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Contents

Abstract

This paper reviews trends in maize production and consumption in Central America and Mexico in the context of the political and economic changes taking place in the region since the 1970s. The authors focus on the effects of the structural adjustment programs in the 1980s and 1990s. The analysis begins by reviewing the economic context in which maize production occurs in the region and the main economic policy instruments affecting the maize economy. Next, trends in maize consumption and production are analyzed, along with the main factors influencing maize production, including trends in the public financing of maize research and extension. The authors find that several factors related to structural adjustment have defined—and are still defining—the course of agriculture, including maize production, in the countries of the region. The impact of these factors on maize production, consumption, and import trends has been different in Central America and in Mexico. In particular, the reduction or complete elimination of production incentives, the reduction of trade barriers, the liberalization of input and product prices, the deregulation of the currency exchange rate, the control of inflation, and the restructuring of agricultural research systems between the public and the private sectors have determined how basic grains are produced in the region and how they will be produced in the future. Furthermore, the visible and increasing deterioration of the natural resource base has raised great concern about the need to promote more sustainable, environmentally friendly uses of production systems and natural resources.

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Maize Production and Agricultural Policies in Central America and Mexico

Gustavo Sain and Miguel A. López–Pereira

Introduction

In the last decades and especially in the last five to ten years, the production of basic grains[1] in Central America and Mexico has been strongly affected by major political, social, and economic changes. The growing integration of the economies, the end of internal armed conflicts, and the implementation of structural adjustment programs are the principal events that have influenced the consumption and production of basic grains in the region.

These events have not only affected the region's economy in general, but they have also defined—and are still defining—the course of agriculture in the countries of the region. In particular, the reduction or complete elimination of production incentives, the reduction of trade barriers, the liberalization of input and product prices, the deregulation of the currency exchange rate, the control of inflation, and the restructuring of agricultural research systems between the public and the private sectors have determined how basic grains are produced in the region and how they will be produced in the future. Furthermore, the visible and increasing deterioration of the natural resource base has raised great concern about the need to promote more sustainable, environmentally friendly uses of production systems and natural resources.

The impact of these factors on maize production, consumption, and import trends has been different in Central America and in Mexico. In Central America until the mid-1980s, maize production and consumption grew at similar rates (Table 1). As of 1985, however, maize consumption began growing much faster than production, and the resulting gap was filled with imports. For this reason, imports of basic grains in general and of maize in particular grew notably in volume after 1985. In Mexico, on the other hand, maize consumption grew faster than production until the mid-1980s, but in 1985 growth in production surpassed growth in consumption. As consequence, imports fell.

Table 1. Growth in maize consumption, production, and imports, Central America and Mexico, 1960–96

	Central America (annual rate in %)			Mexico (annual rate in %)		
Period	Consumption	Production	Imports	Consumption	Production	Imports
1960–84	2.97	2.75	5.72	3.42	1.78	21.29
1985–96	3.52	1.80	13.14	3.98	4.93	–3.68
Change	0.55	–0.95	7.42	0.56	3.15	–24.97

Source: Calculated from the USDA Foreign Agricultural Service database.
Note: Growth rates estimated through semi-logarithmic regression.

[1] Depending on the country, "basic grains" are a combination of all or some of the following: maize, beans, rice, sorghum, and (in Mexico) wheat.

The excess of domestic demand over internal supply has been partially attributed to factors such as population growth, an increase in per capita revenue, and growing urbanization (Byerlee 1986; Huddleston 1984; CIMMYT 1984) on the demand side, and to stagnating productivity on the supply side. These factors are not directly linked to the impact of the policies that arose from structural adjustment programs, but this paper considers the hypothesis that policies related to the adjustment stabilization phase (currency devaluation, reduction of duties and tariffs, restructuring of public credit, and reduction of government expenditure) have had an aggregate impact. In Central America this impact was reflected in rising growth in domestic demand for maize and declining growth in the internal maize supply. In Mexico, policies that promoted maize production seem to have resulted in substantial increases in the internal maize supply; these increases were large enough to compensate for growth in demand.

This paper reviews the maize production situation in Central America and Mexico in the context of the political and economic changes taking place in the region. It also describes the factors related to economic policy that have been likely to affect the structure of maize consumption and production in the region. Given the differences between Mexico and Central America, much of our analysis treats these two geographical areas separately. In some instances we refer to all six Central American countries and Mexico as one region, although for the most part the discussion on Mexico applies to the southern part of that country.

The analysis begins by reviewing the economic context in which maize production occurs in the region and the main economic policy instruments affecting the maize production economy. Next, trends in maize consumption and production are analyzed, along with the main factors influencing maize production. Findings are summarized in the final section of the paper.

Maize in Central America and Mexico: The Socioeconomic Context

International Prices

Basic grains, including maize, are marketable products. The international prices of each crop, as well as the prices of near substitutes in consumption and production and of the inputs used to produce the crop, all play an important role in the economy of each crop. Many changes in production and consumption trends have their origins in changes in international price trends. The economic policy implemented throughout Central America and Mexico in the 1980s has tended to link domestic prices to international prices so that the latter may serve as a reference in the allocation of resources. For this reason, the maize economies of Central America and Mexico cannot be understood without first examining what has happened to world market prices of maize, wheat (a substitute in consumption), sorghum (a substitute in production), and fertilizer.

Figure 1 shows that the maize price in constant currency in the international market fell throughout the 1970s and a good part of the 1980s. As of 1987, prices stabilized and then began to show a mild increase. During the 1980s and 1990s, wheat has become more expensive with respect to maize in the international markets, while sorghum has remained more or less stable (Figure 2). Figure 3 shows international relative prices of nitrogen and phosphorus, two nutrients widely used in maize production. In each case the trend is stable: in other words, international prices of both nutrients fell at almost the same rate as the international maize price. The relative price of phosphorus, however, began to decline in 1987 as the maize price stabilized.

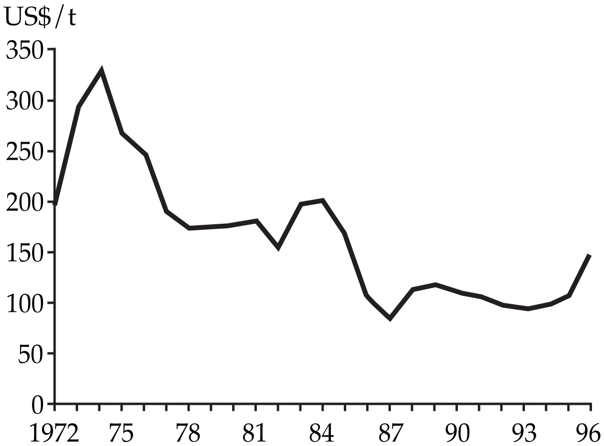

Figure 1. Trends in international maize prices (in 1990 US$/t).
Source: Friedberg and Thomas (1997).

Macroeconomic and Sectoral Policies
Structural Adjustment Programs

The economic policy implemented during the 1970s sought to favor the sector of basic grains production within the context of food security. The official banks provided credit at subsidized interest rates (often negative ones). The state participated in the marketing of products and inputs, buying grain at guaranteed prices (higher than the international equivalents) and selling inputs at subsidized prices. By maintaining overvalued currencies,[2] however, the countries in the region favored imports and reduced incentives to produce agricultural products for export.

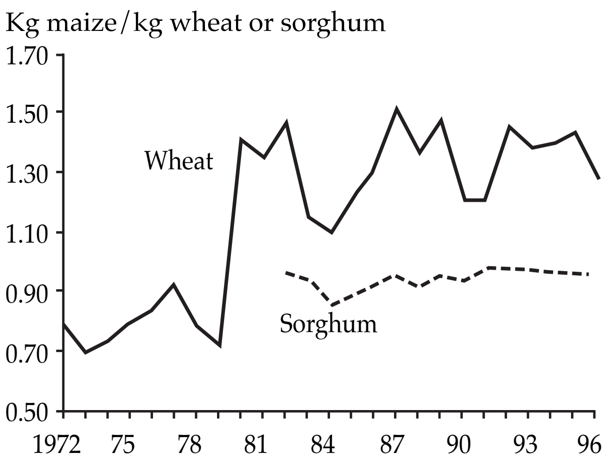

Figure 2. Trends in international wheat and sorghum prices relative to the maize price, 1972–96.
Source: Friedberg and Thomas (1997).

