Maize Food and Feed Consumption in the Developing World

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The views expressed in this paper are not necessarily those of CIMMYT. The FAO data analyzed in this paper are under continuous review and should not be regarded as final.

PREFACE

This study is a detailed analysis of trends in maize use in developing countries. It was prepared as a background document for CIMMYT Maize Facts and Trends. Report Two: An Analysis of Changes in Third World Food and Feed Uses of Maize (1984) and readers of that paper who wish more detail should find this study quite useful. The study examines changes in maize consumption in developing countries and also analyzes maize feed use in both producing and importing countries. An understanding of these trends is quite important to CIMMYT as we try to ensure that maize production is adequate to meet the varied and changing demands of the developing world.

Donald Winkelmann, Director,
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Acknowledgements

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Definitions

The terms and regional aggregates used in this report are defined as follows.

Imports - Gross imports by a country or region without taking into account exports or re-exports

Net Imports - Imports less exports.

Utilization - Production plus net imports.

Direct Consumption - Consumed directly as food. Quantities are calculated on the basis of the weight of the commodity as consumed. Flour, starch, etc. have not been converted back into grain equivalents.

Indirect Consumption - Consumed indirectly as animal feed. Quantities are calculated on basis of the weight of the commodity as consumed.

Annual Growth Rates - Compounded annual growth rates calculated as: $g = 100 [\ln (X_t/X_{t_0})]/t$, where X_t is the average for the three year period t (e.g. 1978-80), X_{t_0} is the average for the three year period t_0 (e.g., 1968-70), and t is the number of years between the midpoints of the two periods (i.e., 10).

DEVELOPING COUNTRIES

Africa

East and Southern Africa: All Sub-Saharan countries east of Angola, Chad and Zaire but excluding South Africa.

West Africa: Angola, Chad, Zaire, and all Sub-Saharan countries to the west.

Near East

North Africa: Morocco to Egypt.

Middle East: Turkey to Afghanistan.

Far East

South Asia: Pakistan to Bangladesh and Sri Lanka.

Southeast Asia and Pacific: Burma to Philippines, Indonesia, and Pacific Islands.

East Asia: China, Korea DPR, and Republic of Korea.

Asian Centrally Planned Economies: China, Korea DPR, Viet Nam.

Latin America

Mexico, Central America and Caribbean: Mexico to Panama and Caribbean Islands.

Andean: Bolivia, Colombia, Ecuador, Guyana, Peru, Surinam and Venezuela.

Southern Cone: Argentina, Brazil, Chile, Paraguay, and Uruguay.

DEVELOPED COUNTRIES

Western Europe, Japan, New Zealand, and Israel

U.S.A., Canada, Australia and South Africa

Eastern Europe and U.S.S.R.

A Note Regarding the Data

The majority of the consumption, production and trade statistics analyzed in this paper were kindly provided by the Food and Agriculture Organization of the United Nations (FAO). These data are under continuous review and subject to revision. They cannot, therefore, be regarded as final.

Considerable caution must especially accompany the interpretation of country specific consumption data for the developing countries. While consumption statistics are, by nature, highly subject to error, estimates for many of the countries included in this analysis can only be viewed as gross approximations. This problem is particularly burdensome with a commodity such as maize. Relative allocations to food and feed are often difficult to judge. Given the fact that many of the countries most dependent on maize have the least developed data bases, even aggregate supplies can be hard to calculate.

This assessment has been conducted, however, in the belief that an analysis of currently available statistics provides at least an indication of the nature of recent trends. Many of the more specific results might best be viewed as hypotheses requiring future validation as improved information becomes available. Yet certain broad consistencies across the data do allow a series of general conclusions to be drawn.

MAIZE FOOD AND FEED CONSUMPTION IN THE DEVELOPING WORLD

Introduction

Over the last decade, the majority of major developing country maize producers have experienced declines in their per capita maize consumption. This trend has most seriously affected many of the poorest producers which tend to rely upon maize for the largest share of their staple calories. Countries with relatively strong wheat or rice production bases have been able to offset at least part of their maize calorie losses by consuming more of these alternative grains. Some middle income countries without such production capabilities have compensated by increasing their wheat or rice imports. But a disturbing number of those countries most dependent on maize have found themselves faced with rising staple calorie deficits and falling total calorie consumption.

In sharp contrast, developing country maize use for animal feed, or indirect demand, has been rapidly growing. Most of this gain has occurred in a relatively small number of higher income countries. Two of these historically have been maize exporters. Most, however, have relied heavily on maize imports. None of these countries have used this commodity to supply more than a minor share of their cereal calories. The most remarkable feature of this trend is the speed with which it has brought these countries to play a major role in world maize markets.

Recent indications suggest this rapid growth in feed demand is beginning to broaden. Countries which have historically produced maize as a major food staple are allocating an increasing share of their supplies to feed. Even some countries with apparent food production deficits seem to be moving in this direction. In such cases, the strength of a country's rising demand for meat may be threatening the priority generally attached to direct cereal consumption needs.

While these trends have often been noted, there has been little detailed analysis of their scope or underlying causes. Numerous unanswered questions hamper predictions of the future speed, or in some instances, even the orientation of consumption patterns in individual countries. Such foresight is essential, however, for the establishment of appropriately responsive government policies and research priorities. Not only must the significance of past trends be clearly recognized, but those factors affecting their development need to be better understood. This report initiates this inquiry.

This study is largely a descriptive analysis of developing country maize consumption patterns over the last ten years. After a review of the trends themselves, factors influencing these are outlined and their immediate significance is judged. Unfortunately, one caveat must accompany this presentation. Due to the uncertain quality of some of the country-specific data, the conclusions must be treated as tentative and must be interpreted with caution. The data do, however, contain broad enough consistencies to testify to the validity of the generalizations derived.

The analysis begins with a description of world production, consumption and trade patterns in order to outline the circumstances under which changing developing country consumption patterns have become an issue of critical importance. Each major trend is then evaluated in turn. Direct maize consumption trends are examined in the context of a brief survey of the consumption patterns associated with alternative staples. The relative importance of different explanatory factors is then assessed and the impact of declining consumption on those countries most dependent on maize calories is discussed.

Next, the growing importance of maize feed use among countries which have historically allocated the dominant share of their production to food is assessed. The relative strength of these trends is evaluated and the key factors which seem to facilitate them are reviewed. A brief discussion draws attention to the possible significance of increasing levels of feed use among the poorer food deficit nations.

Finally, the rapid growth of indirect consumption among the major developing country importers is considered. This section examines the impact of livestock production gains on world maize markets. It concludes with an assessment of whether these trends are indicative of future feed use patterns among the majority of major producers.

A REVIEW OF WORLD PRODUCTION, TRADE AND CONSUMPTION TRENDS

Production Growth

World maize production increased at a 3.8 percent annual rate over the last ten years (1970-72 to 1980-82) to a level of 434 million tons. This represents a 46 percent increase in world supplies. The developing countries led this advance with a production growth rate of 3.9 percent. This gain was dominated, however, by the production growth of the developing world's largest producer. China posted a 6.3 percent annual rate of increase and now accounts for over 40 percent of developing country production. Latin America and the developing market economies of Asia registered moderate 2.8 percent yearly production advances. In contrast, production in sub-Saharan Africa lagged with a disappointing 0.8 percent annual rate of growth.

In the developed countries, aggregate production grew at a 3.8 percent annual rate. This gain was similarly dominated by the grouping's largest producer. The United States achieved a 50 percent increase in

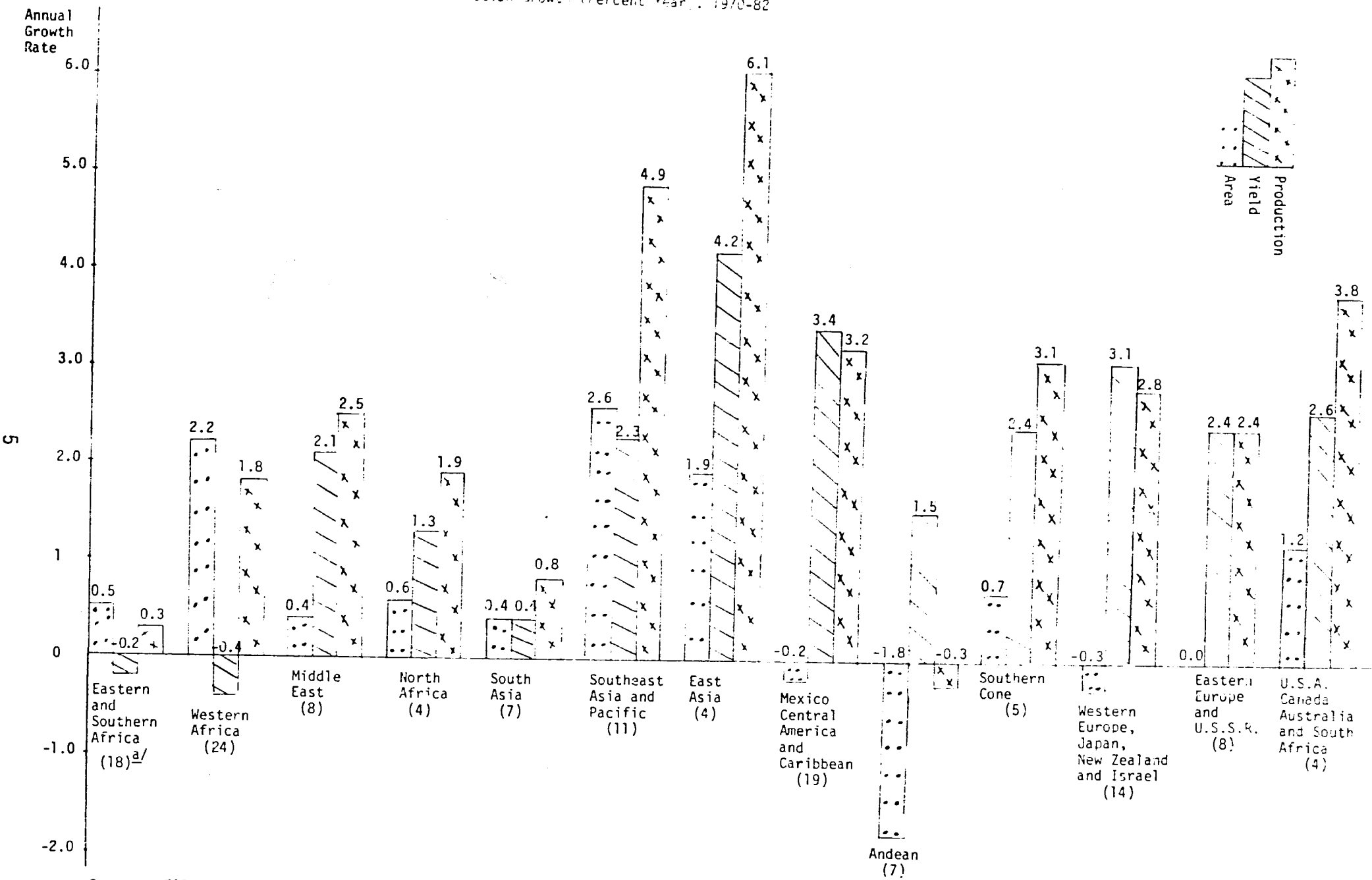
production with a 4.1 percent growth rate. This country now produces over 45 percent of world maize supplies. Canada registered an impressive 8.4 percent yearly production gain, firmly establishing its position as a major world producer. Western Europe experienced a 2.8 percent rate of production growth while a 2.4 percent annual gain was collectively achieved by Eastern Europe and the Soviet Union.

Most of this growth was obtained with yield improvements. In the developing countries yields increased at a 2.8 percent annual rate while area planted expanded by 1.1 percent per year. China registered the most rapid growth in yields among major producers with a 4.3 percent rate of gain. In sharp contrast, yields in sub-Saharan Africa declined at a 0.4 percent yearly pace. This was the only major region where area expanded more rapidly than yields. Most of this gain occurred in Western Africa.

In the developed countries, yields grew at an average annual rate of 2.7 percent and were led by an 8.6 percent annual gain in Greece. In the United States, yields increased by 2.0 percent per year. This country, however, registered a 50 percent jump in area planted. Canada almost doubled its maize hectarage. In the developed countries as a whole, however, area planted annually grew by only 0.7 percent (Figure 1).

The dominance of the developed countries in world maize production is clearly based on their continuing substantial advantage in yields. While the developing countries currently account for 60 percent of area planted tc maize, they produce only 35 percent of world maize supplies. Developing country yields, averaging only 1.9 tons per hectare, are less than 40 percent of the 5.3 tons per hectare average obtained in the developed countries. Furthermore, maize yields in sub-Saharan Africa and the Far East remain low even by developing country standards at 1.0 and 1.3 tons per hectare respectively (Figure 2).

