# 1990-91 CIMMYT
# World Wheat
# Facts and Trends

## Prepared in collaboration with ICARDA

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CIMMYT and ICARDA (the International Center for Agricultural Research in the Dry Areas) are internationally funded, nonprofit scientific research and training organizations. Both organizations form part of a consortium of 16 nonprofit international agricultural research centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is sponsored by the Food and Agricultural Organization (FAO) of the United Nations, the International Bank for Reconstruction and Development (World Bank), and the United Nations Development Programme (UNDP). The CGIAR consists of a combination of 40 donor countries, international and regional organizations, and private foundations.

Headquartered in Mexico, CIMMYT is engaged in a research program for maize, wheat, and triticale, with emphasis on improving the productivity of agricultural resources in developing countries. CIMMYT receives core support through the CGIAR from a number of sources, including the international aid agencies of Australia, Austria, Brazil, Canada, China, Denmark, Germany, Finland, France, India, Iran, Ireland, Italy, Japan, Mexico, the Netherlands, Norway, the Philippines, Spain, Switzerland, the United Kingdom, and the USA, and from the European Economic Commission, Ford Foundation, Inter-American Development Bank, UNDP, and World Bank. CIMMYT also receives non-CGIAR extracore support from Belgium, the Rockefeller Foundation, and many of the core donors listed above.

Established in 1977, ICARDA is governed by an independent Board of Trustees. Based at Aleppo, Syria, ICARDA focuses its research on areas with a dry summer and where precipitation in winter ranges from 200 to 600 mm. The Center has a global responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility—in West Asia and North Africa—for the improvement of wheat, chickpea, and pasture and forage crops and the associated farming systems. Much of ICARDA's research is carried out at its headquarters at Tel Hadya. ICARDA manages other sites where it tests material under a variety of agroecological conditions, and also conducts cooperative research with many countries in West Asia and North Africa.

**Abstract.** A synopsis of recent production trends in rainfed marginal environments of the developing world is followed by a description of the major wheat and barley farming systems in West Asia-North Africa (WANA) and South Asia (the role of livestock is described as well). Successive sections of the report describe the present and potential use of improved technology in rainfed marginal environments of WANA and South Asia; policies affecting wheat and barley; and issues in allocating resources to research aimed at marginal environments. Future research, extension, and policy strategies directed at improving rainfed wheat and barley production are discussed. The report concludes with a brief overview of the world wheat situation for 1990-91, followed by selected statistics on wheat and barley production, consumption, and trade for all regions of the world.

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# Contents

# Foreword

Two years ago in the previous issue of *World Wheat Facts and Trends*, we took a close look at how the "revolution" in wheat production had spread throughout the world in the twenty-odd years since it began in Mexico and South Asia. Our report revealed that growth in Third World wheat production had been impressive; during the 1980s, wheat yields and production rose almost as rapidly as in the first extraordinary years of the Green Revolution. But we also observed that the effects of the wheat revolution were not equally felt among the different production environments in the developing world. In concluding our report we noted that "a continuing challenge...is to exploit the potential of drier environments where the pace of change has been slowest," and indicated that the next issue of *Wheat Facts and Trends* would address that topic in greater detail.

To assess the potential for improving cereal crop production in drier environments of the developing world, we decided to focus on two major geographical areas where such environments predominate: West Asia and North Africa (WANA), where barley as well as wheat is important in rainfed cropping systems; and the areas of South Asia where wheat is grown on residual moisture after the monsoon rains. Once the geographical scope of the report was determined, CIMMYT approached the International Center for Agricultural Research in the Dry Areas (ICARDA) about the possibility of jointly developing the study to incorporate ICARDA's considerable experience in the WANA Region. This study is stronger because of that collaboration. In addition, our colleagues with the Indian Council of Agricultural Research contributed valuable information to the sections of this report on South Asia.

By focusing our attention on wheat and barley production in the Third World's marginal rainfed environments, we have highlighted some of the most acute dilemmas confronting national and international research in recent years. The fact that agricultural change has been slow in marginal areas, where environmental degradation is often said to be proceeding most rapidly, has presented research with an urgent imperative: to effect positive change in agriculture and incomes in less favored areas without endangering their ecological stability.

As the reader will see, our study demonstrates that this challenge is far from simple. The tradeoffs in deciding how to allocate research resources to the greatest benefit of marginal areas are inevitably complex, since they involve weighing the potential benefits that may come from devoting research resources to favored areas (such as lower food prices or increased employment opportunities) against the benefits of research focused specifically on marginal areas. Furthermore, although the following pages strongly advocate greater attention to research for rainfed marginal areas, the research strategies that met with success in more favored areas are not necessarily best suited to the rainfed marginal areas where wheat and barley are produced. More work on crop and resource management relative to plant breeding research will be a key to mitigating problems in marginal areas whose agriculture is characterized by intercropping, crop rotations and fallowing, and crop-livestock interactions. Even so, it must be recognized that, in many cases, formidable agroclimatic constraints will limit the potential for improving productivity despite strong contributions from research.

But research does not work in isolation. If research is to have an impact in marginal areas, extension will need to be able to present farmers with a range of technical options. Farmers will require greater assistance from extension to acquire the managerial skills necessary to adopt increasingly complex technologies with success.

Policy makers will also have to be committed to strengthening agriculture in marginal areas, perhaps through policies designed to reduce the riskiness of wheat and barley production. The extreme diversity, variability, and vulnerability of marginal environments make the need for strong collaboration among research, policy, and extension more urgent. We believe that this report provides information that will be useful in promoting collaboration among all who are interested in effecting positive change in agriculture in the world's rainfed marginal areas.

**Donald L. Winkelmann,**
Director General, CIMMYT

**Nasrat Fadda**
Director General, ICARDA

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# Part 1: Wheat and Barley Production in Rainfed Marginal Environments of the Developing World

Michael L. Morris, Abderrezak Belaid, and Derek Byerlee

The events that precipitated the Green Revolution in wheat are by now well known. During the late 1960s and early 1970s, improved high yielding wheats developed in Mexico (referred to in this report as modern varieties, or MVs) were introduced into a number of the world's most populous developing countries, including India, Pakistan, and Turkey. When grown with increased levels of fertilizer and an assured water supply, MVs performed significantly better than older materials, making possible dramatic increases in wheat production and higher incomes for the millions of small-scale farmers who adopted the technology.

Despite these successes, the agricultural research institutes credited with launching the Green Revolution came under attack from critics who suggested that its major beneficiaries were farmers located in favored production environments. Indeed, some evidence suggests that farmers in marginal production environments who did not adopt the new technology may have been disadvantaged when rapid production increases in favored environments depressed cereal prices (Lipton 1989). Since these negative price effects were not offset by production gains in marginal environments, argued the critics, interregional inequalities in rural income distribution were actually increased rather than reduced by the Green Revolution.

One problem in attempting to evaluate this criticism is that the empirical record is incomplete. Although numerous studies have documented the impacts of improved seed-fertilizer technologies in favored production environments where early and widespread adoption took place, relatively little research has focused on less favored environments. The issue is complicated by the fact that the adoption of technology is often a gradual process spanning many years, so that it is sometimes difficult to know when adoption is still in a relatively early stage or has completely run its course.

This *Facts and Trends* feature report presents an up-to-date picture of wheat production in marginal environments, with emphasis on the past and future role of technical change in these areas.[1] Barley, a close substitute in production in rainfed marginal areas, is also included in the analysis. The focus on marginal environments is motivated by the fact that a large number of poor people currently depend on these environments for their survival, and by the concern that marginal environments present a special challenge for the development of production technologies that will be sustainable in the longer run.

In the following pages, we examine dryland wheat and barley production at a number of different levels. First, we characterize marginal environments for wheat and barley in terms of agro-climatic circumstances and describe the importance of these environments in the major wheat- and barley-producing countries of the developing world. Second, we provide an overview of the principal cereal-based farming systems in two regions where large amounts of wheat and barley are produced under marginal conditions—West Asia and North Africa (the WANA Region), and South Asia. Third, we pose three questions that are addressed in the remainder of the report:

1) What has been the impact of technological change in marginal environments over the past three decades?

2) What types of research promise to deliver the most rapid future gains in wheat and barley production in marginal environments?

3) Should a larger share of research resources be allocated to addressing the special challenges of cereal production in marginal environments, and if so, is a change in research strategy needed to address the specific needs of marginal areas?

This report forms part of a larger effort by CIMMYT and ICARDA to better define the extent of marginal environments for wheat, barley, and maize in the developing world; to characterize the conditions under which these cereals are grown in these environments; and to identify promising research opportunities.

## What Is a "Marginal Environment"?

Although agricultural scientists frequently distinguish between "favored" and "marginal" production environments, in fact there is little consensus on precise definitions for these terms. This is perhaps understandable, since the growth requirements of different plant species vary considerably, and an environment that is favorable for one species may be marginal for another.

Most agriculturalists would probably agree that a marginal environment for crop production is characterized by abiotic stresses which severely inhibit plant growth, such as extreme levels of moisture (drought or waterlogging), extreme temperatures (heat or cold), severe imbalances in soil fertility (absence of essential nutrients or presence of toxicities), unfavorable soil physical characteristics (shallow depth, degraded condition), and/or meteorological conditions which can cause physical damage to growing plants (high winds, hail). However, the presence of one or more of these stresses does not necessarily mean that an environment is marginal. Many of the factors causing abiotic stresses are subject to manipulation; indeed, modern

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[1] Throughout this report, the terms "marginal environments" and "marginal areas" are used interchangeably. "Dryland production" refers to rainfed production taking place in marginal environments.

crop production technologies have enabled some of the world's most inhospitable regions to be transformed into highly productive agricultural zones.

In this report, we adopt a conceptual definition of marginal environments used by the CIMMYT Wheat Program: marginal environments for wheat and barley are defined as those in which irremediable climatic or soil conditions limit yields to less than 40% of potential yields as defined by available solar radiation (CIMMYT 1989b). Conditions are considered irremediable when the cost of ameliorating them is prohibitive, i.e., beyond the ability of a farmer or nation to pay, except perhaps in the very long run (Fischer 1988).

Based on this definition, most marginal environments for wheat and barley are characterized by severe drought, often combined with extreme temperatures (heat or cold). Other types of stresses, such as unfavorable soil chemical and physical conditions, can also define marginal environments for wheat and barley, but the major focus of this report will be on moisture stress. Generally speaking these environments are located in regions that receive less than 350 mm rainfall in the growing season (sometimes much less, as in areas where wheat and barley are grown on residual moisture).

## Distinguishing Types of Rainfed Marginal Environments

In rainfed cereal cropping systems, water used by growing plants comes from two principal sources: rain falling during the growing season, and residual moisture stored in the soil at planting time. The relative importance of these two sources of water varies depending on precipitation patterns, soil characteristics, and farmers' management practices. Two basic types of rainfed marginal environments can be distinguished based on the seasonal distribution of precipitation. In *winter rainfall environments*, moisture availability is usually closely related to rain falling during the growing season (although sometimes significant amounts of water may be stored in the soil at planting time as the result of fallowing and other practices that facilitate moisture storage). In these environments, evapotranspiration often exceeds rainfall at the beginning and end of the growing season, when rainfall is lower and also highly variable (Figure 1). By contrast, in *residual moisture environments*, very little rain falls during the growing season, and the crop derives virtually all of its water requirements from moisture stored in the soil from the preceding monsoon rainfall period. In

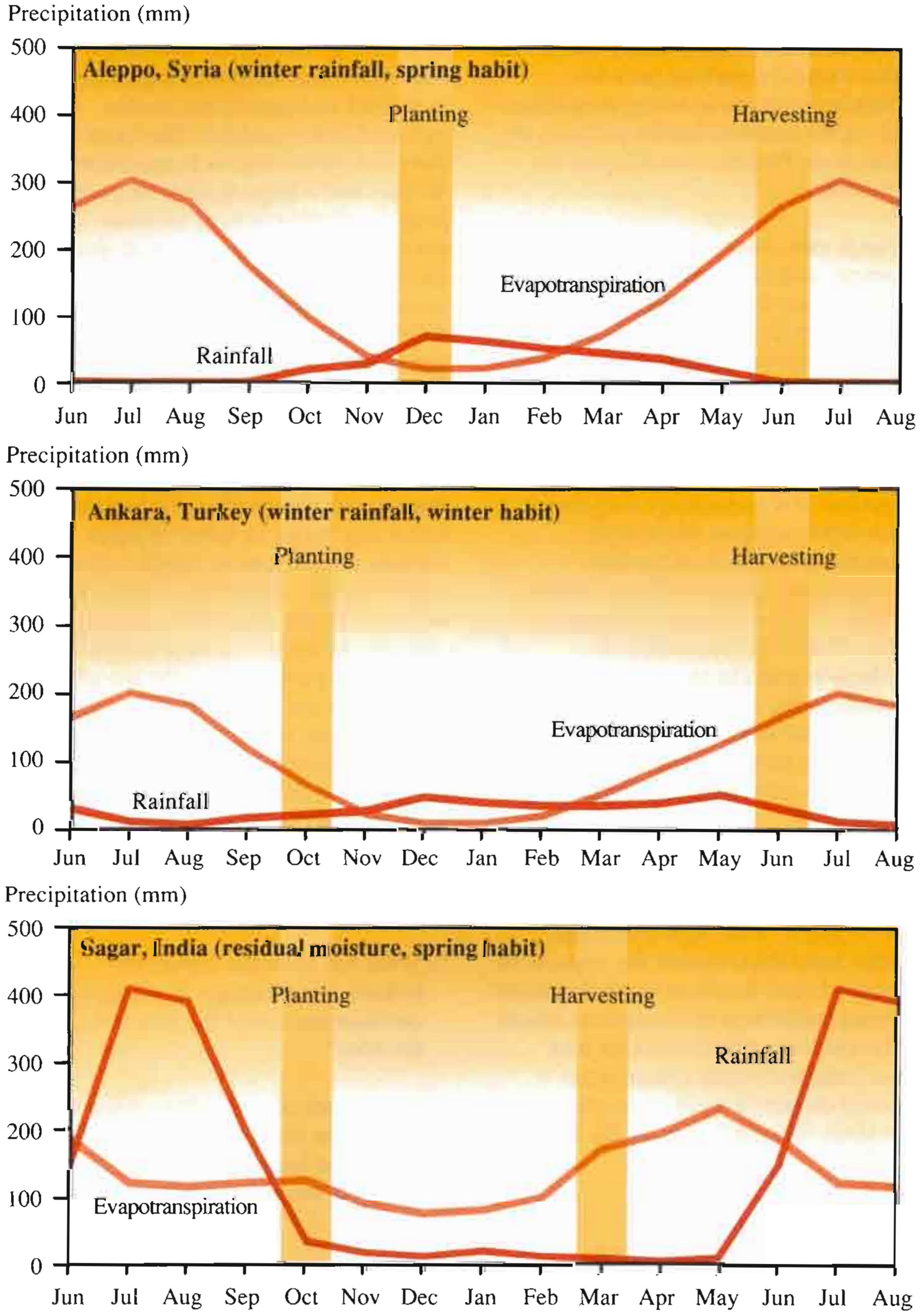

**Figure 1. Seasonal distribution of precipitation and evapotranspiration at three representative sites in rainfed marginal environments.**

these environments, potential evapotranspiration generally exceeds rainfall throughout the season (Figure 1).

The winter rainfall environments are concentrated in the WANA Region, where they can be further broadly classified into Mediterranean climates (in which average minimum temperatures do not usually fall below 0°C in the coldest month) and Continental climates (in which, because of elevation and distance from the coast, a significant proportion of precipitation occurs as snow). Not all winter rainfall environments are marginal. Those classified as marginal usually lie in the zone receiving between 200 and 400 mm of precipitation annually.

The residual moisture environments are concentrated in South Asia. Here annual precipitation is much higher (often over 1,000 mm), but usually less than 100 mm falls during the growing season.

It is important to distinguish between these two basic types of marginal environments, because they are associated with very different levels of production risk. In all low rainfall environments, crop production depends on uncertain and highly variable rainfall. However, where crops are grown on residual moisture, the amount of available water is already known at the time of planting, which means that farmers can modify the area planted and technologies used (including use of purchased inputs and crop husbandry). In contrast, where crop production depends on rain falling during the growing season, the amount of available water is not known at the time of planting, and farmers must therefore select technologies based on expectations which may or may not be fulfilled. (For a discussion of how drought stress influences the yield of cereal crops, see the box, p. 5.)

Other, less extensive marginal environments for wheat and barley are found elsewhere in the developing world and feature somewhat different rainfall and temperature patterns. In South America. a significant amount of wheat is sown in areas where little rain falls during the early part of the growing season, although late-season rainfall is often adequate or even excessive. In northeast China, wheat is grown in areas where winters are so severe that only spring wheats can be planted; in many of these areas, rainfall is often light in the early part of the season, and wheat germinates using residual moisture from snow melt. Rainfall during the second half of the crop cycle can be excessive, however.

## Seven Examples of Rainfed Marginal Environments for Wheat

Wheat breeding at CIMMYT is targeted toward particular *mega-environments*, which are defined as "broad, not necessarily contiguous areas, usually international and frequently transcontinental, with similar biotic and abiotic stresses, cropping system requirements, and consumer preferences" (CIMMYT 1989b). Of the seven mega-environments recognized for wheat, three include areas generally considered marginal because of moisture stress. When these three are subdivided according to the rainfall patterns discussed above, seven rainfed marginal environments can be distinguished (Table 1).

To illustrate the similarities and differences between these seven rainfed marginal environments and highlight the severe limiting effect of moisture stress on yields, a representative site was selected for each environment, and the EPIC crop model was used to simulate potential wheat yields over 50 years.[2] Potential yields are defined by moisture and temperature conditions and are not constrained by other abiotic and biotic stresses, such as soil fertility problems,

**Table 1. Types of rainfed marginal environments for wheat**

| Mega-environment | Moisture regime | Temperature regime | Wheat type | Sowing date | Main location |
|---|---|---|---|---|---|
| ME 4A | Rainfall, late drought | Temperate | Spring habit | Autumn | North Africa, West Asia |
| ME 4B | Rainfall, early drought | Temperate | Spring habit | Autumn | South America |
| ME 4C | Residual moisture | Temperate to hot | Spring habit | Autumn | South Asia |
| ME 5B | Residual moisture | Hot (dry) | Spring habit | Autumn | South Asia |
| ME 6B | Growing season rainfall | Moderate cold | Facultative, winter habit | Autumn | West Asia |
| ME 6D | Growing season rainfall | Severe cold | Facultative, winter habit | Autumn | West Asia |
| ME 7 | Growing season rainfall | Severe cold | Spring habit | Spring | Northeast China |

**Source: CIMMYT Wheat Program.**

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[2] For documentation of the EPIC model, see Williams et al. (1990) and Sharpley and Williams (1990).

**Table 2. Simulated potential wheat yields in seven marginal mega-environments (rainfed vs. irrigated)**

| Mega-environment | Representative site | Dominant wheat type(s) | Average potential rainfed yield[a] (t/ha) (CV) | Average potential irrigated yield[a] (t/ha) (CV) | Potential rainfed/ potential irrigated yield |
|---|---|---|---|---|---|
| ME 4A | Kasba Tadla, Morocco | Autumn sown, spring habit | 1.09<br>(44) | 8.17<br>(8) | 0.13 |
| ME 4B | Marcos Juárez, Argentina | Autumn sown, spring habit | 2.21<br>(52) | 10.38<br>(7) | 0.21 |
| ME 4C | Mirzapur, India | Autumn sown, spring habit | 1.11<br>(14) | 6.05<br>(3) | 0.18 |
| ME 5B | Sagar, India | Autumn sown, spring habit | 2.29<br>(25) | 6.72<br>(6) | 0.34 |
| ME 6B | Diyarbakir, Turkey | Autumn sown, facultative | 2.99<br>(27) | 6.07<br>(8) | 0.49 |
| ME 6D | Ankara, Turkey | Autumn sown, winter habit | 2.05<br>(41) | 7.82<br>(4) | 0.26 |
| ME 7 | Harbin, China | Spring sown, spring habit | 3.64<br>(28) | 6.95<br>(12) | 0.52 |

[a] Calculated from EPIC model simulation results (50-year simulation).

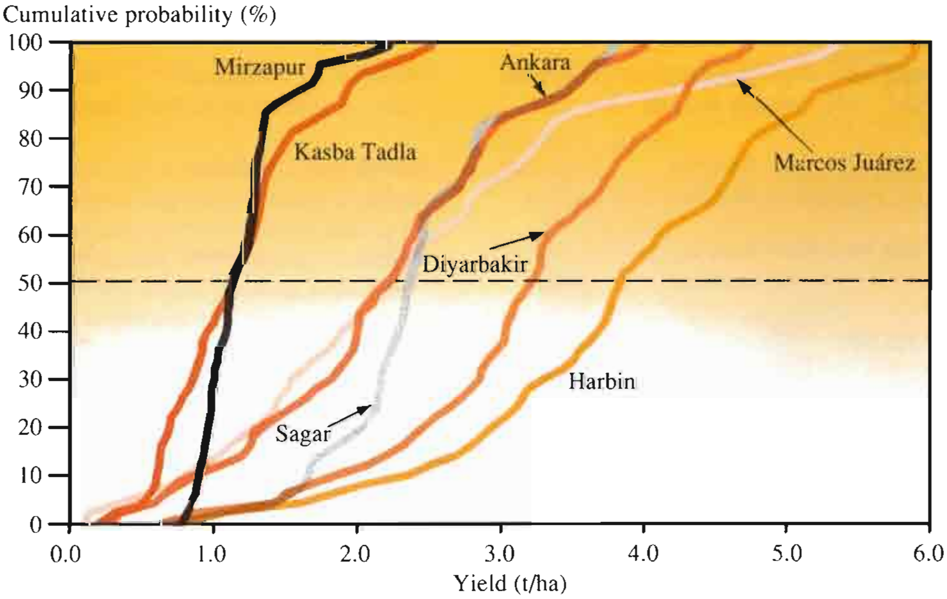

**Figure 2. Cumulative probability distributions for simulated wheat yields in seven rainfed marginal environments.**

diseases, insects, and weeds; thus, simulated potential yields will always be higher than actual recorded yields.[3] To demonstrate the limiting effect of low and uncertain rainfall, the EPIC model was run twice for each site: once under a rainfed production scenario in which the crop received only natural precipitation, and once under an irrigation scenario in which water was added to the soil whenever the crop began to experience moisture stress. Average potential yields and coefficients of variation (CV) for each of these sites under both rainfed and irrigated scenarios appear in Table 2.[4] Cumulative probability distributions of the simulated potential yields under the rainfed scenario appear in Figure 2.

