now receive no FDI will be able to gradually reduce their debt, as Mexico has done, and position themselves for FDI. But it will not be easy to do so until these countries develop policies aimed at reducing debt and having prices and exchange rates determined by the market.

The "non-farm" or agro-industry component of the agricultural system also has an important role to play in agricultural development. Rising disposable income triggers demand for the products of agro-industry. including both off-farm inputs and outputs. Figure 1 3 provides an indication of the relationship between income level and the demand for various forms of processed food.

Canadian processing technology, such as custom feed-mill machinery and oilseed and dairy processing methods. is being successfully promoted in China. Honduras and elsewhere. This aspect of agriculture will grow in importance as real disposable incomes rise in the LDCs.

ENDNOTES: CHAPTER 2

1. Avery, Denis T.. *Global Food* Progress *1991* (Indianapolis: Hudson Institute), p. 44.

2. Ibid.

3. Avery, op. cit., pp. 172-175.

4. The *Economist*. December 12, 1992, p. 8.

5. Avery, op. cit., p. 176.

6. Avery, op. cit., p. 173.

7. Avery, op. cit., p. 187.

8. *The* ***Economist,*** December 12.1992.

CHAPTER 3: LAND-MANAGEMENT ISSUES

INTRODUCTION

This chapter discusses the use (and misuse) of a vital, physical agricultural resource -- land. The quantity and quality of this resource will directly affect our ability to produce enough food in the coming decades in an environmentally sustainable way.

The issues covered here include soil conservation, farm chemicals, deforestation and expansion of cropland. and water and irrigation. We also discuss R&D as it relates to land management. productivity and sustainable agricultural development. All of these issues are critical elements in the global food-supply equation.

In many parts of the developed and less-developed world, land-management practices are deficient. Essentially, they are not sustainable and have resulted in thin, depleted soil, damaged lakes and rivers and contaminated water supplies. Clearly, the world's farmers. in many instances, must change the way they fertilize, water and till the soil. If they do not. serious consequences will result in terms of insufficient food production and unacceptable environmental degradation. The "easy" phase of the Green Revolution is over. The world's ability to feed itself will depend more and more on how we manage our land and view it as an essential agricultural resource to be nurtured and conserved.

CONSERVING THE LAND RESOURCE

Overview

Much of the world's agricultural production occurs on relatively stable, highly productive farmland. However. there are three extremely important eco-regions, primarily in the LDCs. where a disproportionate amount of resource degradation occurs. These are: tropical forest margins: fragile rainfed lands: and irrigated areas. The three eco-regions offer quite different challenges to the objective of sustainable agricultural development.

Forest Margins of the Humid Tropics

Arresting deforestation and resource degradation in the forest margins of the humid tropics is a major challenge for sustainable agricultural development. Converting forests to agriculture in this eco-region can have important costs in the form of reduced biodiversity and land degradation. Millions of people live in this eco-region and will continue to do so. There has been little progress to date in finding ways to improve the livelihood of these people while reducing the resource degradation associated with their farming practices. In the past, research has been concentrated on the primary agricultural lands. Research and ensuing programs for this eco-region are needed to arrest environmental degradation while improving the livelihoods of the people who live there.

Fragile Rainfed Lands

This eco-region includes many types of lands prone to soil degradation. These types include hillsides and mountains prone to soil erosion: sub-humid savannas prone to soil acidification: humid lowlands prone to soil nutrient leaching: and semi-arid lowlands prone to wind erosion and desertification.

Population densities and market integration continue to increase rapidly in these low-potential areas. leading to increased pressure for intensification of production and resource use. The livelihoods of millions of small holders and their communities depend upon the crop, livestock and forest systems in these areas. Their future is also in question due to the present high level of resource degradation and the lack of economically and ecologically viable options that are being used to generate major gains in farm productivity.

Successful models, for the most part yet to be developed, are likely to focus on diverse systems designed to stabilize incomes under high climatic variability, while providing continuous protection for fragile soils. These models might include multi-crop combinations. combinations of farming and non-farm income sources, agro-forestry systems. maintenance of permanent vegetative cover and exploitation of fertile micro-sites for intensive cultivation. Research and programs to address the economic and environmental needs of this eco-region are vital.

Irrigated Areas

Irrigated areas form the third important eco-region with a disproportionate level of resource degradation. The importance of irrigation in meeting world food needs is well known. Resource degradation related to irrigation comes in the form of salinity, waterlogging, groundwater mining and water pollution. Solutions can be found. but they require substantial investment. A continuation of dwindling irrigation investment will result in continued low performance of existing systems. continued or increased environmental degradation. and continued physical and institutional constraints.