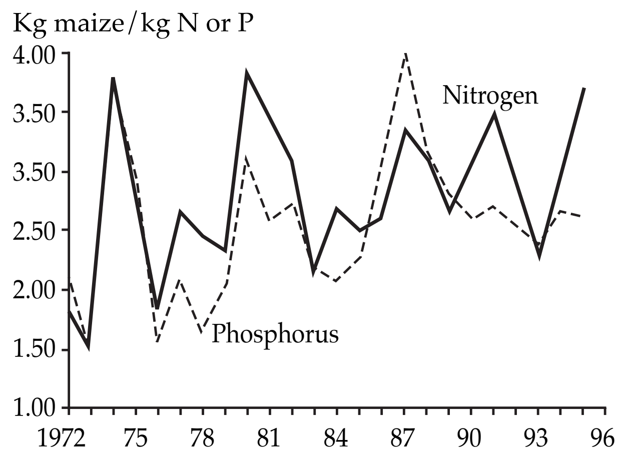

Figure 3. Trends in international nitrogen and phosphorus prices relative to the maize price, 1972–96.
Source: Friedberg and Thomas (1997).

2 A currency is overvalued when its price is below its equilibrium level.

As a consequence of the policies implemented during the previous decade and the structural imbalances of their economies, the countries in the region faced a serious economic crisis in the 1980s. In the second half of this period, a series of economic policy measures known as structural adjustment programs and sectoral adjustment programs began to be implemented. Simply put, the main objectives of these programs were to amend imbalances in the balance of payments, to reduce or eliminate internal inflation, to encourage greater economic efficiency, and to spur greater economic growth with equity and income distribution (for a comprehensive discussion see, for example, Pomareda Benel 1992). The programs emphasized three types of policies (Byerlee and Sain 1991): a decrease or elimination of tariffs and controls on international trade; a decrease or elimination of subsidies to consumers, along with an equalization of domestic producer prices with their world equivalents; and a devaluation of real exchange rates.

These programs were implemented gradually. Wattel and Ruben (1992) have described implementation as occurring in three phases, two of which occurred during the 1980s. The first, a financing phase, emphasized the use of credits to cover the deficit in the countries' balance of payments. The second phase, a monetary and exchange stabilization phase, was characterized by a real devaluation of exchange rates, a reduction of monetary mass to reduce inflation, and a reduction of private and public credit. The third phase, implemented during the 1990s, was designated the fiscal stabilization phase, and it was designed to reduce the fiscal deficit (internal debt) through a reduction in government expenditure and improved tax collection and to improve global economic efficiency by reducing state intervention in the economy.

The 1990s have also been characterized by the integration of regional trade blocks and the opening of trade. In Central America and Mexico, nearly all internal military conflicts came to an end, although social conflicts persist and worsen. The only remaining armed conflict is in southern Mexico, where the poorest sectors, especially the indigenous ones, are struggling to gain access to land and more equitable development.[3] Finally, there is much more pronounced attention toward the establishment of economic development programs that promote the conservation of the environment (natural resources).

Table 2 shows how the structural adjustment phases were implemented in Central America and Mexico. Although all countries entered the first phase of structural adjustment at the beginning of the 1980s, El Salvador was the first country in Central America in which the monetary and exchange stabilization phase was implemented. The other

Table 2. Phases of structural adjustment in Central America (excluding Belize and Mexico)

Country	Financial phase	Stabilization phase: Monetary and exchange	Stabilization phase: Fiscal
Costa Rica	1982	1985–1988/90	1990
El Salvador	1982	1982–1986	
Guatemala	1983	1984–1988	1988– ?
Honduras	1982	1988–1990	1990– ?
Nicaragua	1984	1985–1988/90	1990– ?
Panama	1982	1983–	

Source: Wattel and Ruben (1992).

[3] For a brief account of the origins of the war in Chiapas, see Cattaneo (1994).

countries implemented this stage between 1984 and 1988. Presently all countries in the region are in a relatively advanced stage of the adjustment process. Governments seem be more conscious of the need to make the public sector more efficient and to control macroeconomic variables at realistic levels and without distortions.

Integration with the world market

All countries in the region are signatories of the Uruguay Round of the GATT agreements and members of the World Trade Organization. Thus they have agreed that they will gradually eliminate nontariff barriers to trade, establish clear import and export tariffs, eliminate production subsidies, and, in general, open their economies to free trade. With respect to the agricultural sector, the principal consequences of these reforms have been the elimination of nearly all input subsidies and guaranteed product prices, an export orientation for traditional and nontraditional products, the reduction of barriers to international trade, and the state's withdrawal from the basic grains sector (from both marketing and setting prices). In the last case, international trade is controlled by price bands for imports.

It is believed that, as a consequence of the increase in world trade, one result of the Uruguay Round will be to increase international maize prices by about 10–15%. Another consequence of the Uruguay Round that has implications for how improved maize varieties are developed and diffused is the new legal structure with respect to intellectual property rights. Countries in the region are moving from having very attenuated or no property rights on germplasm to more restrictive property rights structures, such as laws, breeders' rights, and full patent protection. Should these changes continue, it is probable that germplasm flows will be reduced, along with incentives for researchers to share information and germplasm. Furthermore, the trend toward globalization of many national economies suggests that countries in the region will compete for export markets in the future rather than sharing the common goal of food self-sufficiency. This can be expected to reduce the areas of mutual collaboration among countries associated in joint research programs.

In Mexico, the signing of the North American Free Trade Agreement (NAFTA) with the United States and Canada served as a starting point for several programs designed to reorient mechanisms for controlling producer and consumer prices and to encourage the income (productivity) of the production sector (Martínez and Quezada 1995).

All of these factors may make it necessary to reformulate the rules under which collaborative research projects, such as the Regional Maize Program and the Cooperative Regional Bean Program, are carried out. The projects may have to adopt new measures to ensure that new technologies (especially seed) reach small-scale farmers who have few resources.

Domestic prices

During the 1970s and early 1980s, the countries of Central America and Mexico maintained internal maize prices above international prices. Table 3 shows that in the early 1980s these countries maintained a nominal protection coefficient (NPC)[4] larger than one. This trend was maintained even when distortions in the exchange rate were eliminated.

With the second phase of the structural adjustment programs, subsidies on maize production were eliminated, and a system of price bands was adopted. The system aims to generate greater efficiency in the allocation of resources through the link between domestic and international prices. The government minimizes the impacts of variability in the band by setting minimum and maximum internal prices and by regulating imports. The results of this policy in the domestic market depend strongly on the trend of maize prices in the international market. When the latter decreased, domestic maize prices received by producers also declined. As a consequence, many countries changed their traditional policy of food security to a policy of exporting nonfood products and purchasing basic grains on the market. The crisis in world grain stocks in recent years, which brought about grain shortages in the market and an increase of international grain prices, has shown the fragility of this position. The countries have now adopted an integrated approach to food security that involves diversifying agricultural production, promoting exports of nontraditional products, and importing basic grains.

Performance of Economies under the Adjustment Programs in Central America and Mexico

The economic indicators in Tables 4–8 demonstrate that the performance of the economies of the countries in the region has been diverse.

In general, the economies of Panama, Costa Rica, Guatemala, and El Salvador were the most stable over 1979–95, while the Nicaraguan economy was the most volatile. The ending of civil conflicts encouraged growth in the economies of El Salvador and Nicaragua. In Guatemala, agreements were recently signed to put an end to the civil war that has affected the country for three decades. Despite this armed struggle, Guatemala has traditionally had one of the strongest economies in the region. The Nicaraguan internal conflict seems to have been the most unsettling for the economy, setting it back almost 15 years. Not until recently has the Nicaraguan economy

Table 3. Nominal protection coefficient (NPC) and nominal protection coefficient adjusted for maize (NPCA), Central America and Mexico

	NPC		NPCA	
Country	**1980–81**	**1980–86**	**1980–81**	**1980–86**
Costa Rica	1.92	–	2.25	–
El Salvador	1.23	0.99	0.92	0.40
Guatemala	1.18	0.72	1.06	0.34
Honduras	1.30	0.53	1.33	0.53
Mexico	1.65	–	1.42	–
Nicaragua	2.26	–	2.17	–
Panama	1.33	–	1.33	–

Source: Sain and Martínez (1989); Taylor and Phillips (1991).

[4] The NPC is the ratio between the domestic price of a product and its international equivalent, estimated at a given point in the commercial chain.

Table 4. Growth of gross domestic product (GDP) in Central America and Mexico, 1979–95

	Variation of GDP with respect to previous year (%)					
Country	**1979**	**1984**	**1989**	**1993**	**1994**	**1995**
Mexico	9.2	3.6	3.3	0.6	3.5	–6.9
Belize	5.7[a]	2.0	13.0	4.2	2.2	3.7
Costa Rica	4.9	8.0	5.7	6.3	4.5	2.5
El Salvador	–1.7	2.3	1.1	7.4	6.0	6.1
Guatemala	4.7	0.5	3.9	3.9	4.4	NA
Honduras	6.3	4.3	4.3	6.1	–1.4	3.6
Nicaragua	–26.4	–1.6	–1.7	-0.4	3.2	4.2
Panama	4.5	–0.4	–0.4	5.4	4.7	NA

Source: FMI (1996).
Note: NA = not available.
[a] 1980.