The simulated potential yield data reveal considerable differences between marginal environments, depending among other things on temperatures during the growing season, as well as on the amount and distribution of rainfall. In temperate to hot rainfed mega-environments (4A, 4B, 4C, 5B), average potential yields are generally low, with yield variability higher in climates where the crop depends on rainfall during the growing season (4A, 4B) as compared to climates where the crop is grown on residual moisture (4C, 5B). In cold mega-environments (6B, 6D), average potential yields are roughly correlated with the amount of available moisture; yield variability in these mega-environments likewise is influenced by the distribution of rainfall, showing greater stability where rainfall

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[3] In these simulations, the EPIC model was adjusted for each site to take into account soil type, wheat variety, and local crop rotations.

[4] Following conventional practice, throughout this report the coefficient of variation around trend (CV) is used as a measure of yield variability. It should be noted that the CV is a *relative* measure of variability, not an absolute measure. Thus, a decline in yield variability as indicated by a decrease in CV may result from an increase in the mean yield, from a decrease in the standard error term, or from a combination of the two.

# Factors Affecting Water Use Efficiency

The word "drought" conjures up visions of stunted plants; wilted, rolled, or prematurely withered leaves; and heavily constrained yield components (e.g., low spike numbers, fewer grains per spike, and reduced grain size). While these symptoms are indeed the predictable consequences of severe drought, there exist as well a whole range of less dramatic physiological effects caused by lack of water which can reduce grain yield in cereal crops.

Water is fundamental to crop growth, because $CO_2$ uptake by leaves during photosynthesis is necessarily accompanied by $H_20$ vapor loss through transpiration. In addition to water used by the plant in transpiration, moisture is lost directly from the soil through evaporation — generally about 75-120 mm for typical cereal crops (the exact amount depends largely on rain frequency). Evapotranspiration (ET), the conventional measure of crop water use, is the sum of both types of water loss, i.e., transpiration plus evaporation.

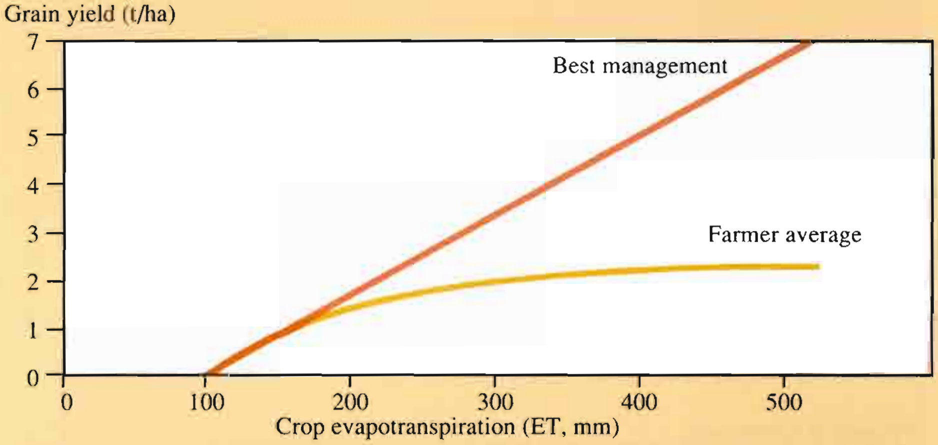
The relationship between ET and grain yield is generally speaking direct and linear, although the mechanisms relating the two are far from simple. The ratio of photosynthesis to transpiration, often referred to as the *transpiration efficiency*, is usually fairly stable for a given crop species (although it is inversely related to the prevailing dryness of the air). A stable transpiration efficiency means that crop dry matter production is more or less directly related to total transpiration and hence, assuming a given amount of evaporation, to ET. Since the ratio of grain yield to total dry matter yield (known as the *harvest index*) also tends to be fairly stable, then the relationship of grain yield to ET is also basically linear. Put simply, for each ton of grain produced, a certain fixed amount of water must be used for ET.

In temperate environments, modern high yielding spring wheat varieties grown without water limitations under excellent management have a (potential) ET of around 500 mm, giving a potential or water-unlimited yield of around 7 t/ha. In drought-prone environments, yield is reduced by lack of water in proportion to the amount by which actual ET falls below potential ET. Farmers' yields are usually well below the ET-determined maximum potential yield because of less-than-perfect crop management.

The performance of a crop in moisture-limited environments is often assessed in terms of water use efficiency (WUE), defined by agronomists as grain yield divided by ET. WUE is influenced by available water supply, defined as total water supply minus losses due to soil evaporation, runoff, and drainage. While the amount of available water is most critical, its distribution relative to the crop cycle can also be important, since yields may fall below the theoretical maximum if water shortage is concentrated sharply around flowering, or if rains come too late in grain filling. In favorable production environments, a crop that uses all potential ET achieves a maximum WUE of around 14 kg/ha/mm (7,000 kg/ha yield divided by 500 mm water).

Average farmers' yields in southern Australia exhibit the expected response of yield to ET, but they also reveal a large effect of crop management on WUE (Cornish and Murray 1989, French and Schultz 1984). WUE is low relative to potential, especially in years of high ET, because of inadequate fertility, poor weed control, poor disease control, poor crop stand, incorrect sowing date, and soil diseases (see Figure). Average WUE (as defined) for the whole of Australia is estimated at around 6 kg/ha/mm (Fischer 1988); WUE levels achieved by farmers in developing countries growing rainfed wheat may be even less.

In an attempt to determine whether progress has been made in breeding for increased WUE, Laing and Fischer (1977) explored the relationship between varieties and water stress, using mean site yield at a large set of rainfed sites as a surrogate for ET amount. Older tall varieties were found to have a lower yield potential of around 4-5 t/ha with unlimited water, and yields fell with reduced ET much as expected. The difference between the older tall varieties and first-generation semidwarfs was that the relative rate at which yields fell with reduced ET was less with the older wheats, presumably due to their drought resistance mechanisms. At severe stress levels (plot yields below 1.5 t/ha), the older varieties actually yielded more than the semidwarfs. For many years, a great deal of controversy surrounded the question as to the exact level of stress at which older varieties began to show their advantage over first-generation semidwarfs. This controversy has now abated, as the second-generation semidwarfs released during the 1980s have clearly moved the MV yield line upwards, apparently at all ET levels. Recent work by Perry and D'Antuono (1989) suggests that MVs now outperform older varieties even under very dry Mediterranean conditions.



**Relationship of grain yield to crop evapotranspiration for spring-habit wheat crops in temperate regions in Australia with best management and with average farmer management.**

is more reliable. Finally, in the high-latitude mega-environment (7), relatively abundant rainfall results in high yield potential compared to the other rainfed mega-environments.

When the results achieved under the rainfed production scenarios are compared with the results achieved under the irrigation scenarios, striking differences emerge. Under simulated natural precipitation, at most of the sites drought stress depresses potential yields to less than half the potential determined by available solar radiation (as revealed by the irrigated simulation runs).[5] In addition, yield variability under irrigation as measured by the CV is very low, confirming that moisture stress is the major factor accounting for high yield variability in these environments (any remaining variability in yields is due to year-to-year temperature fluctuations).

While simulated potential yields do not reflect yields actually achieved by farmers, the simulation results are useful in that they graphically display the large influence of a single climatic factor (moisture) in determining yield potential and variability across a set of representative rainfed sites. (A historical analysis of yield variability in marginal environments is presented in the box, p. 8).

## Extent of Rainfed Marginal Environments in the Developing World

Approximately one-quarter of the area planted to bread wheat in developing countries and nearly three-quarters of the area planted to durum wheat is located in rainfed marginal environments (Table 3).[6] Because of low yields, these environments account for a less-than-proportional (but still significant) amount of total production; rainfed marginal environments produce about 16% of the bread wheat and 53% of the durum wheat grown in the developing world. (Because much more bread wheat is produced in the world than durum wheat, these percentages are somewhat misleading. Even though a relatively small proportion of bread wheat is grown in marginal environments, the total amount of bread wheat produced in marginal environments is still over four times as large as the amount of durum wheat produced in marginal environments.) Similar data are not

**Table 3. Wheat production in rainfed marginal mega-environments in developing countries, mid-1980s**

| Mega-environment | | Bread wheat<br>Area (mill ha) | Bread wheat<br>Yield (t/ha) | Bread wheat<br>Production (mill t) | Durum wheat<br>Area (mill ha) | Durum wheat<br>Yield (t/ha) | Durum wheat<br>Production (mill t) |
|---|---|---|---|---|---|---|---|
| ME 4A | Low rainfall, temperate, late drought | 5.40 | 0.83 | 4.50 | 4.70 | 0.94 | 4.41 |
| ME 4B | Low rainfall, temperate, early drought | 3.15 | 1.27 | 4.00 | 0 | — | 0 |
| ME 4C | Low rainfall, temperate, residual moisture | 4.34 | 1.09 | 4.75 | 0 | — | 0 |
| ME 5B | Low rainfall, hot, residual moisture | 3.17 | 0.90 | 2.84 | 1.49 | 0.81 | 1.20 |
| ME 6B | Low rainfall, moderate cold | 4.48 | 0.88 | 3.92 | 0 | — | 0 |
| ME 6D | Low rainfall, severe cold | 5.91 | 1.48 | 8.73 | 1.21 | 1.40 | 1.69 |
| ME 7 | Variable rainfall, severe cold | 0.99 | 1.51 | 1.49 | 0 | — | 0 |
| **Developing country total** | | **28.46** | **1.09** | **31.04** | **7.46** | **0.98** | **7.35** |
| **Percent of developing country total or average** | | **(32%)** | **(50%)** | **(16%)** | **(72%)** | **(74%)** | **(53%)** |

Source: CIMMYT mega-environments database.

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[5] Strictly speaking, two of the sites may not be truly marginal, since the ratio of rainfed to irrigated potential yields exceeds 40%. However, the sites which clearly conform to the 40% criterion are located in the mega-environments on which this report focuses.

[6] The data on wheat production in marginal environments presented in Tables 3 and 4 are based on subjective estimates made during the mid-1980s by knowledgeable wheat scientists from national agricultural research programs and CIMMYT. While the estimates are believed to be reasonably accurate, occasionally they differ from published government statistics or FAO production data (on which all subsequent analysis contained in this report is based). The estimates are nevertheless reproduced here because they represent the only comprehensive set of production data disaggregated by mega-environment.

available for barley, but the proportion of barley area located in rainfed marginal environments is undoubtedly even higher, since barley is considered the more drought-resistant of the two crops and is frequently planted in drier production zones.[7]

Table 4 presents additional data on the area sown to wheat in low rainfall zones, broken down by region. Although rainfed marginal environments are widely distributed throughout the developing world, it can be seen that wheat production in these environments is concentrated in the WANA Region and South Asia.

## Production Trends in Rainfed Marginal Environments

Evidence of divergent rates of progress between favorable and marginal production environments exists at several levels. When a broad distinction is made between developing countries in which most wheat is grown under well-watered conditions and developing countries in which most wheat is grown under low rainfall, it becomes apparent that wheat area and yields in the low rainfall group of countries have grown at only half the rates recorded in the well-watered group (Figure 3).

Similar discrepancies are apparent within individual countries. Perhaps the most detailed picture of production trends in favorable vs. marginal environments is available for India, where the past three decades have seen a dramatic shift in wheat production from rainfed to irrigated areas (Figure 4). Between 1961-65 and 1984-86, rainfed wheat area in India declined from about 9 million hectares to 6 million hectares, while irrigated wheat area rose from 4 million hectares to 17 million hectares. Hence the conventional wisdom that crop cultivation is expanding into

**Table 4. Area planted to wheat in low rainfall zones of selected developing countries, mid-1980s**

| | Low rainfall bread wheat area (000 ha) | As percent of total bread wheat area in region | Low rainfall durum area (000 ha) | As percent of total durum area in region |
|---|---|---|---|---|
| West Asia/North Africa | 12,464 | 63 | 5,913 | 74 |
| South Asia | 6,785 | 23 | 1,500 | 94 |
| East Asia | 4,730 | 16 | 0 | 0 |
| South America | 3,225 | 38 | 0 | 0 |
| **Developing country total** | **28,459** | **32** | **7,463** | **72** |

Source: CIMMYT mega-environments database.

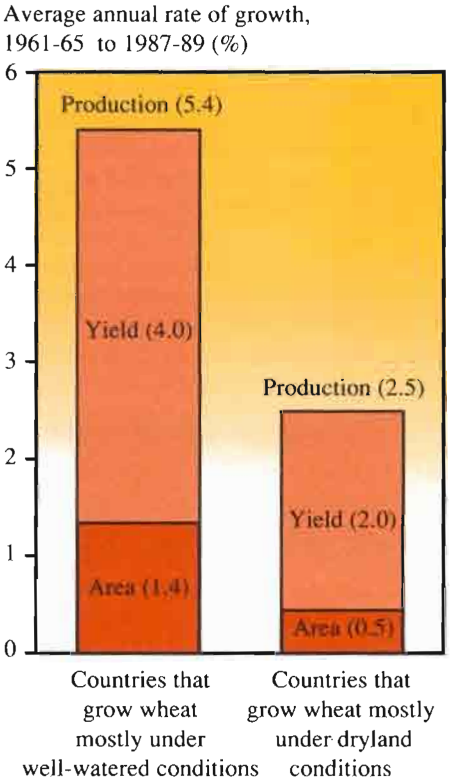

**Figure 3. Growth of wheat area and yields in two groups of developing countries distinguished by moisture regime, 1961-65 to 1987-89.**

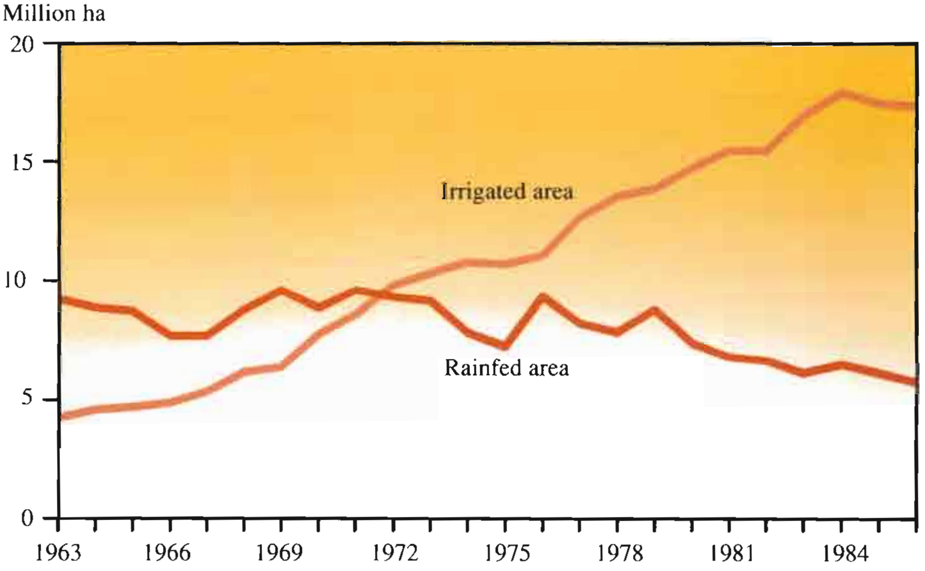

**Figure 4. Trends in rainfed and irrigated wheat area in India, 1963-86.**

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[7] However, in several major barley producing countries such as Turkey, Tunisia, and India, over half of all barley is produced in irrigated or high rainfall zones.

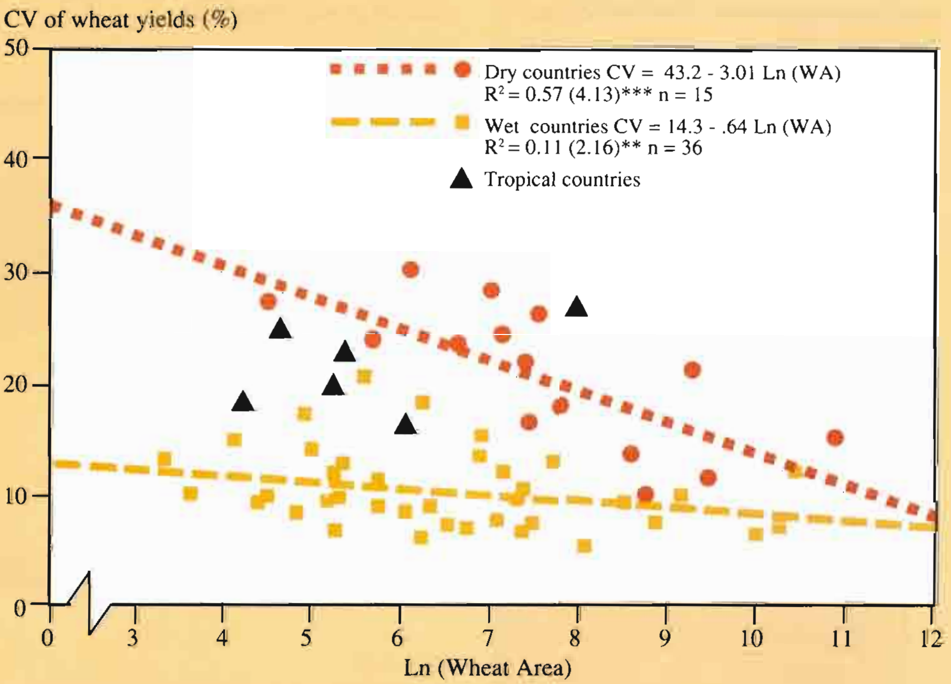
# Variability in Wheat Yields in Marginal Environments

In low rainfall environments, wheat yields are not only low, but they tend to be highly variable. Variability in yields is of concern both at the farm level (since farmers seek stability in food production and income), as well as at the national level (since national food security is a major goal of policy makers).

Singh and Byerlee (1990) recently analyzed wheat yield variability in 57 countries over 35 years (1951-86). Yield variability was measured by calculating coefficients of variation (CV) of yields around linear trend. Singh and Byerlee concluded that rainfall is the predominant factor influencing yield variability: countries in which at least half the wheat area is sown in dryland conditions experience twice as much yield variability as countries in which wheat is mostly grown under well-watered conditions (see Figure). The relationship is particularly strong in small countries; in large countries, drought in one region may be offset by average or above-average rainfall in another region, leading to lower overall yield variability (see Figure). Yield variability also tends to be higher in warmer, subtropical countries because of heat stress. Size of national wheat area, percentage of national wheat area subject to moisture stress, and location of the country in the warmer tropics explain over two-thirds of the variation in CVs of yields across countries. Significantly, and somewhat surprisingly, technological variables such as use of MVs and fertilizer explained none of the variation in CVs.

Not all rainfed marginal environments are characterized by high yield variability. In the residual moisture environment of central and southern India, wheat yields are generally quite stable; in fact, yields in this environment are no more unstable than in adjacent irrigated areas where irrigation water supplies tend to be unreliable (Byerlee 1991). However, among countries in the WANA Region the variability in cereal production (mostly wheat) averages 25-30%, two to three times higher than in most of Asia and Latin America. The high production variability in the WANA Region poses special challenges to policy makers charged with managing national food supplies.

Singh and Byerlee also analyzed changes over time in wheat yield variability in order to evaluate the claim that yields have become more unstable as a result of widespread adoption of Green Revolution technologies, particularly input-responsive MVs. In the case of wheat, no evidence was found to support this hypothesis. Indeed, in the irrigated and well-watered production zones where the Green Revolution had its greatest impact, yield variability has declined sharply in recent years, especially in the Indian Punjab (see Table). Even in dryland areas, wheat yield variability seems to have declined slightly during the most recent decade, the period when seed-fertilizer technology began to spread into more marginal environments. These findings confirm that yield risk is higher in marginal areas, but they do not support the assertion that this risk is exacerbated by the use of improved technology.



**Relationship between coefficient of variation (CV) of wheat yields and wheat area (WA) by climatic regime, 1966-86.**

**Changes in the variability of wheat yields in selected groups of countries, 1951-86**

| | Number of countries | Coefficient of variation around trend (%) 1951-65 | 1966-75 | 1976-86 | Percent change in CV, 1951-65 to 1976-86 |
|---|---|---|---|---|---|
| Irrigated and well-watered temperate | 36 | 10.6 | 8.5 | 6.4 | - 38 |
| Dryland temperate | 15 | 16.2 | 15.2 | 14.4 | - 9 |
| Tropical | 6 | 22.6 | 23.6 | 18.9 | - 16 |
| All countries | 57 | 13.3 | 11.8 | 10.1 | - 23 |
| Indian Punjab | 1 | 18.9 | 12.6 | 6.2 | - 67 |

marginal areas is certainly not valid for wheat in India; on the contrary, as rainfed production zones have been converted to irrigation, the proportion of dryland wheat area has declined from 67% to 25%.

An examination of yield trends in India helps explain the increasing concentration of production in irrigated zones (Figure 5). Wheat yields in irrigated areas averaged 2.2 t/ha in 1985, more than double the 0.9 t/ha achieved in rainfed areas. Significantly, the difference between yields of irrigated and rainfed wheat has been widening; from 1972 to 1985, yields of irrigated wheat grew at an average annual rate of 2.8%, compared to only 1.4% for yields of rainfed wheat. This combination of a declining proportion of rainfed area and a higher growth rate in yields of irrigated wheat has caused the share of rainfed wheat production to fall sharply in India, from around 50% in 1960 to 15% in 1986.

Production data from a number of WANA countries provide further evidence that progress has been slower in dryland areas. For example, cereal yields in irrigated areas of Syria have grown at more than double the rate of yields in rainfed areas (Table 5). Farmers in Syria have responded to the more difficult production conditions in rainfed areas by planting less wheat and more barley. The decrease in rainfed wheat area has been accompanied by a steady expansion in irrigated wheat area, primarily through the installation of tubewells. As a result of these yield and area trends, the percentage of total wheat production grown under irrigated conditions increased from around 15% in the late 1960s to over 40% by the late 1980s (Figure 6). Similar trends leading to the concentration of wheat production in higher rainfall regions are evident elsewhere in the WANA Region, including Morocco and Tunisia (Belaid and Morris 1991).