The challenge is to arrest environmental degradation in irrigated areas while increasing agricultural productivity. In seeking programs to revitalize irrigation systems, research into various water allocation mechanisms, including attempts to structure economic incentives for water users, must be undertaken.

A critical element 01' sustainable agricultural development. particularly in the LDCs, is the prudent use and conservation of cropland. The area of arable land that can be converted to economically viable cropland is virtually non-existent in 182 of 185 nations in the world. Most is concentrated in three countries:

- the United States: about 12 million hectares:
- Brazil: 40 to 50 million hectares: and
- Argentina: 28 to 32 million hectares.

The land with agricultural potential in these countries can help compensate for the inevitable further loss of cropland that will continue globally due to industrial development. urban encroachment. desertification and other Factors. Between 1975 and 1990. arable land increased by 50 million ha, mainly at the expense of forest and woodlands, which declined by 140 million ha. In Asia. more than 5 percent (Figure 14) of forest and woodlands has been lost since 1979.

Figure 14: LDC Cropland 1987-89

	million (ha)	percent change in cropland since 1977-79	percent change in woodland and forest
AFRICA	186	**+4.4**	**-3.6**
ASIA	455	+0.8	**-5.3**
SOUTH **AMERICA**	141	+10.9	**-4.6**

Asia will need to increase food production in future entirely by means of increased productivity. The same applies to Africa and "South America unless huge areas of marginal land are brought into production.

Source: *World Resource Institute.*

Given the limited potential for adding to the current inventory of cropland. and the undisputed increase in the demand for food, it is clear that existing land will have to become much more productive.

Canada has expertise in a number of areas discussed below that relate to conserving cropland -- particularly in soil and water conservation and irrigation technology. Canada's western farmers and ranchers excel in the productive, environmentally sustainable use of marginal land on the prairies, much of it semi-arid, as is the case with a significant part of the land in the LDCs.

Erosion and Desertification

Both of these forms of soil degradation are problematical in the LDCs. Estimates of land damaged or lost for agricultural purposes through erosion and desertification range Ii-em moderate to extremely high. Better [arming practices -- such as conservation tillage and zero tillage (discussed below), judicious use of fertilizers. alley cropping, eliminating the use 01 marginal land for farming, and planting high-yielding seeds -- could greatly reduce soil degradation throughout the world. However. these practices are not widely used in the LDCs. Furthermore. they will not be until sustainable agricultural development receives higher priority on the agriculture/ environment agenda.

Traditional methods of national accounting, employing indicators such as GDP. have assumed that natural resources arc so plentiful that they have no marginal value. Subsequently, the impact of soil and water erosion, destruction of wildlife habitat and other important environmental changes has not been taken adequately into account or has been completely ignored in cost/benefit analysis. New techniques of resource accounting incorporate depreciation allowances for soil degradation and oil-site costs of erosion. Passing on these costs to the farmer in the short run and the consumer in the longer run in the form of higher food prices will be the true test of public commitment to sustainable agriculture and the environment.

Figure 15: Conservation Tillage in the United States

	U.S. Acreage	% of U.S. Plantings
1963	4 million	1%
1966	8 million	2.5%
1970	16 million	5%
1989	72 million	26%
1995**	140 million	50%

** projected

Source: U.. S. *Soil Conservative Service* and *No Till Farming Magazine*, as reported in Global Food Prowess 1991.

Combatting Erosion

In essence. soil erosion stems primarily from a failure to use existing knowledge about soil management. The worst erosion problems occur in countries such as Nepal and Ethiopia which are trying to teed rapidly growing populations by intensifying traditional farming activities.

Two methods 01 tillage have been developed in North America that have reduced soil erosion and cut farmers' costs on this continent. These methods are known as "conservation tillage"(also called "minimum till") and "zero tillage."

Conservation Tillage

Under conservation tillage, farmers plough only after the harvest. Instead. they leave a heavy cover of plant residue on their fields to protect the soil until the next planting. Soils should retain almost all their current fertility and organic matter over the next 1 ()() years with conservation tillage. which also cuts erosion by 5() percent. This method is rapidly becoming the main form of tillage in North America (see Figure 15).