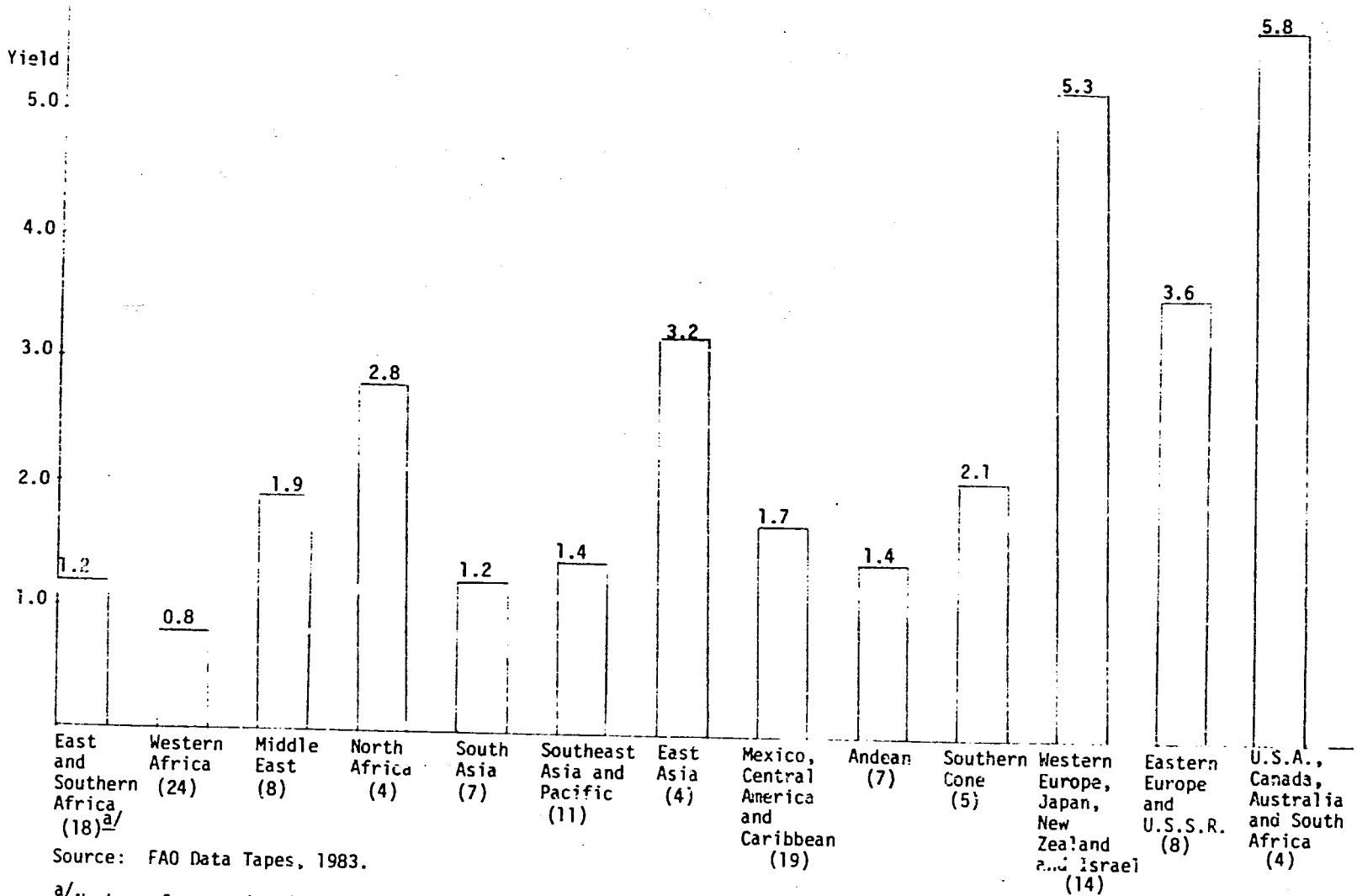
Figure 1. World Maize Area, Yield and Production Growth (Percent Year , 1970-82



Source: FAO Data Tapes, 1983.

a/ Number of countries in region.

Figure 2. World Maize Yields (ton/ha), 1980-82



Source: FAO Data Tapes, 1983.

a/ Number of countries in region.

Trade Trends

World maize trade more than doubled over the ten year 1970-72 to 1980-82 period with an 8.5 percent annual rate of growth. This trend was highlighted by the rapidly increasing reliance of the developing countries on developed country exports. The developing countries imported six times as much maize in 1981 as they did ten years previously. With a 16.4 percent annual growth rate, they increased their share of world imports from 12.3 percent to 26.9 percent. Meanwhile, their share of the world export market sharply declined from 26.0 to 12.2 percent.

This trend exemplifies a larger pattern of broadening world import markets and growing concentration among world exporters. Over the last decade, the European Community's share of world imports dropped from 48 percent to less than 6 percent. The region's maize import levels fell at an annual rate of 2.8 percent. The import share of Japan remained relatively constant while that for the Soviet Union increased sharply. The rapid growth in developing country imports, however, promises to highlight these trends in the future. While four countries--China, the Republic of Korea, Mexico and Brazil--purchased almost one-half of developing country imports in the 1980-82 period, the most rapid developing country import growth rates have been achieved by a number of the non-producing, newly industrializing countries.

The world export market became increasingly dominated by the United States. This country registered a 12.1 percent annual rate of export growth. Its 1981 sales were over four times those achieved ten years earlier. Its world market share rose from 45 to over 75 percent. World market prices, as a result, are currently largely determined by U.S. production and stockholding policies.

Only two countries now account for over 93 percent of developing world exports. Argentina, the world's second largest exporter, and Thailand, the fifth largest, annually increased their sales by 2.2 and 4.5 percent respectively. But significant export declines in many other countries caused total developing country exports to register only a minor gain. Two countries, Mexico and Brazil, changed from an initial status as major maize exporter to become major net importers (Table 1).

Direct and Indirect Consumption Trends

An examination of world maize consumption trends for the slightly earlier 1968-70 to 1978-80 period discloses a pattern of generally slow growth in food consumption and rapid gains in feed use. Growth rates in direct world maize consumption of 1.6 percent were clearly outstripped by a 3.7 percent average yearly gain in indirect consumption. The developing countries led both increases with annual growth rates of 1.7 percent for food use and 5.3 percent for feed allocations. Throughout Asia and the Near East feed utilization has grown at more than three times the rate of food consumption. In Africa, feed use gains have been almost twice as rapid as those for food, though feed use levels remain relatively low.

In the developed countries, maize feed and food use grew at annual rates of 3.2 percent and 1.4 percent. Feed use in the Soviet Union more than doubled with an 8.5 percent yearly rate of growth. Feed use in the world's largest feed consumer, the United States, annually rose by only 1.7 percent.

The developing countries still account for almost 90 percent of world maize food consumption and only 25 percent of world feed consumption. Both of these percentage shares are increasing. At current growth rates livestock production is rapidly becoming the dominant source of maize

Table 1. Distribution of World Maize Trade

	Export Level (1,000 t) 1980-82	Export Share (percent) 1970-72	Export Share (percent) 1980-82	Annual Growth (percent/yr.) 1970-82
United States	55,650	50.8	72.8	12.1
Argentina	5,956	14.7	7.8	2.2
France	2,907	10.3	3.8	-1.4
South Africa	3,906	6.0	5.1	7.0
Thailand	2,576	5.1	3.4	4.5
Other Developed	4,777	7.0	6.2	7.5
Other Developing	614	6.3	1.0	-5.6
World	76,572	100.2	100.1	8.5

	Import Level (1,000 t) 1980-82	Import Share (percent) 1970-72	Import Share (percent) 1980-82	Annual Growth (percent/yr.) 1970-82
European Community	11,897	48.2	15.6	-2.8
Japan	13,330	17.5	17.5	8.5
USSR	12,010	5.4	15.7	19.2
Eastern Europe	6,808	4.5	8.9	15.4
China	3,947	3.3	5.2	12.9
Other Developed	11,777	12.2	15.4	10.9
Other Developing	16,622	8.9	21.8	17.5
World	76,392	100.0	100.1	8.5

Source: FAO Data Tape, 1983.

demand in most regions. In fact, by some estimates, the majority of developing country maize is now allocated in this direction.[1/] According to the United Nations Food and Agriculture Organization, Africa and the developing market economies of the Far East are the only major regions still using most of their maize for food. If current rates of consumption growth are maintained, by 1990, Africa will be the only remaining region in this position (Table 2).

Per Capita Production and Consumption

The significance of these production and consumption trends becomes particularly apparent when they are viewed on a per capita basis. The Asian centrally planned economies represent the only developing country grouping registering significant yearly gains in per capita production through the 1970s. In Latin America, per capita maize production declined at a one percent yearly rate. Sub-Saharan Africa experienced a 2.2 percent rate of annual decline.

Per capita maize food consumption declined in every developing region except, surprisingly, the Near East. Overall yearly declines averaged around 0.8 percent. By contrast, per capita maize feed consumption has been increasing throughout the developing world. In the Asian market economies and the Near East, this gain has been greater than seven percent per year. In the developing countries as a whole, per capita feed use has grown at an annual rate of 2.8 percent. Interestingly, the developed countries experienced the most rapid regional growth rate in per capita

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[1/] Again, it must be noted that this data should be interpreted with caution. Estimates of consumption levels in countries with less developed databases are subject to high degrees of error. This particular estimate depends upon the judgement that China currently uses the majority of its maize for feed.

Table 2. Evolving Maize Utilization Patterns[a/]

	Percentage Allocation of Maize 1978-80		Projected Percentage Allocation of Maize[b/] 1990	
	Food	Feed	Food	Feed
Africa	82.1	17.9	76.8	23.2
Latin America	38.5	61.5	35.1	64.9
Near East	49.9	50.1	33.2	66.8
Far East	66.1	33.9	47.6	52.4
Asian CPE	34.6	65.4	22.9	77.1
Developing	45.2	54.8	36.0	64.0
Developed	3.3	96.7	2.7	97.3
World	18.9	81.1	15.7	84.3

Source: FAO Data Tape, 1983.

[a/] Consumption only.

[b/] Based on linear extrapolation of current growth trends.

direct consumption and second smallest rate of growth in per capita feed use (Table 3).

In sum, maize production in most developing countries has failed to keep pace with rapid population growth. One reason is that area planted to maize has declined in over one-third of those countries producing at least 100,000 hectares of the commodity in 1980-82. In addition, one quarter of these countries have experienced declining yields. As a result, many countries which began the decade as maize exporters ended it with a growing reliance on maize and alternative cereal grain imports. Per capita direct consumption levels necessarily suffered.

In apparent contradiction to these trends, substantial growth has occurred in maize allocations to feed. Most of this gain has been achieved by a relatively small number of higher income countries. Given the fact that the majority of these are not major producers, this source of demand has stimulated a large increase in developing country maize imports. There are also indications, however, that this trend is beginning to broaden, encompassing countries which have traditionally relied upon maize for food.

It is impossible to understand the full significance of these trends without a closer examination of country-specific data. A regional transition may not be indicative to changes taking place in most of its constituent nations if the production or consumption levels of one or two countries make up a large proportion of the total. Also, an understanding of future demand and supply prospects requires an analysis of causal relationships and consequences for individual producers and consumers. This assessment begins with a review of the evolution of direct consumption patterns.

Table 3. World Per Capita Maize Production and Consumption

	Annual Production (kg) 78-80	Annual Percentage Growth 68-80	Annual Food Consumption (kg) 78-80	Annual Percentage Growth 68-80	Annual Feed Consumption (kg) 78-80	Annual Percentage Growth 68-80
Africa	38.0	-0.6	27.9	-0.4	6.1	2.6
Latin America	115.0	-1.0	38.4	-0.4	61.3	1.1
Near East	26.0	0.2	16.4	0.4	16.5	7.1
Far East	14.7	-0.1	8.8	-0.2	4.5	7.2
Asian CPE	58.8	4.6	18.6	-2.2	35.2	2.9
Developing	43.6	1.4	18.0	-0.8	21.8	2.8
Developed	226.4	3.7	6.1	0.5	178.9	2.4
World	92.3	2.3	14.8	-0.4	63.6	1.7

Sources: FAO Production Yearbook, 1973, 1975, 1980.
FAO Data Tapes, 1983.

DIRECT MAIZE CONSUMPTION IN THE DEVELOPING COUNTRIES

Relative Importance of Maize Calories

Maize is the third most important food source in the developing world. Only wheat and rice provide a larger share of cereal calories. Fifty-two countries planted an average of over 100,000 hectares to this commodity over the 1978-80 period.[1/] They accounted for over 99 percent of developing country production and 98 percent of developing country maize food consumption. This group has accordingly been identified as the base sample of countries with which this study is concerned.

Most of these countries derive a substantial proportion of their cereal calories from maize. This commodity is the principal food source in 23 of the 52 major producers. It supplies over 10 percent of national cereal calories in 40 of these countries. In many nations where wheat or rice are the dominant national food grains, maize represents an important regional food source. Only three countries allocate less than ten percent of their production to food.

The highest levels of per capita direct consumption are found in the regions of Central America and East and Southern Africa (Table 4). The 18 major producers in this group account for approximately 27 percent of maize food consumption in the developing countries. They consume an estimated annual average of 68 kg per capita (1978-80). Maize represents the principal source of cereal calories in all but two of these countries.

A relatively high level of dependence on maize calories is also

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[1/] Afghanistan, Angola, Argentina, Benin, Bolivia, Brazil, Burma, Burundi, Cameroon, Central African Republic, Chile, China, Colombia, Ecuador, Egypt, El Salvador, Ethiopia, Ghana, Guatemala, Haiti, Honduras, India, Indonesia, Ivory Coast, Kenya, Korea DPR, Lesotho, Madagascar, Malawi, Mexico, Morocco, Mozambique, Namibia, Nepal, Nicaragua, Nigeria, Pakistan, Paraquay, Peru, Philippines, Somalia, Tanzania, Thailand, Togo, Turkey, Uganda, Uruguay, Venezuela, Vietnam, Zaire, Zambia, Zimbabwe.