The picture is slightly different in Turkey, the country with the largest wheat and barley areas in the WANA Region. Wheat and barley production in

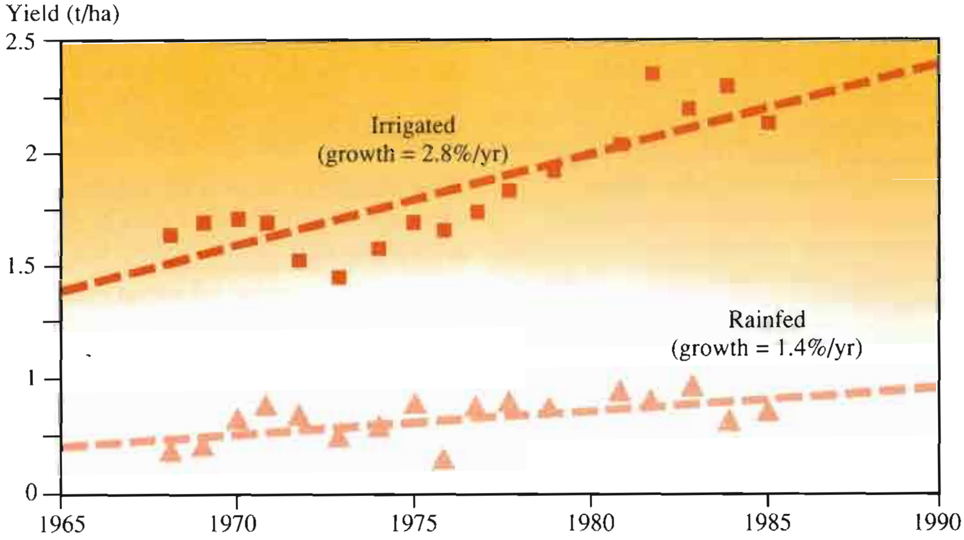


**Figure 5. Trends in rainfed and irrigated wheat yields in India, 1968-86.**

**Table 5. Cereal production data for Syria by moisture regime, 1968-87**

| | Area and yield | | Growth rates | | | |
|---|---|---|---|---|---|---|
| | | | Wheat | | Barley | |
| | Wheat 1985-87 | Barley 1985-87 | 1968-70 to 1978-80 | 1978-80 to 1985-87 | 1968-70 to 1978-80 | 1978-80 to 1985-87 |
| **Area** | (000 ha) | | (%/yr) | | | |
| Rainfed | 946 | 1,490 | 2.0 | -4.0 | 3.5 | 3.9 |
| Irrigated | 236 | 12 | 8.5 | 3.8 | 0.5 | -3.4 |
| **Yield** | (t/ha) | | (%/yr) | | | |
| Rainfed | 1.12 | 0.53 | 4.9 | 1.4 | 1.6 | -4.7 |
| Irrigated | 3.07 | 1.85 | 7.9 | 3.0 | 5.2 | 0.9 |

Source: Calculated from data provided by the Syrian Ministry of Agriculture (1989).

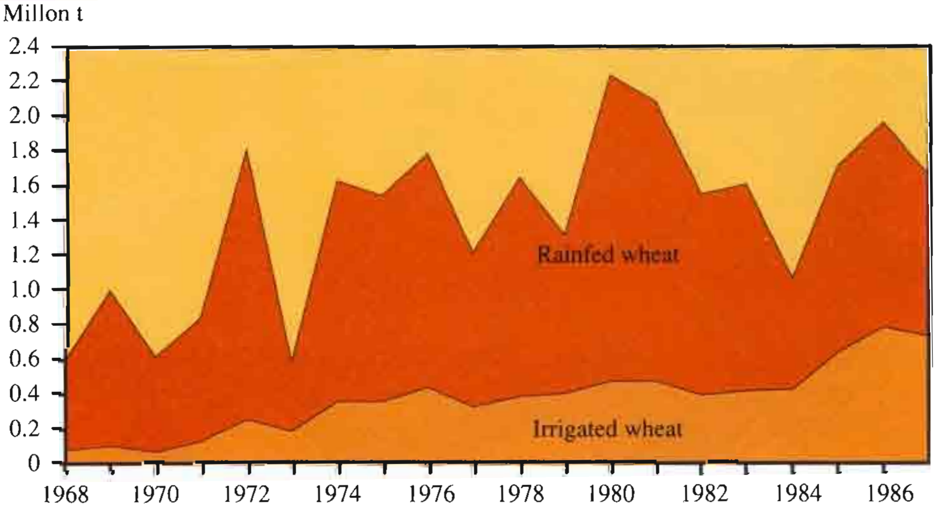


**Figure 6. Production of rainfed and irrigated wheat in Syria, 1968-87.**

Turkey are distributed across both favored areas (e.g., the well-watered temperate zones along the Mediterranean coast and in Thrace) and marginal areas (e.g., the dry, cold Anatolian Plateau) (Figure 7). High yielding semidwarf spring wheat varieties and fertilizer were adopted rapidly in the favored areas beginning in the mid-1960s (Demir 1976), leading to dramatic increases in wheat yields throughout these environments (Table 6). Although MVs were not adopted nearly as rapidly in the marginal production zones of Central Anatolia, significant progress nevertheless was achieved in raising yields through improvements in crop management, including improved tillage practices, increased fertilizer use, and better weed control.

Evidence from a number of countries thus appears to confirm the widespread perception that the rate of growth in wheat yields achieved in rainfed marginal environments has not kept pace with that achieved in favored environments (including irrigated areas). Farmers have responded by increasing the area planted to wheat in favored zones and by concentrating relatively more production in these zones.

In an attempt to uncover the reasons for these apparent differential rates of yield growth, the next two sections of this report examine in some detail the experiences of two regions containing extensive dryland wheat and barley production zones—the WANA Region (a winter rainfall environment), and central and southern India and parts of Pakistan (a residual moisture environment).

**Table 6. Historical growth in wheat yields in four production zones of Turkey, 1967-87**

| | Average wheat yield (t/ha) | | | Annual growth in yield (%) | |
|---|---|---|---|---|---|
| **Production zone**[a] | **1965-69** | **1974-78** | **1983-87** | **1967-76** | **1976-85** |
| **Favored environments** | | | | | |
| Mediterranean Coast | 1.68 | 2.71 | 3.28 | 5.3 | 2.1 |
| Thrace | 1.23 | 2.80 | 2.96 | 9.2 | 0.6 |
| **Marginal environments** | | | | | |
| Central Anatolia | 1.24 | 1.69 | 1.98 | 3.5 | 1.7 |
| Eastern Anatolia | 0.88 | 1.01 | 1.15 | 1.6 | 1.5 |

[a] Based on data from the following provinces: Adana, Hatay (Mediterranean Coast); Edirne, Kirklareli, Tekirdag (Thrace); Ankara, Eskesehir (Central Anatolia); Artvin, Kars, Erzurum, Agri, Mus, Bitlis, Siirt, Hakkari, Van (Eastern Anatolia).

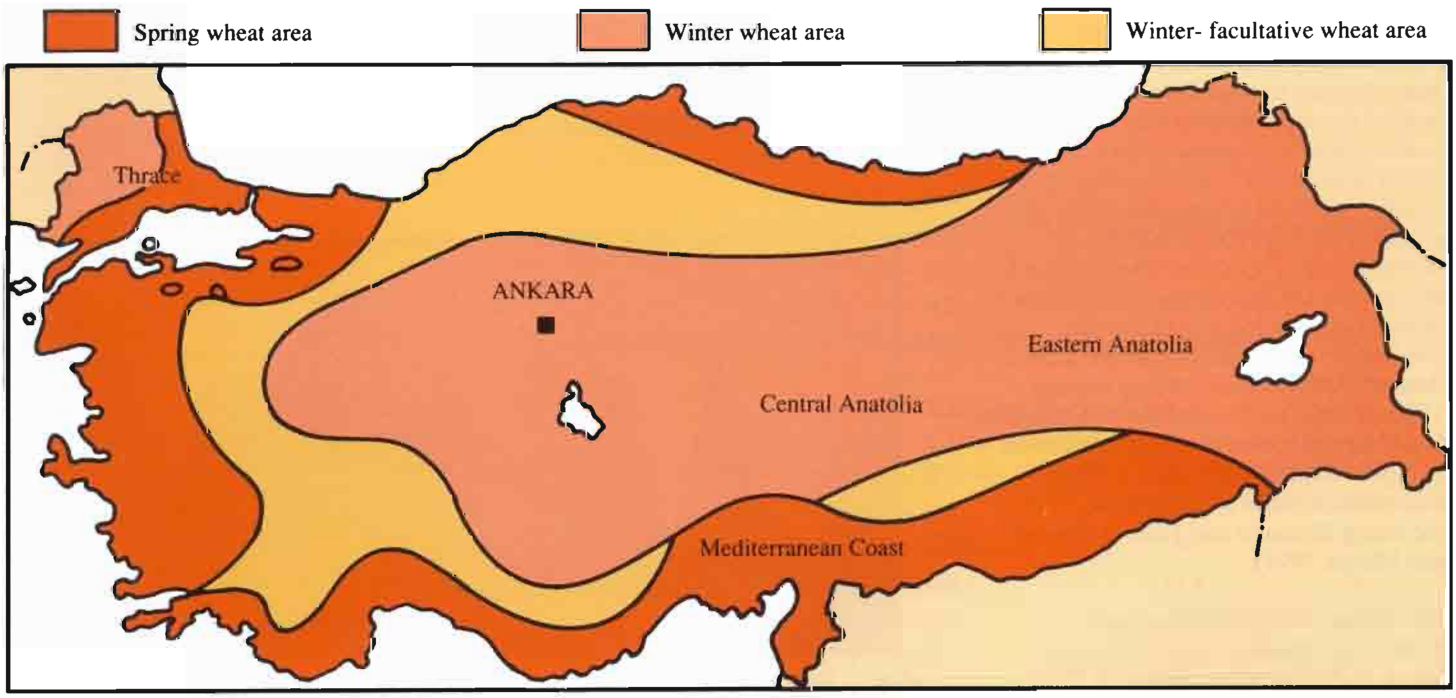


Figure 7. Wheat production zones in Turkey.

## Rainfed Marginal Environments of West Asia and North Africa[8]

By far the greatest concentration of dryland wheat and barley production in the developing world is found in the WANA Region, where approximately 25 million hectares are planted to wheat, of which only about 20% is irrigated (mostly in Egypt and Saudi Arabia). Of the rest, nearly three-quarters is located in areas receiving less than 500 mm annual rainfall. An additional 12 million hectares are planted to barley in the WANA Region, of which an even higher proportion is located in low rainfall zones.

### Types of Farming Systems in the WANA Region

A broad overview of the rainfed agricultural systems of WANA, ignoring local variations imposed by topography, shows a transition from crop cultivation in wetter areas to livestock-based systems in drier areas. In general, coastal areas are wettest and support intensive horticulture and agriculture. Rainfall declines with increased distance from the coast, so that moving inland one first encounters rainfed systems dominated by wheat and then systems dominated by barley. Where annual rainfall drops below 200 mm, rainfed farmland gives way to large expanses of steppe that provide grazing for nomadic or transhumant flocks of small ruminants. Deserts predominate in the interior of the region, where only irrigated agriculture is possible (Figure 8).

Rainfall in the dryland wheat and barley zones of the WANA Region is not only low but highly variable. In addition to varying from year to year, rainfall also varies through space; steep gradients in precipitation frequently occur across short distances, with changes sometimes as large as 3-4 mm/km. This marked spatial and temporal variability in rainfall, and the corresponding variability in potential growing season, is the most important factor contributing to risk and uncertainty in rainfed crop production.

Like rainfall, temperatures also fluctuate considerably from year to year in the WANA Region, causing the length of the growing season to vary by as much as to three to four weeks at any given location (Cooper and Bailey 1990). Given the sharp increase in evaporative demand due to a rapid rise in temperatures in spring and early summer, wheat and barley crops are usually stressed during grain set and grain filling.

In higher rainfall areas of the WANA Region (350-600 mm average annual rainfall), the main crop is usually wheat. Both bread wheat and durum wheat are grown, with the proportion between the two determined partly by climatic factors and partly by utilization patterns. Bread wheat tends to predominate at the wetter end of the rainfall spectrum, while durum wheat tends to predominate at the drier end.

Throughout much of the WANA Region, a fallow-wheat rotation was traditionally widespread, but in wetter areas and on better soils wheat is increasingly being

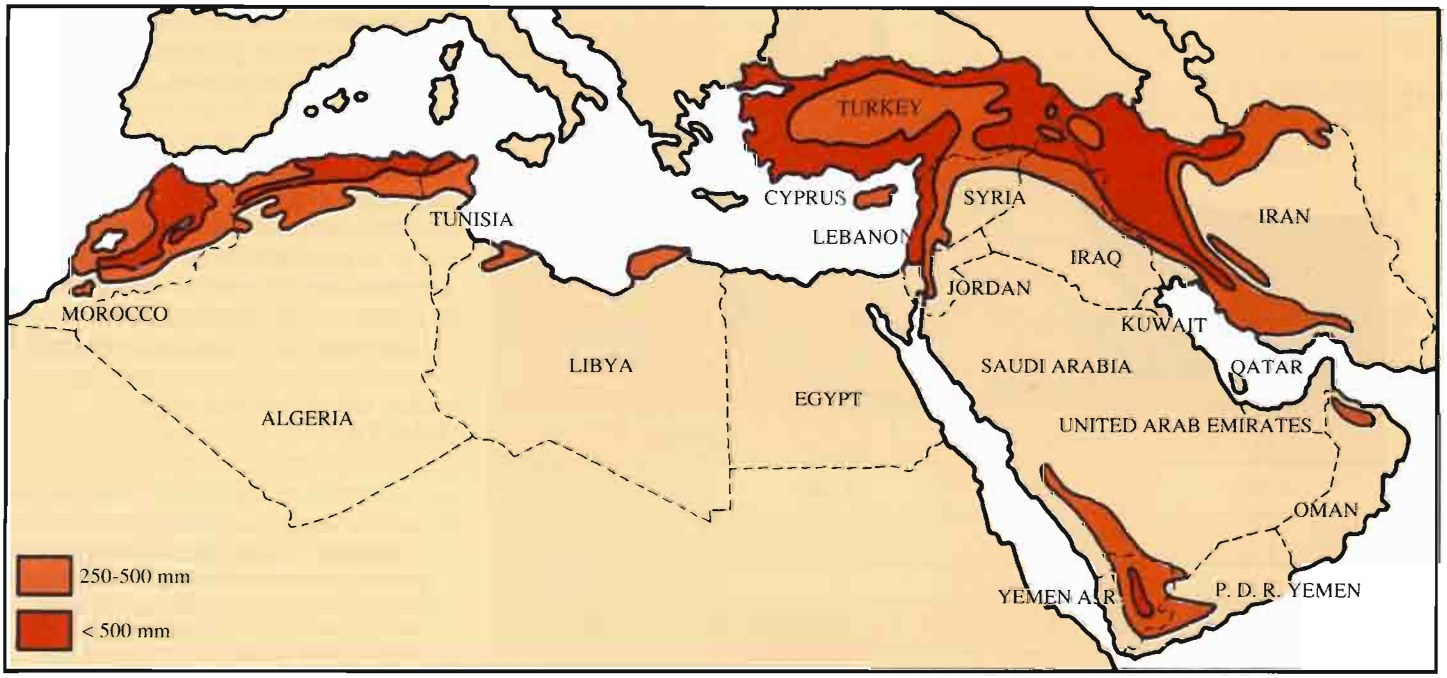


**Figure 8. Distribution of rainfed marginal environments, defined by precipitation, in the WANA Region.**

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[8] This section draws on Belaid and Morris (1991).

grown in two- or three-crop rotations with food or feed legumes and summer crops such as melon, maize, sesame, sunflower, and cotton. Since most wheat farmers own both sheep and cattle, they also grow some barley, using the grain and straw for feed, together with other crop residues such as wheat and legume stubble.

At the drier end of the rainfall spectrum, on land adjacent to the dry steppe (200-350 mm average annual rainfall), livestock production is the dominant enterprise, providing most of the income of farm families. Animal production (principally sheep and goats) is based on annually sown feed crops, notably barley, with both grain and straw used as livestock feed. In some years barley may be lightly grazed as a spring pasture, but its main purpose is to provide grain and straw for winter feeding. Since barley is the most important source of feed, farmers attempt to sow at least enough area to be self-sufficient.

Because of the production risks inherent in the environment, barley production in these drier areas is frequently based on minimum-input technologies. Throughout the region, a barley/fallow rotation predominates, although fallow management practices vary considerably. In some areas farmers cultivate fallow land to reduce weeds, increase water infiltration, and maximize moisture storage. Elsewhere, a more common practice is to leave fallows uncultivated (weedy fallow), since weeds and volunteer crops provide a valuable source of livestock feed. However, as demand for livestock feed rises, fallow is increasingly regarded as an inefficient use of land, and continuous barley production is becoming more common.

The important role played by livestock in the farming systems of WANA countries directly influences the crop production strategies of most cereal farmers, particularly in drier areas where barley/livestock systems predominate. In these areas, the largest share of agricultural income (i.e., excluding income from off-farm employment) typically is derived not from crops, but rather from animals and animal products, including milk, cheese, and yoghurt. Studies in the dry rainfed zones of Syria and Algeria, for example, indicate that the sheep enterprise alone provides up to 82% (Thomson, Bahhady, and Nordblom 1982) and 77% (Boutonnet 1989) of agricultural income, respectively.[9]

In addition to being an important source of income, livestock act as a financial buffer against yearly fluctuations in crop production caused by rainfall variability. In drought years when crops are poor and harvesting would be uneconomic, farmers graze animals on their crops and also may reduce their flocks through sales, thereby generating income and at the same time reducing feed requirements in the following winter when stored barley grain and straw will be in short supply because of the poor harvest.

The straw of cereal crops, particularly barley, is one of the most important feedstuffs, utilized either as grazing *in situ* or as a component of supplementary diets in winter (Figure 9). In drier areas, particularly in dry years when the harvest index is low, the total economic value of cereal and legume straw per hectare can exceed that of grain (Table 7).

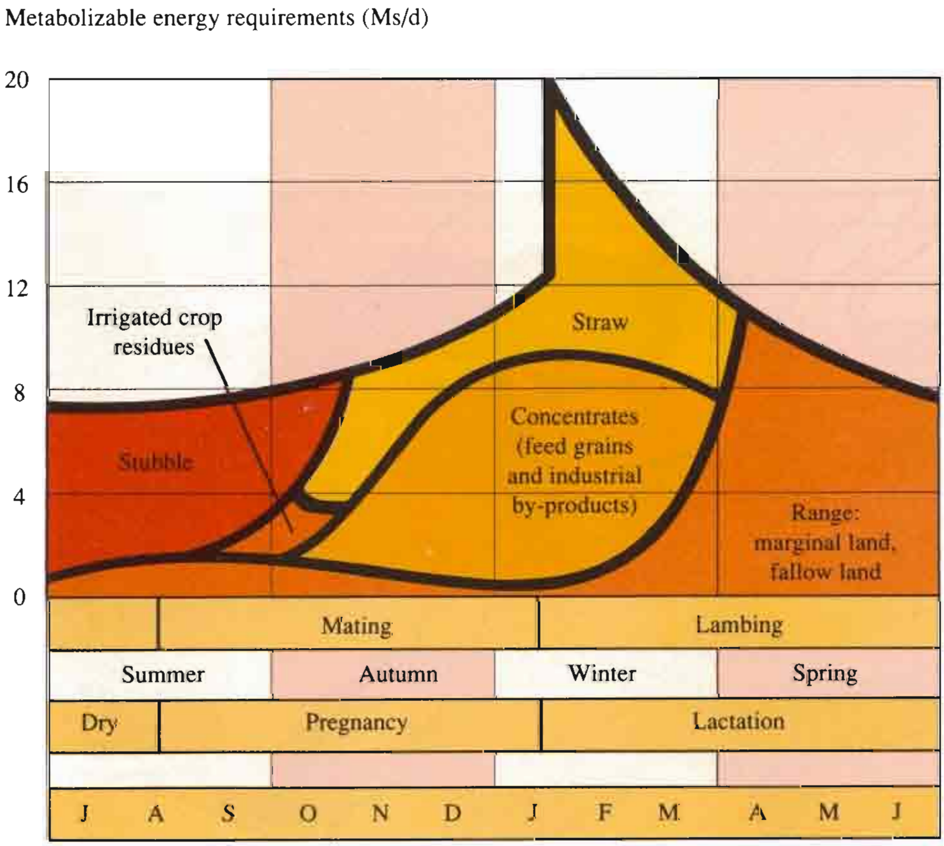

**Figure 9. Livestock feeding cycle in the WANA Region.**
Source: Cocks and Thomson (1988).

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[9] In both of these studies, the value of feed crops produced for use on the farm as an input into the livestock enterprise was not taken into account; therefore, the economic importance of cereals was understated. Nevertheless, even when the value of cereals produced for feed use on the farm is included, the sheep enterprise clearly remains of major importance.

The integration of barley and livestock management is crucial to the survival of many farmers in dry areas. Few crop decisions are made without considering the feed requirements of livestock, and few livestock decisions are made without considering feed availability (Thomson, Bahhady, and Nordblom 1982). Strategies for improving crop production, such as better fallow management, weed control through herbicide use, or the introduction of new varieties, must take account of these interactions with livestock production and not jeopardize vital sources of feed.

## Use of Improved Technology

***Varietal development and diffusion—*** Throughout most of the WANA Region, adoption of modern varieties (MVs) has proceeded much more slowly than in South Asia, where in countries such as India and Pakistan over 60% of the wheat area was already sown to MVs in 1975, rising to about 90% by 1990. In the WANA Region the area sown to MVs was estimated at 17% in 1976-77, rising to an estimated 42% by 1985-86 (Dalrymple 1978, CIMMYT 1989c). Although few comprehensive adoption studies have been undertaken in recent years, available evidence suggests that MVs have been adopted quite extensively in favored environments and much less extensively in marginal environments. For example, in 1989 less than 7% of low rainfall wheat area in Syria was sown to MVs, compared to nearly 57% of high rainfall and irrigated area (Syria Ministry of Agriculture, unpublished data). Similarly, in 1983 only 1% of the low rainfall area in Tunisia was planted to modern durum wheats, compared to 58% of the high rainfall area (Johnson, Ferguson, and Fikry 1983).

Broadly speaking, in the WANA Region use of MVs is highest for spring bread wheats, followed by spring durums, winter bread wheats, and facultative bread wheats. Adoption of improved winter durums, facultative durums, and barley has been less common. This pattern, which roughly corresponds to past availability of MVs, not coincidentally also reflects the rainfall gradients under which these different cereal types grow. Spring bread wheats are grown in the wettest areas, followed by spring durums and winter bread wheats. Winter durums and barley are grown in the driest areas.

Differences in adoption patterns according to wheat type and rainfall regime also have been evident in Turkey. Spring bread wheats moved rapidly into the well-watered coastal zones of Turkey, and by the mid-1970s, less than 10 years after improved varieties first appeared in the country, the majority of farmers in these zones had adopted them. Meanwhile, adoption rates in the marginal production environments of Central Anatolia, where winter bread wheats and durum wheats are grown, remained extremely low.