Like zero tillage (discussed below). it is a technology that has enormous potential to replace slash-am-burn agriculture in sub-Sahara regions and in other parts 01 the Third World where dry-land agriculture is practised.

Zero Tillage

Fifteen years ago, a number of progressive farmers in Manitoba and North Dakota began to experiment with zero tillage. With this tillage method, the ground is not tilled at all between the harvest and planting in the next season.

Zero-tillage production costs arc lower than those of either conservation tillage or traditional methods that involve ploughing after the harvest and again before planting.

Through the Agricultural Institute of Canada, CIDA finances a zero-till project in Zimbabwe involving small farmers. It is evident that this technology, along with conservation tillage. is well suited for labour-intensive. low-technology farming. h-o-till farming has the potential to reduce soil and water erosion to negligible levels in a short time in large areas of the world. [1] However. introducing zero-till farming to expanded regions would require an enormous effort to transfer the necessary technology because it differs so much from the traditional farming approaches that have been used for generations.

Although zero till does involve the use of fertilizers and agricultural chemicals, it does not require significantly more than conventional methods do. The challenge for CIDA and others is to make this technology more available to the LDCs. Given Canada's leadership role in developing conservation and zero tillage, we are in a good position to transfer this technology to other countries that could benefit from it.

FARM CHEMICALS

Overview

Farm chemicals -- fertilizers. herbicides and insecticides -- will continue to play a key role in agriculture. Although scientists and laypeople debate the effects of these chemicals, evidence points to the fact that they will remain in use. The debate has obvious political overtones. It involves, on one side, the proponents of maintaining the high production levels associated with chemical-intensive farming practices. on the other side are those who are more concerned about the possible consequences of these practices in terms of the environment and human health.

The farm-chemical problem is more evident in Europe than in most parts of the world. Therefore. the EC as a whole and individual countries have placed the environment at the top of the political agenda. For example, the Netherlands has laws that:

- limit the number of pigs and other livestock that can be produced within its borders:
- limit the use of commercial fertilizer: and
- call for an immediate 50 percent reduction in the use of pesticides.?

These signs indicate that some countries have recognized the trade-off between chemical-intensive agriculture, with its high productivity, and the need to protect the environment. Due to intense political and economic pressure. EC agriculture of the 21st century will be much less intensive than it has been over the last two decades. and much less damaging to the environment, but it will no doubt produce significantly less than it does today. A more immediate reason for the change is that agricultural subsidies, which are closely linked to the overuse of chemicals, will begin to disappear as a result of the December 1993 GATT Uruguay Round Agreement.

The challenge in the LDCS (where farm chemicals are less widely available and used) is to raise productivity without unduly stressing the soil and other elements of the environment. one means of achieving this goal is better knowledge of fertilizers. herbicides and pesticides. and using them in a more environmentally benign way. The task of transferring the new technology to the LDCs without further delay will be formidable.

Fertilizer

The Need for Fertilizers

Fertilizer is necessary because. without it, soil releases only about 30 kilograms of nutrients per hectare each year in many parts of the world. This amount is enough to yield a mm-e 1 to 1.5 tonnes of cereal grains per hectare, which is well below the present world average of 2.6 tons per hectare. It is also a fraction of the yield needed to feed the world's current population.

The Economics of Fertilizer Use

This topic has been well researched and carefully monitored for more than 3() years. This ongoing research clearly sets forth the relationship of fertilizer to crop yields, All highly productive agriculture uses commercial fertilizer extensively. with the farmers of the EC applying more than twice as much fertilizer per hectare than the global average. While farmers in developed countries have been using heavy doses of fertilizer, the opposite is true in most developing countries. For example, Africa applies about one-fifth the world average amount of fertilizer per hectare (*World* **Resources 1992-93.** *page 271).* However. the LDCs in Africa and elsewhere will have to use much more of it in the future because their current levels of fertilizer will not allow them to boost production enough to meet the demand for food in future.

Developing countries have been discouraged from using more fertilizer by (a) scarce foreign exchange. (b) high transportation costs, and (c) government-sponsored monopolies that charge too much for it. [3] In addition, farmers in developing countries also often lack plant varieties that can make good use of fertilizers. However, developing countries around the world are beginning to use these chemicals more effectively, thanks in part to the efforts of organizations like the Potash and Phosphate Institute of Canada (PPIC) and the International Fertilizer Development Centre (IFDC). However. these efforts fall far short of the need. For its part, CIDA is active in promoting the use of fertilizers. For example, in Jamaica. CIDA is providing technical assistance in conjunction with its aid program to help farmers use fertilizers more efficiently. CIDA uses the services of a private fertilizer company. India Potash Limited (IPL). to deliver extension services in that country that have led to more efficient use of fertilizers and the creation of village development trusts, which provide credit facilities. other objectives relating to fertilizer use arc being met through the India-Canada Agricultural Extension Project. More similar programs aimed at encouraging the "optimum" use of fertilizers in the LDCs are essential.