Table 4. Regional Patterns of Direct Maize Consumption (1978-80)

	Number of Countries	Average Annual kg. Per Capita	Proportion of Cereal Calories Composed of Maize	Consumption Share Among Major Producers
Central America and Caribbean	6	81	69	16
East and Southern Africa	12	61	54	13
Southeast Asia (w/o China)	5	18	12	10
South Asia	4	12	8	10
South America	10	22	26	8
West Africa	10	34	48	5
North Africa and Middle East	4	27	14	5
China	1	20	12	33
Total/Average	52	39	38	100

Source: FAO Data Tape, 1983.

found in West Africa. Maize constitutes the largest source of cereal calories in six of the ten major producers in this region. Estimated annual consumption averages about 34 kg per person.

Relative levels of national dependence on maize are low in most other parts of the developing world, though regional consumption levels within particular countries may be high. China is estimated to account for almost one-third of total direct developing country consumption. Yet maize is judged to supply only 12 percent of this nation's cereal calories. The nine remaining Asian producers account for an estimated 20 percent of direct developing world consumption, again despite the fact that rice generally dominates cereal diets in the region. The ten major producers in South America and four in North Africa and the Middle East account for eight and five percent of direct developing country consumption respectively. Maize constitutes the largest single source of cereal calories in only one of these 24 countries, Paraguay, though it provides at least one-quarter of the cereal calories in 6 others.

Maize Consumption Trends

Between 1968-70 and 1978-80, per capita maize consumption declined in 29 of the 52 major developing country producers. The loss of maize calories most seriously affected those countries placing greatest dependence on this source of food. Direct per capita consumption fell in 14 of the 20 countries which, in the late 1960s, relied upon maize for at least 50 percent of their cereal calories. In contrast, most of those countries with low levels of maize calorie dependence either maintained or increased their per capita consumption.

The significance of these trends is disclosed when they are compared with the consumption trends for alternative staples in the major maize producers. One finds that maize consumption declines have been part of a

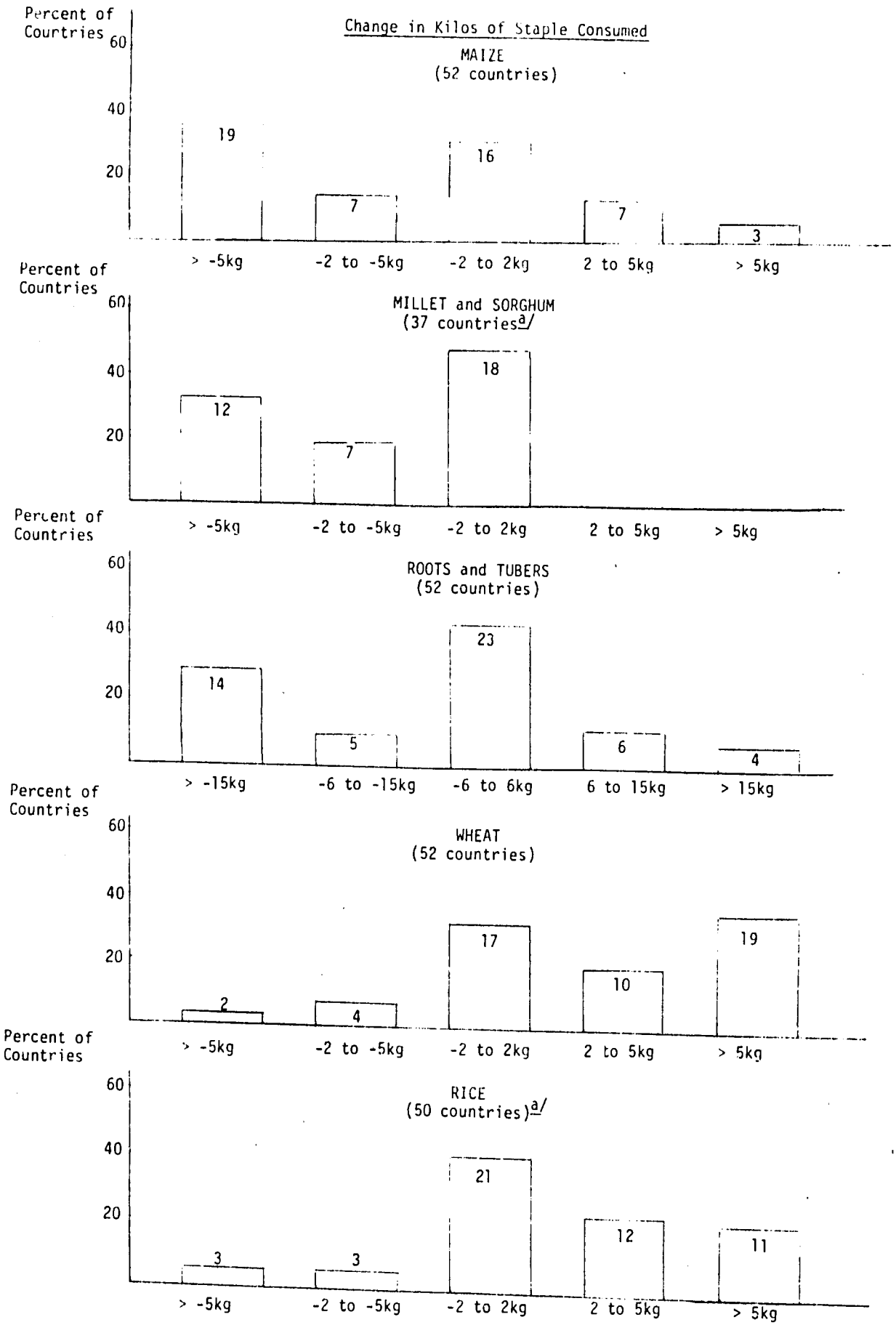
broader pattern of falling consumption for coarse grains, roots and tubers (Figure 3). As Figure 3 indicates, none of the major maize producers registered significant increases in millet and sorghum consumption over the period under investigation. The number of countries experiencing rising per capita consumption levels of maize or roots and tubers was far outweighed by those with consumption declines.

In sharp contrast, per capita consumption levels of wheat and rice have generally remained constant or risen. Just over half of the maize producers experienced relatively strong per capita consumption gains in wheat. The proportion of countries with increasing consumption of rice is only slightly lower. In each case, relatively few countries registered consumption declines.

The impact of these trends is indicated in a review of the shifting composition of national staple diets (Figure 4). A major reorientation has occurred toward greater relative reliance on wheat and rice. The proportion of cereal calories made up of maize has declined in 60 percent of the major maize producers. Over 80 percent of the producers consuming significant levels of millet and sorghum have also experienced proportional declines in the consumption of these commodities. The contribution to national cereal calories of wheat and rice has risen, however, in three-quarters of the producers. This shift shows no relationship with the level of initial reliance on these commodities.

Declines in per capita millet and sorghum consumption have generally reinforced falling maize consumption trends. Despite the fact that wheat and rice represent a growing proportion of most countries' cereal diets, per capita consumption gains in these commodities have generally not compensated for alternative cereal calories losses. Over half of the countries experiencing declining levels of per capita maize consumption

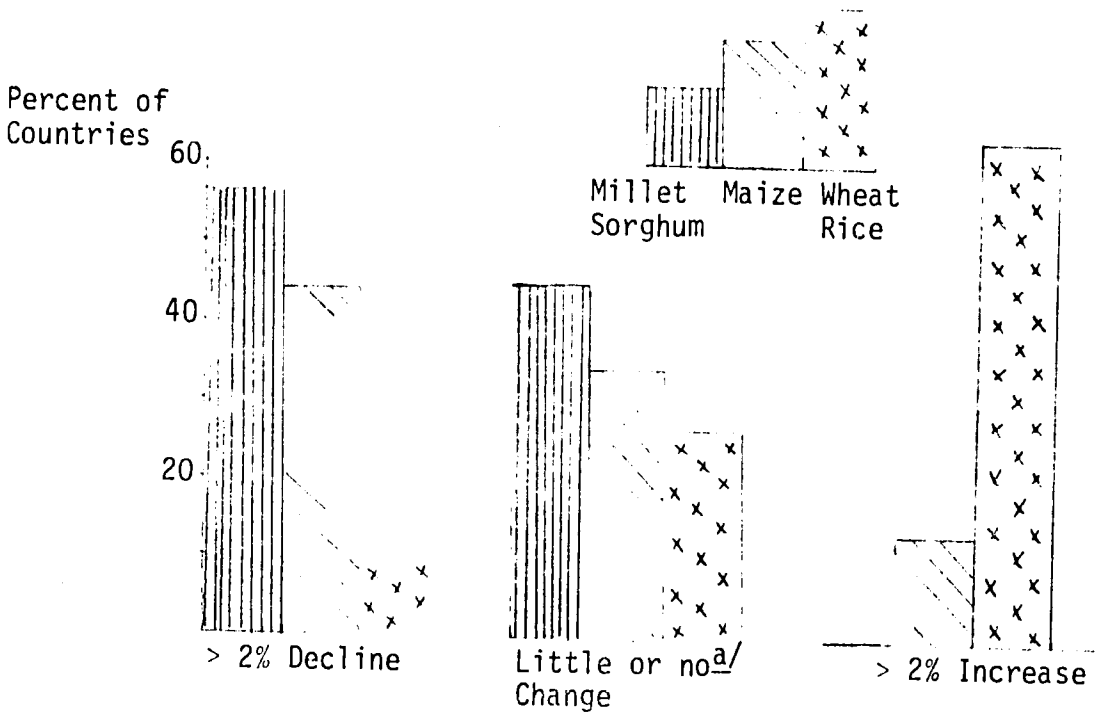
Figure 3. Changing Food Consumption Patterns Among Major Maize Producers, 1968-80



Source: FAO Data Tapes, 1983.

a/ Not all major maize producers consumed these commodities.

Figure 4. Change in Commodity Composition of Diets, 1968-80



Change in the Proportion of Cereal Diets in the Major Producers Made up of Alternative Grains

Source: FAO Data Tapes, 1983.

a/ Less than 2% changes.

registered per capita cereal calorie losses. Almost half of the major maize producers overall have experienced declining levels of cereal calorie consumption. This includes the majority of those countries most heavily dependent on maize calories.

By contrast, the majority of countries registering per capita cereal calorie consumption growth had substantial production bases in wheat or rice. Only five of the 25 major maize producers wherein one or the other of these alternative cereal grains provide the largest share of cereal calories experienced per capita cereal consumption declines. In almost every country where cereal consumption increased, strong gains in wheat and/or rice consumption occurred.

Two major conclusions can be derived from this assessment. First, maize calorie losses appear closely related to declining levels of per capita cereal calorie consumption. Those countries most dependent on maize tend also to be those facing the greatest consumption constraints. The associated loss of millet and sorghum calories only compounds these burdens. Those maize producers with relatively large production bases in wheat and rice have generally been hurt less. These countries have been able to offset maize consumption losses with greater reliance on these alternative staples.

In countries where per capita maize consumption has increased, wheat and/or rice consumption have often advanced further. This suggests that shifting cereal consumption patterns may not simply be a function of domestic cereal grain availability. They are likely also being influenced by such factors as income growth and urbanization.

Ultimately, these changing consumption patterns should be viewed as products of both necessity and choice. Countries with declining maize

productivity may have little option but to increase their reliance on alternative commodities. Those which have maintained their production levels may be finding their relative consumption levels affected by shifting tastes and preferences. Many producers are probably facing a combination of these circumstances.

A thorough assessment of both these trends and their underlying causes requires a disaggregated analysis of the consumption patterns characterizing population groups differentiated by income and location within each country. Unfortunately, little of the data necessary for this analysis are currently available. Certain generalizations regarding causal relationships can be derived, however, from a closer examination of major determinants of supply and demand.

Review of Major Causes Underlying Maize Consumption Trends

1. Maize Availability - Production and Net Imports

Thirty-nine of the 52 major maize producers experienced declining levels of per capita maize production during the 1970s. This includes 17 of the 20 countries initially relying on maize for at least 50 percent of their cereal calories. Eight of these countries have registered per capita production declines in excess of two percent per year.

Absolute levels of production have fallen in 14 of the 52 major producers. Average yields have decreased in 13 countries while area planted has declined in 19. Seventeen of the 22 major producers in Sub-Saharan Africa have experienced either area or yield declines. Paradoxically, production growth appears strongest among those countries least reliant on maize for food.

Per capita maize imports have increased in 31 of the major producers including most countries with the highest levels of maize calorie

dependence. These gains have generally not been large enough, however, to offset production losses. Thirty-one countries have experienced declining per capita maize availability, again, including the majority of nations most dependent on these calories. Many of those countries with the largest per capita import gains are allocating substantial quantities of maize to feed. Very little of the maize sold on world markets consists of white grain varieties, the type many of these countries prefer for direct consumption. While some countries are mixing imported yellow grain with locally produced white, others seem to have turned to world wheat, or, to a lesser degree, rice markets to offset their production deficits.

The relative consumption trends for alternative cereals in these 52 countries are similarly related to their associated production records. Per capita production of millet and sorghum has declined in two-thirds of the producers of these grains. These declines have also been largest among countries most dependent on these calories. The largest production gains have occurred in countries allocating substantial amounts of these grains to feed. Imports of sorghum and millet for consumption as food are minor.