The pattern of adoption of MVs in Turkey is consistent with the number of varietal releases coming out of the national breeding program. Turkish breeders, working with colleagues from international research institutes, have been very successful in breeding varieties for favorable production environments, as evidenced by the high proportion of spring wheats released for these environments. Less success has been achieved in breeding for rainfed marginal environments, where winter (and facultative) durum and bread wheat production is concentrated. During the 1980s, for example, only a small proportion (10%) of the varieties released were winter wheats specifically targeted for the rainfed areas.

To some observers, the fact that MVs have diffused relatively slowly into low rainfall areas is puzzling. Even though many breeding programs in the WANA Region have been slow in releasing varieties recommended specifically for marginal areas, most of the materials developed for favorable production conditions offer a yield advantage in all but the harshest environments, even when grown under low rainfall conditions. Thus, it seems odd that farmers in low rainfall zones have been slow in adopting MVs. One possible explanation is that the yield gains achieved from adopting improved germplasm alone tend to be modest in drier areas, and frequently the extra yield may not be enough to offset price premiums commanded by traditional varieties. However, since crop and soil management practices that conserve moisture interact positively with the higher yield potential of MVs, continuing improvements in crop management practices can be expected to further stimulate the adoption of MVs.

If improved wheat varieties are now available that offer limited yield gains in rainfed areas, improved barley varieties

**Table 7. Relative value of wheat grain and straw under different levels of rainfall in Baluchistan, Pakistan, 1985-88**

| | Poor year | Average year | Good year |
|---|---|---|---|
| Grain yield (kg/ha) | 16 | 146 | 412 |
| Straw yield (kg/ha) | 134 | 335 | 1,115 |
| Grain price (Rs/kg) | 2.0 | 2.0 | 2.0 |
| Straw price (Rs/kg) | 1.0 | 0.5 | 0.6 |
| Gross benefits (Rs/kg) | 166 | 460 | 1,493 |
| Percent of gross benefits from straw | 81 | 38 | 45 |

Source: Rees et al. (1991).

that yield more than local materials are still not common, especially in drier areas. In a series of multilocational yield trials in Syria, Cooper (1985) found that most improved barley varieties did not perform significantly better than the local check. More recently, however, as national barley breeding programs have begun to mature, improved barley materials have been developed which perform well even under extremely dry conditions (for example, the improved variety Rihane tested and selected in Tunisia) (INRAT, unpublished data).

***Improved management practices and inputs***— In the WANA Region, aggregate **fertilizer** consumption has expanded considerably during the past two decades, apparently paralleling the adoption of MVs. The experience of Tunisia typifies this pattern: fertilizer use on wheat in Tunisia doubled from 20 kg nutrient/ha in 1970 to 40 kg nutrient/ha in 1980. Over the whole region, farmers now apply an average of 40-50 kg nutrient/ha to wheat (CIMMYT 1989c), although fertilizer use on barley remains negligible. As expected, fertilizer is used more extensively in the irrigated and well-watered rainfed areas where MVs are concentrated and where crop response is highest. In these areas, fertilizer application rates often exceed 100 kg nutrient/ha. Less fertilizer is applied in drier zones where barley predominates, on shallower soils, or when a legume crop precedes the cereal crop in the rotation (Kukula and Dakermanji 1986, Belaid and Morris 1991). In areas receiving less than 350 mm rainfall, only a small percentage of farmers use fertilizer.

Many countries in the WANA Region once provided price incentives for using fertilizer, either by directly subsidizing fertilizer or by introducing favorable prices for cereals. The effects of these policies are evident in the low nitrogen-to-grain price ratios prevailing in many WANA countries, which are generally below those found in other major wheat producing countries (Table 8). Nonetheless, recent policy reforms may have adversely affected overall fertilizer use in the WANA Region by raising fertilizer prices.

Extensive research on fertilizer use in dryland production zones of the WANA Region has led to the conclusion that yields of wheat and barley grown under rainfed conditions can be considerably improved by using nitrogenous and phosphorous fertilizers (for example, see Bolton 1979, 1981; Harmsen 1984; Jones, Matar, and Pala 1988; ICARDA 1989a, 1989b; Mazid 1990). Moreover, fertilizer can substantially enhance the efficiency of moisture use. In one extensive series of on-farm experiments in dry areas of Syria, yields of fertilized barley plots (measured in yield per unit of growing season rainfall) were three times that of unfertilized plots (Figure 10).

However, crops do not benefit automatically from fertilizer applications, because response to fertilizer in dryland environments varies substantially through time and space as a result of variability in climatic conditions. The amount and temporal distribution of rainfall is the dominant influence on crop response to fertilizer, especially to nitrogen. On average, at prevailing low fertilization levels of 40-50 kg/ha of nutrient, a 100-mm increase in rainfall increases the grain-to-nitrogen response ratio by about five (Somel, Mazid, and Hallajian 1984).[10]

Given the strength of this relationship, rainfall variability greatly augments the risk of using fertilizer in dryland production zones. Many farmers attempt to protect against this risk by applying split applications of nitrogen. By varying the number and level of fertilizer applications according to rainfall during the course of the growing season, farmers fine-tune doses depending on the perceived crop potential for that particular year. However, the strategy is not completely foolproof, and yields may be reduced by excessive nitrogen if rainfall at the end of the season turns out to be inadequate.

Response to fertilizer is influenced by a large set of interacting agroclimatic, soil, and management factors, many of which are beyond the control of the farmer. For practical purposes, the important question is whether or not it is profitable

**Table 8. Nitrogen-to-wheat price ratios in selected countries, 1989-90**

| Country | Farm level nitrogen price (US$/t) | Farm level wheat price (US$/t) | Nitrogen-to-wheat price ratio |
|---|---|---|---|
| Afghanistan | 216 | 180 | 1.2 |
| Algeria | 360 | 394 | 0.9 |
| Syria | 989 | 664 | 1.5 |
| Turkey | 337 | 208 | 1.6 |
| India | 305 | 203[a] | 1.5 |
| Pakistan | 330 | 110 | 3.0 |
| Argentina | 559 | 74 | 7.6 |
| Brazil | 680 | 152 | 4.5 |
| Mexico | 306 | 180 | 1.7 |
| Australia | 562 | 104 | 5.4 |
| Canada | 530 | 100 | 5.3 |
| USA | 413 | 96 | 4.3 |

Source: CIMMYT survey.
[a] Price in dryland central India.

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[10] A similar response can be observed in the Mediterranean-type dryland environments of Australia (Byerlee and Winkelmann 1980).

to use fertilizer in low rainfall zones. Economic analysis of the extensive Syrian data set generated by ICARDA and the Syrian Soils Directorate led to the conclusion that using nitrogenous fertilizer on wheat tends to be profitable only under certain conditions, such as when application levels are modest (40-80 kg N/ha) and the land is continuously cropped. Likewise in the dryland Settat area of Morocco, results from on-farm trials indicate that the profitability of fertilizer use varies as a function of rainfall, crop rotation, and soil type. Depending on the minimum acceptable rate of return on fertilizer required by the farmer (itself a function of the farmer's risk preference), investment in fertilizer might or might not be considered attractive.

These results from Syria and Morocco illustrate the difficulty of translating experimental data on crop response to fertilizer into blanket recommendations for farmers in marginal areas. Based on economic analysis, investment in a modest level of nitrogenous fertilizer would appear to be wise under a wide range of rainfall outcomes for farmers engaged in continuous cereal cropping, but the returns to fertilizer use become far less certain when cereal crops are grown after a legume crop or after fallow. Because the profitability of fertilizer thus depends on a number of interrelated factors, efforts to promote fertilizer use must concentrate on informing farmers about the complex nature of fertilizer response functions and letting them decide for themselves what practice to adopt in light of their own attitudes toward risk.

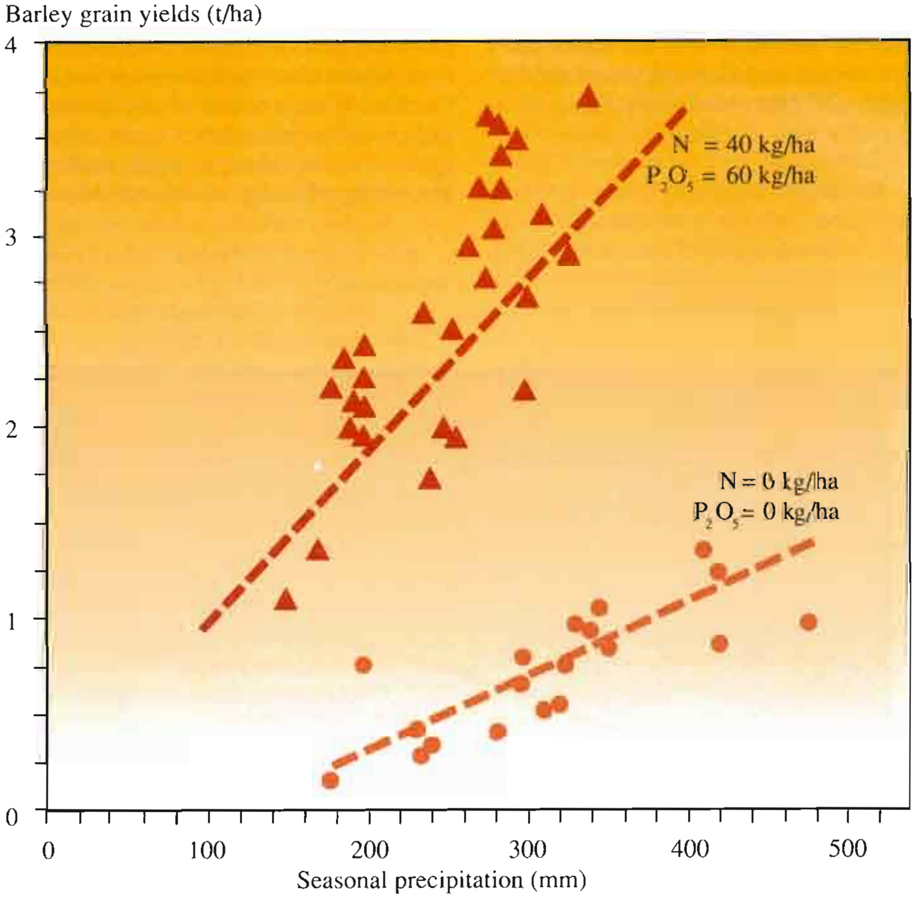

**Figure 10. Relationship between barley grain yield and seasonal precipitation under two levels of fertilizer, northern Syria, mid-1980s.**
Source: Cooper et al. (1988).

Mechanical **weed control** prior to planting is widely practiced throughout the WANA Region. Adequate tillage and proper seedbed preparation can be important in minimizing weed infestation, reducing the need to resort to expensive manual or chemical control methods once the crop emerges. Farmers usually wait until weeds emerge after the early rains to destroy them with a light tillage before planting. However, this practice carries its own risk, since yield losses resulting from late planting may actually offset the yield gains from improved weed control.

Hand weeding of cereal crops is common in areas where family labor is available and is often performed by women and children. Hand weeding is sometimes preferred to other weed control methods because of the high economic value of weeds as green fodder for livestock.

Farmers in many areas supplement manual weed control with use of chemical herbicides, particularly in higher rainfall areas where fallowing has been eliminated and weed infestation can be severe. For example, more than 80% of the bread wheat area in Meknes Province of Morocco (a favorable rainfed zone) is sprayed with herbicides (Serghini 1986). In contrast, the proportion of wheat area treated with herbicides does not exceed 6% in El Jadida Province (an intermediate rainfall zone). Likewise in Tunisia less than 20% of the wheat area is habitually sprayed with herbicides, and in drought years chemical weed control is practiced on less than 5% of the total cereal area (Tunisia Ministry of Agriculture 1989).

Chemical weed control is not always effective. Weed-induced yield losses are often exacerbated by the nearly exclusive reliance on phenoxy acid herbicides (e.g., 2,4-D), which control only broadleaf weeds. Chemicals effective on wild oats and other grassy weeds (e.g., Suffix and Illoxan B) are not extensively used because of limited supply, lack of information, and much higher costs.

Given the ability of weeds to depress cereal yields, the importance of adequate weed control cannot be overemphasized. Chemical weed control is credited with increasing wheat yields by as much as 60% in northern Tunisia (Daaloul 1985), from 11% to 68% in central Turkey (Avci et al. 1988; Durutan et al. 1990), and from 22% to 33% in Syria (Pala et al. 1987). At prevailing prices, yield increments of this order usually justify the cost of chemical weed control. Data from Tunisia and Turkey indicate that the total cost of applying 2-4,D (including costs of capital and equipment) is equivalent to approximately 100 kg of wheat (Byerlee and Winkelmann 1980).

**Mechanization** has spread rapidly throughout the WANA Region in response to increased labor costs resulting from competition both within as well as outside the agricultural sector. In dryland production zones, mechanization has enabled cereal farmers to expand total cultivated area and to increase cropping intensity. Perhaps the most striking example of this trend has occurred in Turkey, where the growth of the national tractor fleet has been accompanied by a steady decrease in fallow area (Figure 11). Mechanization has also significantly reduced the time required for critical operations such as sowing and harvesting, leading to higher yields (by allowing more timely stand establishment) and reduced crop losses (by minimizing grain shattering because of delayed harvesting).

Mechanized tillage based on tractor rental is the norm throughout most WANA countries, although animal draft tillage is still common in areas where topography makes the use of tractors hazardous. Mechanized harvesting has also spread rapidly but remains less widespread than mechanized tillage. Mechanization of other crop operations has not been as extensive. For example, mechanical seed drilling remains uncommon, despite its potential to improve yields by placing seed and fertilizer where they can better utilize the available moisture. Farmers still broadcast wheat and barley seed by hand and make use of any of a variety of implements to cover the seed.

Farmers in the WANA Region have had little experience with reduced or conservation tillage. In dryland wheat areas of Australia, Canada, the USA, and other industrialized countries, a growing number of wheat farmers practice conservation tillage based on chemical weed control (chemical fallowing) and establishment of a protective soil mulch composed of crop residues. Such practices not only greatly increase the efficiency of moisture conservation in the fallow period (Greb 1979), but they can also play an important role in reducing soil erosion. In the WANA Region, conservation tillage may have potential for conserving moisture and slowing soil erosion, but the complexity of managing conservation tillage practices, combined with the high local value of crop residues and weeds used as fodder, will likely slow adoption.

In drier areas of the WANA Region, most wheat and barley is produced in a **cereal-fallow rotation**. Fallowing is widely regarded as essential for conserving moisture and stabilizing yields, especially in dry years. However, the efficiency of moisture conservation through fallowing is often reduced by the practice of maintaining weedy fallow for feeding livestock. Recent research on the role of fallow has cast doubt on the benefits of fallowing in some marginal environments. For example, in Syria it is estimated that less than 10% of the rain that falls during the fallow season remains in the soil profile by planting time for cereal crops (Harris 1989). Similarly, in areas of Turkey receiving less than 350 mm of annual rainfall and where soil depth does not exceed 90 cm, fallowing probably is not beneficial in terms of accumulating moisture (Guler and Karaca 1988).

Introducing changes in traditional fallowing practices is not always easy. Even where clean fallowing can improve moisture storage or facilitate desirable early sowing, managing a clean fallow system requires changes in the method and timing of tillage which may disrupt

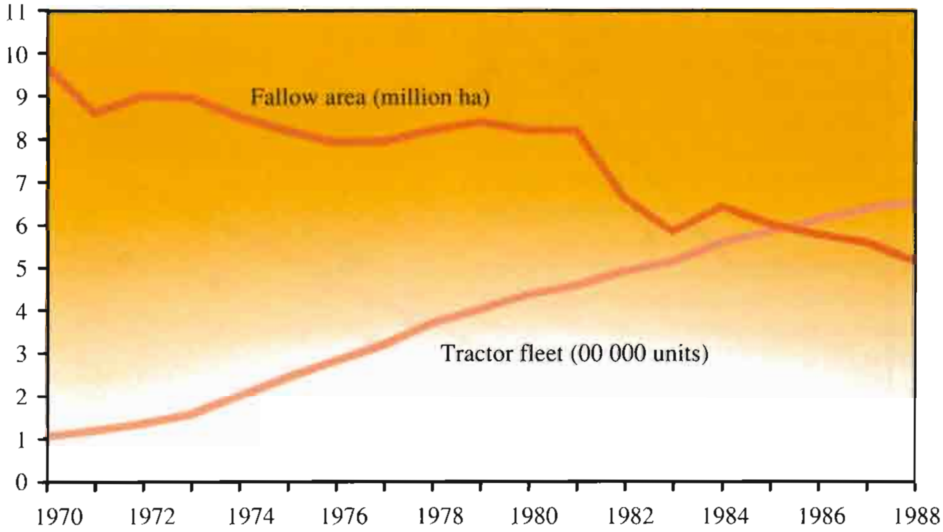

**Figure 11. Growth in national tractor fleet and associated decrease in fallow area in Turkey, 1970-88.**
Source: Turkey Ministry of Agriculture (1990).

livestock enterprises. For example, research on early tillage in the Anatolian Plateau of Turkey revealed that the increased value of higher grain yields achieved through early tillage may not offset the loss of pasture suffered when weedy fallow or stubble is plowed under.

In recent years, rising demand for food and feed, coupled with the rapid spread of mechanization, has led to significant increases in cropping intensity through reduced fallowing. Unfortunately, in some areas where fallowing is declining, lack of crop diversification poses serious problems, since the fragile soils which characterize many marginal environments will not withstand continuous intensive cultivation of cereal crops. Researchers have thus begun to look for more sustainable rotations.

One way of reducing weedy fallow and promoting more sustainable crop rotations is to practice cereal-legume rotations for providing food or cash or for increasing the production of fodder through forage legumes. Maintaining (or increasing) legume production is especially important, since the area sown to legumes tends to decline in drier areas. One successful example of crop diversification is the fallow replacement project undertaken in the northern Anatolia region of Turkey, where food legumes (lentils and chickpeas) and feed legumes (mostly Hungarian vetch) have been introduced on a large scale in the rotation as substitutes for fallow, along with an improved input package involving fertilizer, herbicide, improved varieties, and mechanization. This successful experience, which is progressively being extended to other regions of Turkey where fallow predominates, shows that there is scope for technological change in rainfed areas.

Another alternative to fallowing which has been widely tested in the WANA Region is the so-called ley farming system, in which annual self-reseeding legume pastures (mainly medicago) are grown in rotation with wheat. This system is popular in areas of southern Australia characterized by a Mediterranean-type climate and has played a major role in increasing the productivity of wheat/sheep farming systems. However, when implemented in the WANA Region the system has failed to yield significant results, primarily because local land use customs impede precise control of the timing and intensity of grazing pressure, but also because of the system's intensive management requirements.

## The Policy Environment for Wheat and Barley

Because wheat is the primary staple food throughout most of the WANA Region, wheat prices are politically sensitive as well as economically important. In an effort to reconcile sometimes conflicting economic and political goals, many governments have chosen to pursue independent producer and consumer price policies. For example, in Morocco real consumer prices for wheat products decreased by 30% between 1970 and 1987, while real producer prices for wheat increased by 19%. In general, domestic wheat prices are supported above import prices (Gardner and Skully 1986, Boutonnet 1989), although overvalued exchange rates often reduce producer incentives in real terms.[11]

Although direct producer price support frequently has been extended to wheat, the same cannot be said about barley. Official producer prices for barley are usually published along with those for wheat, but barley prices are rarely supported through extensive government purchases of barley grain. This usually results in low barley prices relative to wheat prices. On the other hand, in some countries government lack of interest in barley has paradoxically allowed free-market barley prices (which are largely unregulated) to rise above official wheat prices (which are strictly enforced). In Algeria, for example, the strong demand for feed barley in recent years has led to the emergence of a thriving parallel market in which unofficial barley prices often are 2-3 times higher than the official prices paid for wheat by the government grain procurement agency.

Of course, in deciding how to allocate resources among alternative enterprises, farmers' primary concern is not *absolute profitability* but rather *relative profitability* (i.e., the returns they are likely to earn on resources invested in one enterprise relative to the returns they would earn by investing the same resources in the most profitable alternative enterprise). In irrigated zones, cereal crops have a hard time competing with high value crops such as vegetables, oilseeds, and fruit, which means cereal prices would have to be raised to unreasonable levels for cereals to displace these crops. In rainfed zones, attractive alternatives to cereals in crop production are more limited, but given the close integration of cereal crop and livestock enterprises, crop-to-livestock price relationships are often critical to farmers' management decisions. This is particularly true for barley. In fact, any attempt to understand historical changes in the profitability of barley production by examining barley grain prices misses the point. To begin with, the value of barley straw often equals or even exceeds the value of barley grain, so grain prices tell only part of the story. In addition, since most barley in the WANA Region is marketed indirectly in the form of livestock, in order to understand the changing profitability of barley it is necessary to consider long-term movements in livestock prices.

In most WANA countries, prices of livestock and livestock products have demonstrated strong growth relative to prices of wheat, aided by rapid growth in consumption averaging 4% per year (Oram 1988) and explicit or implicit trade barriers which have effectively restricted imports. For example, in

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[11] In a number of countries, large differences between domestic prices and import prices, combined with high consumer subsidies, have actually led governments to favor imports over domestic production in order to reduce fiscal outlays for food subsidies.

Algeria the ratios of mutton prices to wheat prices more than doubled between 1970 and 1987, while the price of barley grain relative to wheat grain changed only slightly (Table 9). Significantly, meat-to-grain price ratios in Algeria are 40 times higher than similar ratios in Australia, a major exporter of both products and therefore representative of world price trends. Southern Australian cereal/livestock production systems have been established under climatic conditions nearly identical to those in much of the WANA Region, although (not surprisingly) stocking rates tend to be considerably higher in the WANA Region than in southern Australia. In Australia relative prices strongly favor cereals over livestock and provide incentives for adoption of improved crop production technologies that might not be viable in the very different economic climate of WANA countries.[12]

In most WANA countries, wheat's importance as the leading staple food and a primary wage good is recognized through direct government participation in wheat marketing. Retail prices of both bread wheat and durum wheat are universally regulated and usually highly subsidized, with the goal of keeping wheat affordable for consumers, especially poor urban consumers. Subsidization of consumer wheat prices has contributed to falling bread prices and high levels of wheat consumption throughout the WANA Region, where average per capita utilization is currently far higher than in all other regions of the developing world (Table 10).

As a result of demographic changes (e.g., urbanization) and policy influences (e.g., consumer subsidies), there has been marked substitution among cereals in recent years throughout the WANA Region. Food use of barley has fallen dramatically, with direct human consumption now restricted to a few rural areas of Algeria, Morocco, and Tunisia. However, feed use of barley has risen rapidly because of higher demand for livestock products, driven by sharp increases in incomes associated with the oil boom of the 1970s. At the regional level, feed use of barley has risen from 65% of total production in 1960 to an estimated 90% today.