Applying the optimum amount is important if the LDCs are **to avoid** the EC'S environmental problems [lowing from the use of too much fertilizer. Both inorganic fertilizers. which are commercially manufactured, and organic fertilizers, which consist primarily of animal manure, can cause problems when farmers apply too much or apply them improperly. For example. both kinds can cause eutrophication in lakes. streams and rivers. organic fertilizers can contaminate groundwater with harmful bacteria.

Pesticides

For the purposes of this paper. we will confine our brief discussion of pesticides to the following:

- the need for pesticides:
- health risks and pesticides: and
- advances in pesticide technology.

The Need for Pesticides

Pesticides are necessary for the world to maintain an adequate level of food production. No evidence is available to support the view that we could meet the demand for food without using pesticides to reduce crop losses from insects. *Global* Food *Progress 1991* notes that. after carrying out a thorough analysis, the United States estimates that eliminating the use of pesticides and commercial fertilizers from U.S. agriculture would result in a 45 pm-cent increase in food cost and a 50 pm-cent decrease in the supply of fruits and vegetables. The elimination of pesticides alone would result in yield losses of 25 percent of wheat. corn and soybean production in the United States.

Health Risks and Pesticides

A detailed discussion of the risks from consuming pesticide residues on fruits and vegetables and working with pesticides on the farm is beyond the scope of this paper. However, the following points are relevant.

In the MDCs. the health risks from consuming residues of pesticides and using pesticides in agriculture are negligible. However, what should be of interest to CIDA is that the situation is different in the LDCs. The health risks associated with pesticides are much greater in these countries. Problems exist because peasant farmers lack the training and information they need to apply pesticides safely and properly. For example. they often apply chemicals by hand without following safety precautions and apply

too much 01 these products. (See p. 18 for an example 01 the need for outreach and extensionist programs in pesticide use for the small farmer.)

Programs aimed at educating the small farmer are an essential part of improving their ability to produce safe products for the home and export markets. These programs seem even more necessary given the December 1993 GATT negotiations. which point to a freer global market for exported agricultural products.

Improved Pesticide Technology

Research has produced -- and is continuing to produce -- new pesticides that can reduce health risks and lower the stress on the environment, Specifically, pesticides are being developed that target particular pests. Pesticides arc available that have shorter lives: their toxicity declines quickly. which reduces accumulation in the food chain and the environment.

Clearly, pesticides are improving. Again. the challenge for CIDA and others involved in development activities is to devise strategies and programs aimed at getting more of the new chemicals into the hands of more small farmers in the LDCs and teaching them how to use these products. Such efforts would directly contribute to promoting sustainable agricultural development.

DEFORESTATION AND **SLASH-AND-BURN** AGRICULTURE

Figures 5 and 1 2 demonstrate that the amount of cropland in the LDCs has increased somewhat over time. However. much of this increase has been at the expense of the forests. Despite the disturbing amount of forest land being degraded by slash-and-burn activity. there has been little net increase in global cropland since 1'970. Most of the world is planting the same cropland as it has for decades.

These facts have serious implications for sustainable agricultural development. First. the loss of forests and wildlife habitat. particularly in the tropical rain forests in South America. has. in itself, obvious environmental anti ecological consequences. Second. the slash-anti-burn practices used to convert forest and other fragile land to cropland have often produced fields with poor soil conditions and. therefore, low productivity. They have also led to flooding anti erosion.[4]

The *World Development Report. 199.2* argues that 60 percent of the deforestation in the LDCs has been the result of agricultural expansion. with most occurring in Africa and Latin America. This expansion may be led by small subsistence farmers either seeking a livelihood or being driven by growing market demand. But regardless of why forests are being destroyed to create marginal cropland. one fact is clear: *The growing shortage of productive cropland in the LDCs will make it impossible to increase food production enough to meet the growth in demand unless the yields per hectare ca n be dramatically improved over the next 50 years.*

Through the Agricultural Institute 01 Canada and in cooperation with the Soil and Water Conservation Society of Thailand. CIDA has started to support efforts to mitigate the effects of slash-and-burn agriculture on the hillsides in northern Thailand. working directly with hillside farmers. Such pilot projects will eventually need to be cloned a thousand times if an effort commensurate with the need is to be realized.

of interest to CIDA is that more effort is urgently needed to create agricultural development that offers alternatives to slash-and-burn agriculture and deforestation - for example, programs that would make it possible for LDC farmers to eventually double or triple the productivity of the better existing cropland. Therefore. the need to extend agriculture to the forests or fragile lands would be reduced.