Per capita rice production has fallen in 21 of the 49 producers of maize and rice. Most of these declines, however, have been small. Growth in net imports has also been limited due to the thin and underdeveloped nature of world rice markets. Yet almost 60 percent of the major maize producers have increased their net rice imports. As a result, most major maize producers have increased their per capita rice supplies.

Per capita wheat production has similarly declined in almost half of the 38 maize and wheat growers. Substantial growth in per capita net

imports, however, has offset most of these losses. These have increased in almost 70 percent of the maize producers including many of those countries with little or no wheat production of their own. Three-quarters of these countries have increased their per capita wheat supplies.[1/]

A clear link exists between maize production and consumption trends. Most countries with declining per capita maize production also experienced declining per capita consumption. Those with rising per capita production generally registered rising consumption.

Almost every country achieving increased per capita cereal calorie consumption, however, obtained these gains on the basis of strong growth in rice and/or wheat supplies. Substantial growth in wheat imports particularly contributed to these gains. If future large scale dependence on cereal grain imports is to be avoided, the maize producers must reaffirm priorities attached to improving their staple food production.

2. Income Growth

Rising incomes are often cited as a major cause of changing consumption patterns in the developing countries. These promote the substitution of preferred 'luxury' foods for less preferred staples. Higher levels of meat consumption, for example, are commonly associated with declining consumption of basic grains. This could represent one justification for falling per capita maize consumption. Per capita meat consumption has, in fact, increased in the majority of major producers.

This sort of trade-off may similarly occur among alternative staples. In this case, however, the impact of rising incomes may be less pronounced.

[1/] For a fuller description of the growing importance of wheat consumption throughout the developing world, see Byerlee, 1983.

Insofar as these commodities share a status as basic subsistence foods, income growth can be expected to prompt a larger shift in consumption away from rather than within this grouping. In view of the evidence of shifting patterns of cereal consumption identified above, however, it is worth examining the possible influence of income on the consumption of alternative cereal grains.

An example of survey data distinguishing cereal consumption levels by income and expenditure class is found in Table 5. This limited sample indicates the existence of a relatively strong relationship between income and consumption. At higher income levels individuals tend to consume less maize. In several cases, maize consumption seems to rise through middle income or expenditure levels. In most, however, maize consumption only falls as expenditures increase. Only in rural Kenya is direct maize consumption still rising at the highest income or expenditure class.

By contrast, in almost every case, wheat and rice consumption rises with income. Also, in every country, the proportion of cereal calories made up of these commodities increases in relation to maize. Thus, even where maize use is still rising, wheat or rice consumption is increasing more rapidly.

This same relationship is evident in estimates of the income elasticities of demand for the alternative cereal commodities (Table 6). In almost every case, the elasticities for maize and coarse grains are lower than those for wheat and rice. In a number of cases, these are negative. In contrast, the elasticities for wheat and rice are almost all positive. Those for wheat are generally about the same size or slightly higher than those for rice.

The widespread evidence of higher elasticities for wheat and rice indicate that as incomes rise, the consumption of these commodities will

Table 5. Direct Cereal Consumption Patterns by Income and Expenditure Class

	Expenditure or Income Class		
	Low	Middle	High
India (urban)			
Maize (kg/month)	0.14	0.20	0.07
Wheat (kg/month)	2.00	3.28	5.25
Rice (kg/month)	1.95	4.59	5.75
India (rural)			
Maize (kg/month)	0.76	0.91	0.73
Wheat (kg/month)	0.71	2.57	6.87
Rice (kg/month)	3.20	6.06	9.28
Indonesia (nationwide)			
Maize flour (kg/month)	0.19	0.11	0.06
Maize Broken (kg/month)	2.26	1.53	0.98
Rice (kg/month)	2.95	8.67	12.50
Philippines (nationwide)			
Maize (kg/month)	1.65	0.91	0.52
Wheat (kg/month)	1.00	1.51	1.43
Rice (kg/month)	8.42	8.79	9.11
Peru (urban Lima)			
Maize (kg/month)	0.14	0.11	0.07
Wheat (kg/month)	2.51	2.89	2.57
Rice (kg/month)	2.71	2.95	3.00
Kenya (urban)			
Maize (kg/month)	8.11	7.40	6.09
Wheat Bread (kg/month)	1.07	1.89	1.96
Wheat Flour (kg/month)	0.45	1.09	1.96
Rice (kg/month)	0.17	0.47	1.09
Kenya (rural)			
Maize (kg/month)	4.37	7.32	11.95
Wheat Bread (kg/month)	0.17	0.59	1.47
Wheat Flour (kg/month)	0.02	0.30	0.86
Rice (kg/month)	0.01	0.12	0.47

Sources: India - Government of India (1977); Indonesia - Tabor (1979); Philippines - Bovis (ND); Peru - Ferroni (ND); Kenya - Shah and Frohberg (1980).

Table 6. Income or Expenditure Elasticities for Direct Cereal Consumption

Country/Region	Maize	All Coarse Grains	Rice	Wheat
Malawi	.20	-	1.20	1.00
Kenya (Mombassa)	.20	-	.60	.70
Mexico	-.17	-	.35	.61
East Africa	.28	-	.58	.51
Southern Africa	.35	-	.56	1.46
West Africa	.15	-	.65	.87
Mexico and Central America	-	.10	.35	.35
Venezuela	-	.15	.15	.35
Venezuela (Barcelona)	-1.60	-	-.10	.30
Philippines	-.94	-	.31	.61
Brazil (Rural)	-.04	-	.17	.32
Brazil (Urban)	-.15	-	.32	.12
Peru (Lima)	-.50		0.0	1.0
Indonesia	-.13	-	.45	.55
Indonesia (Rural Java)	-.93	-	.12	-
Indonesia (Urban Java)	-.80	-	.51	-
India	-	.20	.70	.70
Thailand	-	.20	.10	.20
Argentina	-	-.25	.15	-.10
East Asia (Low Income)	-	.20	.20	.35
East Asia (High Income)	-	.05	.05	.10
North Africa/Middle East (Low Income)	-	.10	.20	.05
North Africa/Middle East (High Income)	-	.15	.30	.25

Sources: Malawi, Kenya, Venezuela (Barcelona), Peru, - FAO (1977); East, West and Southern Africa - Christensen et al. (1981); Mexico - Lustig (1980); Mexico and Central America, Venezuela, India, Thailand, Argentina, East Asia, North Africa/Middle East - USDA (1978); Philippines - Bennagen (1982); Brazil - Gray (1982); Indonesia - Tyers and Rachman (1981); Indonesia (Rural and Urban Java) - Dixon (1982).

increase faster than the consumption of maize or coarse grains. If income alone affects consumption decisions, these preferred commodities should represent a growing proportion of cereal diets. It can also be inferred that as diets shift away from basic grains, the coarse grains are more likely to be replaced first.

A closer examination of both the survey and elasticity data for individual countries reveals that the strongest relationship between consumption preferences and income are found in urban areas or those countries with relatively larger production bases in wheat or rice. These tend to have lower income or expenditure elasticities for maize. They also appear to have registered the largest income induced-changes in the surveyed consumption levels for different commodities. This suggests that factors such as urbanization or alternative cereal grain availability may have a larger impact on consumption patterns than income. In some cases they may reinforce the influence of income growth, and, in others, retard it.

Despite the survey and income elasticity statistics, there is little discernible evidence of a relationship between income growth and changing patterns of cereal consumption in the aggregate national data. In the 50 major producers for which data are available, per capita GNP grew at an average annual rate of 2.0 percent over the 1960 to 1980 period. This translates into an income gain of almost 50 percent. Income growth was generally lower than the mean in those most dependent on maize calories. Declines in per capita maize consumption among these countries appear more closely related to production constraints. Several of those countries experiencing the most rapid income growth were still increasing their per capita maize consumption. There, similarly, appears little relationship between shifting patterns of consumption and income levels.

There are a number of reasons why the income-consumption relationship may not be evident in aggregate national data. Per capita GNP figures may not accurately reflect the relative incomes of major maize consumers or the changing incomes of those consumers whose diets are most likely to be evolving. If, for example, the distribution of income gains strongly favors the higher income classes, and if these make up a small proportion of a country's population, income growth may have little impact on aggregate levels of maize consumption. If income gains are more widely distributed in another country, a relatively small national growth rate could stimulate relatively large changes in consumption patterns.

Given the range of additional factors which also influence consumption patterns, the impact of income growth alone may simply be obscured. A disaggregated or country-specific analysis is probably necessary to measure the full significance of this relationship. In the context of this study, however, the influence of income alone on maize consumption does not appear substantial.

3. Urbanization

Urbanization can lead to shifting consumption patterns for several reasons. As producers move out of the rural areas diets may no longer be confined within the bounds of what can be locally produced. The character of market channels and market policies become more important determinants of consumption opportunities. Market channels may be more highly developed, for example, between certain regions and for particular commodities. These can influence the quantity and quality of local food supplies as much if not more than national production levels. They influence relative food prices and the evolution of individual tastes and preferences.

Urban areas are often particularly affected by national import policies. Cities that are situated along coastlines may find imports a more consistent and less costly source of cereal supplies than domestic production. Transport links between ports and inland cities are commonly the most highly developed market arteries. For many countries these food imports are more likely to consist of wheat or rice than maize.

Similarly, urban life styles commonly attach higher opportunity costs to labor and leisure time. This promotes demand for convenience foods which can be quickly prepared or purchased ready for immediate consumption. Wheat-based products such as various sorts of bread profit considerably from this trend. Growing interest in composite flours, which include maize, may preserve some degree of demand for this commodity. Yet acceptance of these alternative flours has generally been slow.

The ultimate affect of urbanization is difficult to quantify. The link between urbanization and declining per capita consumption of maize relative to wheat and rice, however, is commonly evident.

4. Food Aid

While some effort has been made to provide food aid in the recipient country's principle staple, the vast majority of such assistance has been in the form of wheat. The impact of this aid on the recipient country's production incentives and consumption preferences is subject to debate. Broadly based concerns have been raised, however, regarding an associated growing dependence on wheat imports. Many countries with little or no wheat production capabilities have significantly increased their wheat imports following the introduction of wheat-based food assistance. This may speed the transition in the diets of urban populations. It may also reduce local food production incentives. A number of tropical countries

have recently expressed interest in developing their wheat production capabilities in many cases where none previously existed. Meanwhile, maize production records have languished.

5. Pricing Policies

Consumer price relationships among competing cereal staples may also strongly influence consumption patterns. Commonly, these are administered or at best strongly influenced by government policies. Reliable and consistent retail price information is scarce. Government-set prices may not correspond with those found in the marketplace. Prices across national markets may differ for reasons other than storage or transport costs. Data may depend on the season in which it is collected. Yet a few general observations can be made.

In the limited sample of countries for which time series price data were available, maize prices frequently rose more rapidly than wheat and rice prices through the 1970s. In Mexico, for example, retail maize tortilla prices were 46 percent of those for a similar quantity of bread in 1970. By 1982, tortilla prices had risen to 77 percent of those for bread. In Brazil, maize prices started at 37 percent of those for wheat in 1970, but rose higher than those for wheat in 1979. Government-sponsored consumer price subsidies for wheat have often simply been larger and more consistent than those for maize. In Egypt, this distortion is said to have advanced to such an extreme that, at least for a period, bread was being purchased for animal feed.

The widespread occurrence of overvalued currencies has also favored wheat. These lower the relative cost of wheat imports. They may foster dependence on food imports and create a disincentive for local food production. Exchange rate distortions, in addition, increase the need to

maintain foreign exchange earnings thereby stimulating greater investment in the production of export commodities. Such investments may divert resources away from efforts to promote maize production.

Producer price policies indirectly influence consumption patterns by affecting production incentives, and thereby, relative cereal grain supplies. Taxes or subsidies on various production inputs or market operations have a similar impact. If wheat production, for example, relies more heavily on the use of a particular input than maize, and if the price of this input is subsidized, wheat production may, in effect, be favored at the expense of maize. Governments, oftentimes, have complex systems of taxes and subsidies on their agricultural sectors and lack a clear understanding of the ultimate effect of these policies on the production of individual commodities. If political power is unequally aligned among different sorts of producers, however, the ultimate effect of government pricing policies may be discriminatory.

6. Other Government Policies

Pricing policies are but one means to facilitate production or consumption objectives. The size of national research investments or orientation of research priorities guide the development of production opportunities. Extension investments or the quality of extension management may influence which farmers, and indirectly which commodities, benefit from research attention. Consumption opportunities may be influenced as much by the purchasing power of impoverished populations as staple availability. Low incomes could be a major cause of declining per capita consumption of coarse grains. Government efforts to resolve food consumption deficits may directly or indirectly stimulate a reorientation in consumption patterns.

The impact of these manifold factors is difficult to distinguish without an in-depth analysis of country-specific circumstances. Variables found to hold explanatory power in one country may be relatively unimportant in another. Those which appear significant at one point in time may be relatively insignificant a few years later.