With growth in cereal consumption outstripping production gains, imports of both food and feed grains have been necessary to meet demand. Over the past three decades, wheat imports into the WANA Region have risen sharply (Figure 12). The region currently imports over 20 million tons per year, representing over 30% of total consumption requirements. In an effort to slow growth in wheat consumption, a number of countries raised bread prices considerably during the 1980s. Rising prices precipitated protests by consumers in some countries and occasionally led to violent demonstrations, as in Tunisia, Morocco, and Egypt. These experiences demonstrate how policies favoring wheat consumption can provoke situations in which policy makers have limited leeway to implement much-needed economic reforms. As a result, the WANA Region remains the only part of the world where most countries continue to subsidize wheat consumption heavily.

**Table 9. Grain-to-livestock price ratios in Algeria and Australia, 1970-72 and 1985-87**

| Producer price ratio | Ratio in 1970-72 | Ratio in 1985-87 | Percentage change |
|---|---|---|---|
| **Algeria** | | | |
| Barley : bread wheat | 0.7 | 0.7 | +3 |
| Mutton : bread wheat | 23.2 | 45.5 | +96 |
| **Australia** | | | |
| Mutton : wheat | 4.3 | 1.0 | -77 |

Source: Calculated from Boutonnet (1989) and data provided by the Australian Bureau of Agricultural and Resource Economics.

**Table 10. Per capita utilization of wheat by developing country region, 1987-89**

| | 1987-89 wheat utilization (kg per capita) | Annual growth rate (%), 1961-63 to 1987-89 |
|---|---|---|
| West Asia | 220 | 0.4 |
| North Africa | 204 | 1.8 |
| Sub-Saharan Africa | 13 | 1.9 |
| South Asia | 60 | 2.3 |
| Southeast Asia and Pacific | 12 | 2.9 |
| East Asia | 93 | 4.2 |
| Latin America | 61 | 0.1 |

Source: Calculated from FAO data.

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[12] The higher quality of Australian wool, a joint product with mutton, also influences the relative profitability of livestock as compared to cereals.

## Rainfed Marginal Environments of South Asia[13]

The second major marginal environment in which wheat is grown is the extensive dryland wheat area of South Asia, where wheat production depends largely on residual moisture from the monsoon rains. The rainfed wheat area of South Asia is concentrated in central and southern India, especially the northern part of Madhya Pradesh (Figure 13), as well as in northern Pakistan.

### Types of Farming Systems in South Asia

The rainfed wheat production zones of South Asia include a range of environments, some of which receive abundant rainfall and therefore cannot be characterized as marginal. For example, in the higher rainfall areas of northern India, rainfed wheat production systems resemble adjacent irrigated systems, which are often based on a rice-wheat rotation. However, in central and southern India, dryland farming systems are very distinct from those in adjacent irrigated areas. The following discussion focuses mainly on these more marginal rainfed zones in central and southern India. Reference is also made to the dry rainfed (*barani*) areas of northern Pakistan, which receive somewhat more rainfall in the growing season but are critically dependent on residual moisture and thus share many of the same characteristics as the systems of central India.

In central and southern India, dryland wheat is grown almost exclusively on deep black vertisols. Because of their high clay content, vertisols are exceedingly sticky when wet; on drying they develop large, deep cracks. This makes them very difficult to manage during the monsoon period. However, vertisols have a high moisture retention capacity. In the deep vertisols of northern Madhya Pradesh, 400 mm or more of moisture may be stored in the soil profile at the end of the monsoon, at least half of which is available for winter (*rabi*) season crops such as wheat. Because of these special characteristics, the dominant rotation is fallow in the monsoon (*kharif*) season followed by wheat grown on stored moisture in the *rabi* season, when rainfall is very low (usually under 100 mm). Over two-thirds of the moisture available to the wheat crop comes from stored moisture. Given that most rain falls during the *kharif* season, however, the fallow-wheat system is relatively inefficient in using available moisture, since only about one-quarter of the annual rainfall is used for crop evapotranspiration.

In addition to limited moisture, the other major climatic constraint on wheat production in this zone is high temperatures. Practically the entire dryland wheat area of central and southern India lies in the tropical zone (defined as having mean January temperatures above 17.5°C). Figure 14 illustrates why the relationship between rainfall and temperature is critical for dryland wheat farmers. At the end of the monsoon in September, stored soil moisture is at its maximum level. However, the temperature of the soil is also high and will impede germination and seedling emergence if wheat is sown early. Over time, temperature declines, allowing germination and seedling emergence rates to increase. However, farmers must be careful not to delay planting too long; late planted wheat must develop in a steadily receding moisture profile and runs the risk of suffering from severe drought during flowering and grain filling. The optimum time for planting current varieties in these environments is late October; harvesting usually occurs in late February or March. This means that the critical period of heat stress is in the seedling stage.

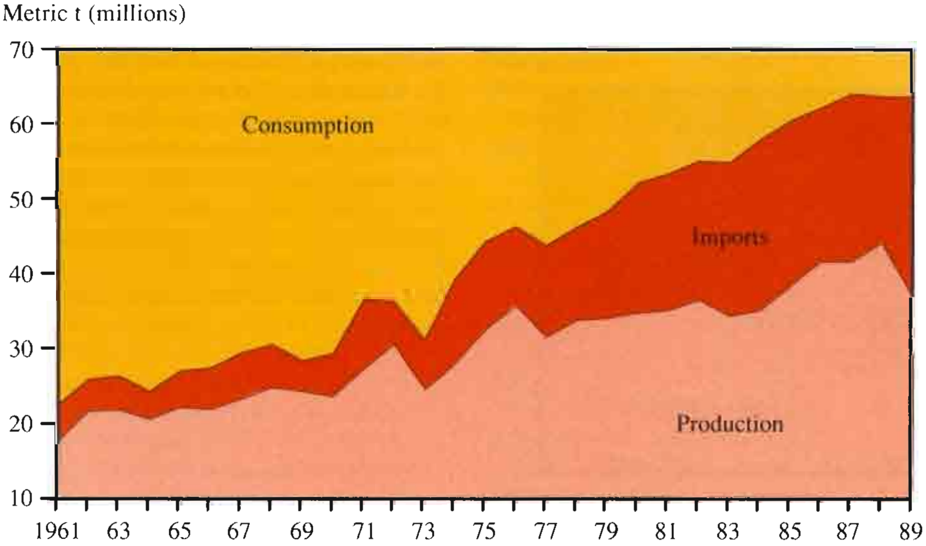

**Figure 12. Wheat production and consumption in the WANA Region, 1961-89.**

In the main dryland wheat belt of central India, 70-90% of total area is left fallow during the *kharif* season before being sown to wheat in the *rabi* season, resulting in an overall cropping intensity of about 100% (Byerlee 1991). Pulses, chickpeas, and lentils are also important in the *rabi* cycle and tend to dominate in areas where soils are shallow and less fertile. In medium depth, better drained soils, soybeans have been found to be suitable for the *kharif* season and have spread quite rapidly in recent years in some areas. This has implications for wheat: where soybeans are grown in the *kharif* season, land will typically be left

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[13] This section draws on Byerlee (1991), Hanchinal (1990), Sheopuria (1990), and IARI (1990).

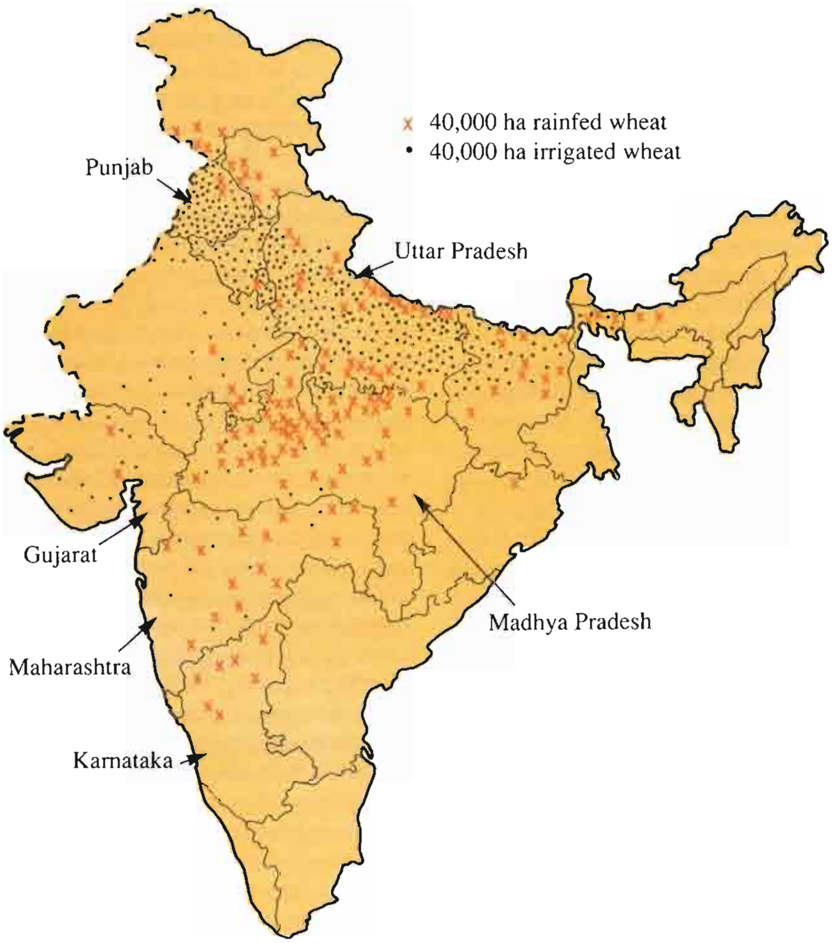

**Figure 13. Distribution of rainfed and irrigated wheat area in India.**

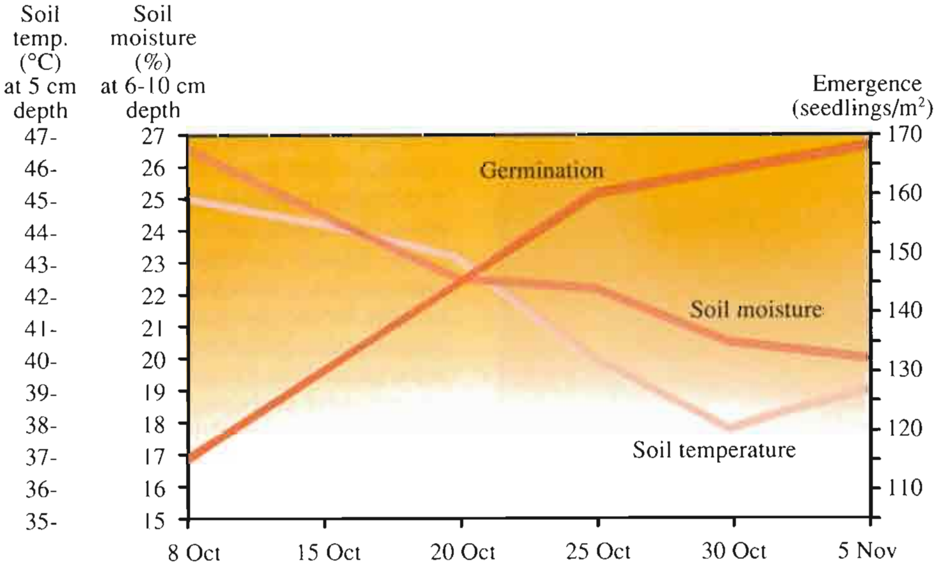

**Figure 14. Effect of soil temperature and moisture on germination of wheat, Indore, India, 1986-88.**

Source: IARI, Indore (1990).

fallow in the following *rabi* season, since sufficient moisture is available for wheat after soybeans in less than one out of every three years (Pandey 1986). Much of the expansion in soybean area has occurred on larger farms where the opportunities for substitution between wheat and soybeans are greater. In contrast, farmers with less land place considerable priority on meeting their subsistence needs for grain and fodder and hence favor wheat production. Farther south where there is no risk of frost, farmers replace wheat with *rabi* sorghum as the primary food crop and usually grow cotton as the main cash crop.

Throughout the dryland wheat areas of South Asia, wheat is frequently intercropped. In central India, common intercrops include chickpeas, lentils, and linseed, whereas in southern India wheat is intercropped between rows of safflower. In Pakistan's *barani* tract, farmers commonly intercrop wheat with mustard, which is removed as a green fodder before wheat flowering. These intercrop combinations appear to be more profitable than sole cropping and are also likely to reduce risk (Hobbs et al. 1985, Byerlee 1991).

Because livestock are important in the dryland farming systems of South Asia, straw is a valuable by-product from wheat production. Straw typically contributes one-third of the total value of the wheat crop (at post-harvest prices), and in very dry areas or very dry years, the total value of straw may equal or even exceed that of grain. With increasing tractor use and the spread of irrigation, however, the value of straw may be decreasing in some areas. Nonetheless, for small-scale farmers who continue to use bullocks, production of wheat straw for fodder is an important objective.

## Use of Improved Technology

***Varietal development and diffusion***—Traditionally a large part of the dryland wheat area of central and southern India was sown to durum wheats, which were used to make *chapatis* as well as many specialized dishes. Durum wheats still predominate in the driest and hottest areas (e.g., Gujarat, Maharashtra, and Karnataka), but most of the wheat sown is now bread wheat.

Over the past three decades, India has released numerous wheat varieties for rainfed production conditions. However, the physical characteristics of these varieties have varied according to rainfall zone. Many of the varieties released in the relatively well-watered rainfed zones in northern India and Pakistan have been semidwarf varieties which are also recommended for adjacent irrigated areas. In contrast, most of the varieties recommended for the dryland areas in central and southern India have tended to be tall. This difference reflects the much harsher conditions prevailing in central and southern India, where varietal characteristics such as drought tolerance, a long coleoptile (allowing the seedling to emerge from where it has been deeply planted to benefit from residual moisture), and the ability to germinate in hot conditions are more important than the input-responsiveness associated with semidwarf materials. To date, wheat breeders have been unsuccessful in finding semidwarf materials that perform well under these conditions. In recent years, the proportion of varieties released in India specifically for rainfed production conditions has declined. This is consistent with the decline in the share of rainfed wheat production.

Throughout India, over 50% of rainfed wheat area is now planted to MVs, up from only 15% in 1976. Varietal adoption data suggest that use of improved materials in India has been closely correlated with availability of irrigation. Beginning in the late 1960s, the first Green Revolution varieties moved into irrigated districts. Adoption in rainfed areas lagged, despite the fact that traditional land races grown in dryland areas were highly susceptible to leaf and stem rust, which in some years resulted in severe losses (Sheopuria 1990).

Adoption of MVs in dryland areas of India has been slowed by the fact that yield gains in varieties released for these areas have been relatively modest (Hanchinal 1988) or in some cases negligible. For example, experiments conducted over five years at Indore found that local varieties yielded more than the "improved" varieties recommended for the area. The slightly better performance of the local varieties appeared to be due to their higher germination rate in hot soils. Nonetheless, despite their lower germination rates, some improved varieties have been widely adopted because they possess better disease resistance and excellent drought tolerance.

Another critical factor in adoption of MVs is quality. Many traditional varieties grown in rainfed areas produce high quality grain, which allows them to fetch premium prices in the market. Since the quality of many MVs currently grown in irrigated areas is lower, the supply of high quality wheats has tended to decline, causing the price premium for grain quality to widen. Farmers in dryland areas have responded by specializing in quality wheats to take advantage of this price premium. Improved varieties developed for dryland areas therefore must possess quality characteristics that meet farmers' criteria. In Gujarat, for example, the successful durum variety GW-1 (released in 1986) showed only a modest yield advantage under dryland conditions over the farmers' variety A-206 (released in 1954) (Wheat Research Institute, Vijapur, unpublished data). Nonetheless, GW-1 has replaced A-206 over a significant area because of its improved rust resistance and higher quality (and hence higher price).

Experiences are similar in the *barani* tract of Pakistan. In the higher rainfall areas (>500 mm), MVs were adopted rapidly beginning in the mid-1970s with the release of the semidwarf variety Lyallpur-73. Although originally intended for irrigated areas, Lyallpur-73 also performed well under rainfed conditions. During the 1980s, Lyallpur-73 was largely replaced by another variety recommended for irrigated areas, Pak-81 (based on material from CIMMYT's spring x winter wheat crossing program). However, in lower rainfall areas (<500 mm), local varieties continue to dominate (Table 11). Varietal trials indicate that the first generation semidwarfs such as Lyallpur-73 yield only 5-10% more than local varieties under improved management; since the local varieties enjoy a price premium of roughly 15%, this yield advantage is insufficient to encourage adoption. The second generation MVs such as Pak-81 show a yield advantage of 16% and have been adopted somewhat more widely. Given these

**Table 11. Varietal adoption by rainfall zone, northern Punjab, Pakistan, 1990**

| | Higher rainfall (> 500 mm) (% area) | Low rainfall (< 500 mm) (% area) |
|---|---|---|
| Local varieties | 15 | 73 |
| First generation semidwarfs (e.g., Lyallpur-73) | 17 | 8 |
| Second generation semidwarfs (e.g., Pak-81) | 68 | 19 |

Source: Ahmad and Ahmed (1991).

experiences, it remains to be seen whether Pakistani breeders' strategy of relying exclusively on semidwarf materials eventually will succeed in producing varieties suitable for the dry areas.

***Improved management practices and inputs***—For all India, **fertilizer** use on wheat now averages around 110 kg nutrient/ha, compared to only 25 kg nutrient/ha in 1969. As with MVs, adoption of fertilizer began later and proceeded more slowly in dryland wheat areas than in irrigated and high rainfall areas. By the mid-1970s, fully 70% of the irrigated wheat area was fertilized, at an average rate of close to 80 kg nutrient/ha. By contrast, only about 10% of rainfed wheat area was fertilized, at an average rate of only 35 kg nutrient/ha (Desai 1982).[14] While the extent and level of fertilizer use in rainfed wheat areas are still low, substantial progress has been made over the past decade. Currently perhaps half the dryland wheat area in central and southern India is fertilized, and increased fertilizer use may account for much of the modest increase in dryland wheat yields recorded since 1970 (Byerlee 1991).

Fertilizer use on rainfed wheat varies depending on numerous factors, including prevailing moisture conditions, soil types, and cropping patterns. The general recommendation is to apply 40-20-0 kg NPK/ha, but farmers approximate these doses only in areas of better rainfall and deep soils. In drier areas, farmers who apply fertilizer use only 10-20 kg nutrient/ha (equally divided between N and $P_2O_5$). However, in the few years benefiting from timely rainfall in the growing season, farmers may top-dress nitrogen to boost yields.

Variation in fertilizer use reflects expected crop response to fertilizer. At low application levels, the average grain-to-nutrient response ratio for rainfed wheat in Madhya Pradesh is about 10 kg wheat/kg nutrient (Fertilizer Association of India 1985, Rao 1976). However, in drier areas the response is considerably lower; for example, Kohli (1976) reports a response ratio of 5.5:1 in Maharashtra. In extremely dry areas, the response may even be negligible. No response at all to fertilizer was reported in over six years of fertilizer trials in Gujarat's dryland wheat areas (Maliwal 1989).

**Moisture conservation** is critical to the success of dryland wheat production in South Asia, since the wheat crop depends on stored soil moisture. During the monsoon season, most farmers therefore attempt to maintain a clean fallow that improves water infiltration and reduces the amount of moisture lost to weeds. Many farmers use a shallow scraper-harrow to kill weeds and leave a shallow soil mulch in the top 5 cm of the soil surface that helps to conserve moisture.

Another widely used soil conservation technique is to level and bund fields, which allows monsoon rainfall to stand in the field for up to two months. This technique, locally called the *haveli* system, achieves several objectives: it prevents runoff and hence soil erosion; it conserves moisture, since 50% of monsoon rainfall may be lost to runoff (Singh and Raje 1984); and it helps prevent the germination of weeds in the *kharif* season. The main disadvantages of the *haveli* system are the high capital costs of levelling the field and constructing bunds, as well as the loss in flexibility that results from the need to dedicate a bunded field to *rabi* cropping (farmers therefore cannot substitute between *rabi* and *kharif* crops). Despite these drawbacks, the practice has become widespread in the main dryland wheat belts of central India.

Improvements in the physical structure of soils may also help conserve moisture. For example, promising experimental results are being obtained from rotating wheat with deep-rooted crops like castor, which help to improve the physical structure of soils (IARI 1990). Organic manure, such as farm yard manure and green manure, also improves moisture conservation. Farmers in the dryland wheat area of Pakistan concentrate farm yard manure on fields close to the village. The improved moisture-holding capacity of these fields not only boosts wheat yields but allows double cropping. Research in the same area has also demonstrated that deep tillage with a moldboard plow greatly increases moisture storage and root penetration, providing an average increase in wheat yields of 25%. During the past decade, farmers in dry areas have rapidly adopted this practice.

By concentrating crop production in the dry season, the current fallow-wheat system is inefficient in utilizing available moisture; on average, less than 1 kg/ha of grain is produced for each 1 mm of annual rainfall. One logical strategy for using monsoon rainfall more efficiently would be to plant *kharif* land that is currently left fallow. The International Crops Resarch Institute for the Semi-Arid Tropics (ICRISAT) has devoted a decade to research on a technology to allow *kharif* cropping of deep vertisols in a double cropping sequence (Foster et al. 1987, Walker and Ryan 1990). The ICRISAT technology, which involves the construction of broad beds and furrows across the slope to facilitate drainage and moisture conservation, has been extensively demonstrated over several years in central India, with only partial success. Farmers tend to adopt elements of the package, but the key component—a bullock-drawn wheeled tool carrier—has not been adopted because of high initial investment, high operating costs, increased availability of tractors, and the uncertainty associated with double cropping. Low adoption is also explained by farmers' strong desire to maintain a considerable proportion of area under wheat both for subsistence grain and fodder production. As noted

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[14] These data, which represent an average for all of India, are likely to overestimate the use of fertilizer in drier areas of central and southern India.

earlier, double cropping by planting wheat after soybeans greatly decreases the probability that sufficient moisture remains for the wheat crop and augments the risk of crop failure in the *rabi* season (Pandey 1986).

Investment in **irrigation** facilities is the most widely used strategy to protect against drought in central and southern India. Rural electrification facilitated rapid growth in the number of tubewells over the past two decades, so that over 40% of total wheat area is now irrigated. However, chronic overexploitation of groundwater in many areas has lowered water tables, raised the cost of irrigation, and in some cases, led to serious water shortages in dry years. Given these trends, the rate of expansion of irrigated wheat area is likely to decline in the future.