IRRIGATION AND THE USE OF **WATER**

Agriculture is the world's largest user of water. 13ut up to 60 percent of it is wasted. Most is either applied too heavily or applied on poorly levelled fields. which sharply increases the soil's salinity and causes waterlogging problems.

Existing irrigation technology could reduce the problem 01 over-irrigation significantly in the LDCs. For example. lining irrigation canals, shifting from flood irrigation to other methods such as tube wells and introducing crop management techniques that conserve water would improve productivity and make irrigation a more efficient and less damaging process.

Canada has a tremendous amount of experience with various types of water management. ranging from drainage systems to sprinkler-, drip- and gravity-type irrigation systems. The Centre for Drainage Studies at

MacDonald College and the University of Alberta are both leaders in water-management technologies. Canada has been active for a number of years in helping such countries as Egypt, Bangladesh and India to manage their water resources more effectively. This involvement represents an opportunity for CIDA to participate in programs aimed, for example, at improving or creating the infrastructure associated with irrigation.

RESEARCH AND DEVELOPMENT

Overview

R&D is a critical input to sustainable agricultural development. It is a "land-management" issue to the extent that it can affect the quantity or quality of the yield of farmland while reducing degradation of the soil and environment. R&D is essential to establishing a truly sustainable global agricultural system that must double its output within the next few decades and triple it within the next 50 years.

Some of the most promising directions for agricultural R&D are those aimed at developing ecologically benign methods of controlling pests, developing improved oilseed and pulse crops and finding ways to use water more efficiently.

Most LDCs urgently need R&D assistance. Many of the least-developed countries -- which need food most -- rely too heavily on borrowing their technology from the rich countries and international research stations. However, because this technology may not always be entirely appropriate or adaptable to local conditions, the LDCs do not always realize all its potential benefits. These countries are short of R&D funds, but few investments have matched the long-term economic growth pay-offs flowing from agricultural research, through raising food production and cutting costs. Canada is in an advantageous position to provide R&D help to LDCs in the areas noted below.

Biological Pest Controls

The thrust of biological pest control R&D includes research into developing pm-resistant crop varieties and controlling pests through Integrated Pest Management (IPM) technology, defined below.

Canadian laboratories in the universities and private sector are highly active in developing crop varieties that have a natural resistance to predators and that may permit farmers to reduce the use of pesticides. Research into IPM is also active. IPM involves introducing natural predators into an area and relying less on chemicals to control pests. IPM has proven effective. The introduction of predator pests to fight the cassava mealybug in Africa is among the world's largest successes with IPM to date. The mealybug had cut cassava yields by two-thirds by 1983. Through the efforts of CIAT and IITA and financial support from CIDA and others, natural enemies were found that could control the spread of the pest. These costly but highly cost-effective efforts brought the problem under control. opportunities exist for CIDA to become involved in similar IPM projects elsewhere.

Oilseed Development

As noted earlier, the demand for foods such as vegetable cooking oils will increase disproportionately in the LDCs as disposable incomes rise. Some of the most significant achievements in oilseed research have occurred in Canada, e.g., the development of Canola from rapeseed. Canada is already active in India and Bangladesh, supporting institutional development, carrying out oilseed research and introducing related agricultural technology to those countries.

CGIAR: RESEARCH INTO SUSTAINABLE FARMING PRACTICES

Economic studies have demonstrated that conventional agricultural research has been under-funded, considering the benefits that it brings, in view of agricultural production problems and the associated environmental problems, much more funding is justified for research into how to make agricultural production more sustainable. The Consultative Group for International Agricultural Research (CGIAR) is the world's most prominent international agricultural research institution. A number of CGIAR members have developed new research programs and taken new directions focused on sustainability. But while CGIAR's responsibilities have been increasing, its funding in real terms has been dwindling. As its members continue their efforts and place new emphasis on natural resource management, their research will be increasingly difficult and costly. Significant new funding should be made available from aid institutions to support CGIAR work on sustainable farming practices.