Despite this, the analysis concluded with an attempt to formulate a cross-sectional regression equation designed to measure the relative strength of the relationship between direct maize consumption and income, production, and alternative cereal commodity dependence (see Appendix A for details). Not surprisingly, the result held little explanatory power. The relationship between production growth and consumption changes was positive and reasonably consistent. At this aggregate level of analysis income growth did not appear to strongly influence maize consumption trends, though this relationship is clearly apparent in some individual country data. A related variable for urbanization similarly failed to show much explanatory power. Calorie consumption gains were negatively related to the level of dependence on maize calories. This is disturbing, given the fact that many of those countries most dependent on maize face cereal calorie consumption deficits.

Continuing Reliance on Maize Among Major Consumers

Seventeen major producers still rely on maize for over 50 percent of their cereal calories. An evaluation of the relative status of these countries with regard to several basic production and consumption indicators displays the importance still held by the goal of increasing maize productivity for meeting basic human needs. This assessment is summarized in Table 7.

Two-thirds of what might be identified as the 17 major maize consumers experienced declines in per capita maize consumption over the 1968 to 1980 period. Countries only moderately dependent on maize calories registered similar declines, but those least dependent on maize calories generally maintained or increased their per capita consumption levels. The significance of these figures is apparent in their reflection in cereal consumption trends. Three-quarters of the major maize consumers experienced declining levels of per capita cereal consumption. In sharp contrast, only 37 percent and 25 percent of the moderately maize-dependent and least dependent countries showed such declines.

The major justification for these falling per capita consumption levels is evident in the production records of the respective groupings. The heavily dependent consumers experienced an average per capita production decline of 0.9 percent. Omitting the single producer registering strong production gains the rate of decline increases to 1.4 percent. In contrast, those countries least dependent on maize calories showed an average per capita production rate of loss of only 0.2 percent. Yields in the maize-dependent consumers averaged only 60 percent of those in maize producers primarily relying upon alternative sources of cereal calories. Yields were declining in almost half of the consumer countries most dependent on maize calories but only 25 percent of the countries least dependent on maize.

Two sources of maize food supply are available to compensate for the production deficits. Maize which has been previously allocated to feed can be redirected toward food consumption. There is some evidence that this has in fact occurred in a number of those countries with the largest direct dependence on maize calories. Yet these producers also

Table 7. Production and Consumption Characteristics for Countries with Greater or Lesser Dependence on Maize Calories

	Producers Wherein Maize Represents		
	>50% of Cereal Calories[a/]	20-50% of Cereal Calories[b/]	<20% of Cereal Calories[c/]
Number of Countries	17	19	16
Proportion with Declining Per Capita Maize Consumption, 78-80 (%)	65	68	38
Proportion with Declining Per Capita Cereal Consumption, 78-80 (%)	76	37	25
Average Per Capita Production Growth, 68-80 (%/yr.)	-.9	-1.9	-.2
Average Yields, 78-80 (+/ha.)	1.1	1.3	1.8
Proportion of Maize Used as Feed, 78-80 (%)	9.3	16.7	30.5
Proportion of Countries Importing Maize, 78-80 (%)	47	47	38
Average Per Capita GNP, 1980 ($U.S.)	636 (16 countries)	829 (18 countries)	1050 (14 countries

Sources: FAO Data Tapes, 1983.
World Development Report, 1982.

[a/] Angola, Benin, Burundi, El Salvador, Ghana, Guatemala, Honduras, Kenya, Malawi, Mexico, Namibia, Nicaragua, Paraguay, Tanzania, Zaire, Zambia, Zimbabwe.

[b/] Bolivia, Brazil, Cameroon, Central African Republic, Colombia, Ecuador, Egypt, Ethiopia, Haiti, Ivory Coast, Lesotho, Mozambique, Nepal, Peru, Philippines, Somalia, Togo, Uganda, Venezuela.

[c/] Afghanistan, Argentina, Burma, Chile, China, India, Indonesia, Korea DPR, Madagascar, Morocco, Nigeria, Pakistan, Thailand, Turkey, Uruguay, Viet Nam.

tend to allocate the smallest share of their production to feed to begin with. This opportunity is accordingly limited.

Alternatively, these countries can increase their maize imports. But only about one percent of world maize trade consists of white grain, the type generally preferred for direct consumption. Most of this is destined for Europe or Japan as a source of starch. While almost one-half of the major consumers have imported maize over the last few years, import levels in these countries have generally been low.

Other cereals such as wheat and rice can also be imported to maintain per capita cereal consumption levels. In fact, 70 percent of the major maize consumers have increased their per capita wheat imports over the 1968 to 1980 period. Two-thirds of these countries increased their per capita imports of rice. These import levels were generally low, however, in comparison to national needs. This may be due in large part to the fact that most of these countries have low relative income levels and severely limited holdings of foreign exchange. In other words, many of the producers most dependent on maize calories are also those least able to turn to alternative sources of food supply.

INDIRECT MAIZE CONSUMPTION PATTERNS IN THE MAJOR PRODUCERS

Maize Feed Use Levels and Trends

Forty-four of the 52 major developing country maize producers currently allocate a portion of their maize to animal feed. Over the 1978-80 period, per capita maize feed use levels in these countries ranged from less than one kilo to more than 110 kilos per year. In general, however, feed use levels were low. The median annual level of feed utilization was 7 kilos per person. Per capita indirect consumption in excess of 25 kilos was experienced in only 11 countries.

These figures are reflected in the low proportions of domestically utilized maize allocated to feed. Among this same group of 44 countries, maize destined for animal feed ranged from 2 to 96 percent of total utilization. However, most of these countries allocated less than 12 percent of their maize to feed. Only 13 producers used more than one quarter of their maize for feed.

Despite relatively low levels of production growth, half of the major producers consistently allocating maize to feed have experienced positive per capita feed utilization growth rates over the 1968-80 period. Median annual feed use growth was 2.7 percent. But total maize feed use in these countries advanced at a 4.9 percent annual rate. Growth rates in a number of countries were remarkably high. In most countries these growth rates still appear to be rising.

Most countries with rising per capita levels of maize feed use also maintained rising per capita levels of direct maize and/or cereal consumption. If direct maize consumption was declining, this was generally compensated for by increasing per capita consumption of wheat or rice.

Per capita maize feed use is growing in only a few countries where maize food consumption is falling. Over two-thirds of the 44 feed consumers are allocating an increasing proportion of their maize to feed. Part of this gain can be attributed to increases in production. In addition, however, maize previously destined for direct consumption is now being redirected to meet a rapidly growing demand for feed. Though the satisfaction of maize food requirements is generally assumed to take priority over feed allocations, in some producers the two consumption sources appear increasingly competitive.

Most of the maize allocated to feed in the developing countries is used for the production of pork, poultry, and eggs. Each of these commodities has registered strong production growth rates over the decade under consideration. Pork is produced in 49 of the 52 major maize producers. National production of this commodity has advanced at an average annual rate of 3.3 percent over the 1969-81 period. Fifteen of these countries experienced annual growth rates in excess of 5 percent. Estimates of poultry production are available for all but one of the major maize producers. This has averaged a 6.4 percent annual growth rate. Egg production in all 52 maize producers averaged a yearly growth rate of 5.2 percent. This compares with 2.7 percent, 5.1 percent, and 1.9 percent production growth rates in the developed countries for each of these respective commodities. These developing country livestock production growth rates also seem to be rising.

The rapid growth in demand for livestock products should stimulate large future increases in demand for livestock feed. Maize will likely be a principal beneficiary of these trends. The developing countries as a whole are already allocating the majority of their maize to feed. This

statistic is largely based, however, on the large quantities of maize being imported by countries which are not themselves maize producers. In most major producers, maize is still predominantly allocated to food consumption. But this proportion is broadly declining. The key question now is how rapidly and to what extent this decline will continue.

Principal Factors Influencing Maize Feed Demand

Rising incomes are the principal determinant of feed use patterns. Once a country achieves an income level whereby average basic cereal calorie requirements are fulfilled and discretionary income is available for purchases of meat, a rapid increase in the use of maize for feed tends to occur. This advance may initially be faster than the growth in an individual country's income. Growth rates in meat consumption, and thereby feed use, should eventually level off, however, at higher consumption levels when meat is no longer a luxury good. The developing countries now appear to be at the initial levels of this growth path. In comparison, meat consumption in many developed countries now appears to be leveling off.

These trends are matched by indications of high income and expenditure elasticities for pork, poultry, and egg consumption in a representative sample of major maize producers. Table 8 lists a few examples of these. The elasticity levels for these livestock products are on the whole much larger than those for direct maize consumption. They suggest that a greater proportion of a given increase in income will be used to purchase these commodities than to purchase cereal grains. In combination with the evidence of high livestock production growth rates, these elasticity statistics also indicate the likelihood of continuing rapid growth in maize feed demand in the future.

Table 8. Income and Expenditure Elasticities for Livestock Products

		Income or Expenditure Class		
		Low	Middle	High
Kenya (nationwide)	Meat (other than beef)	.300	.350	.602
	Eggs	.72	.488	-1.340
Brazil (urban)	Meat and Fish	.363	.481	.075
	Eggs	1.930	.630	.144
Brazil (urban)	Meat and Fish	.413	.336	.238
	Eggs	1.150	.603	.100
Philippines (nationwide)	Pork	-	.622	-
	Poultry	-	.492	-
	Eggs	-	.623	-
Brazil (nationwide)	Pork	-	.400	-
Mexico and Central America (nationwide)	Pork	-	.600	-

Sources: Philippines - Bennagen (1982); Brazil (nationwide); Mexico - (1978); Kenya - Shah (1982); Brazil (urban, rural) - Gray (1982).

Regressions were conducted (detailed in Appendix A) to test this income-consumption relationship. These questioned the importance of income in guiding maize feed allocation patterns and evaluated the consistency of this apparent relationship. Several possible additional explanatory variables were also included in this analysis to account for a broader range of country-specific circumstances. These include the relative level of total calorie consumption, urbanization, and the relative importance of maize production. The lack of price information precluded the attempt to calculate demand functions per se. Instead, these equations measure demand relationships. The variable for total calorie consumption accounts for the hypothesis that direct cereal consumption takes priority over indirect consumption. The variable for urbanization measures the impact of shifting consumption patterns associated with growing dependence on purchased commodities and rapidly changing tastes and preferences. Maize production potential accounts for the availability of maize relative to alternative feed grains. Feed use patterns were assessed in terms of aggregate levels of maize feed use, per capita levels of maize feed, and the percentage of total maize utilization allocated to feed.

Several complications, however, constrain the attempt to draw explanations from available data. First, hypothesized relationships between maize feed use and income must take account of the fact that maize and maize bran make up an average of only 45 percent of total cereal feeds among the major maize producers. Maize alone constitutes an average of only 34 percent of cereal feed. Therefore, trends relating to the increase in feed use and the development of a livestock industry may not be simply reflected in increased maize or maize and maize bran feed use.

Feed use patterns in Mexico provide a good example of this. Growth in the feed and livestock industry of this country has been primarily based on the use of sorghum. While increasing amounts of maize have been

allocated to feed, the rates of increased usage have not matched the rates of growth in feed use overall. Over the 1966 to 1980 period, per capita sorghum utilization has risen at an annual rate of 5.5 percent. At the same time, per capita maize feed use has actually declined.

Yet maize is clearly the most popular feed source in both the developed and developing countries. It accounts for, respectively, 40 percent and 43 percent of total cereal feeds in the two groups. Wheat, rice, sorghum and barley and their associated by-products respectively make up a 18, 18, 8 and 7 percent of developing country cereal feeds. The contributions of wheat and rice are largely made up of bran. Each of these commodities must be considered as important substitutes for maize (Table 9). This assessment was accordingly extended to also consider those relationships underlying cereal feed consumption as a whole.

The analysis has primarily emphasized the allocation of maize as opposed to both maize and maize bran for feed. Maize bran is a necessary by-product of the milling of flour for food. It does not have any major competing uses. Therefore, the level of bran feed usage depends largely on levels of maize production and direct consumption rather than feed demand per se. Measurements of the use of maize alone for feed provide a truer indication of the transition in allocation patterns with which this analysis is most concerned.

By the same token, however, insofar as wheat consumption is rising as a proportion of total cereal calorie consumption, the use of wheat bran for feed is also rising. In several countries which have become major importers of wheat, the use of wheat bran is increasing more rapidly than feed consumption of either maize or maize bran. Heavily subsidized wheat prices can also lead to the use of wheat itself for animal feed. Thus, the

Table 9. Importance of Relative Feed Grains, 1980

	Maize[a/] as Percentage of Cereal Feeds	Wheat[a/] as Percentage of Cereal Feeds	Barley as Percentage of Cereal Feeds	Sorghum as Percentage of Cereal Feeds	Rice[a/] as Percentage of Cereal Feeds	Millet as Percentage of Cereal Feeds
Africa	33.1	24.1	16.5	6.8	4.1	12.1
Latin America	56.7	11.7	1.3	24.7	3.2	0.4
Near East	18.8	30.6	40.1	2.5	1.8	3.0
Far East	20.9	19.5	1.4	2.3	51.6	2.6
Asian CPE	51.7	18.1	1.7	3.5	19.1	2.5
Developing	43.3	18.5	6.6	8.5	17.9	2.4
Developed	40.4	22.0	21.0	4.0	0.3	0.2
World	41.1	21.2	17.6	4.5	4.5	0.8

Source: FAO Data Tapes, 1983

[a/] Includes bran.

increased use of wheat and rice bran may appear, at least in part, to be a subsidiary by-product of the transition in direct cereal consumption patterns.