In most areas, scarce tubewell water is allocated to wheat before other crops. Nonetheless, tubewell water is often depleted before the end of the growing season, so the wheat crop receives only a limited number of irrigations. However, most studies show that even one irrigation at planting will increase yields by 0.5-1.0 t/ha. Hence an important priority for research is to develop appropriate recommendations for the large area of wheat grown under limited irrigation.

## The Policy Environment for Wheat

Since 1965, real prices received by Indian farmers for wheat have steadily fallen, except for a short period during the world food crisis of the mid-1970s (Sidhu and Byerlee 1991). Different grades of wheat command different prices in India's wheat markets: prices are higher for bread wheat produced in rainfed areas than for bread wheat produced in irrigated areas, reflecting a premium for the higher quality of rainfed wheats. As mentioned earlier, farmers in rainfed areas have capitalized on this market opportunity by specializing in premium quality durum and bread wheats. Durum wheat carries a significant price premium over bread wheat. This price premium, although apparent even before the Green Revolution, had increased by the 1980s to about 50% (Figure 15). Consequently, although all Indian wheat farmers have seen real wheat prices decline since the Green Revolution, this decline has been less marked in rainfed areas than it would have been if these areas did not enjoy a comparative advantage in producing premium quality wheats.

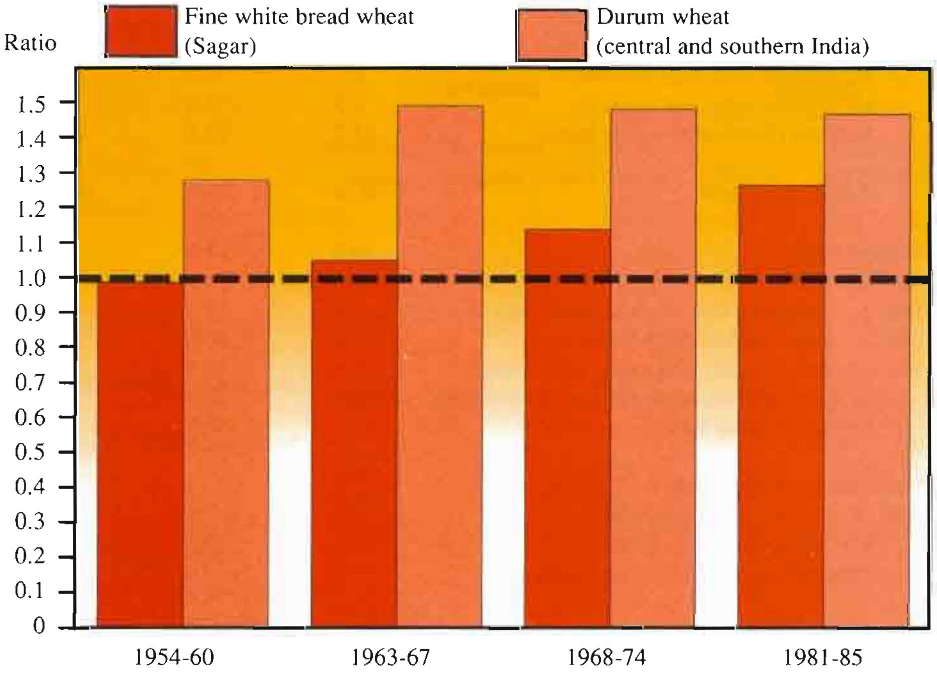


**Figure 15. Ratio of wholesale prices of bread wheat in Sagar and durum wheat in central and southern India to prices in Ludhiana, Punjab, India, 1954-85.**

## Toward a Research Strategy for Marginal Environments

The evidence reviewed in this report suggests that researchers have only partially succeeded in developing improved technologies for wheat and barley in rainfed marginal environments. Not only have yields in marginal areas remained low, but the rate at which yields have grown has lagged compared to favorable areas. These macro-level trends have been borne out by micro-level evidence on technology adoption, which shows that, in dryland areas, MVs and improved crop management practices have been adopted relatively slowly, less extensively, and with less dramatic results.

But the less pronounced impact of improved production technologies in marginal environments does not necessarily mean that the institutions responsible for developing technology have somehow failed. At least three related factors help explain the relatively slow rate of progress in marginal environments. First, the climate in dryland production zones severely constrains the yield potential of cereal crops, so the impact of improved seed-fertilizer technologies is bound to be less dramatic than in the more favored areas of the world where these technologies are so successful. Second, investment in agricultural research targeted at rainfed areas has been modest, in part because such research was perceived (correctly) as having a lower potential payoff. Third, largely because of the first two factors, many countries have been slow to implement policies that would promote cereal production in rainfed areas, such as policies to develop transportation infrastructure, improved input delivery systems, and marketing facilities. Thus, it is not really correct to say that research institutions have been unsuccessful in developing improved production technologies for rainfed marginal environments. Rather, it would seem that some important conditions for successful development and adoption of improved technologies have simply been lacking.

Research managers both in the international centers and within national programs must now decide whether it is time to devote more resources to marginal areas. A comprehensive answer to this question is beyond the scope of this report, but preliminary analysis suggests that further information may be needed before any decision is taken to shift significant amounts of research resources from favored to marginal areas, at least in the case of wheat breeding (see box, this page). One reason for this conclusion is that although marginal environments account for a significant proportion of total cereal area, their share in total cereal production is much lower. Since most policy makers would agree that production is the single most important consideration in allocating research resources (certainly more important than area *per se*), caution should be exercised before allocating research resources on the basis of area alone.

On the other hand, further considerations (especially the desire to alleviate poverty) might justify increased allocations to research targeted at marginal areas. Without a doubt, many people who live in marginal environments are poor. However, the issue is complicated by the fact that many of the poorest people in marginal environments are net food purchasers; thus, the most efficient way to alleviate poverty in marginal environments may actually be to increase productivity in favored areas, if that reduces the real price of food. Alternatively, poverty in marginal environments may be

## Research Resource Allocation to Marginal Environments

Policy makers in many countries must decide what proportion of available research resources should be allocated to research targeted at marginal environments. Although this complex issue cannot be resolved here, it seems appropriate briefly to describe one simple approach that can be used to inform research planning. Under *congruency analysis*, research resources are allocated among regions or environments in relation to their share in the value of production. For example, if favorable and marginal areas account for 70% and 30%, respectively, of the total value of wheat production, then wheat research resources should be allocated to the two types of environment in a 70:30 ratio (Barker 1988, Scobie 1984).

**Table A. Indices of wheat area, production, and weighted production by mega-environment**

| Mega-environment (characteristics) | Estimated area (%) | Estimated production (%) | Weighted production (%) |
|---|---|---|---|
| **Bread wheat** | **89.5** | **92.4** | **92.1** |
| **Spring habit** | | | |
| ME 1 (irrigated, low rainfall, temperate) | 36.1 | 42.7 | 43.4 |
| ME 2 (high rainfall, temperate) | 8.5 | 10.4 | 9.5 |
| ME 3 (acid soil, high rainfall, temperate) | 1.9 | 1.3 | 0.4 |
| ME 4A (low rainfall, temperate, winter rain) | 6.1 | 2.3 | 2.1 |
| 4B (low rainfall, temperate, winter drought) | 3.6 | 2.1 | 0.8 |
| 4C (low rainfall, temperate, stored moisture) | 4.9 | 2.5 | 2.1 |
| ME 5A (high temperature, low humidity) | 4.4 | 4.9 | 5.7 |
| 5B (high temperature, low humidity) | 3.6 | 1.5 | 1.2 |
| ME 7 (severe winter, spring sown, high latitude) | 6.2 | 6.8 | 5.8 |
| Subtotal (spring habit) | 75.3 | 74.5 | 71.1 |
| **Facultative/winter habit** | | | |
| ME 6A (moderate cold, high rainfall) | 5.1 | 9.8 | 10.9 |
| 6B (moderate cold, low rainfall) | 7.4 | 2.0 | 2.4 |
| 6C (severe cold, high rainfall) | 6.7 | 9.2 | 11.5 |
| 6D (severe cold, low rainfall) | 5.5 | 4.6 | 4.2 |
| Subtotal (facultative/winter habit) | 24.7 | 25.5 | 29.0 |
| Bread wheat total | 100.0 | 100.0 | 100.0 |
| **Durum wheat** | **10.5** | **7.6** | **7.9** |
| **Spring habit** | | | |
| ME 1 (irrigated, low rainfall, temperate) | 3.6 | 7.9 | 6.9 |
| ME 2 (high rainfall, temperate) | 23.0 | 33.6 | 46.6 |
| ME 4A (low rainfall, temperate, winter rain) | 45.6 | 32.0 | 23.5 |
| 4C (low rainfall, temperate, stored moisture) | 14.5 | 8.7 | 5.0 |
| Subtotal (spring habit) | 86.7 | 82.1 | 81.9 |
| **Facultative/winter habit** | | | |
| ME 6C (severe cold, high rainfall) | 1.6 | 5.6 | 6.7 |
| 6D (severe cold, low rainfall) | 11.7 | 12.3 | 11.4 |
| Subtotal (facultative/winter habit) | 13.3 | 17.9 | 18.1 |
| Durum wheat total | 100.0 | 100.0 | 100.0 |
| **Total bread wheat and durum wheat** | **100.0** | **100.0** | **100.0** |

Congruency analysis was recently used at CIMMYT in preparing the Center's five-year budget plan (CIMMYT 1989a). To assist in determining an appropriate pattern of research resource allocation between the different environments and wheat types on which CIMMYT's wheat breeding focuses, an index was constructed of wheat production in developing countries. Production data were disaggregated by mega-environment and weighted according to a set of criteria deemed important in light of CIMMYT's mandate: 1) the expected value of wheat production, 2) the per capita income of wheat producers and consumers, 3) the perceived ability of national research programs to carry out effective research on different types of wheat, and 4) expected rates of progress due to wheat breeding in different mega-environments (Table A).

The distribution (by type of wheat and by mega-environment) of weighted global wheat production was then compared to the current allocation of research resources within the CIMMYT Wheat Program. The objective was to determine whether the resources allocated to different wheat research activities were congruent with the weighted value of production, taking into account the factors deemed important in terms of CIMMYT's mandate. Thus, bread wheat was found to make up approximately 92% of weighted production, while durum wheat was found to make up only 8%. Only 10% of weighted bread wheat production was found to take place in low rainfall environments, as compared to 90% for moderate and high rainfall environments. In contrast, fully 40% of weighted durum wheat production occurs in low rainfall environments. These results suggest that caution should be exercised before resources devoted to bread wheat improvement are shifted from favorable to marginal areas, but that in durum wheat improvement considerable emphasis should be placed on research targeted at marginal areas.

In a more focused application of congruency analysis, Byerlee (1991) examined whether the current allocation of Indian research resources to wheat breeding for rainfed areas is congruent with the value of production of rainfed wheat. Indian wheat production was divided into three major zones and two moisture regimes. Table B presents data on area planted to wheat and a weighted index of production in each zone (using a weighting procedure similar to CIMMYT's), as well as a measure of the allocation of research resources (as indicated by the number of varietal releases for each zone). In general, the share of varieties released for rainfed environments corresponds well to rainfed environments' share in the weighted value of production. Although dryland areas of central and southern India account for 16% of total wheat area, they account for only 6% of the weighted index of production. This difference is due to the very low yields in dryland areas, as well as the slow rate of yield gains (0.5% per year) expected to be obtained through breeding in this zone. On the other hand, rural income levels in the dryland areas were estimated to be only half of those in the irrigated northwest, and this increased the weight assigned to the dryland areas. However, in order to justify increased allocation of research resources to dryland wheat breeding, planners need to believe that research progress in these areas will be much more rapid than in the past, or they need to attach a very high weight to alleviating poverty.

Both of these examples of congruency analysis consider only the research resources invested in breeding. Given the evidence presented in this report, the potential to increase wheat productivity through research on crop and resource management may by relatively high. Hence a congruency analysis of allocation of resources devoted to crop and resource management research may give quite a different picture.

**Table B. Summary of congruency analysis of allocation of Indian wheat research resources by zone**

| | Irrigated | | | Rainfed | |
|---|---|---|---|---|---|
| | Northwest plains | Northeast plains | Central and South | North | Central and South |
| Percent of area[a] | 38.6 | 25.4 | 9.9 | 10.1 | 16.1 |
| Percent of value of production[b] | 49.4 | 24.5 | 11.5 | 6.3 | 8.2 |
| Percent weighted production[c] | 31.8 | 39.5 | 18.6 | 4.5 | 5.6 |
| Percent of varieties released: | | | | | |
| 1960-85 | 26.9 | 21.3 | 31.5 | 7.4 | 13.9 |
| 1976-85 | 31.0 | 22.4 | 36.2 | 6.9 | 3.4 |

Source: Byerlee (1991).

[a] Current area and production.

[b] Based on projected production and prices.

[c] Weighted by reciprocal of agricultural income per capita and rates of research progress.

alleviated most effectively by creating opportunities for work off of the farm. (For a more detailed discussion of this and related issues, see the box, p. 27).

Despite these caveats, it seems clear that more effort will be needed to improve cereal productivity in marginal environments where yields remain well below potential. However, prospects for future gains in productivity, as well as promising research strategies, differ somewhat between the WANA Region and South Asia.

In the WANA Region, cereal productivity in very low rainfall zones shows little potential for improvement, given the adverse agroclimatic conditions and high levels of production risk, which combine to limit profitability. In view of the long-term downward trend in world wheat prices, coupled with structural adjustment reforms currently being implemented in many WANA countries, high-cost local wheat production is unlikely to receive additional subsidies, thus lessening the incentives to raise productivity in wheat. Barley will continue to have relatively greater importance in low rainfall zones, especially for use on the farm as an input into the livestock enterprise, but it seems unlikely that livestock prices—already high by global standards—will rise to levels capable of inducing significant technical change in barley production practices. Meanwhile, in higher rainfall zones and irrigated areas, both wheat and barley are likely to face increasing competition from higher valued crops. Eliminating the driest and wettest areas of the WANA Region leaves a relatively narrow belt of land, characterized by roughly 300-400 mm of annual rainfall, where cereal yields are low but considerable potential exists to increase production. Within this belt, opportunities for expanding arable land are limited, so production gains are most likely to be realized through increased yields, as well as through increased cropping intensity achieved by bringing fallow land into cultivation. This belt will be important in meeting the region's growing demand for grain, which given current trends is projected to result in an import deficit of 60 million tons by the year 2000.

In South Asia's dryland wheat zones, the potential for increasing wheat yields under residual moisture conditions appears to be much more limited. In normal years, maximum yield potential is only around 2 t/ha, and in a good growing season when rainfall is timely, maximum yield potential rarely exceeds 3 t/ha. Nevertheless, wheat will continue to occupy an important place in the farming systems of these environments. Not only is it a preferred subsistence food and fodder crop, but it is also regarded as a secure crop. In higher rainfall areas, the level of residual soil moisture is nearly always sufficient to guarantee at least a modest harvest; in lower rainfall areas, farmers protect against crop failures by adjusting area planted according to the available moisture. Input use is low, as wheat production requires only minimum tillage, seed, and sometimes a small dose of fertilizer; after planting, no weeding is needed, and the only other necessary operation is harvesting. On average, farmers can recoup variable costs with a yield of only 200-300 kg/ha. In the main dryland wheat belt, the probability is very high that farmers can obtain yields of at least that level. Because of the security it provides, wheat will not diminish in importance in the rainfed marginal environments of South Asia, even though only modest gains in productivity can be expected.

Where will future productivity gains come from in marginal environments? Given that moisture is the key yield constraint, three strategies offer the most hope for increasing and stabilizing yields: 1) increasing the water supply through irrigation, 2) improving moisture conservation, and 3) utilizing moisture more efficiently. Of the three options, the first is clearly the most effective solution. For this reason, expansion of irrigated area has long been the major strategy employed in India to improve production in marginal areas; more recently, many WANA countries have followed suit. However, aside from the fact that irrigation is technically feasible only in some areas, putting rainfed land under irrigation is extremely costly. Also, even where irrigation has been successful (such as in central India), its long run sustainability is uncertain, given limited groundwater supplies. Therefore, the two remaining strategies—improving moisture conservation practices and enhancing the efficiency of moisture use—should not be overlooked. Research has consistently highlighted the critical role of improved crop and soil management practices in conserving moisture and raising the efficiency with which moisture is used in marginal areas (Cooper et al. 1988; Durutan, Yilmaz, and Kiziltan, 1988; Durutan et al. 1989; Harris and Pala 1988; Byerlee and Winkelmann 1980).

Although MVs may play some role in boosting wheat and barley yields in marginal areas, germplasm will usually not be the main stimulus for rapid technical change, as was the case in favorable areas. On the contrary, in marginal environments improvements in crop and soil management practices will often precede changes in variety (as has already happened in Turkey). This suggests a larger role for research on crop and soil management relative to breeding research, as well as some reorganization of research and extension strategies.

Traditional commodity-based research programs focusing exclusively on cereal crops are likely to have limited success in marginal environments, given the importance of intercropping, crop rotations and fallowing, and crop-livestock interactions. Instead, a more integrative approach to crop and soil management is needed, in which researchers give attention to system-wide implications of new technologies. The role of extension will also be critical to diffusing new technologies. The "technology package" approach so widely employed in favorable environments is likely to be less relevant

# Interregional Effects of Technological Change: Evidence from Favored and Marginal Environments of Pakistan

It is now generally accepted that improved seed-fertilizer technologies have succeeded in raising the incomes of adopting farmers in a wide range of production environments. More controversial is the question of how the gains attributable to technological change have been shared among various socioeconomic groups and between regions. If MVs and associated inputs have disproportionally benefited wealthier farmers and/or people living in favorable production zones, then the technology may have widened the income gap between the rich and the poor, as well as between inhabitants of favored and marginal areas.

This issue was addressed by a recent study (Renkow 1991) carried out in Pakistan, a country with well-defined favorable (irrigated) and marginal (rainfed) wheat production zones. Since MVs were introduced in the mid-1960s, most of the improved germplasm developed for use in Pakistan has been better suited to irrigated production conditions. Following a lag of about 10 years, MVs eventually spread into rainfed areas as well, although the resulting yield increases were significantly smaller than in irrigated areas (average wheat yields in rainfed areas are currently less than half those of irrigated areas).

Interestingly, even though yield increases in irrigated areas have consistently outpaced those in rainfed areas, rural incomes in rainfed areas have grown more, particularly since the mid-1970s. In both rainfed and irrigated areas, large farm households have consistently enjoyed the highest incomes from all sources (including crop production, agricultural labor, and nonagricultural employment). However, during the past 25 years poorer small farm and landless households registered faster real income growth (mainly because of relatively greater increases in off-farm income) (see Figure). Particularly striking is the rapid growth of the incomes of poorer households in rainfed areas.

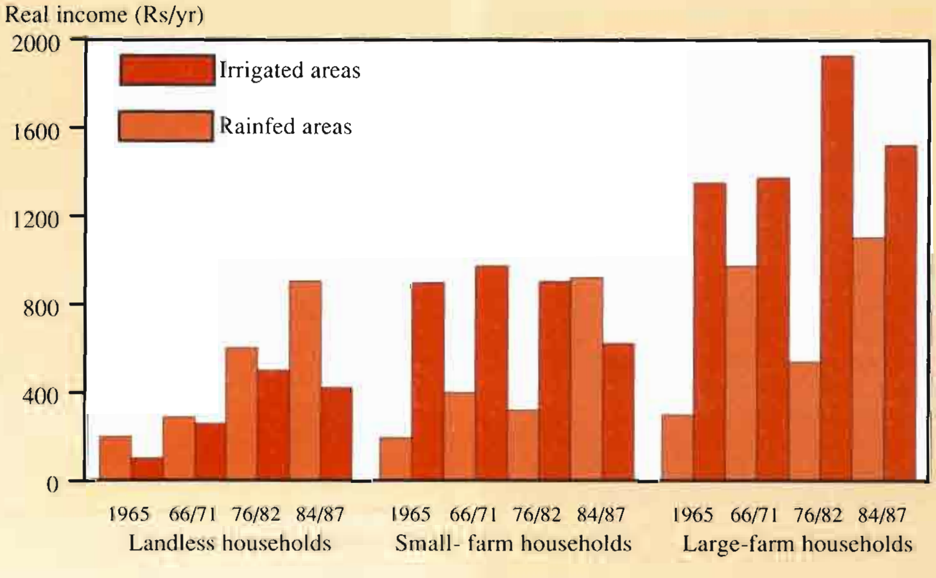
Renkow's study attempted to unravel the many factors influencing income growth in an attempt to isolate the effects attributable to changes in wheat production technology. Aside from directly influencing the level of production, technological change can also produce benefits that are transmitted indirectly, possibly with different consequences for various socioeconomic groups. For example, by increasing production of a commodity such as wheat, a new technology may help lower the price of the commodity, making it cheaper than it would have been in the absence of technological change. For an important staple food such as wheat in Pakistan, net consumers of the food—both non-producers (such as urban dwellers) and rural producers for whom production fails to meet household consumption requirements—stand to benefit from lower wheat prices. Moreover, because poor consumers tend to spend a greater proportion of their incomes on food, this price effect is likely to benefit poorer consumers to a greater extent than the more well-to-do.

It is important to note, however, that increased wheat production will directly lead to a lower wheat price only if the price is determined by the forces of domestic supply and demand. In Pakistan, as in most other developing countries, the government plays an active role in setting producer and consumer prices for wheat and flour, and these prices may remain largely unaffected by domestic supply and demand conditions. Thus, while producer and consumer prices of wheat and wheat products have been declining over the past 25 years, it is not clear that these price changes can be attributed directly to technological change in wheat production.

In addition to increasing productivity, technological innovations such as MVs usually require greater amounts of labor for harvesting, threshing, and crop care. As long as agricultural labor is not available in unlimited supply, increased labor requirements put upward pressure on agricultural wage rates (as well as the implicit return to family labor of subsistence producers). Higher wages obviously have positive effects on the incomes of poorer rural dwellers dependent on agricultural labor for a large share of their incomes. Moreover, such wage increases need not be confined to the areas in which labor-intensive technologies are adopted if interregional differences in wage rates cause agricultural laborers to migrate from low wage to high wage areas.

In Pakistan, real agricultural wages in both rainfed and irrigated areas have increased steadily over time, supporting the idea that the increased labor requirements of the Green Revolution technologies have benefited agricultural laborers in both favorable and marginal

(continued, p.28)



**Relative real incomes in the Punjab, Pakistan, 1965-87.**

production environments. However, wages in nearly all sectors of the economy have risen dramatically since the mid-1970s. This period coincided with the beginning of large-scale migration to the Middle East, an activity that created labor shortages in many key sectors of Pakistan's economy (including the agricultural sector).