Table 5. Variation of consumer price index (CPI) in Central America and Mexico, 1979–95

	Variation of CPI with respect to previous year (%)				
Country	**1979**	**1984**	**1989**	**1994**	**1995**
Mexico	18.2	65.5	20.0	7.0	35.0
Belize	11.2[a]	3.4	0.0	0.7	2.9
Costa Rica	9.2	12.0	16.5	13.5	23.2
El Salvador	14.6	11.5	17.6	10.6	10.0
Guatemala	11.3	3.4	11.4	10.9	8.4
Honduras	12.1	4.7	9.9	21.7	29.5
Nicaragua	48.2	35.4	4,770.4	7.8	11.0
Panama	8.0	1.6	0.1	1.3	1.0

Source: FMI (1995, 1996).
[a] 1980.

Table 6. Exchange rates in Central America and Mexico, 1979–95

	Exchange rate (local currency/1 US$)				
Country	**1979**	**1984**	**1989**	**1994**	**1995**
Mexico	22.80	192.56	2.64	5.33	7.64
Belize	2.00	2.00	2.00	2.00	2.00
Costa Rica	8.57	44.53	81.50	157.70	179.73
El Salvador	2.50	2.50	5.00	8.75	8.76
Guatemala	1.00	1.00	2.82	5.75	5.81
Honduras	2.00	2.00	2.00	8.40	10.34
Nicaragua	2.79	2.95	3.12[a]	6.72	7.55
Panama	1.00	1.00	1.00	1.00	1.00

Source: FMI (1995, 1996).
a Million córdobas per US dollar.

seemed to revive. Effects of the recent currency devaluation are still felt in Mexico after several periods of relative stability and growth. It is interesting to note that Honduras, which had no internal armed conflict, presented acceptable growth levels until the early 1990s, but the first structural adjustment programs in 1990 and 1994 and the energy crisis of 1994 affected the economy greatly. The Honduran economy in many ways is suffering the effects that marked the beginnings of adjustment programs in other countries in earlier years, such as inflation and exchange rate adjustment and reduction.

Table 7. Balance of trade (exports less imports) in Central America and Mexico, 1979–94

	Goods trade balance, FOB (million US$)			
Country	**1979**	**1984**	**1989**	**1994**
Mexico	(2,142)	13,186	405	(18,467)
Belize	–	(23)	(64)	(119)
Costa Rica	(315)	5	(239)	(686)
El Salvador	178	(189)	(592)	(1,035)
Guatemala	(180)	(50)	(358)	(997)
Honduras	(20)	(139)	(45)	(91)
Nicaragua	228	(323)	(229)	(434)
Panama	(633)	(741)	(356)	(902)
Central America	(742)	(1,460)	(1,882)	(4,263)
Central America and Mexico	(2,884)	11,726	(1,477)	(22,730)

Source: FMI (1995, 1996).
Note: Figures in parentheses are negative values.

Table 8. Size of external debt in Central America and Mexico, 1979–93

	Total external debt (million US$)				Total external debt (% of GNP)			
Country	**1979**	**1984**	**1989**	**1993**	**1979**	**1984**	**1989**	**1993**
Mexico	42,774	94,822	95,641	118,000	21	42	41	35
Belize	72	97	134	NA	23	41	40	NA
Costa Rica	2,110	3,973	4,468	3,900	33	94	71	55
El Salvador	886	1,730	1,851	2,000	12	35	29	28
Guatemala	1,040	2,353	2,601	3,000	6	21	26	37
Honduras	1,182	2,284	3,350	3,900	36	58	61	121
Nicaragua	1,487	5,106	9,205	10,400	73	149	511	746
Panama	2,604	4,369	5,800	6,800	76	74	86	103
Central America	9,381	19,912	27,409	30,000	23	59	74	89
Central America and Mexico	52,155	114,734	123,050	148,000	21	44	46	40

Source: UNDP (1996); World Resources Institute (1994).
Note: NA = not available.

At present, a factor affecting all economies in the region is the weight of the external debt (Table 8). The joint external debt of Central American countries for 1993 reached US$ 30 billion, almost 90% of the gross national product (GNP) of that year. The countries with the greatest external debt problems are Nicaragua, Honduras, and Panama, where the debt is already greater than the GNP. In contrast, the external debt of El Salvador seems be under control, since it represents only 28% of GNP, which frees valuable resources for the development of the economy. Though the external debt of Mexico is one of the highest in Latin America, the amount is still small relative to GNP. The primary effect of the external debt in the agricultural sector, especially in basic grains production, is that it compels governments to reduce the investment in social programs and in support of agricultural production for domestic consumption.

Maize Consumption in Central America and Mexico

Total maize consumption is the aggregate of two principal components:[5] direct human consumption and indirect consumption as a component of livestock feed (most in poultry, egg, and pork production). White maize is used for direct human consumption in Central America, while yellow maize is used mainly for indirect consumption. Growth in total maize consumption results from growth in both components.

The factors contributing to changes in maize prices relative to prices of a near substitute in consumption are analyzed below.[6] In the case of direct human consumption, wheat and its flour derivatives and bread are the main products that have substituted for white maize. Wheat is imported, since it is not produced in significant amounts in the region, whereas white maize can be produced within the region.[7] In indirect consumption, sorghum competes most closely with maize in the composition of balanced feeds. Like maize, sorghum is produced within the region.[8]

Direct Consumption

Figure 4 shows the trend in direct maize consumption in Central America between 1961 and 1992. Until 1984, consumption fluctuated around 78 and 83 kg/inhabitant/yr, maintaining a mild declining trend. As of 1985, direct consumption began to increase, fluctuating between 83 and 90 kg/inhabitant/yr.

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5 Besides these two components, total use includes seed use, industrial use, and waste. For Central America these other uses are not important, representing less than 10% of the total. In Mexico, however, industrial use represents an important part of total consumption.

6 A product *j* behaves as a substitute of product *i* if there is a direct relationship between the demand for *i* and the price of *j* relative to the price of *i*. In other words, if the price of *j* increases with respect to the price of *i*, then the demand for *i* increases and vice versa.

7 Not produced in Central America and Mexico. Although wheat is grown in the Guatemalan *altiplano*, the volumes are not significant with respect to total consumption.

8 Sorghum is used mainly to feed animals on the farm, although occasionally it is used for direct human consumption, especially in rural areas where subsistence farming dominates, in cases of maize shortage, and where local varieties of sorghum are cultivated.

Two important factors that determine consumption are the income level of the population and product prices for substitute crops. Figure 5 shows trends in per capita income measured by the per capita GNP in Central America. Figures 4 and 5 seem to indicate an inverse relationship between per capita income and direct maize consumption. Between 1971 and 1984, a period of high growth in per capita income in the region, direct maize consumption declined. As of 1985, however, when per capita income stopped rising, direct maize consumption began to grow, although at a slow pace.

In addition to being influenced by income level, consumption levels are influenced by the relative price of substitute crops. Relative prices play an important role in the substitution of different food products, above all between basic foods produced locally, such as maize, and imported foods, such as wheat and its derivatives.

Given the policies implemented during the second phase of structural adjustment, such as the real currency devaluation, the elimination or reduction of subsidies on bread, and the reduction of assistance programs such as PL-480, we would expect that consumer prices of wheat and its derivatives would increase relative to the maize price and that wheat consumption and imports would fall. The limited empirical evidence shows that this was not the case in Central America, although it did occur in Mexico, which, in addition to devaluing its currency, withdrew subsidies (Tables 9 and 10). In general, the price of bread relative to maize has decreased. It should be taken into account, however, that

Table 9. Changes in real prices of bread and maize in some Central American countries and Mexico, 1970–80 and 1980–88

	Percent change per year	
Country and period	Bread	Maize
Mexico		
1970–80	-4.7**	-1.1 (tortilla)
1980–88	7.5**	-3.1 (tortilla)
Costa Rica, 1980–88	-6.7**	1.5 (grain)
Guatemala, 1980–88	-3.4**	-3.3** (tortilla)
Honduras, 1980–87	-0.3	-4.5** (grain)
Panama, 1980–88	-1.1**	0.5 (grain)

Source: Adapted from Byerlee and Sain (1991).

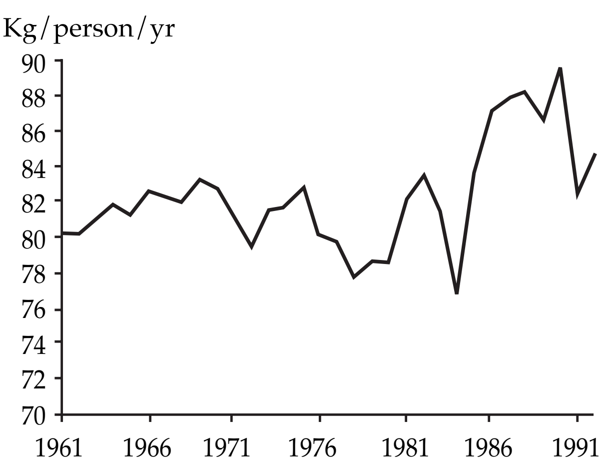

Figure 4. Trends in direct maize consumption in Central America, 1961–92.
Source: FAO Agrostat.