The attempt to generalize about overall developing country feed use trends is also complicated by the influence of different relative resource endowments, utilization policies, and relative cereal prices. Countries with relatively larger barley or sorghum crops can be expected to rely more heavily on these feed sources. Major rice producers depend heavily on broken rice and rice bran as principal and growing feed sources. Alternatively, in Mexico, the government has subsidized sorghum imports while placing restrictions on maize feed use. Heavy consumer subsidies on maize aim to ensure adequate levels of direct consumption only. In Egypt, maize feed use has been rapidly growing, but heavy subsidies on wheat flour and bread have motivated at least some feed use of these commodities which would otherwise only be used for food. With only fragmentary price and policy data, the overall impact of these variables is difficult to distinguish. Even in the few cases where relative price data are available, it can often be difficult to judge the relationship between official prices and the actual relative commodity costs facing the feed grain industry.

Questions might also be raised regarding the accuracy of the feed use data. A review of alternative information sources reveals wide variability in estimates of commodity levels allocated to feed. Within two of the most comprehensive sources of data (USDA and FAO), estimates of feed use are frequently substantial.[1/] In many cases where feed

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[1/] In the most extreme case, the USDA estimates that no maize is used for feed in China. FAO estimates China allocates approximately 35 million tons of maize, or 60 percent of its total domestic consumption, to feed.

statistics are low or not readily available, they may be calculated as a residual following estimates of production, food use, stock charges and waste. In others, feed calculations are based on grain conversion factors and livestock production statistics. Yet the quality of both livestock production data and the associated feed conversion ratios are themselves open to question. Inquiries in one country found that a one kilo weight gain for pork required anywhere from 4.5 kg to 35 kg of maize feed. Much depends upon the structure and efficiency of the livestock production industry.

Despite these limitations, the analysis of factors affecting feed use still seems to have produced some important and useful information. While the actual maize utilization trends for any particular country remain difficult to predict, certain general and significant patterns of indirect consumption are apparent.

Whether measured in terms of the percentage of maize utilization allocated to feed or per capita maize feed use levels, a cross-sectional analysis of major maize producers shows a strong positive relationship between maize feed use and income levels. This relationship is highly significant in statistical terms. Per capita maize feed use is also closely associated with high levels of total calorie consumption. This suggests that once a basic level of subsistence is achieved, the consumption of livestock products can be expected to increase.

As expected, income levels appear even more closely associated with levels of per capita cereal feed use. In fact, the same two variables identified above, income and total calorie consumption, combine to explain

almost 75 percent of individual country differences in per capita cereal feed allocations. When an additional variable measuring per capita cereal production levels is added, almost 88 percent of the variation is explained. In other words, countries with strong cereal production bases, which are more likely to experience surplus supplies once direct food demand has been met, are also more likely to have better developed feed grains industries. Given the range of alternative factors which influence feed use rates, this degree of explanatory power is remarkable. Clearly, cereal feed use is strongly related to the relative degree of advancement of a nation's agricultural base as well as the associated level of per capita GNP. In a sense, the per capita level of cereal feed usage can be employed as one measure of the overall state of a country's agroeconomic development.

Two factors help explain the weaker relationship underlying maize feed utilization patterns. First, there appears to be a statistically significant negative relationship between initial levels of maize representation among cereal calories and the percentage of maize which is allocated to feed. This suggests that in countries more heavily dependent on maize as a source of cereal calories, the transition to maize use for feed will be slower. Alternatively, in countries with readily available cereal calorie substitutes, the likelihood of shifting maize allocations is greater. As incomes rise, the consumption of preferred cereal grains (wheat and rice) increases and the residual maize goes to pork and poultry production.

Second, an analysis of changes in the feed composition of individual countries over time indicates the importance of the relative price and availability of competing feed cereals. In Asia, maize tends to represent

a fairly small percentage of total cereal production and cereal feeds. In six out of seven of the major producers examined, rapid growth in wheat consumption was associated with large increases in the percentage of cereal feed made up of wheat bran. In five of these cases, wheat bran represents the fastest growing source of cereal feed.

In Latin America, maize provides the dominant share of cereal feed in five out of seven of the countries examined. In three of these, however, sorghum has been rapidly increasing its share of feed. This seems to be a function of either rapid production growth rates or rising imports. In one country, the percentage share of wheat bran has been growing more rapidly than that for maize. This is similarly associated with high import growth rates for wheat. These trends both suggest favorable price relationships for these commodities. In contrast, maize production or imports have been relatively strong in those countries where maize represents a rapidly growing proportion of cereal feed.

Absolute levels of maize feed use are declining in only three of the above cited 14 Asian and Latin American countries. In most countries, rising levels of total cereal feed use seem to be associated with similarly strong growth in the feed use of maize. In some producers, however, the use of alternative cereal feeds such as sorghum or wheat bran may be growing even faster.

Cereal feed use in the entire group of 52 major maize producers has registered an annual gain of 3.9 percent over the 1968-80 period. The faster rate of growth for maize experienced by these countries overall has led to an increase in its representation in total cereal feeds from 35 percent to 39 percent over this period. At the same time, the share of maize bran has declined from 6 percent to 5 percent due to a relatively

small bran use growth rate of 1.2 percent. This reflects the fact that indirect maize consumption is rising much more rapidly than direct consumption.

Future Patterns of Maize Feed Demand

Five of the 52 major maize producers allocated over 50 percent of their maize to feed over the 1978-80 period. Fifteen countries used more than 20 percent of their maize for feed.[1/] Nineteen countries currently use between 5 and 20 percent of their maize for feed, and 18 countries allocate less than 5 percent of their maize for feed. Seven basic production and consumption indicators for these last three groupings are displayed in Table 10. This comparative assessment of feed use trends for major, moderate and minor feed users displays several noteworthy relationships.

As the regression results indicated, both the proportion and level of a country's feed use are closely related to its level of income. The average income of countries allocating a relatively large proportion of their maize to feed is more than twice the level for medium level maize feed users and more than four times that for low level feed consumers. Average total calorie consumption also clearly increases as greater amounts of maize go to feed. But maize tends to represent a relatively smaller percentage of cereal production and calories in the major feed users. This suggests that wheat or rice are readily available as direct consumption substitutes.

Two facts relevant to maize feed use growth patterns are evident in this Table. First, the highest average feed use growth rates appear

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[1/] Argentina (96%), Chile (81%), Brazil (73%), Korea (69%), Uruguay (64%), Paraguay (56%), China (50%), Turkey (49%), Bolivia (47%), Peru (43%), Morocco (43%), Egypt (33%), Venezuela (28%), Ecuador (22%), Haiti (20%).

Table 10. Characteristics of Maize Feed Users, 1978-80

	Percentage of Maize Utilization Allocated to Feed		
	<5%	5%-20%	>20%
Number of Countries	18[a/]	19[b/]	15[c/]
Per Capita Maize Feed, 1978-80 (kg)	1.2	9.7	42.1
Per Capita Cereals Feed, 1978-80 (kg)	12.2	30.6	100.0
Per Capita GNP, 1980 ($U.S.)	311 (17 Countries)	681 (18 Countries)	1479
Total Calories, 1975-77	2134	2201	2564
Maize as Percent of Cereal Production, 1978-80	37.2	55.2	29.8
Per Capita Maize Feed Growth, 1968-80 (Percent/Year)	2.3 (10 Countries)	1.8	3.3
Per Capita Cereal Feed Growth, 1968-80 (Percent/Year)	-0.1	1.4	2.2

Source: FAO Data Tapes, 1983.
FAO Food Balance Sheets, 1980.
World Bank, World Development Report, 1982.

[a/] Benin, Burma, Burundi, Central African Republic, Ethiopia, India, Indonesia, Kenya, Madagascar, Mozambique, Namibia, Nepal, Pakistan, Somalia, Tanzania, Togo, Zaire, Zambia.

[b/] Afghanistan, Angola, Cameroon, Colombia, El Salvador, Ghana, Guatemala, Honduras, Ivory Coast, Lesotho, Malawi, Mexico, Nicaragua, Nigeria, Philippines, Thailand, Uganda, Viet Nam, Zimbabwe.

[c/] Argentina, Bolivia, Brazil, Chile, China, Ecuador, Egypt, Haiti, Korea DPR, Morocco, Paraguay, Peru, Turkey, Uruguay, Venezuela.

associated with those countries with the highest levels of feed use. While these statistics appear somewhat variable in the country-specific data, they do suggest that feed grain industries can be expected to grow even at relatively high levels of usage.

Also, on an aggregate basis, the rising relative importance of maize is indicated by the fact that feed consumption of this commodity has grown more rapidly than that for cereal food consumption as a whole in each of these groupings. At low levels of feed consumption maize accounts for only 11 percent of total cereal feeds. At high levels this proportion increases to 42 percent. At higher levels of dependence on maize for direct consumption, greater reliance is placed on alternative feed sources. A large percentage of these tend to be cereal by-products. As feed industries become more developed, however, feed demand for maize rises.

The greater use of maize grain for feed, however, does not appear to be offsetting the use of alternative feed grains. Declining levels of alternative feed grain consumption are associated with greater maize feed grain consumption in only three of the 52 major producers. Though maize generally represents a rising proportion of cereal feeds, the consumption of alternative grains is usually also growing.

Between 1968 and 1980, ten producers experienced annual maize feed growth rates in excess of 7.5 percent.[1/] There is little basis for distinguishing why feed use in these particular countries grew as rapidly. Each of these countries might be classified as middle income in status. But per capita GNPs range from $420 to $3630 (U.S.). Per capita

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[1/] Kenya (24%), Paraguay (17%), Ivory Coast (16%), Morocco (15%), El Salvador (15%), Venezuela (13%), Egypt (13%), Cameroon (10%), Honduras (9%), Nigeria (8%).

cereal feed levels also range quite broadly from 8.4 kilos to 114 kilos. These countries allocate anywhere from 3 to 56 percent of their total utilization to feed. Maize may represent either a high (85 percent) or low (14 percent) proportion of total cereal feed. Maize representation in cereal diets and production shows a similar spread. Actual production levels are rising in some countries and falling in others. A similar pattern describes the range of trends regarding the representation of maize in total cereal diets.

In addition, it is interesting to note that maize grain feed use appears to have risen in 63 percent of those producers with declining per capita direct cereal calorie consumption. Per capita maize feed consumption increased in 25 percent of these producers. Total cereals feed use grew in all but three of the 52 major maize producers. Per capita cereals feed use grew in 63 percent of these countries and almost half of those with declining per capita direct cereal consumption.

These data contradict the widely held assumption that indirect demand will not become significant until incomes have risen and most basic direct consumption needs have been met. Part of the gain in total cereal feed usage resulted from greater use of grain by-products. Yet evidence also clearly suggests that many producers with apparent food deficits were allocating cereal grain itself to feed. Thus feed and food consumption may, within certain bounds, be competitive. Rapid growth in the demand for meat in one segment of a country's population may be threatening the diets of poorer consumers who lack sufficient calories in their basic staples.

In sum, food and feed consumption trends appear surprisingly distinct. There appears to be no clear shift from a primary dependence on maize for food to a dependence on maize for feed. Both food and feed consumption

are rising in most countries with rapid maize production growth rates. While the sharpest declines in per capita direct maize consumption are generally associated with declining per capita levels of maize or cereal feed consumption, this relationship is sometimes contradicted. Minor declines in per capita maize or cereal food consumption are frequently associated with rising per capita levels of feed consumption. Aggregate levels of feed use are clearly related to national income levels. Current trends in feed consumption, however, often are not.

MAIZE FEED USE AMONG THE MAJOR IMPORTERS

Levels and Trends of Maize Feed Use

A comparative assessment of feed utilization trends was sought in the analysis of maize consumption patterns in fourteen major maize importers which are not significant maize producers.[1/] These countries were chosen on the basis of annual net import levels greater than 10 kg per capita and maize production areas less than 100,000 hectares over the 1978-80 period. In order to maintain a reasonable degree of similarity with conditions in the major feed-using producers, countries with populations less than one million or average incomes greater than $8000 were omitted from this sample.

These 14 countries imported an average of 5.78 million metric tons of maize between 1978 and 1980. This represents approximately 32 percent of developing country maize imports and 8 percent of world imports. The actual level of per capita net imports in these countries ranges from 11 kilos to 164 kilos. But most countries were situated on the lower end of the scale. The median per capita net import level was 37 kilos.

[1/] Cuba, Dominican Republic, Hong Kong, Iran, Iraq, Jamaica, Jordan, Korea Republic, Lebanon, Malaysia, Singapore, Syria, Trinidad and Tobago, Tunisia.

The predominant reliance on international market purchases by the 14 major importers is indicated by the fact that these make up an average of 90 percent of total domestic utilization. While several of these countries maintain small maize production bases, only one nears major producer status. Cuba's production area was maintained at between 75 and 77 thousand hectares over the 1976 to 1980 period, but this represents a decline from a high of 126 thousand hectares in 1972. Five of the 14 importers produce less than 100,000 hectares of total cereal crops. In no case do maize imports appear likely to be offset by strong domestic cereal production in the near future.