Foreign migration appears to be the main explanation for the pattern of changes observed in the incomes of rural dwellers in Pakistan's rainfed areas since the mid-1970s. Particularly for landless and small farm households, an increasingly large share of total household income has come from nonagricultural sources (of which foreign remittance are most important). Between 1965 and 1971, about 65% of the income of small farms came from agricultural activities; between 1984 and 1987, nearly 90% of these households' incomes came from nonagricultural sources. The data for landless and large farm households in rainfed areas indicate similar (although somewhat less dramatic) trends in the composition of household income.

Meanwhile, since 1965 the composition of household income for all types of households in irrigated areas has remained relatively constant. In these areas, the fortunes of rural dwellers appear to have been tied more directly to the profitability of agriculture.

Thus it appears that rural income growth in rainfed areas of Pakistan has been due mainly to the ability of inhabitants of those areas to take advantage of income-generating opportunities outside the agricultural sector. That the rate of income growth in rainfed areas has exceeded that of irrigated areas over the past 15 years indicates that those nonagricultural opportunities proved to be even more remunerative than agricultural opportunities in the irrigated areas. An interesting implication of this finding is that differences in wheat productivity across production environments may have provided an important incentive for the inhabitants of Pakistan's less productive rainfed areas to broaden their income-generating activities outside of the agricultural sector.

in marginal areas, where the high degree of agroclimatic variability over space and through time means that farmers must be able to select among an array of technological options to meet the requirements of a specific field or season. This also implies the need for better education of farmers to ensure the higher skill levels needed to manage increasingly complex technologies.

Likewise, an appropriate policy environment is also critical to encourage the adoption of improved crop and soil management practices, especially since many marginal areas lack effective input delivery systems and marketing infrastructure. Since economic incentives in many marginal areas still favor livestock production, price policy reforms may be necessary to increase expected returns to cereal enterprises and/or reduce their riskiness. Precisely because they are characterized by a high level of climatic variability, dryland environments will require a stronger joint technology/policy effort if cereal production practices are to change significantly.

Too, there is a need to remain aware of the potential effects of technological change on fragile ecologies. Higher yields and increased cropping intensity are desirable goals only if they can be met without seriously degrading the environment. Until significant productivity increases are achieved, rising demand for food will likely force farmers to further expand the area sown to wheat and barley into even more fragile ecologies. Thus, as farmers, researchers, and policy makers confront the formidable challenge of raising productivity and incomes in rainfed marginal environments, they must pay close attention to the longer term implications of short- and medium-term production strategies.

One final point emerging from this report concerns the extreme diversity of marginal environments. The two major environments reviewed here—the winter rainfall areas of the WANA Region, and the residual moisture areas of South Asia—are characterized by tremendous variability in temperature and rainfall patterns, soils, cereal types, and socioeconomic circumstances. This variability poses a special challenge for researchers seeking to develop appropriate technologies capable of increasing productivity and, at least in the case of the WANA Region, stabilizing production. Recognizing the diversity of marginal environments also underlines the importance of identifying the different types of marginal environments in which wheat and barley are grown as a basis for developing appropriate research strategies for the years to come.

# Part 2: The Current World Wheat Situation

Ignoring short-run fluctuations caused by weather variability and policy changes, world wheat production continues to rise along a long-term upward trend. However, the sources of growth in global wheat production have changed over time (Figure 16). Boosted by increasing use of improved germplasm, fertilizer, and other purchased inputs, wheat yields at the global level have grown strongly at 2-3% per year throughout the past four decades. In contrast, the rate of area expansion has slowed dramatically, with total area planted to wheat actually declining during the decade of the 1980s. Much of the contraction in area has occurred in the industrialized countries, where chronic wheat surpluses have led to policies encouraging farmers to take land out of production.

World wheat production in 1990-91 is estimated at a record 589 million metric tons (MT), an increase of nearly 10% over the previous year. The enormous world wheat harvest of 1990-91 can be attributed primarily to two factors. First, area planted expanded considerably in response to high prices at planting time (a legacy of reduced North American production in 1987 and 1988, which resulted when significant area was kept out of production due to policy incentives to set aside farm land). Second, favorable weather in all major wheat-producing zones of the northern hemisphere enabled wheat farmers to achieve record yields.

Despite a significant increase in feed use of wheat, world wheat production in 1990-91 is projected to surpass utilization by 5%, leading to the biggest increase in stock volume since the early 1980s. This indicates that efforts by the major exporting countries to rein in chronic overproduction have not succeeded, and it suggests that aggressive surplus-disposal efforts and export competition will likely continue in the near future.

## Wheat Production

Increased plantings, combined with record yields, led to all-time high levels of production in many of the world's leading wheat producers, including the USSR, China, USA, and Canada. While not reaching record levels, production nevertheless increased significantly in the EC-12, Eastern Europe, Australia, and Argentina. India and Pakistan also enjoyed good harvests, while Egypt increased production by 25% on the strength of yields averaging over 5.0 t/ha (all wheat in Egypt is produced under irrigation). The only major producer to suffer a significant production decline was Brazil, which experienced extremely unfavorable growing-season weather.

## Wheat Utilization

Buoyed by demographic growth, wheat food use at the global level is projected to grow 3% in 1990-91 despite efforts in many developing countries to curtail consumption of imported wheat. In addition, falling prices during late 1990 and early 1991 encouraged increased feed use of wheat as livestock producers substituted large amounts of wheat for other relatively more expensive feed grains such as maize and sorghum. Increased feed use helped to raise total wheat utilization in 1990-91 to an estimated 563 MT, up nearly 5% from the previous year but still well short of world production.

## International Wheat Prices

World wheat prices fell sharply in 1990-91 as a result of the record harvest. The main international reference price for wheat (No.2 Hard Red Winter, F.O.B. Gulf Ports) decreased from US$ 169/t in January 1990 to US$ 114/t in January 1991, a decline of nearly 33%. This steep decline pushed real wheat prices back below their long-term trend level, which they had regained only two years earlier in response to weather-induced declines in production, as well as policy adjustments made in a number of important exporters (Figure 17).

Although the US export price is widely used as a barometer of global price trends, it is important to note that this price does not necessarily reflect the prices at which transactions in the global

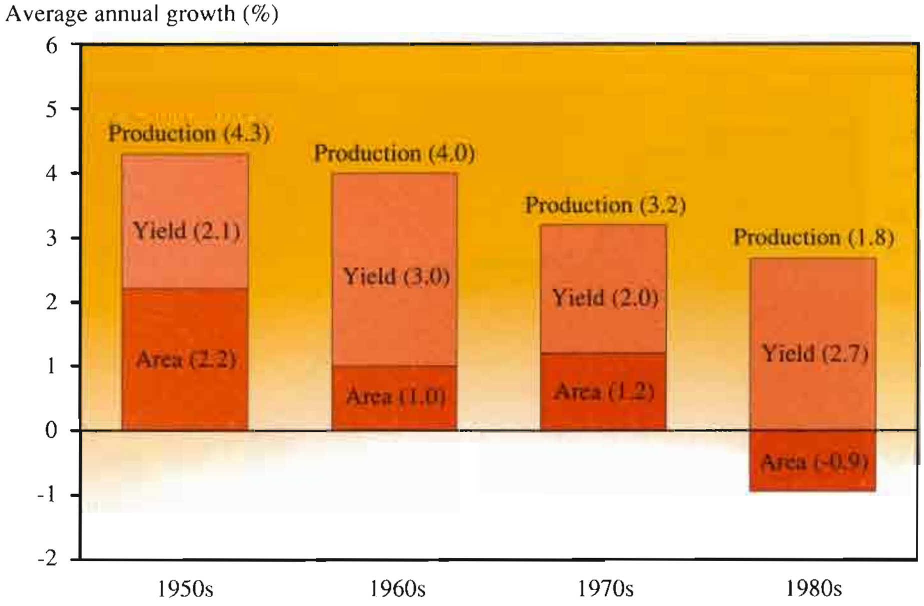


**Figure 16. Sources of growth in world wheat production, 1950s-80s.**

market actually take place. In recent years, leading wheat producers such as the USA and the EC-12 have relied heavily on export promotion measures to dispose of surplus production. Because of these export promotion measures, which include concessional sales, subsidized credit, and food aid, a significant portion of the wheat moving through global markets in fact is sold at prices well below commonly cited international reference prices based on US export prices. Figure 18 presents data relating to US wheat exports in 1987 (the latest year for which such figures are available) showing that only one-quarter of all US wheat exports were sold at the commercial export price. Subsidized credits provided through the Export Enhancement Program and other programs reduced the effective price for nearly one-third of US exports to around 70% of the commercial export price, while concessional sales provided through P.L. 480 and other food aid programs reduced the effective price on nearly one-quarter of US exports to only 10% of the commercial export price. A large portion of the wheat exported by the EC-12 similarly is sold at prices well below international reference prices.

Since the proportion of the total world wheat trade affected by export promotion programs has been increasing steadily, the long-term decline in commonly cited international reference prices based on the US export price in fact understates the decline in *effective* wheat prices actually prevailing in global markets. The International Wheat Council estimates that traded prices in 1990 ranged from US$ 68/t to US$ 85/t, the lowest levels seen since 1972 (International Wheat Council 1990).

## Outlook for Wheat

Considerable uncertainty continues to surround the long-term outlook for the world wheat market. The sharp rise in production recorded in 1990-91 and the resulting increase in world wheat stocks suggests that the industrialized countries have done little to curtail overproduction. While importing countries continue to benefit from depressed world prices, policy makers in many developing countries have begun to express concern over rising levels of dependency on imported wheat and wheat flour. Despite low world prices, strong consumption growth has caused the foreign exchange cost of wheat imports to escalate drastically in many developing countries, prompting governments to initiate policy reforms aimed at reducing consumption. These policy reforms have begun to produce results in a number of African and Latin American countries, which have seen wheat imports level off or even decline.

In the short run, current high stock levels and continuing support to wheat producers in many industrialized countries suggest that wheat will remain plentiful in global markets at affordable prices.

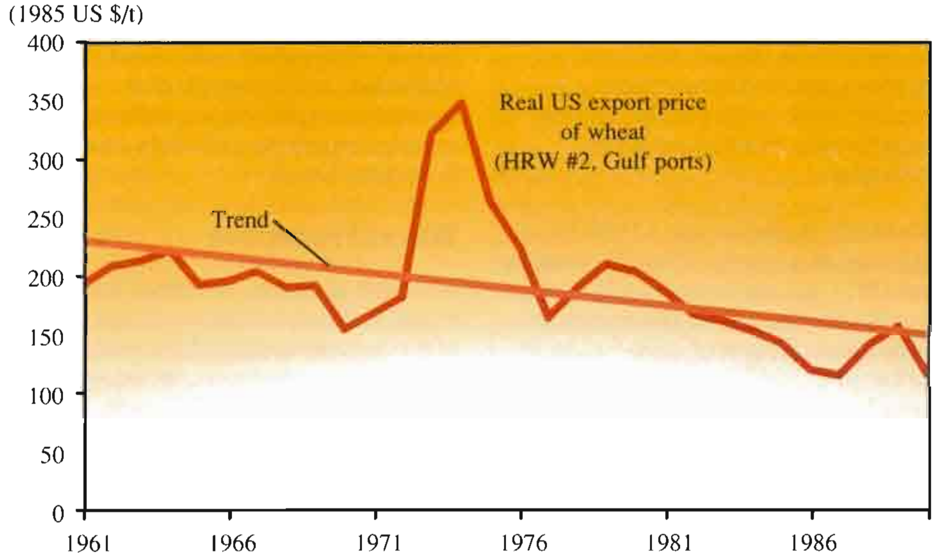


**Figure 17. Evolution of real world wheat prices, 1961-90.**

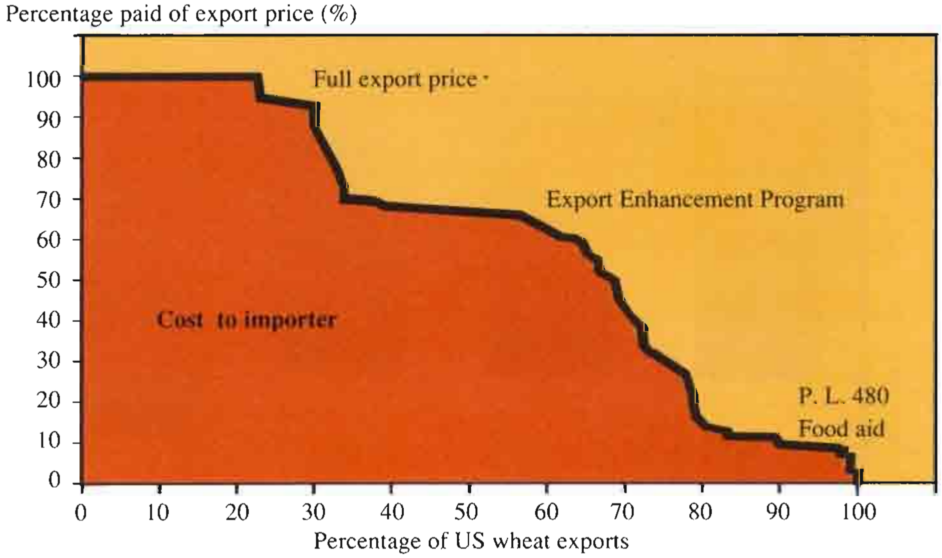


**Figure 18. Effective price of US wheat exports, fiscal year 1987.**
Source: Skully (1990)

Over the longer term, prospects are more uncertain. Future developments in the world wheat market are likely to be influenced by at least three factors. First, much will depend on the ability of exporting countries to negotiate reductions in the level of support extended to wheat producers. The problems arising during the Uruguay Round of the GATT negotiations (largely over the issue of reducing support to agriculture and liberalizing agricultural trade) indicate that serious differences remain between the major players, although the re-opening of talks suggests that all parties are seriously interested in reducing the current high levels of support. Second, much will depend on future developments in the USSR, the world's largest producer and consumer of wheat. Should current economic and political difficulties in the USSR be resolved quickly, wheat production levels could increase dramatically. But if the Soviet economy continues to struggle, wheat production could be seriously impaired, possibly leading to a large increase in import demand from the world's largest wheat importer. Third, increasing concern over the environment in many industrialized countries may make it more difficult for wheat farmers to respond to short-run price signals by increasing area planted. Recently enacted farm legislation in the USA, Canada, and the EC-12 contains numerous provisions designed to protect against soil mining and land degradation, with the result that wheat farmers may find it difficult to put land back into production without jeopardizing their participation in farm programs.

What is likely to happen to the world wheat market should some sort of agreement be reached to reduce support levels to cereal producers and liberalize agricultural trade? This question has been addressed by a number of researchers working with econometric simulation models. While much would depend on the precise nature of the reforms enacted, several consequences seem fairly certain. First, assuming a general reduction in the level of support extended to wheat farmers in industrialized countries, production would almost certainly shift out of Europe (where wheat production is heavily subsidized) to countries such as Argentina, Australia, USA, and Canada (which have the capacity to be low-cost producers). Second, assuming a reduction in the current high levels of export subsidies and an abatement in the trade wars, world wheat prices would almost certainly rise by 15-30%.

What would be the welfare implications of these changes for developing countries in general, and in particular for those which participate actively in the world wheat trade? Here, differences of opinion arise among the modelers.[15] Nearly all agree that developing country wheat producers which are already able to compete in the world market (e.g., Argentina and Turkey) would stand to gain significantly from a strengthening in global prices, since they are clearly low-cost producers. But for developing country importers, the prospects are more uncertain. Some of the models predict that such countries will suffer significant welfare losses as the result of having to pay higher prices for wheat imports. However, other models assume that higher international food prices will induce technological change in food production in developing country importers, leading ultimately to increased domestic food production capacity and net welfare gains over the longer term.

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[15] For an excellent review of the major trade models and a summary of their principal conclusions, see Runge (1991).

# Part 3: Selected Wheat Statistics

The tables that follow present 44 statistics related to wheat and barley production, trade, utilization, and prices, as well as some basic economic indicators. The statistics were selected to provide the latest available information.

Countries listed in the tables are classified either as wheat producers or consumers. Wheat consumers include developing countries consuming over 100,000 t of wheat per year and developed countries consuming more than one million tons of wheat per year from 1987 to 1989. Wheat producers include developing countries in which wheat production exceeded 100,000 t/yr from 1987 to 1989 or accounted for 50% of total wheat consumption, and developed countries in which wheat production exceeded one million tons per year from 1987 to 1989 or accounted for 50% of total wheat consumption.

Unless otherwise indicated, the regional aggregates given in the last table include all of the countries of a particular region (see Annex 1, inside back cover). Note that barley imports and exports (variable 31) given in that table do not add up; this is because they do not add up in the source from which CIMMYT obtained the information.

All prices reported in the tables were converted to US dollars at official exchange rates.

## Notes on the Variables

**Variable 1:** This information is drawn from the FAO diskettes of population statistics (1990).

**Variables 2-3:** The source of these variables is the World Bank *World Development Report* (1990). For countries that are not World Bank reporting members, the source is the United Nations Population Fund, *The State of World Population 1990.*

**Variables 4-27:** Data for these variables are taken from the FAO diskettes of production statistics (1990). Growth rates were calculated using the standard formula for annual percentage compound growth:

$$X_t = X_o [1 + (g/100)]^t$$

Where:

$X_t$ = average of data for ending period;

$X_o$ = average of data for base period;

t = number of years from the midpoint of one period to that of the other; and

g = average annual percent growth rate.

In the calculation of annual growth rates, figures were rounded to the nearest tenth of a percent, so the sum of the growth rates of harvested area and yield may not necessarily equal the production growth rate.

**Variables 28-33:** The source of these data is the FAO diskettes of trade statistics (1990). Net imports were calculated as imports minus exports. Negative numbers indicate that the country is a net exporter. Consumption was calculated as production plus net imports. Growth rates were calculated using the standard formula given above.

**Variables 34-39:** These data (which are for 1989-90) were collected through a general country survey of knowledgeable wheat scientists. Some data were estimated by CIMMYT staff. Regional totals and regional averages in some instances were based on data from a subset of countries in the region. Regional data are reported only when information was available for at least 50% of the area in the region (or 50% of wheat production, depending on the variable).

**Variables 40-44:** These data were collected through a general country survey of wheat scientists and economists. Data for the majority of the countries refer to the wheat crop harvested in 1989-90, although in some cases 1988-89 is the reference year. The wheat and barley prices are the post-harvest prices received by farmers. The nitrogen price is usually the price paid by farmers for the most common nitrogenous fertilizer. In some countries, the price of compound fertilizer only was available, and the variable refers to the price of nutrient only, whether it is N, $P_20_5$, and/or $K_20$.

| | | Producers | | | | | Consumers | | Regional total or average |
|---|---|---|---|---|---|---|---|---|---|
| | | Ethiopia | Kenya | Sudan | Tanzania | Zimbabwe | Mozambique | Somalia | |
| General indicators | 1. Estimated population, 1990 (millions) | 47.8 | 24.7 | 25.1 | 27.2 | 9.6 | 15.8 | 7.5 | 225.3 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 3.3 | 3.4 | 2.7 | 3.4 | 2.7 | 3.1 | 3.1 | 3.2 |
| | 3. Per capita income, 1988 (US$) | 120 | 370 | 480 | 160 | 650 | 100 | 170 | 272 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 131 | 139 | 129 | 163 | 248 | 33 | 82 | 129 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -0.8 | -1.5 | -0.2 | 1.8 | -0.4 | -3.6 | 0.8 | -0.7 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 657 | 154 | 142 | 55 | 44 | 4 | 4 | 1,125 |
| | 7. Wheat yield, 1987-89 (t/ha) | 1.29 | 1.53 | 1.38 | 1.51 | 5.74 | .. | .. | 1.51 |
| | 8. Wheat production, 1987-89 (000 t) | 845 | 236 | 196 | 83 | 253 | .. | .. | 1,704 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | -4.2 | -1.0 | 10.8 | 2.4 | 17.6 | .. | .. | -1.1 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 2.8 | 2.6 | -5.6 | 2.0 | 0.6 | .. | .. | 1.0 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 1.9 | 0.0 | -0.4 | 2.1 | 2.8 | .. | .. | 2.7 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 2.8 | -0.3 | 3.0 | 0.8 | 3.0 | .. | .. | 2.1 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | -2.4 | -1.0 | 10.4 | 4.5 | 20.9 | .. | .. | 1.7 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 5.7 | 2.4 | -2.8 | 2.8 | 3.7 | .. | .. | 3.1 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 13 | 8 | 2 | 2 | 2 | <1 | <1 | 4 |
| | 16. Barley area harvested, 1987-89 (000 h) | 870 | 12 | 0 | 4 | 5 | 0 | 0 | 894 |
| | 17. Barley yield, 1987-89 (t/ha) | 1.23 | .. | .. | .. | .. | .. | .. | 1.26 |
| | 18. Barley production, 1987-89 (000 t) | 1,074 | .. | .. | .. | .. | .. | .. | 1,130 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | -0.6 | .. | .. | .. | .. | .. | .. | 0.0 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | 0.3 | .. | .. | .. | .. | .. | .. | -0.3 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | 3.0 | .. | .. | .. | .. | .. | .. | 3.0 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 1.6 | .. | .. | .. | .. | .. | .. | 1.9 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | 2.4 | .. | .. | .. | .. | .. | .. | 3.0 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | 1.9 | .. | .. | .. | .. | .. | .. | 1.6 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 18 | 1 | 0 | <1 | <1 | 0 | 0 | 4 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 1.2 | 1.7 | 0.5 | 1.3 | 1.3 | 0.6 | 0.7 | 1.1 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 1.9 | 0.8 | -2.5 | 3.1 | 0.4 | -2.5 | 1.4 | 0.6 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 741 | 131 | 612 | 68 | 48 | 139 | 136 | 2,208 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 35 | 16 | 34 | 6 | 33 | 10 | 19 | 18 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 2.4 | 0.3 | 2.7 | 0.1 | 2.3 | 0.5 | 6.6 | 1.5 |
| | 31. Net imports of barley, 1987-89 (000 t) | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 24 | 1 | 0 | <1 | 3 | 0 | 0 | 5 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | 0.0 | -0.5 | .. | 16.4 | 11.3 | .. | .. | -0.6 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 0 | 0 | 100 | 0 | 100 | .. | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | 0 | 0 | .. | .. | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | 0 | .. | 0 | 100 | .. | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 80 | 95 | 74 | 20 | 100 | .. | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | 15 | 100 | .. | .. | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | 100 | .. | 20 | 100 | .. | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 314 | 203 | 240 | 194 | 189 | .. | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | 411 | 219 | .. | .. | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | 180 | .. | 296 | 189 | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 2.7 | 2.5 | 1.1 | 1.2 | 3.0 | .. | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | 5 | 8 | 5 | 2 | 14 | .. | .. | .. |

= Not calculable or not available.