CONCLUSION AND OPPORTUNITIES FOR CIDA

Throughout this paper. we have noted areas in which CIDA could help LDCs to increase their agricultural production in a sustainable way. We have also stressed that agricultural solutions are central to alleviating poverty and environmental degradation in the LDCs.

The challenge of developing agriculture in a sustainable way is larger than that 01' increasing sustainable yields. It is also necessary to consider a broad range of alternative strategies for achieving sustainable increases in rural livelihoods. including those offered by international trade. and inter-sectoral and inter-regional linkages. Not ail countries or regions should attempt to produce all their food needs: nor is agricultural development necessarily the only way of increasing livelihoods for the rural poor. it also must be recognized that macro. trade and sector policies have an important bearing on the economic opportunities available to different regions.

In an ideal world, no agricultural activity would occur on the forest margins. hillsides. mountains and other fragile areas. as described earlier in Chapter 3. Similarly. thin-c would be less need for this production, since the productive capacity on the best lands would be so developed that there would be little or no demand for the food produced on marginal lands.

in reality. it is evident that a substantial portion of the many millions of small farmers who presently make their livelihoods in these fragile eco-regions will remain there. Their economic need for an improved livelihood. combined with society's environmental need to reduce degradation. can no longer be ignored. Meanwhile. improved productivity on the world's primary agricultural areas is the best strategy for minimizing the propensity of poor people to cultivate these fragile eco-regions.

The challenge of managing natural resources must start with the premise that farmers and other private users of natural resources are rational decision makers anti, it' resource degra dation is occurring. there are probably good reasons for it. People degrade resources when the benefits they obtain are greater than the perceived costs they must bear individually. if the management of natural resources. including farm resources. is to be improved. then it is necessary, first. to have a comprehensive understanding of what prompts households to degrade resources and, second. to identify appropriate ways of eliminating the incentives for that behaviour.

CIDA has a number of opportunities to involve itself in activities that could produce measurable results in terms of the Iong-term social and economic benefits that remain in a country after a given project ends. In essence, CIDA could contribute lasting. high-impact benefits by participating in the kinds of activities and programs listed below. All contribute directly to sustainable agricultural development, which lies at the heart of improving the prospects for a better standard 01 living in manv LDCs.

Among the key types of programs and activities are the following:

- programs that lead to expanded development and introduction of appropriate. cost-effective technologies and management practices. and that must offer farmers comparable or better returns than conventional practices:
- programs that monitor the accuracy of farmers' perceptions about resource degradation taking place both on-site and off-site:
- programs leading to the reform of property rights. particularly in countries where it is most evident that the absence of reform is linked to resource degradation:
- policy support to governments that enables them to better understand the consequences 01 their policies and incentives. as they relate to sustainable agricultural development:
- more research programs to identifv combinations of technologies. policies anti institutional arrangements in the margins of the tropical forest and increase productivity in sustainable ways. given that the conversion of tropical forest to agriculture can have important costs in the form of soil degradation. reduced biodiversity anti changes in regional and global climate:
- programs to improve market infrastructure. market intelligence and inter- anti intra-market integration, contributing to sustainable agriculture:

- programs leading to more sustainable resource use, tailored to households and communities in rainfed farming systems in environmentally fragile environments (such programs would identify and introduce policies and technologies to sustain and improve rural livelihood without resource degradation):

- programs to increase the productivity and efficiency 01' irrigation systems, while achieving more satisfactory solutions to various socio-economic constraints and such problems as water-logging, salinization, groundwater mining and water pollution:

- programs to facilitate appropriate community responses that lead to improved property rights to natural resources and ultimately a reduction in the degradation of those resources:

- technology transfer programs for both primary agricultural areas and marginal areas, using new approaches to transfer sustainable agricultural practices to small farmers:

- farm practices and farmer organizations that help farms in LDCs to group together to access new knowledge and markets:

- R&D and technology transfer in areas such as bio-technology, leading to more efficient resource use:

- programs to greatly expand the protection of watershed and other environmentally fragile sites within rural communities: and

- programs to encourage more efficient management of agro-chemicals and tillage practices in agricultural intensification.

l'anticipating in programs and activities such as these represents a significant step toward developing the capacity to triple the production of food, u'bile easing the pressure to exploit marginal and fragile land and encroach upon the world's forest reserves.

ENDNOTES: CHAPTER 3

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