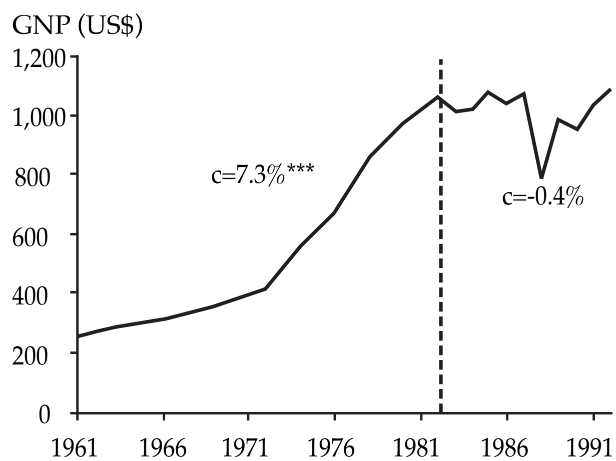

Figure 5. Trends in per capita gross national product (GNP) in Central America, 1961–92.
Note: Growth rates calculated through semi-logarithmic regression.

declining real incomes have also played a role in the decrease of relative bread prices. Income levels have a greater impact on products such as bread, which has a greater income elasticity than maize. The evidence on wheat consumption and imports does not seem to support the hypothesis of reduced consumption, either (Figure 6).

Recently, a new factor may have contributed to displacing the demand for maize for human consumption: the increasing use of white maize for industrial processing, especially for the production of maize flour. The growing urbanization of the population has created greater demand for processed products. New factories have been installed to produce maize flour and other maize-derived products. Throughout the region, medium- and large-scale commercial farmers produce maize under contract with processing plants (mainly of Mexican origin). In Costa Rica, for example, as a result of farmers' contracts with processing companies, maize area increased in recent years after almost disappearing. Under these contracts, companies guarantee that they will pay a minimum price to farmers and pay part of the contract in advance to purchase inputs (López-Pereira, Borge, and Benítez 1996). Given the preferences of people in Central America and Mexico for white maize, which is produced in limited quantities in other regions and traded only in very small quantities on international markets, growth in industrial processing of white maize may represent a powerful incentive for increasing maize productivity in the region.

Table 10. Change in relative prices of bread and maize in some Central American countries and Mexico, 1970s and 1980s

Country and period	Bread price relative to maize price
Mexico	
1970-72	2.2 (tortilla)
1979-81	1.5 (tortilla)
1986-88	2.7 (tortilla)
Costa Rica	
1980-81	5.5 (grain)
1986-88	3.2 (grain)
Guatemala	
1979-81	2.4 (tortilla)
1986-88	2.4 (tortilla)
Honduras	
1979-81	3.4 (grain)
1986-88	4.0 (grain)
Panama	
1979-81	2.9 (grain)
1986-88	2.0 (grain)

Source: Adapted from Byerlee and Sain (1991).

Indirect Consumption

The growing level of maize imports in Central America (mostly yellow maize) suggests that indirect maize consumption in the form of animal feed has increased more than proportionally. Figure 7 clearly shows this trend. Until 1984, maize consumption in balanced feeds grew at an annual rate of 3.4%, while as of 1985 indirect consumption began to increase at an annual rate of 4.5%.

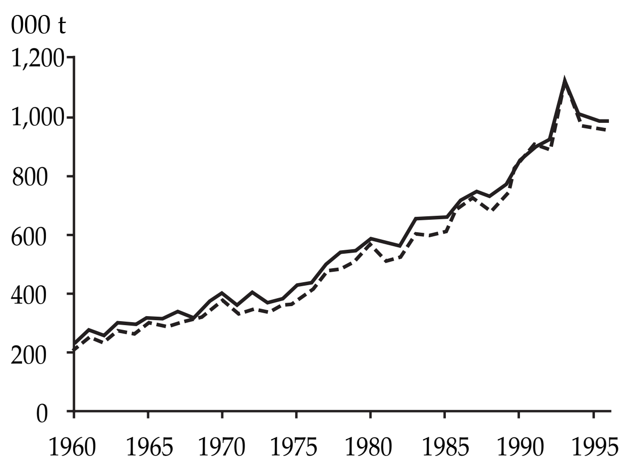

Figure 6. Trends in wheat consumption and imports in Central America, 1960s to 1990s.
Source: USDA Foreign Agricultural Service.

In this case, the demand for maize is regarded as a derived demand. In addition to the maize price and the prices of substitute crops, other factors are involved in determining the demand for the final product (that is, for poultry meat, eggs, and pork). Figure 8 shows the notable growth in consumption and production of poultry meat in Central America. Although both variables grew over 1975–86, it was in 1987 that growth actually shot up. Since maize and sorghum are the main components (in volume) of concentrated feeds for the poultry industry, demand for both grains increased proportionally.

Maize and sorghum volumes used in manufacturing balanced feeds depend fundamentally on the domestic availability of sorghum and its relative prices. Maize and sorghum both provide substantial energy to animal diets. In Panama, where little sorghum is produced, sorghum is not often used in animal feed, whereas maize accounts for 64% of the volume of a typical feed ration (Sain, Nuila, and Pereira 1992). On the other hand, in El Salvador, which produces a relatively large amount of sorghum, the typical composition of animal feed was approximately 70% maize and 30% sorghum until 1986, and then the proportion was reversed (Figure 9).

Strong demand for both grains and the possibility of substitution between them has stimulated sorghum production, along with recent productivity increases and a greater profitability relative to maize (Sanders and López-Pereira 1996). In Nicaragua and Honduras, large areas are planted to sorghum grown under high levels of technology and under contract to companies that produce concentrates. This “mini technological revolution” in sorghum production, especially in Honduras, El Salvador, and Nicaragua (Sanders and López-Pereira 1996), has caused the sorghum area to expand more rapidly than maize area (Barkin, Batt, and DeWalt 1990). At the same time, the use of sorghum in feed concentrates has slightly alleviated the pressure to use maize for this purpose, and a relatively greater quantity of maize is available for direct human consumption.

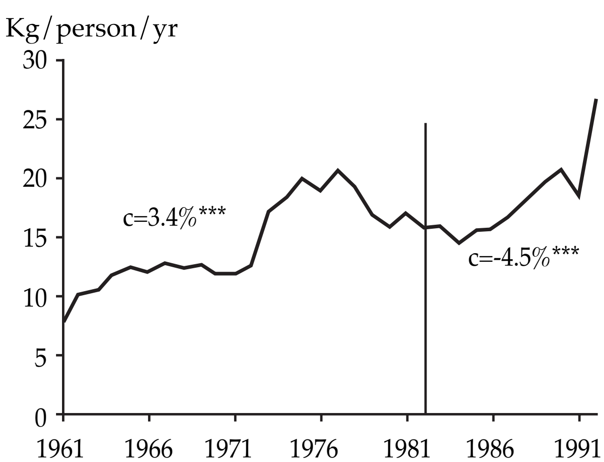

Figure 7. Trends in indirect maize consumption in Central America, 1961–92.
Source: USDA Foreign Agricultural Service.

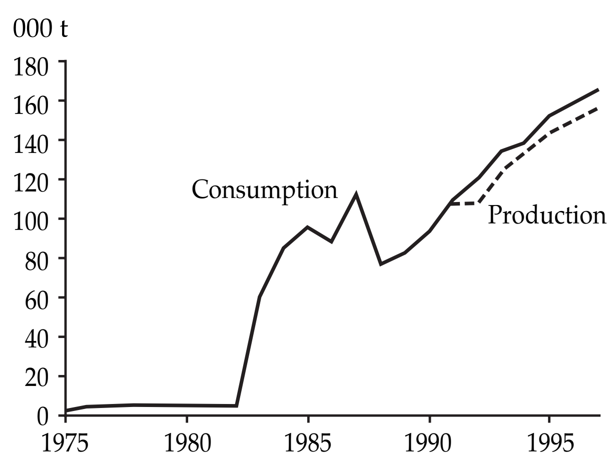

Figure 8. Trends in production and consumption of poultry meat in Central America, 1975–96.
Source: USDA Foreign Agricultural Service.

Feed manufacturers can substitute not only between maize and sorghum but also between yellow (imported) and white (locally produced) maize. Figure 10 illustrates the relationship between the production and relative use of yellow and white maize in animal feed. Although data are scarce, they seem to indicate that the level of yellow maize imports in a given period depends on the domestic production of white maize in previous years. Thus, the fall in internal production in 1981 and 1982 was followed by a considerable increase in yellow maize imports during 1983 and 1984.