Maize imports are predominantly destined for feed in each of these countries. Over the 1978-80 period, an average of 86 percent of total domestic maize utilization was allocated to feed. Only just over 9 percent was used for food.[1/] These utilization patterns are comparable to those in the developed countries where 97 percent of domestically utilized maize goes to feed and 3 percent to food. In most of the importers maize food consumption is declining. If current rates of feed consumption growth are maintained, the utilization patterns of the importers will match those of the developed countries within five years. Thus, the

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1/ These figures, like most of those relating to consumption and utilization patterns which follow, should be interpreted with caution. They do seem to represent reasonable orders of magnitude. In this particular case, however, questions arise regarding whether certain food consumption estimates may be overvalued. The data used in this analysis suggest that in a four year period maize food consumption in Iran rose from 17 to 51 percent of domestic utilization due to a large increase in food use. Given that 90 percent of Iran's maize is imported, such high levels of food consumption seem unlikely. A check on the Singapore data also suggests that maize food consumption levels may be overestimated. Reliance on this data base was maintained, however, because it is the most complete available source of recent statistics, and few such discrepancies were identified.

analysis of maize consumption trends in these countries largely involves questions regarding the development of their feed grain and livestock production industries.

Over the ten year period from 1968-70 to 1978-80, net maize import growth rates in these 14 countries have averaged 21.4 percent per year. While these rates have ranged widely, two-thirds of these countries have experienced annual growth rates in excess of 10 percent. The net import growth rates of three countries exceed 30 percent. Maize feed use has accordingly risen at an average rate of 17.2 percent per year. Per capita maize feed use has been growing by almost 15 percent annually. If such rates are maintained, per capita feed consumption will double within five years. The imports of those countries will also constitute a substantially larger share of the international maize market.

Strong production growth rates for pork, poultry, and eggs are clearly associated with these trends. These advances have been much more rapid than the growth of meat production as a whole. Over the 1969-81 period, pork production has been growing at a 4.4 percent average annual rate in the 14 major maize importers. This rate would be even higher if not for religious restrictions against pork consumption in the predominantly Moslem countries. In comparison, poultry production has grown at an 8 percent annual rate, and egg production has grown by 6.1 percent per year. Stronger growth rates for these commodities in the Moslem countries tend to make up in part for the reduced level of maize demand for pig feed.

Factors Influencing Maize Utilization Levels and Growth

The principal hypothesis underlying the analysis of feed utilization trends in the 14 major importers is that maize feed use can be expected

to be a function of income levels and of a related measure of basic dietary sufficiency entailed in total calorie levels. A rapid growth in meat and egg consumption is expected to follow the consumption of an adequate subsistence level of cheaper calories from cereals.

An examination of these consumption indicators confirmed this. Both income and total calorie consumption appear closely related to the status of a country as a major maize importer, and, thereby, a major user of cereal feed. While this relationship is not significant within the subset of importers alone, it shows up strongly when these countries are compared with the sample of major developing country maize producers. This comparison suggests that the use of significant amounts of feed is largely dependent on the relative magnitude rather than the absolute level of income or calorie consumption. A regression equation in Appendix A confirms this.

The comparison of several key variables related to feed consumption for both the importers and the largest feed users among the major producers displays some surprising similarities (Table 11). Both groups have relatively high per capita incomes. The average per capita GNP for the importers is more than 50% higher than that for the related group of producers. But when 3 countries with incomes over $4000 are dropped from this sample, the difference falls to 11 percent. The income level of every country in this sample is greater than $1000.

The two groups of countries also display similar levels of total calorie consumption. Though the figure for importers (2401 calories) is slightly lower than that for major feed-using producers (2564 calories), it is substantially higher than the consumption level of major producers allocating relatively little maize to feed (2168 calories). This difference suggests that once a country has reached some relative magnitude of average calorie consumption, feed use grows rapidly.

Table 11. Average Utilization Characteristics of Major Developing Country Users for Maize Feed

	Importers[a/]	Producers[b/]
Percent maize utilization allocated to feed, 1978-80	85.6	42.1
Per capita maize feed, 1978-80 (kgs)	42.3	42.1
Per capita cereals feed, 1978-80 (kgs)	85.8	100.0
Maize as percentage of cereals feed, 1978-80	49.2	41.1
Maize feed growth rate, 1968-80 (%)	17.2	5.7
Cereal feed growth rate, 1968-80 (%)	8.2	4.6
Per capita GNP, 1980 ($U.S.)	2266 (13 countries)	1479
Per capita total calories consumption, 1975-77	2401	2562

Source: FAO Data Tapes, 1983.
World Bank World Development Report, 1982.

[a/] 14 major importers.

[b/] 15 major maize producers allocating more than 20 percent of domestic utilization to feed.

The two groups are also surprisingly similar in their actual feed use statistics. Average per capita levels of maize feed differ by less than one kilo. Again, these are at levels substantially higher than for most major producers. The per capita cereal feed levels of importers are lower than for the feed using producers, though still almost three times the level of the next highest class of producers allocating 5-20 percent of their maize to feed. An interesting result is that maize represents a higher proportion of cereal feeds for the major importers than for the major producers.

This fact is associated with the relatively larger cereal production base in most of the major producers. This base provides a greater quantity of alternative feeds. Higher levels of total wheat and rice consumption associated with the generally larger populations in these countries also provide larger amounts of bran for feed.

The average maize feed growth rate experienced by the major importers is over three times that for the major feed using producers. This statistic is particularly significant given the fact that both groups now consume similar levels of maize feed. Once again, these rates are substantially higher than the average annual growth in the use of cereal feed as a whole. Non-maize cereal feed growth in the major importers has averaged less than one-third the level of maize feed growth. Maize, accordingly, represents a rapidly growing proportion of total feed supplies. In 1968-70, this commodity represented an average of only 33 percent of total cereal feeds. Ten years later this share had risen to 50 percent. In 9 of the 14 importers the relative proportion of maize feed is even higher, ranging up to 89 percent in Jamaica.

Factors Affecting the Choice of Maize as a Feed Grain

In most cases, maize is imported to supplement domestically produced sources of feed. The rapid import growth of this single commodity raises questions regarding what factors govern its choice as the major component of animal diets. This issue is qualitatively different from that involved in the indirect consumption decisions of the major producers. The composition of cereal feeds is less dependent on the nature of domestic production opportunities. Particularly for those countries which are not major cereal grain producers, the decision to import maize more explicitly involves an assessment of cereal nutrient composition and relative world market prices.

In most countries, a rapid increase in maize usage has been accompanied by increases in the use of wheat and rice bran. One or the other of these represent the second major feed source for most minor producers of cereals. If direct wheat consumption is rapidly increasing, one can expect greater amounts of wheat bran to be employed for feed. A similar relationship holds between rice consumption and rice bran usage. Most of these gains have not been large enough, however, to allow these commodities to increase their share of total cereal feeds.

Maize, itself, is generally preferred for feed for two reasons. The content of total digestible nutrients (TDN) tends to be higher for maize than for the rice and wheat bran alternatives. This may partly offset the relatively higher costs of maize imports. The total digestible nutrients of barley are also slightly lower than those for maize. The other chief substitute for maize feed, sorghum, has a total digestible nutrient level comparable to that for maize. Sorghum prices have tended to fluctuate around those for maize. As a reuslt, sorghum

has been highly competitive with maize among a number of the major maize producers who are importing feedstuffs. Sorghum imports in these 14 countries, however, have generally been far lower than those for maize. Few countries use any appreciable amounts of this commodity for feed.

Maize also seems to be a preferred animal feed because of the carotene content of the grain. This is particularly important for egg production as it provides the yoke with its preferred deep yellow color. While substitutes have been developed, these do not seem to be widely favored. As long as maize maintains an international market price which is reasonably competitive, a continuing rapid growth in demand can likely be expected.

Barley production in the Middle East and North Africa only shows potential for partly offsetting maize imports in Iran and Tunisia. During the last ten years, however, the relative share of barley in cereal feeds has sharply declined in each country.

Likelihood of Continued Growth in Maize Feed Utilization

Two factors indicate that maize feed use will continue its rapid advance in countries relying heavily on imports. First, as was found among the maize producers, there is no apparent relationship between feed use levels and growth rates. Among the four major importers annually using more than 100 kg of cereal feed per capita, feed use growth rates continue to average 7.6 percent per year. Maize feed growth rates are even higher.

In addition, per capita production levels for pork, poultry and eggs generally remain low by developed country standards. Pork production averaged 29 kg per person in the developed countries over the 1979-81 period. Among the developing country maize importers, only Hong Kong's production exceeds this level. Per capita pork production levels in the

remaining non-Arab producers average approximately 7 kg per person. Only two of the 52 major developing country maize producers have per capita pork production levels greater than 10 kg.

Poultry production averages about 16 kg per person in the developed countries. Only two of the 14 major developing country maize importers have attained larger levels of production. In the remaining importers per capita poultry production levels average approximately 7 kg. None of the major developing country maize producers approach developed country production levels.

A review of per capita egg production records for the three groups reveals a similar relationship. Though one of the maize importers approaches developed country levels of per capita production, most are still well below this average. All of the producers lie substantially below this level.

Maize is clearly the most important feed grain in most of the large scale importers. Given the persistence of rapid maize import growth rates, this commodity will likely further increase its share of total cereal feed use in these countries. Continuing strong world maize production and relatively low international prices can only reinforce this trend.

CONCLUSIONS

This paper started from an interest in evaluating the character of direct and indirect maize consumption trends and the relationship between them. It questioned whether reliance on demand projections extrapolated from past trends was an appropriate way to measure future consumption requirements. The analysis discovered the two trends to be related though in many ways quite distinct. A rapid growth in the consumption of maize feed is linked to a broadly evidenced growth in demand for

livestock products. These trends appear likely to persist. Widespread stagnation in the direct consumption of maize calories seems to be associated with a complex range of causal factors including production constraints, income growth, urbanization and the relative configuration of alternative cereal grain prices. The incidence and impact of these variables differ widely across the major producers. Future direct consumption trends thus remain difficult to predict. These findings can be summarized in the following manner.

Strong growth rates in maize feed use are closely linked with the incidence of rising developing country incomes. Income growth prompts changes in the relative proportion of family budgets allocated to higher priced 'luxury' goods as opposed to basic subsistence needs. In this case, pork, poultry, and egg consumption have been principal beneficiaries.

This pattern of maize feed use growth has been most pronounced in those countries with relatively lower dependence on maize for food consumption. Countries which have maintained a strong dependance on maize calories are likely to experience a slower and later growth (in relation to income advances) of maize feed demand. Also, in the initial periods of feed consumption growth, maize will represent a smaller proportion of total feed grains. Those with a larger production base in alternative cereal calories, wheat and rice in particular, should alternatively make this transition both at lower relative income levels and more rapidly. The proportion of maize allocated to feed will rise both as maize calories are replaced by those derived from wheat and rice and as greater feed production is pursued for its own sake.

Insofar as feed demand grows more quickly than either maize production, or declines in direct maize consumption, an increasing dependence on maize imports will be required. During the last ten years the number of developing country maize exporters has dramatically fallen while import levels have sharply increased. The importing countries have, therefore, become increasingly vulnerable to yearly fluctuations in world maize supplies and prices. Sharp changes in U.S. production policies, in particular, can significantly affect world market conditions. To date, however, import trends among the non-producers have been relatively stable.

While developing country maize food consumption is still growing on an absolute basis, most major producers have experienced per capita consumption stagnation or declines. The reason for this is not so clearly apparent as the justification for feed utilization trends.

Declining levels of per capita maize production have reduced the relative availability of this cereal grain. Extremely low yields, even by developing country standards, have severely limited the production levels of many of those countries with the highest proportion of their diets made up of maize calories. As a result, these nations have become increasingly dependent on cereal grain (mostly wheat) imports, and many have experienced declines in total calorie consumption.

In addition, the greater availability of wheat and rice in itself has fostered a stagnation or decline in maize consumption. This stagnation has resulted from a number of different factors. In certain countries, the production advances associated with these grains may simply have been stronger than those for maize. Alternative grain imports may have been used to ensure a more consistent supply of food to a country experiencing transport or storage constraints or fluctuating production. Wheat-

based food aid may have promoted a reorientation of consumer preferences. Overvalued currencies and government pricing policies also tend to make maize more expensive than wheat in many countries.

Intra-country survey data and elasticity statistics indicate that per capita direct maize consumption will decline as incomes rise. However, this relationship does not appear strongly evident in aggregate national data. In fact, many of those producers with the highest relative income levels are still registering per capita consumption gains. Most producers, particularly those maintaining the greatest relative dependence on maize calories, have very low incomes.

Thus, strong growth in feed consumption does not appear associated with a major reallocation of domestic supplies from food to feed. While the relative proportion of these allotments is changing, this trend cannot be simply viewed as a product of evolving consumption preferences. Many of the major producers are experiencing either rising or falling levels of both direct and indirect consumption. In others, feed use is growing despite evidence of basic food consumption deficits. Accordingly, these may best be viewed as two distinct though related trends. In any individual country, they may well be affecting different groups of consumers. In some countries the two sources of demand may be in growing competition.

Future maize feed consumption trends are likely to be conditioned by income growth, maize availability and relative feed grain prices. Those countries with well established maize feed consumption patterns can probably expect continued strong growth in this source of demand. Maize will represent a rising proportion of feed grains even if this requires greater dependence on feed grain imports. Many of those countries currently allocating most of their production to food will begin to experience a rapid growth in maize feed demand.