Maize Production in Central America and Mexico

Trends in Area and Yield

Trends in the basic components of maize production, cultivated area and yield, also show a divergent history in Central America compared to Mexico. The stagnant growth in maize production in Central America over the last 11 years was basically caused by stagnating productivity (Table 11). Although there is some variation among countries, in Central America as a whole until 1984 production grew because yields grew. In 1984, yields

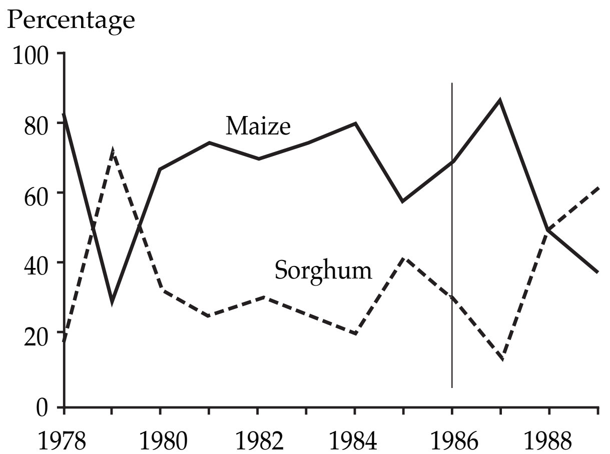

Figure 9. Relative importance of sorghum and maize in the composition of balanced animal feed, El Salvador, 1978–89.
Source: Sain et al. (1992).

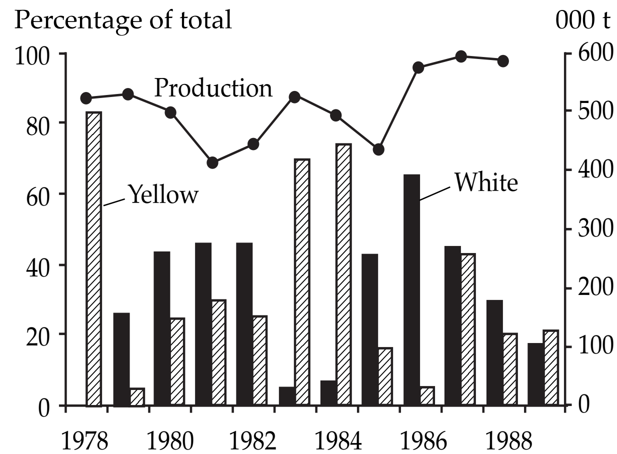

Figure 10. Domestic maize production and proportion of yellow and white maize in balanced animal feed in El Salvador.
Source: Sain et al. (1992).

Table 11. Growth in maize production and its components in Central America and Mexico, 1960–96

	Central America (annual rate in %)			Mexico (annual rate in %)		
Period	**Production**	**Area**	**Yield**	**Production**	**Area**	**Yield**
1960–84	2.75	0.49	2.26	1.78	–0.09	1.87
1985–96	1.80	0.92	0.88	4.93	0.41	4.52
Change	–0.95	0.43	–1.39	3.15	0.50	2.65

Source: Calculated from the USDA Foreign Agricultural Service database.
Note: Growth rates estimated through semi-logarithmic regression.

stopped increasing and even fell in some countries. In Mexico, growth in productivity rose considerably over both periods. Together with moderate growth in cultivated area, yield growth contributed to Mexico's high growth rate in maize production.

Compared with Latin America and the world in general (Table 12), maize production and yields in Mexico during the last ten years grew at a higher rate than in the rest of Latin America and the world. Production grew more rapidly in Central America than in the world in general but at a slower rate than in the rest of Latin America. As compared to other regions, however, maize production in Central America grew because of an increase in cultivated area, whereas maize production in Mexico, the rest of Latin America, and the world grew thanks to substantial yield increases rather than to growth in area, which was small.

When these trends are examined for individual countries in the region over 1985–94 (Table 13), it can be observed that, except for Costa Rica and Panama,[9] most Central American countries

Table 12. Growth in maize production and its components by geographical area, 1961–94

Period	Central America	Mexico	Latin America	World
Production				
1961–84	2.64	2.37	2.89	3.51
1985–94	2.22	5.51	2.87	1.68
Area				
1961–84	0.25	–0.24	0.76	0.85
1985–94	1.57	1.24	0.03	0.09
Yield				
1961–84	2.39	2.62	2.13	2.67
1985–94	0.66	4.26	2.85	1.59

Source: FAO (1995).
Note: Annual growth rates estimated with semi-logarithmic regression.

Table 13. Growth in maize production and its components by country, Central America, 1961–94

	Belize	Costa Rica	Guatemala	El Salvador	Honduras	Nicaragua	Panama
Production							
1961–84	9.56	1.48	2.83	4.74	2.04	0.82	–1.10
1985–94	1.29	–16.79	2.04	3.61	3.19	3.86	1.50
Area							
1961–84	4.21	–0.69	–0.53	1.82	1.41	0.04	–1.88
1985–94	2.14	–17.75	0.41	2.74	3.63	5.02	–0.41
Yield							
1961–84	5.35	2.17	3.36	2.92	0.63	0.78	0.77
1985–94	–0.86	0.96	1.63	0.86	–0.44	–1.16	1.92

Source: FAO (1995).
Note: Annual growth rates estimated with semi-logarithmic regression.

[9] Unlike the northern part of Central America, in Nicaragua, Costa Rica, and Panama maize is not so important for human consumption. Rice, beans, and tubers are the basic constituents of people's diets in these countries (López-Pereira, Borge, and Benítez 1996).

relied far more on area rather than productivity increases to increase maize production. In fact, in Honduras and Nicaragua, maize yields have fallen in the last decade, and all growth in maize production can be attributed to an increase in cultivated area. Guatemala and El Salvador showed steady growth in maize yields in 1961–84 and then more modest growth in 1985–94.

Maize production in southern Mexico (the states of Oaxaca, Veracruz, Tabasco, Chiapas, Campeche, Yucatán, and Quintana Roo) represents approximately 20% of the country's total production (Table 14). Even so, and despite the fact that yields in southern Mexico are lower than in the rest of Mexico, southern Mexico produces more maize than the whole of Central America (López-Pereira and García 1997). Growth rates vary among the states of southern Mexico, but maize production in the area as a whole rose by 3.5% per year, which is higher than the rate for Central America over the same period though lower than for Mexico as a whole.

As explained later in this paper, an important factor that must be considered in analyzing these differences in productivity growth is the structure of the maize production sector. A great proportion of maize in Central America and Mexico is produced by small-scale farmers who have limited access to resources and opportunities and live in hillside areas with low production potential. This contrasts sharply with the structure of the maize production sector in other Latin American countries and in other regions of the world, where large-scale farmers with easy access to resources and good opportunities for marketing and organization are in the majority, and maize is grown in areas that present few biophysical limitations.

Table 14. Maize production (000 t) in Mexico and southern Mexico, 1985–94

Year	Southern Mexico	Other Mexico	All Mexico	% Southern Region
1985	2,949.3	11,154.1	14,103.5	20.9
1986	2,433.9	9,379.0	11,812.8	20.6
1987	2,477.4	9,141.1	11,618.4	21.3
1988	2,382.6	8,216.9	10,599.5	22.5
1989	2,635.4	8,317.5	10,952.8	24.1
1990	2,712.6	11,922.8	14,635.4	18.5
1991	2,480.9	11,770.6	14,251.5	17.4
1992	3,338.6	13,631.1	16,969.7	19.7
1993	3,188.8	14,772.9	17,961.7	17.8
1994	3,788.0	17,523.0	21,311.1	17.8
Average				
1985–87	2,620	9,891	12,512	20.9
1992–94	3,439	15,309	18,748	18.3
Percent	31.2	54.8	49.8	–12.4
Annual growth rate (%), 1985–94	3.5	6.5	5.9	–2.4

Source: Consejo Nacional Agropecuario [Mexico].
Note: Annual growth rates estimated through semi-logarithmic regression.

In short, domestic maize supply has been unable to respond to increased maize demand more because of stagnating productivity than because of the effect of cultivated area. Average maize yields at the domestic level increased in the period before structural adjustment but have remained static or declined from the mid-1980s to the present, and increases in production were accomplished through increases in cultivated area.

Where, How, and by Whom Is Maize Produced in Central America and Mexico?
Despite large similarities in basic grains production throughout Central America and Mexico, there are also marked differences in the importance of maize area. These differences are partially determined by the relative importance of the crop in each country's diet. Maize and beans, for example, are more important in southern Mexico, Guatemala, El Salvador, and Honduras (the area known as "Mesoamerica") than in the rest of the region.

Most countries in the region are mountainous, and a great percentage of their area is considered suitable for forestry and mountain crops (Figure 11). Hillside regions occupy an especially large area in Mesoamerica. Because hillside areas account for a considerable proportion of the arable land in Mesoamerican countries, particularly in El Salvador (40%) and Guatemala (30%), a considerable hillside area is planted to annual crops, especially basic grains.

Although there is no doubt that soil erosion must affect resource productivity in Central America, empirical evidence is scarce. Research has focused on measuring effects of erosion on the resource base, but little or no evidence exists at the regional level on the impact of soil erosion on maize yields (Lutz, Pagiola, and Reiche 1993).

Because of topographic and climatic factors, basic grains production in Central America and Mexico is characterized by two well-differentiated systems (Sanders and López-Pereira 1996). In the first system (the commercial system), medium- and large-scale farmers produce basic grains in valleys and in other zones with high productive potential, normally as part of a diversified operation. These farmers normally use high levels of purchased inputs, such as improved seed and inorganic fertilizer. In contrast, in the second system (the peasant production system), small-scale farmers produce basic grains in the hillside areas, normally in associated systems of two or more crops, especially maize–sorghum and maize–beans. These farmers use traditional management practices and very few purchased inputs. The most important inputs in these cultivation systems are labor (almost always family labor), land, traditional seed, and in some instances animal traction.

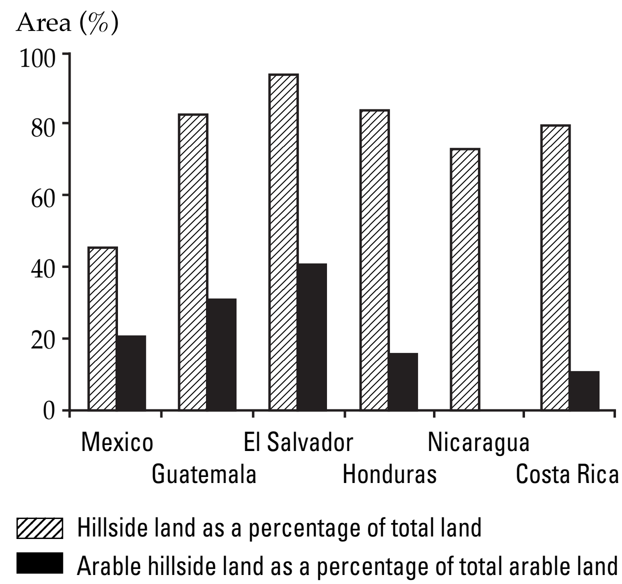

Figure 11. Importance of hillside regions in Central America and Mexico.
Source: Posner and MacPherson (1980).

Two important characteristics of both systems are the size of cultivated area and the destination of production. In the commercial system, the production scale is relatively large and the product is mainly destined for sale. In the peasant production system, both farm size and production are small (commonly about 1 ha of maize), the product is destined mainly for domestic consumption, and the excess is sold. It should be noted, however, that this classification does not have well-defined limits; on the contrary, within the peasant and commercial sectors there is sufficient variation to make classification imprecise. For example, there is a "mid-peasant sector" whose level of purchased input use, better land quality, and dependence on the market indicates that these farmers should be classified as belonging to the commercial sector. This group of farmers has drawn the attention of many governmental programs in the past.

Although there are no precise figures about the percentage of farmers and total production in each of these categories, there is consensus that most small-scale farmers in Central America and Mexico belong to the peasant system and that approximately half of the maize, sorghum, and bean production originates in this traditional cultivation system. In other words, a large number of small-scale farmers with low productivity coexist with a smaller number of commercial farmers who maintain a high yield level.

This differentiation by production system, although simple, is important because opportunities to increase productivity differ in each system. Not only is the technological gap different in each system, but the whole economic structure of the system is different; therefore the impacts of economic policies are different as well for each group of farmers.

Actual and Potential Productivity

According to aggregate data at the country level, none of the Central American countries has superseded the yield barrier of 2 t/ha; in Nicaragua and Panama, yields hardly surpass 1 t/ha (Table 15). In Mexico, as observed previously, average maize yields at 2.2 t/ha are similar to those elsewhere in Latin America (2.4 t/ha). Average maize yields at the world level, however, are about 4 t/ha, double the yields in Central America. These figures should be interpreted as indicators of average trends at the domestic level. In all countries of the region there is a wide variation in yield levels, because there are areas with higher and lower productivity. In Guaymango, El Salvador, the average yield at the field level is higher than 3 t/ha, while the national average is 1.9 t/ha. In Azuero, Panama, yields vary from 4–5 t/ha, while the national average is 1 t/ha (Pereira de Herrera and Sain 1999).

Table 15. Maize yields (t/ha) in Mexico and Central America, 1960–96

	Mexico	Central America	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama
1960–69	1.0	1.0	1.1	1.1	0.9	1.1	0.9	0.8
1970–79	1.2	1.1	1.3	1.7	1.1	1.1	0.9	0.9
1980–89	1.5	1.5	1.6	1.9	1.5	1.4	1.2	1.0
1990–96	2.2	1.5	1.7	1.9	1.6	1.4	1.2	1.0

Source: USDA Foreign Agricultural Service.

The previous figures are indicative of the gap between current and potential productivity. Table 16 shows the size of the productivity gap, defined as the difference between current yields and potential yields estimated for two types of improved maize: hybrids and open-pollinated varieties (OPVs). The values in Table 16 reveal the opportunities to increase maize productivity in the region. Even in commercial systems located in more favorable areas, productivity could be increased by 50–85% with the available technology. The gap is still larger for the peasant system (productivity could grow 300–400%).

Reducing these gaps depends, however, on the objectives of sectoral policies. It is probable that a more rapid and greater impact could be made on aggregate production levels if research efforts were directed to closing the gap in the commercial sector rather than in the peasant sector, although in the latter case a larger number of beneficiaries are located in the lower income distribution strata.

Factors Affecting Maize Productivity in Central America and Mexico

Availability of Land and Land Tenure

High population growth rates, combined with small increases in cultivated area, substantially reduced the availability of total and cultivated land per inhabitant in the region from 1980 until the mid-1990s (Table 17). In all countries except Honduras and Nicaragua, the availability of arable land per capita fell to less than 0.3 ha, and in the case of El Salvador and Costa Rica, to less than 0.2 ha. When nonarable areas, forests, and relatively unpopulated regions are eliminated (e.g., the Petén in Guatemala and the Mosquitia in Honduras and Nicaragua), the population densities for all countries substantially increase. Even so, population pressure is generally not as heavy in Central America and Mexico as in other regions of the world.

Table 16. Estimated technological gap (in t/ha) for maize production in Central America and Mexico

		Hybrids	Open-pollinated varieties
Potential yield[a]		4.97	4.09
		Difference between potential and present yield	
Present yield by farm type			
Commercial farm[b]	2.7	2.27 (84%)	1.39 (51%)
Small farm[c]	1.0	3.97 (397%)	3.09 (309%)

[a] The potential yield of hybrid and open-pollinated varieties is the average of yields of nine cultivars from the Regional Maize Program for Central America and the Caribbean, evaluated over 11 locations in Central America and in Mexico (Bolaños et al. 1993).

[b] The current yield on commercial farms is an average of 28 observations in farmers' fields or validation plots in Central America (Bolaños et al. 1993).

[c] Farmers' yields vary enormously by region and country, but the average of 1.0 t/ha adequately reflects the small farm system's low productivity level.

The experience of Honduras illustrates the relationship between population pressure and area planted to basic grains (Table 18). Until the late 1970s and early 1980s, Honduras was a net maize exporter, but the rural population almost tripled from 1952 to 1993. The availability of land with basic grain crops per rural inhabitant was notably reduced, despite substantial increases in the productivity of these crops. Even with record levels of maize and sorghum production, Honduras has not been able to satisfy the growing demand for these grains.

Another factor that has influenced the availability of land for basic grain production in the region has been the conversion of forest and agricultural land into pasture for cattle production. Although this trend has diminished in recent years, pasture areas are still very

Table 17. Trends in the relationship between population and land in Central America and Mexico, 1980–93

Country and period[a]	Total area (000 km^2)	Population (000 inhabitants)	Population density (inhabitants/km^2)	Cultivated area		Availability of cultivated area	
				(km^2)[b]	(% of total)	(inhabitants/km^2)	(ha/inhabitant)
Mexico							
1980–82	1,958	68,725	35	246,350	13	279	0.36
1991–93	1,958	88,155	45	247,250	13	357	0.28
Belize							
1980–82	23	150	7	530	2	283	0.35
1991–93	23	198	9	570	3	347	0.29
Costa Rica							
1980–82	51	2,354	46	5,090	10	462	0.22
1991–93	51	3,192	63	5,290	10	603	0.17
El Salvador							
1980–82	21	4,573	221	7,250	35	631	0.16
1991–93	21	5,386	260	7,320	35	736	0.14
Guatemala							
1980–82	108	7,115	66	17,640	16	403	0.25
1991–93	108	9,747	90	18,850	17	517	0.19
Honduras							
1980–82	112	3,801	34	17,630	16	216	0.46
1991–93	112	5,463	49	18,490	17	295	0.34
Nicaragua							
1980–82	119	2,886	24	12,530	11	230	0.43
1991–93	119	3,959	33	12,730	11	311	0.32
Panama							
1980–82	76	2,000	26	5,630	7	355	0.28
1991–93	76	2,515	33	6,570	9	383	0.26
Central America							
1980–82	509	22,879	45	66,300	13	345	0.29
1991–93	509	30,460	60	69,820	14	436	0.23
Central America and Mexico							
1980–82	2,467	91,604	37	312,650	13	293	0.34
1991–93	2,467	118,615	48	317,070	13	374	0.27

Source: FAO (1994).