In contrast, maize food utilization patterns appear likely to remain variable and subject to fluctuation. They will probably continue to be particularly sensitive to production trends as well as the intended and unintended effects of government intervention in national cereal grain markets. Most producers still have a large potential for growth in direct maize consumption. The widespread relationship between maize and total cereal calorie consumption declines suggests that greater efforts are required to stimulate improved food production. Strong growth in maize feed demand should not be interpreted as a sign of the reduced importance of direct consumption requirements.

APPENDIX A

REVIEW OF REGRESSION RESULTS

Several cross-sectional regression models were used to examine relationships underlying evolving maize demand trends. For the major maize producers, explanations were sought for shifting patterns of direct consumption and relative levels of indirect consumption. These data were then combined with those for the 14 major non-producing maize importers to test the strength of feed use models for the entire group of major utilizers of maize.

Two qualifications should accompany the consideration of these results. First, given questions regarding the accuracy of available consumption statistics, the regressions should be interpreted as signifying where explanatory relationships may lie rather than as strict evidence of the strength of these relationships. While this caveat should accompany the consideration of most regression models, the caution seems particularly relevant in this case.

Second, a major variable underlying these sorts of demand relationships has been omitted due to the lack of sufficient data. Demand is

obviously heavily influenced by relative cereal grain prices. The following equations encompass what are perceived to be the most important non-price variables influencing consumption trends. The coefficients of variables correlated with prices, however, are likely to be biased.

Each of the equations was calculated with an ordinary least squares estimator.

1. Direct Consumption Among Major Maize Producers

A country was classified as a major producer if it planted an average of over 100,000 hectares of maize over the 1979-81 period. The following equation indicates what variables may be associated with absolute changes in direct maize consumption. Due to the lack of income data for four countries, only 48 observations are included in this analysis.

a. $$\underset{(.862)}{CPCMC = 1.625} - \underset{(-.694)}{.3415\,GNPG} + \underset{(3.45)^{***}}{.1492\,CPM} - \underset{(-2.14)^{**}}{.0694\,MCC}$$

D.F. = 44 Corrected R^2 = .30 F = 7.69***

where

CPCMC = Change in per capita maize consumption 1968-70 to 1978-80 (kg)

GNPG = Per capita gross national product growth 1960-1980 ($U.S.)

CMP = Change in per capita maize production 1968-70 to 1978-80 (kg)

MCC = Percentage of cereal calories made up of maize, 1968-70.

Numbers in parentheses refer to T statistics whereby

*** = significant at 1 percent level

** = significant at 5 percent level

* = significant at 10 percent level

The sign on the income statistic was as expected. But this coefficient had a high standard error and is not statistically significant. This may be due to an increase in bias associated with the lack of a price variable.

The other coefficients had the expected signs. Consumption should increase with strong maize production growth. Greater initial dependence on maize calories in relation to the consumption of alternative cereal grains has generally been associated with consumption declines.

2. Indirect Consumption Among Major Maize Producers

Three distinct equations were found to reflect major feed use relationships. Two assess relative levels of maize use for feed, and the third examines a similar set of relationships for cereal feeds as a whole. Given the fact that maize represents only one of several sources of cereal feed, this final equation may provide a truer indication of the factors underlying livestock industry development. A complete set of data were available for only 49 countries.

b. $MAF = 5.59 + 0.0455\ GNP - 0.0000087\ GNP^2 - 0.2874\ MCC$
$\quad\quad\quad\quad (.97) \quad\quad (4.52)^{***} \quad\quad (-2.62)^{**} \quad\quad (-3.15)^{***}$

$D.F. = 45 \quad\quad$ Corrected $R^2 = 58.7 \quad\quad F = 23.77^{***}$

where

MAF = Percentage of domestic maize utilization (production + imports - exports) allocated to feed, 1978-80.

GNP = Per capita gross national product, 1980. ($ U.S.)

MCC = Percentage of cereal calories made up of maize, 1978-80.

*** = significant at the 1 percent level

** = significant at the 5 percent level

The sign on each variable matched expectations. The percentage of maize allocated to feed (as opposed to food) is strongly related to a country's per capita income level. As incomes increase, feed use rises sharply, though apparently at a decreasing rate. The maximum level of

feed use appears at an income level higher than any held by the countries in this sample. This corresponds with the fact that high maize feed growth rates are still being registered by a number of countries with high feed utilization levels.

The negative relationship between feed allocations and the relative dependence on maize as a source of cereal calories reflects the precedence of food over feed demand. The greater implied availability of wheat and rice, the chief substitutes for maize calories, may allow a more rapid growth in allocation of maize to feed. A high degree of dependence on maize calories may slow this process.

c. PCMF = -78.0 + 0.162 GNP - 0.594 MCC + 0.0344 TC + 0.664 MCP
(-1.42) (3.65)*** *-3.84)*** (3.23)*** (5.21)***

D.F. = 38 Corrected R^2 = 63.9 F = 19.56***

where

PCMF = Per capita level of maize feed, 1978-80. (kg)

GNP = Per capita gross national product, 1980. ($ U.S.)

MCC = Percentage of cereal calories made up of maize, 1978-80.

TC = Per capita total calorie consumption, 1975-77.

MCP = Percentage of cereal production made up of maize, 1978-80.

*** = significant at the 1 percent level

The sign on each variable matched expectations. This relationship is similar to that described in equation b. The two dependent variables are slightly different, however. Certain countries may have a high percentage of maize allocated to feed with a relatively low per capita maize feed level or a relatively low percentage allocation with a higher level.

Again, countries with higher incomes and lower dependence on maize calories are likely to experience higher feed levels. The strong positive

impact of total calorie levels suggests countries that are on average better fed tend also to eat more maize-fed meat. Each of these trends is further reinforced by the maintenance of a relatively large maize production base. In other words, the availability of grain substitutes is important in order to facilitate shifting direct consumption. But the demand for a strong maize production base will be maintained with the development of a feedgrains industry.

d. PCCF = -184 + 0.0247 GNP + 0.0915 TC
(-1.43) (3.91)*** (6.09)***

D.F. = 46 Corrected R^2 = 74.6 F = 71.6***

where

PCCF = Per capita level of cereal feeds, 1978-80. (kg)

GNP = Per capita gross national product, 1980. ($ U.S.)

TC = Per capita total calorie consumption, 1975-77.

*** = significant at the 1 percent level

The signs on both of these variables were as expected. Their importance was confirmed in the previous equation. The strength of the relationship with cereal feed usage as a whole, however, displays the fact that maize feed use patterns do not necessarily reflect cereal feed use patterns as a whole. Strong competing demands for maize as a food grain significantly limit demand for it as a feed. The use of less preferred food grains such as sorghum or millet may make up for this. The relative composition of cereal feeds may also be strongly affected by relative cereal grain price relationships. This equation confirms the significance of the general income-feed use relationship, however.

3. Indirect Consumption Among Major Producers and Major Importers

The major importers were classified on the basis of annual per capita imports greater than 10 kg, populations greater than 1 million, and maize

production less than 100,000 ha over the 1979-81 period. These countries were added to the sample of major producers to check whether the above-described relationships would be maintained. Equations were examined testing explanations for maize and cereal feed use.

e. PCMF = -95.2 + 0.00751 GNP + 0.0471 TC
(-1.13) (2.95)** (4.15)***

D.F. = 52 Corrected R^2 = 45.4 F = 23.48***

f. PCCF = -193 + 0.0178 GNP + 0.0985 TC
(-1.37) (4.34)*** (7.36)***

D.F. = 58 Corrected R^2 = 72.9 F = 83.24***

*** = significant at the 1 percent level

** = significant at the 5 percent level

where

PCMF = Per capita level of maize feed, 1978-80. (kg)

GNP = Per capita gross national product, 1980. ($ U.S.)

TC = Per capita total calorie consumption, 1975-77.

PCCF = Per capita level of cereals feed, 1978-80. (kg)

In both cases the relationships characterizing major producers alone are maintained. Even without a large maize or cereals production base, a strong level of feed demand can be generated. Demand for maize represents an important component of overall feed demand. As incomes rise, greater use of maize feed can be expected.

Appendix B

Table B.1. Country Data on Maize Production, Consumption and Imports in 52 Major Developing Country Producers

	Percent Cereal Calories from Maize (1978-80)	Absolute Change in Per Capita Maize			Change in Per Capita Cereal
		Production (kg) (1968-80)	Net Imports (kg) (1968-80)	Direct Consumption (kg) (1968-80)	Consumption (kg) (1968-80)
Malawi	93	-24.9	3.6	-9.0	-7.1
Namibia	81	-3.6	0	2.5	-2.7
Guatemala	80	-4.1	9.1	-15.7	-10.7
Zambia	79	-35.1	23.0	-9.1	-10.3
Kenya	77	-70.2	18.0	-17.1	-20.2
Honduras	76	-23.9	9.4	-4.5	0.9
Mexico	74	-25.5	35.5	-7.1	-1.3
Zimbabwe	69	-14.1	16.4	0.1	-15.1
Angola	70	-35.8	30.5	5.3	0
Nicaragua	69	-37.2	8.7	-17.2	-26.2
El Salvador	66	25.1	5.6	14.4	16.9
Tanzania	65	-9.2	5.9	-5.1	-1.6
Benin	65	13.1	0	-6.5	-1.5
Zaire	62	-1.1	4.8	1.8	2.4
Burundi	53	-1.4	0	0.4	-2.1
Paraguay	53	80.2	3.9	-0.4	-0.9
Ghana	51	-10.2	4.8	-2.7	-6.3
Uganda	49	-4.3	-2.0	2.9	-12.6
Lesotho	48	6.2	0	-0.4	15.7
Mozambique	48	-21.4	15.7	-6.3	-7.0
Togo	45	-6.9	-0.1	0.6	4.4
Haiti	39	-21.4	0	-3.8	-1.2
Venezuela	38	-13.6	33.2	-6.4	3.4
Colombia	36	-9.2	4.4	-5.0	13.6
Cameroon	34	-0.5	0	0.3	7.6
Bolivia	30	-5.0	0	-5.3	0
Central African Republic	29	-10.0	0	-8.1	-9.3
Somalia	29	-15.1	9.7	-12.9	-23.4
Philippines	29	14.4	2.4	11.6	18.1
Ecuador	28	-9.6	0.9	-3.4	2.3
Egypt	26	3.2	12.3	2.8	19.8
Ethiopia	26	-1.2	0	0.3	-18.0
Ivory Coast	24	-10.7	-0.7	-8.8	7.0
Peru	23	-11.0	12.4	2.3	4.1
Nepal	22	-22.7	0.2	-17.8	-13.9
Brazil	21	-4.1	24.1	-0.1	11.7
Afghanistan	18	-0.6	0	-6.5	-21.3
Nigeria	15	-2.0	1.4	3.3	6.5
Indonesia	13	2.8	1.6	2.7	32.3
China	12	6.7	4.4	-3.1	24.2
Uruguay	11	-4.4	-0.1	4.5	-2.8
Madagascar	6	-5.7	0.3	-3.8	3.0
Viet Nam	6	2.2	3.1	2.8	-22.5
Morocco	6	-8.0	5.8	-5.3	7.3
Turkey	5	-8.1	-0.1	0.3	0.4
Pakistan	5	-0.9	0	0	13.1
India	4	-2.4	0	-1.5	4.6
Korea DPR	4	7.6	-10.6	-5.3	40.9
Argentina	4	-16.2	-19.3	1.2	2.3
Chile	3	+9.2	9.3	0.9	10.4
Thailand	2	17.5	-2.7	2.4	-3.0
Burma	1	0.3	-0.1	0.3	12.8

Source: FAO Data Tapes, 1983.

(continued)

Table B.1 (continued)

	Per Capita Direct Consumption (kg) (1978-80)	Per Capita Indirect Consumption (kg) (1978-80)
Malawi	162.4	11.1
Namibia	84.2	0
Guatemala	96.7	19.5
Zambia	102.2	7.3
Kenya	88.1	3.7
Honduras	91.9	16.8
Mexico	107.0	21.1
Zimbabwe	89.2	38.9
Angola	45.8	3.4
Nicaragua	62.9	7.8
El Salvador	80.3	20.6
Tanzania	46.2	1.8
Benin	51.3	1.9
Zaire	18.7	0.7
Burundi	28.8	0.7
Paraguay	44.9	92.2
Ghana	27.8	1.9
Uganda	23.8	2.6
Lesotho	90.4	11.2
Mozambique	32.4	0
Togo	40.8	0
Haiti	35.1	6.2
Venezuela	34.6	28.3
Colombia	29.7	3.7
Cameroon	27.9	6.0
Bolivia	25.1	30.1
Central African Republic	10.1	0
Somalia	21.6	0
Philippines	40.6	6.3
Ecuador	18.7	6.3
Egypt	50.5	30.1
Ethiopia	31.3	0
Ivory Coast	23.2	5.2
Peru	22.0	20.2
Nepal	35.0	0
Brazil	20.1	107.2
Afghanistan	28.0	3.6
Nigeria	15.1	1.9
Indonesia	21.0	0.5
China	19.1	33.6
Uruguay	10.1	26.4
Madagascar	10.1	0.4
Viet Nam	8.3	1.0
Morocco	9.8	9.7
Turkey	7.9	14.3
Pakistan	6.8	0.6
India	6.2	0.2
Korea DPR	8.1	70.4
Argentina	3.9	110.8
Chile	4.6	50.3
Thailand	2.7	2.0
Burma	1.9	0.1

Source: FAO Data Tapes, 1983.

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