[a] Data for each period are annual averages.

[b] Cultivated land includes annual and permanent crops as well as land in fallow. It does not include pastures.

important (Table 19). Forest areas have been reduced very rapidly throughout the region in favor of annual crops, permanent crops, and pastures (Table 20).

Table 18. Trends in the availability of land for basic grains in Honduras, 1952–93

	1952	1965	1974	1993
Cultivated area (000 ha)				
Maize	283	275	287	358
Beans	50	73	62	85
Rice	57	42	53	57
Sorghum	11	9	14	21
Total	401	399	416	521
Rural population (000 inhabitants)	1,133	1,449	2,024	2,902
Availability of land (ha/rural inhabitant)				
Maize	0.25	0.19	0.14	0.12
Other grains	0.10	0.09	0.06	0.06
Total	0.35	0.28	0.21	0.18

Source: Based on Baumeister and Wattel (1996).

Table 19. Land use in Central America and Mexico, 1989–91

	Annual and permanent crops		Pastures		Forest		Other uses	
	000 ha	%	000 ha	%	000 ha	%	000 ha	%
Mexico	24,713	13	74,499	39	42,460	22	49,197	26
Guatemala	1,882	17	1,400	13	3,750	35	3,811	35
El Salvador	733	35	610	29	104	5	625	30
Honduras	1,824	16	2,560	23	3,250	29	3,545	32
Nicaragua	1,273	11	5,400	45	3,380	28	1,822	15
Costa Rica	529	10	2,327	46	1,640	32	611	12
Panama	649	9	1,560	21	3,300	43	2,090	28
Central America	6,890	14	13,857	28	15,424	32	12,504	26
Central America and Mexico	31,603	13	88,356	37	57,884	24	61,701	26

Source: WRI (1994); UNDP (1994).

Table 20. Growth (%/yr) in land use in Central America and Mexico, 1980–92

Country	Annual crops	Permanent crops	Pastures	Forest	Irrigated land
Mexico	0.1	0.3	0.0	–1.2	1.6
Guatemala	0.8	0.1	0.7	–1.8	2.8
El Salvador	0.1	0.0	0.0	–2.3	0.7
Honduras	0.4	0.7	0.5	–1.9	0.9
Nicaragua	0.2	0.1	0.9	–2.6	0.7
Costa Rica	0.1	0.7	1.2	–0.8	5.3
Panama	1.1	2.2	1.1	–2.0	1.0

Source: FAO (1994).

In addition to the availability of land, another factor that directly affects the adoption and use of new technologies, and therefore the productivity level, is the land tenure system under which maize is produced. Although in recent years important efforts have been made to reduce land tenure insecurity through agrarian reform and titling programs, the problem and its bias are very important throughout the region. Except for Costa Rica, in the 1980s most farms in Central America were occupied by families who could not subsist on their production because the farms were too small (Table 21). Large farms, which represented a very small proportion of the total number of farms, occupied most of the land. This problem was especially serious in Guatemala and El Salvador.

Supply of New Technologies

As part of government restructuring and the trend towards privatizing many activities that governments traditionally conducted, the public systems for generating and transferring technology have been drastically reduced in the last decade (López-Pereira and Filippello 1994). Although the trend towards reducing the size of research systems began in the mid-1980s, the national agricultural research systems began restructuring in earnest in the 1990s with the third phase of structural adjustment.

In Central America, investment in research increased by 52% between 1971–75 and 1981–85; the number of researchers increased by 111% (Table 22). This growth in research staff reduced the investment per researcher by 28%, indicating that fewer funds were available for operating costs.

Between 1970 and 1990, resources assigned to research and extension on basic grains in Guatemala and El Salvador declined in real terms (Table 23). Real expenses for maize research and extension in Guatemala's national research program, ICTA (Instituto de Ciencia y Tecnología Agrícolas), fell from approximately 370,000 quetzales in 1981 to 130,000

Table 21. Agricultural land tenure structure in Central America

		Percentage of farms with:			Percentage of total area with:		
	Land:	Abundant[a]	Sufficient	–	Abundant[a]	Sufficient	–
Country	Labor:	–	Sufficient[b]	Abundant[c]	–	Sufficient[b]	Abundant[c]
Costa Rica		22	32	46	88	10	2
El Salvador		2	6	92	50	23	27
Guatemala		2	10	88	72	14	14
Honduras		2	26	69	60	28	12
Nicaragua		22	27	51	85	11	4

Source: Lassen (1980), cited in Leonard (1987).

a A farm with abundant land indicates that the household has more land than can be worked by family labor and that external labor can be hired.

b A farm with sufficient labor and land indicates that the household has sufficient land for maintaining a satisfactory standard of living with the use of family labor.

c A farm with abundant labor does not have sufficient land to satisfy the basic needs of the family or to allow the use of family labor on the farm during the whole year.

quetzales in 1990. In only nine years, the real level of public investment in technology generation and transfer for the nation's most important crop was reduced by 65% in real terms (Reyes Hernández 1996).

Availability of Credit

Structural adjustment greatly reduced the availability of public credit for producing basic grains. Not only were subsidies to credit eliminated, but public funds were reduced, and those that remained were directed toward the most dynamic sectors in agriculture, such as traditional and nontraditional export products. The availability of public credit for small-scale maize farmers was drastically reduced in the second half of the 1980s. Access to credit is strongly associated with the use of inputs that farmers must buy at the beginning of the production period, such as improved seed and fertilizer, so the reduction in credit caused the use of inputs to decline. For example, in El Salvador there is a close correlation between the availability of public credit, use of improved seed, and maize yield (Figure 12) (Choto, Sain, and Montenegro 1996).

Table 22. Investment in agricultural research in Central America and Mexico, 1970–85

	Investment in agricultural research (million US$ 1985)		Number of researchers with BS degree or equivalent		Investment per researcher (000 US$ 1985)	
	1971-75	1981-85	1971-75	1981-85	1971-75	1981-85
Mexico	36.4	129.0	444	1,058	82.1	121.9
Costa Rica	3.4	2.8	60	114	57.3	24.4
El Salvador	3.5	5.4	77	131	45.7	41.3
Guatemala	6.0	7.3	63	160	95.9	45.9
Honduras	2.3	2.6	56	65	40.9	39.5
Nicaragua	3.0	5.1	29	65	103.4	78.6
Panama	1.0	6.1	23	115	43.9	52.9
Central America	19.3	29.3	308	650	62.7	45.1
Central America and Mexico	55.7	158.3	752	1,708	74.1	92.7

Source: WRI (1994).

Table 23. Resources (in 000 US$ 1970) assigned to research and extension in basic grains in Guatemala and El Salvador, 1970–91

	1970	1980	1989	1990	1991
Research	335.5	609.9	379.5	214.3	207.9
Extension	–	–	452.5	269.6	366.0
Total	–	–	649.1	580.3	573.9

Source: PRIAG (1996).

The importance of credit in the adoption of new technologies depends partly on whether a technology requires a cash expenditure. Farmers living along the Atlantic Coast of Honduras have incorporated a legume (*Mucuna deeringiana*) into their maize cropping system in a rotation that practically doubles maize yields yet requires no public or private credit to adopt (Buckles, Sain, and Triomphe 1998). In Guaymango, El Salvador, however, state credit in the form of cash and inputs was a fundamental element in the adoption of a technology package that included hybrid maize seed, fertilizer, and conservation tillage (Sain and Barreto 1996).

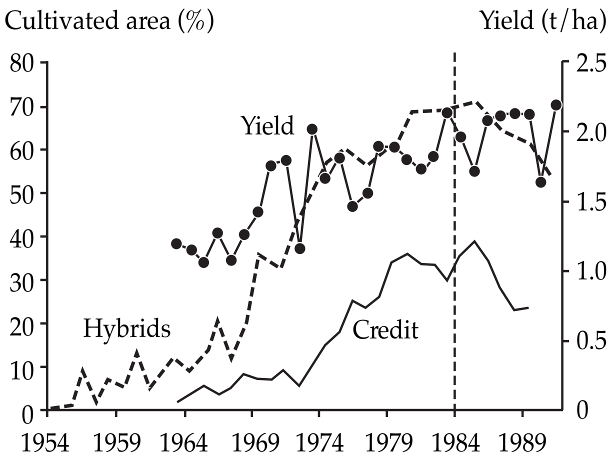

Figure 12. Trends in use of credit, use of hybrids, and maize yields in El Salvador, 1954–92.
Source: Choto, Sain, and Montenegro (1996).

Use of Inputs: Improved Seed

Although prices of improved maize seed in Central America and Mexico are among the world's lowest (CIMMYT 1986) (Table 24), improved varieties have not diffused throughout the region (Table 25). Only 17% of the total maize area in Central America and 26% in Mexico was sown with improved seed in 1993.

Given that the region's national research programs have a long tradition of maize research, and given the large number of improved materials that these programs have developed and marketed, the low use of improved seed in the region indicates

Table 24. Maize seed prices in Central America and Mexico, by seed type and origin, 1993

	Seed price/grain price			Hybrid price
	Open-pollinated variety	Public hybrid	Private hybrid	Private/public
Mexico	5.8	12.8	16.7	1.3
Costa Rica	2.8	5.2	6.2	1.2
El Salvador	3.4	4.6	5.7	1.2
Guatemala	3.6	5.5	6.1	1.1
Honduras	2.5	3.9	4.7	1.2
Nicaragua	5.8	6.9	8.2	1.2
Panama	4.6	9.2	–	–
Central America	4.1	5.6	6.2	1.1
Central America and Mexico	4.5	7.6	9.7	1.3

Source: López-Pereira (1995).
Note: Open-pollinated varieties and public hybrids are produced by the public research system. Private hybrids are produced by private seed companies.

Table 25. Maize area in Central America and Mexico by maize seed type, 1993

	Maize area in 1993 (000 ha)		Percentage area with:		
	Total	Improved seed	Local varieties	Open-pollinated varieties	Hybrids
Mexico	7,348	2,638	64	10	26
Costa Rica	24	5	81	12	7
El Salvador	321	111	65	1	34
Guatemala	650	200	69	19	12
Honduras	435	82	81	7	12
Nicaragua	192	19	90	7	3
Panama	79	79	0	38	62
Central America	1,701	496	71	12	17
Central America and Mexico	9,049	3,134	65	10	25

Source: López-Pereira (1995).

that there are important barriers to adoption of these technologies. The two barriers that are most frequently mentioned in the literature are problems of seed quality and adaptation and problems with making improved seed available on time to farmers (López-Pereira and Filippello 1994, Sain and Martínez, forthcoming). These factors are related to the type of farmer and the prevailing environments for maize production in the region.

The changing roles of the public and private sectors in the supply of inputs and services are most apparent in the seed industry. In the case of maize seed, and probably seed of other crops as well, at the beginning of the 1990s the private sector had already captured more than 80% of the improved seed market. State participation in marketing improved seed declined from approximately 8% in 1980 to 0% in 1994 in El Salvador (Choto, Sain, and Montenegro 1996), while in Guatemala it decreased from 30% in 1978 to only 1% in 1985 (Véliz 1993).

Given the different characteristics of commercial and peasant production systems described previously, the doubt remains as to whether the private sector will be interested in the needs of small-scale farmers or will have the capacity to make improved seed available to them.

Management of Natural Resources

One of the unhappy results of economic deterioration has been the growing human migration toward increasingly marginal lands, which have been exploited for agriculture. To support growth in yields, technology—in the form of improved seed and fertilizer and other agrochemicals—had to substitute in part for the lesser quality of fragile soils in these marginal areas. Not surprisingly, fertilizer consumption per unit of land grew at an annual pace of 2.8% in Central America from 1970 to 1987 (Table 26).

Table 26. Fertilizer consumption (100 g/ha) in Central America, 1970–87

	1970	1975	1980	1984	1985	1986	1987
Guatemala	300	285	489	375	492	515	652
El Salvador	1,043	1,442	832	1,132	749	1,155	893
Honduras	286	226	162	159	205	127	215
Nicaragua	283	200	435	557	383	497	534
Costa Rica	1,001	1,353	1,229	1,705	1,841	1,532	1,607
Panama	387	455	533	410	496	449	608
Central America	550	660	613	723	694	712	752

Source: IICA-FLACSO (1991).

This trend sparked a renewed interest in generating and transferring technologies that, in addition to improving maize productivity, conserve soil and substitute for chemical fertilizers. These technologies include the use of leguminous cover crops, conservation tillage (in which seed is sown into the stubble of the previous crop), organic fertilizers, and the establishment of live barriers. These technologies substantially reduce the need for using inorganic fertilizers and permit better management of water and soil resources, which are particularly important in hillside maize production systems. Technologies such as these, designed for resource conservation, should be seen as complements rather than substitutes of technologies designed to raise productivity (Sain 1996). In fact, some research programs in Central America have successfully combined both types of technology in a package that farmers adopted (Sain and Barreto 1996).

Although numerous technologies are aimed at resource conservation, the structure of their cost and benefit flows has implications for economic policy. In general, the initial costs of introducing such technologies into agricultural systems are high and the benefits are considerably delayed (often by several years). This pattern greatly affects the diffusion of resource-conserving technologies among small-scale farmers. For example, precarious land tenure arrangements reduce the farmer's planning horizon, giving the long-term benefits of the technology less weight in the farmer's decision to invest in the technology. The degree of risk aversion is another factor that weighs in farmers' decisions to adopt technologies with uncertain benefits to be obtained in the future.

The divergence between social and private costs and benefits for the adoption of conservation technologies, which mainly results from factors external to the farm and from failures in natural resource markets, justifies the use of incentives to promote the adoption of these technologies.

Summary and Conclusions

During the last ten years in Central America, as growth in domestic maize consumption has surpassed growth in domestic production, net maize imports have risen almost exponentially. In Mexico, although consumption also increased compared to previous decades, domestic production grew at an even greater pace and maize imports were reduced. Part of the difference between Central America and Mexico can be attributed to the impact of the economic policies implemented with structural adjustment.

On the demand side, currency devaluation, trade integration, and the elimination of subsidies on imported food substitutes for maize (such as bread and its derivatives) helped promote the consumption of white maize in the form of tortillas and maize flour. On the other hand, imports of yellow maize for manufacturing animal feed increased considerably as their domestic prices were reduced as a result of currency devaluation and the elimination or reduction of trade barriers. The aggregate impact of these factors was a substantial increase in the level of maize imports as of 1986 into the entire region, with the exceptions of Mexico and Nicaragua.

Maize production in Central America did not grow at the same pace as consumption. Until the mid-1980s, growth in domestic maize production was achieved primarily through increases in land productivity (yields), but thereafter, production grew mainly through increases in cultivated area. These trends should be interpreted with care, however. The general impact of the new economic policies was to stimulate the allocation of the most fertile land to traditional and nontraditional export crops. Shrinking state resources, credits, and technical assistance, and in some cases increased subsidies to promote agricultural exports, favored export crops over basic grains. This process, accompanied by population growth, internal migration, and resettlement of demobilized soldiers, increased pressure on the land and caused an expansion in cultivated area in marginal lands with less productive potential.

In general, price policies have had an important influence on maize supply. Prices of imported inputs such as fertilizers and pesticides rose in the wake of currency devaluations, but the lowering of tariffs and other trade barriers also served to reduce input prices somewhat. The lack of public credit made it even more costly to acquire inputs off of the farm. Changes in relative prices particularly affected the use of two fundamental capital inputs that increase productivity in the short term: fertilizer and improved varieties. At the same time, programs to reduce internal debt (the fiscal deficit) reduced the public resources assigned to research and extension.

Nearly all of the national programs devoted to technology generation and transfer are in a process of adjustment, which means that fewer resources are available for these activities in the short and medium term. Throughout Central America and Mexico, the role of the public sector is being discussed, particularly those activities that produce technologies whose benefits may be appropriated by the private sector. Furthermore, several countries are discussing the possibility of gradually privatizing agricultural extension. These measures have important implications for small-scale farmers. Studies of factors that affect smallholders' adoption of technologies indicate that researchers and extension agents play an important role in the decision to adopt the technology (Sain and Barreto 1996; Sain and Martínez, forthcoming; Pereira de Herrera and Sain 1999).

The new economic policies of the structural adjustment programs did not affect prices of inputs and services alone; product prices also changed. The new policies tended to increase the bind between domestic grain prices and international prices. To gain efficiency in production, the countries in the region abandoned the political objective of food security to accept a policy that made them more dependent on international markets to supply grains. Declining international maize prices meant declining domestic prices for producers. The disappearance of public agencies for purchasing grain affected small-scale (usually less politically organized) farmers in greater measure. As a consequence, the area cultivated to maize has declined, especially in the region's southern countries, where maize is not very important in the diet and thus the political cost of setting aside food security is smaller. The recent increase in international prices following the reduction of international grain stocks showed how volatile this policy is, however. Central American governments recently agreed to adopt a price band system to regulate domestic prices and to impose special tariffs in cases of world overproduction to protect domestic production (La Nación, January 26, 1997).

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