# West Africa

| | | Consumers | | | | | | | | Regional total or average |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Angola | Cameroon | Côte d'Ivoire | Ghana | Mauritania | Nigeria | Senegal | Zaire | |
| General indiactors | 1. Estimated population, 1990 (millions) | 10.0 | 11.4 | 12.5 | 15.0 | 2.0 | 112.1 | 7.4 | 35.8 | 268.5 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 3.0 | 3.2 | 3.8 | 3.0 | 2.7 | 3.1 | 3.2 | 3.0 | 3.0 |
| | 3. Per capita income, 1988 (US$) | .. | 1,010 | 770 | 400 | 480 | 290 | 650 | 170 | 365 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 36 | 77 | 95 | 83 | 80 | 115 | 143 | 35 | 109 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -4.3 | -1.7 | -0.3 | 1.6 | -0.5 | -1.7 | -1.1 | 1.1 | -1.0 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 3 | 1 | 0 | 0 | 1 | 35 | 0 | 28 | 74 |
| | 7. Wheat yield, 1987-89 (t/ha) | .. | .. | .. | .. | .. | 1.43 | .. | 1.14 | 1.28 |
| | 8. Wheat production, 1987-89 (000 t) | .. | .. | .. | .. | .. | 50 | .. | 32 | 94 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | -0.9 | .. | 4.7 | 5.3 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | 13.3 | .. | 18.0 | -0.8 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | 1.8 | .. | -2.8 | 4.8 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | -4.2 | .. | 4.2 | -7.5 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | 0.8 | .. | 1.7 | 10.4 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | 8.6 | .. | 22.9 | -8.2 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | <1 | <1 | 0 | 0 | <1 | <1 | 0 | 2 | 0.2 |
| | 16. Barley area harvested, 1987-89 (000 h) | 0 | 0 | 0 | 0 | <1 | 0 | 0 | 1 | 1 |
| | 17. Barley yield, 1987-89 (t/ha) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 18. Barley production, 1987-89 (000 t) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 0 | 0 | 0 | 0 | <1 | 0 | 0 | <1 | 0 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 0.3 | 1.0 | 0.8 | 1.1 | 0.9 | 1.3 | 0.8 | 0.9 | 0.9 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | -4.4 | 1.4 | -0.1 | 1.0 | 4.2 | 3.3 | 1.4 | 0.9 | 1.5 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 129 | 266 | 251 | 155 | 115 | 64 | 132 | 251 | 1,981 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 14 | 25 | 22 | 11 | 60 | 1 | 19 | 8 | 8 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | -0.5 | 6.2 | 3.2 | 0.8 | 8.1 | -5.0 | 1.3 | 3.1 | 1.8 |
| | 31. Net imports of barley, 1987-89 (000 t) | 0 | 0 | 0 | 3 | 0 | 18 | 0 | 0 | 21 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 0 | 0 | 0 | 0 | <1 | <1 | 0 | <1 | <1 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | .. | .. | .. | .. | 3.4 | 14.1 | .. | -11.4 | 6.4 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. | .. |

.. = Not calculable or not available.

| | | Producers | | | | | Regional total or average |
|---|---|---|---|---|---|---|---|
| | | Algeria | Egypt | Libya | Morocco | Tunisia | |
| General indiactors | 1. Estimated population, 1990 (millions) | 25.2 | 54.0 | 4.6 | 25.1 | 8.2 | 117.0 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 2.9 | 2.3 | 3.6 | 2.4 | 2.2 | 2.5 |
| | 3. Per capita income, 1988 (US$) | 2,360 | 660 | 5,420 | 830 | 1,230 | 1,282 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 68 | 187 | 70 | 275 | 121 | 171 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -3.3 | -0.6 | -0.7 | 0.4 | -2.1 | -0.8 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 1,318 | 601 | 287 | 2,412 | 605 | 5,223 |
| | 7. Wheat yield, 1987-89 (t/ha) | 0.67 | 4.83 | 0.67 | 1.43 | 1.10 | 1.55 |
| | 8. Wheat production, 1987-89 (000 t) | 880 | 2,903 | 193 | 3,458 | 667 | 8,099 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | -1.2 | 0.9 | 0.1 | -0.9 | 2.9 | -0.2 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | -3.6 | 0.7 | 1.6 | 2.9 | -4.7 | -0.5 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | -2.0 | 2.1 | 2.9 | -0.2 | -0.8 | 0.3 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 2.5 | 4.0 | 6.7 | 4.6 | 4.9 | 5.0 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | -3.2 | 2.9 | 2.9 | -1.1 | 2.1 | 0.1 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | -1.2 | 4.7 | 8.4 | 7.7 | 0.0 | 4.5 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 56 | 32 | 67 | 45 | 58 | 47 |
| | 16. Barley area harvested, 1987-89 (000 h) | 921 | 45 | 137 | 2,404 | 390 | 3,896 |
| | 17. Barley yield, 1987-89 (t/ha) | 0.75 | 2.77 | 0.72 | 1.11 | 0.68 | 0.99 |
| | 18. Barley production, 1987-89 (000 t) | 693 | 124 | 98 | 2,665 | 267 | 3,847 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | 0.9 | -3.4 | -1.8 | 1.0 | 5.0 | 1.0 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | 2.2 | -0.1 | -8.0 | 0.4 | -0.1 | 0.2 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | -2.8 | 3.9 | 2.5 | -2.9 | -0.1 | -2.3 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 4.1 | 0.2 | 6.6 | 3.3 | 4.0 | 3.6 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | -1.9 | 0.3 | 0.7 | -2.0 | 4.9 | -1.4 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | 6.4 | 0.1 | -1.9 | 3.7 | 3.8 | 3.8 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 39 | 2 | 32 | 45 | 38 | 35 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 0.7 | 5.1 | 0.7 | 1.2 | 0.9 | 1.7 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 0.2 | 1.6 | 4.5 | 1.1 | 1.1 | 1.5 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 4,055 | 7,105 | 733 | 1,566 | 1,151 | 14,609 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 207 | 194 | 218 | 210 | 232 | 204 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 1.5 | 2.8 | 2.3 | 1.2 | 1.3 | 2.0 |
| | 31. Net imports of barley, 1987-89 (000 t) | 395 | 17 | 443 | -87 | 240 | 1,008 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 46 | 3 | 127 | 108 | 65 | 44 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | 1.2 | -1.6 | 2.8 | -1.7 | 3.5 | -0.4 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 1 | .. | .. | .. | 8 | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | 1 | .. | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | 0 | .. | .. | .. | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 40 | .. | .. | .. | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | 40 | .. | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | 5 | .. | .. | .. | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 394 | 150 | .. | .. | 235 | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | 526 | .. | .. | .. | 276 | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | 302 | .. | .. | .. | 169 | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 0.9 | 1.6 | .. | .. | 1.6 | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | 40 | .. | .. | .. | 17 | .. |

.. = Not calculable or not available.

# West Asia

| | | Producers | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Afghanistan | Iran | Iraq | Saudi Arabia | Syria | Turkey | Yemen Arab Republic |
| General indiactors | 1. Estimated population, 1990 (millions) | 17.0 | 56.5 | 18.9 | 13.1 | 12.5 | 55.8 | 8.1 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | .. | 3.1 | 3.4 | 3.8 | 3.6 | 2.0 | 3.6 |
| | 3. Per capita income, 1988 (US$) | .. | .. | .. | 6,200 | 1,680 | 1,280 | 640 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 228 | 209 | 107 | 255 | 250 | 517 | 102 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -1.3 | 0.1 | -3.3 | 4.5 | -1.4 | 0.1 | -2.8 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 1,619 | 6,381 | 800 | 655 | 1,052 | 9,333 | 73 |
| | 7. Wheat yield, 1987-89 (t/ha) | 1.19 | 1.08 | 0.89 | 4.55 | 1.50 | 1.97 | 1.70 |
| | 8. Wheat production, 1987-89 (000 t) | 1,925 | 6,889 | 714 | 2,984 | 1,581 | 18,395 | 124 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | 1.1 | 0.6 | -1.9 | -0.5 | 3.2 | 1.1 | 9.5 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | -3.4 | 1.6 | -3.5 | 25.5 | -3.5 | -0.1 | 1.3 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 0.3 | 2.9 | -2.5 | 1.1 | 1.5 | 4.2 | -1.2 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 0.0 | 0.4 | 2.9 | 8.9 | 5.0 | 0.8 | 6.8 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 1.4 | 3.5 | -4.4 | 0.6 | 4.7 | 5.4 | 8.2 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | -3.4 | 2.0 | -0.7 | 36.6 | 1.3 | 0.8 | 8.2 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 63 | 68 | 42 | 84 | 41 | 69 | 9 |
| | 16. Barley area harvested, 1987-89 (000 h) | 245 | 2,432 | 995 | 88 | 1,424 | 3,175 | 45 |
| | 17. Barley yield, 1987-89 (t/ha) | 1.02 | 1.09 | 0.95 | 3.48 | 0.86 | 1.98 | 1.02 |
| | 18. Barley production, 1987-89 (000 t) | 250 | 2,644 | 948 | 304 | 1,228 | 6,300 | 46 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | -0.3 | -2.6 | -2.3 | -8.3 | 5.2 | -0.2 | -8.5 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | -2.3 | 7.2 | 4.0 | 26.6 | 3.1 | 1.7 | -0.4 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | -1.1 | 3.9 | -2.9 | 6.4 | -6.5 | 3.0 | -2.3 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 0.0 | 0.5 | 1.5 | 7.6 | 6.4 | 0.8 | 1.6 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | -1.4 | 1.2 | -5.2 | -2.5 | -1.7 | 2.9 | -10.6 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | -2.3 | 7.7 | 5.6 | 36.2 | 9.7 | 2.5 | 1.2 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 10 | 26 | 52 | 11 | 56 | 24 | 5 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 1.3 | 1.2 | 1.0 | 4.3 | 1.1 | 2.1 | 0.9 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 0.2 | 1.6 | -0.3 | 5.9 | 1.3 | 2.4 | 1.2 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 252 | 3,533 | 3,161 | -1,691 | 1,092 | -493 | 864 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 145 | 196 | 219 | 99 | 230 | 334 | 131 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | -1.3 | 1.2 | 1.9 | 3.6 | 1.1 | 0.4 | 11.3 |
| | 31. Net imports of barley, 1987-89 (000 t) | 0 | 300 | 198 | 5,374 | -91 | -57 | 0 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 17 | 55 | 65 | 434 | 98 | 116 | 6 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | -2.5 | 1.4 | -2.2 | 21.8 | 1.3 | 0.3 | -7.1 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 50 | 35 | .. | .. | 25 | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | 0 | .. | .. | 15 | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | 20 | 38 | .. | .. | 0 | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 28 | 95 | .. | .. | 70 | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | 85 | .. | .. | 50 | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | 10 | 70 | .. | .. | 10 | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 180 | .. | .. | 550 | 664 | 208 | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | .. | .. | .. | 754 | 217 | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | 220 | .. | .. | .. | 486 | 163 | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 1.2 | .. | .. | .. | 1.5 | 1.6 | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | 6.1 | .. | .. | .. | 15 | 57 | .. |

= Not calculable or not available.

# West Asia, continued

| | | Consumers | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Jordan | Kuwait | Lebanon | Oman | United Arab Emirates | Yemen Democratic Republic | Regional total or average |
| General indiactors | 1. Estimated population, 1990 (millions) | 3.3 | 2.0 | 2.9 | 1.5 | 1.6 | 2.5 | 197.1 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 3.6 | 2.8 | .. | 3.9 | 2.3 | 3.0 | 3.0 |
| | 3. Per capita income, 1988 (US$) | 1,500 | 13,400 | .. | 5,000 | 15,770 | 430 | 2,531 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 35 | 2 | 10 | 1 | 3 | 49 | 277 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -7.7 | .. | -6.0 | -5.9 | .. | -0.4 | -0.5 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 89 | <1 | 9 | 1 | 1 | 11 | 20,028 |
| | 7. Wheat yield, 1987-89 (t/ha) | 0.78 | .. | .. | .. | .. | .. | 1.63 |
| | 8. Wheat production, 1987-89 (000 t) | 70 | .. | .. | .. | .. | .. | 32,729 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | -5.0 | .. | .. | .. | .. | .. | 0.9 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | -3.1 | .. | .. | .. | .. | .. | -0.1 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | -8.2 | .. | .. | .. | .. | .. | 3.0 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 8.0 | .. | .. | .. | .. | .. | 1.7 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | -12.7 | .. | .. | .. | .. | .. | 3.9 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 4.7 | .. | .. | .. | .. | .. | 1.6 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 60 | 7 | 67 | 39 | 76 | 15 | 63 |
| | 16. Barley area harvested, 1987-89 (000 h) | 55 | <1 | 2 | 0 | <1 | 2 | 8,515 |
| | 17. Barley yield, 1987-89 (t/ha) | 0.57 | .. | .. | .. | .. | .. | 1.40 |
| | 18. Barley production, 1987-89 (000 t) | 31 | .. | .. | .. | .. | .. | 11,891 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | -2.9 | .. | .. | .. | .. | .. | -0.5 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | 1.3 | .. | .. | .. | .. | .. | 3.4 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | -11.5 | .. | .. | .. | .. | .. | 1.5 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 9.1 | .. | .. | .. | .. | .. | 1.0 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | -14.0 | .. | .. | .. | .. | .. | 1.0 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | 10.6 | .. | .. | .. | .. | .. | 4.5 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 37 | 69 | 18 | 0 | 8 | 2 | 27 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 0.7 | 5.6 | 2.0 | 1.1 | 4.8 | 1.6 | 1.6 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | -0.5 | 6.5 | 4.2 | -0.2 | .. | -0.4 | 1.9 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 354 | 164 | 330 | 107 | 111 | 255 | 8,204 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 139 | 85 | 126 | 78 | 74 | 116 | 220 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | -2.0 | -1.3 | -0.6 | 6.4 | -1.6 | 2.4 | 0.6 |
| | 31. Net imports of barley, 1987-89 (000 t) | 115 | 145 | 24 | 46 | 91 | 0 | 6,432 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 48 | 76 | 10 | 33 | 61 | 1 | 98 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | 0.2 | 3.7 | -4.8 | .. | 14.2 | -4.3 | 2.0 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | .. | .. | .. | .. | .. | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | .. | .. | .. | .. | .. | .. | .. |

.. = Not calculable or not available.

# South Asia

| | | Producers | | | | | Consumer | Regional total or average |
|---|---|---|---|---|---|---|---|---|
| | | Bangladesh | India | Myanmar | Nepal | Pakistan | Sri Lanka | |
| General indiactors | 1. Estimated population, 1990 (millions) | 115.0 | 849.2 | 41.6 | 19.2 | 122.3 | 17.2 | 1,166.1 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 2.4 | 1.8 | 2.0 | 2.5 | 3.1 | 1.1 | 2.0 |
| | 3. Per capita income, 1988 (US$) | 170 | 340 | .. | 180 | 350 | 420 | 322 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 231 | 217 | 352 | 272 | 170 | 133 | 218 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -0.7 | 0.6 | 0.1 | -0.7 | 0.9 | 1.4 | 0.4 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 524 | 23,429 | 118 | 577 | 7,581 | 0 | 32,124 |
| | 7. Wheat yield, 1987-89 (t/ha) | 1.91 | 2.06 | 1.63 | 1.31 | 1.72 | .. | 1.96 |
| | 8. Wheat production, 1987-89 (000 t) | 1,003 | 48,162 | 193 | 759 | 13,037 | .. | 62,978 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | 8.8 | 4.0 | -0.6 | 7.4 | 1.1 | .. | 3.3 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 9.9 | 0.8 | 3.1 | 4.9 | 1.6 | .. | 1.1 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 8.6 | 3.4 | 4.6 | -0.2 | 3.6 | .. | 3.4 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 0.6 | 3.3 | 7.2 | 1.7 | 2.0 | .. | 3.0 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 18.2 | 7.5 | 3.9 | 7.1 | 4.7 | .. | 6.9 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 10.6 | 4.1 | 10.6 | 6.7 | 3.6 | .. | 4.1 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 5 | 23 | 2 | 21 | 66 | 0 | 24 |
| | 16. Barley area harvested, 1987-89 (000 h) | 18 | 1,153 | <1 | 29 | 162 | 0 | 1,367 |
| | 17. Barley yield, 1987-89 (t/ha) | .. | 1.44 | .. | 0.88 | 0.76 | .. | 1.33 |
| | 18. Barley production, 1987-89 (000 t) | .. | 1,656 | .. | 25 | 123 | .. | 1,819 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | .. | -3.8 | .. | -0.1 | 0.5 | .. | -3.5 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | .. | -5.5 | .. | 1.3 | -0.6 | .. | -4.9 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | .. | 1.9 | .. | -1.1 | 1.9 | .. | 1.8 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | .. | 2.5 | .. | 0.2 | 0.5 | .. | 2.1 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | .. | -1.9 | .. | -1.2 | 2.5 | .. | -1.8 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | .. | -3.1 | .. | 1.5 | -0.1 | .. | -2.9 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | <1 | 1 | 0 | 1 | 1 | 0 | 1 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 2.4 | 1.7 | 2.7 | 1.8 | 1.7 | 2.8 | 1.8 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 1.7 | 2.7 | 2.8 | 0.1 | 2.3 | 1.1 | 2.5 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 1,999 | 613 | 0 | 27 | 1,049 | 663 | 4,369 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 27 | 60 | 5 | 43 | 122 | 39 | 60 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 3.6 | 2.1 | 4.3 | 4.6 | 0.7 | -1.5 | 1.9 |
| | 31. Net imports of barley, 1987-89 (000 t) | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | <1 | 2 | 1 | <1 | 1 | <1 | 2 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | -4.4 | -4.6 | 27.5 | -2.4 | -1.9 | 0.6 | -4.5 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 60 | 82 | .. | 18 | 82 | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | 10 | .. | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | 50 | .. | .. | .. | .. | 50 |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 80 | 90 | .. | 75 | 90 | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | 40 | .. | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | .. | .. | 0 | .. | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 186 | 114 | .. | 112 | 110 | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 1.7 | 2.6 | .. | 2.9 | 3.0 | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | 5 | 5 | .. | 11 | 14 | .. | .. |

.. = Not calculable or not available.

# Southeast Asia and Pacific

| | | Consumers | | | | | | | Regional total or average |
|---|---|---|---|---|---|---|---|---|---|
| | | Hong-Kong | Indonesia | Malaysia | Philippines | Singapore | Thailand | Vietnam | |
| General indiactors | 1. Estimated population, 1990 (millions) | 5.8 | 181.1 | 17.3 | 61.8 | 2.7 | 55.6 | 66.8 | 411.0 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 0.9 | 1.7 | 2.2 | 1.9 | 1.0 | 1.3 | 2.0 | 1.7 |
| | 3. Per capita income, 1988 (US$) | 9,220 | 440 | 1,940 | 630 | 9,070 | 1,000 | .. | 876 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 0 | 273 | 104 | 225 | .. | 453 | 275 | 273 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -30.4 | 2.5 | -0.9 | 1.0 | .. | 0.3 | 0.1 | 1.1 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 7. Wheat yield, 1987-89 (t/ha) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 8. Wheat production, 1987-89 (000 t) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 16. Barley area harvested, 1987-89 (000 h) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 17. Barley yield, 1987-89 (t/ha) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 18. Barley production, 1987-89 (000 t) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 1.8 | 3.6 | 2.6 | 1.9 | .. | 2.1 | 2.8 | 2.6 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 0.9 | 3.7 | 1.0 | 2.4 | .. | 0.8 | 2.3 | 2.4 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 233 | 1,740 | 638 | 1,060 | 206 | 287 | 228 | 4,639 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 41 | 10 | 39 | 18 | 78 | 5 | 4 | 12 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 1.1 | 5.7 | 1.2 | 0.3 | -1.3 | 7.4 | -5.0 | 1.5 |
| | 31. Net imports of barley, 1987-89 (000 t) | 1 | <1 | 13 | 40 | <1 | 7 | 0 | 62 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | <1 | <1 | 1 | 1 | <1 | <1 | 0 | <1 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | -7.8 | 32.3 | 11.4 | 47 | -9.7 | 33.3 | .. | 9.9 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | .. | .. | .. | .. | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | .. | .. | .. | .. | .. | .. | .. | .. |

.. = Not calculable or not available.

# East Asia

| | | Producers | | | Consumers | | Regional total or average |
|---|---|---|---|---|---|---|---|
| | | China | North Korea | Mongolia | South Korea | Taiwan | |
| General indiactors | 1. Estimated population, 1990 (millions) | 1,109.5 | 22.9 | 2.2 | 43.4 | 19.8 | 1,197.8 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 1.3 | 2.2 | 3.1 | 0.9 | .. | 1.3 |
| | 3. Per capita income, 1988 (US$) | 330 | .. | .. | 3,600 | .. | 454 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 329 | 540 | 374 | 204 | 144 | 325 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | 2.0 | 1.7 | 1.0 | -0.5 | -2.2 | 1.9 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 29,134 | 214 | 486 | 1 | 1 | 29,836 |
| | 7. Wheat yield, 1987-89 (t/ha) | 3.00 | 4.01 | 1.31 | .. | .. | 2.98 |
| | 8. Wheat production, 1987-89 (000 t) | 87,424 | 860 | 639 | .. | .. | 88,929 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | 1.4 | 1.6 | 1.4 | .. | .. | 1.4 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 0.1 | 3.9 | 2.1 | .. | .. | 0.1 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 5.1 | 2.2 | 2.1 | .. | .. | 5.0 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 5.1 | 5.4 | 6.4 | .. | .. | 5.1 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 6.6 | 3.9 | 3.5 | .. | .. | 6.5 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 5.2 | 9.5 | 8.6 | .. | .. | 5.3 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 33 | 8 | 77 | <1 | <1 | 31 |
| | 16. Barley area harvested, 1987-89 (000 h) | 977 | 260 | 101 | 210 | 0 | 1,548 |
| | 17. Barley yield, 1987-89 (t/ha) | 3.07 | 2.43 | 0.99 | 2.58 | .. | 2.76 |
| | 18. Barley production, 1987-89 (000 t) | 3,000 | 631 | 100 | 543 | .. | 4,274 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | -3.8 | 2.9 | 19.3 | -4.1 | .. | -3.1 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | -4.2 | 3.9 | 1.6 | -8.6 | .. | -3.8 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | 6.6 | -2.3 | 2.2 | 1.3 | .. | 4.1 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 3.3 | 1.8 | 5.2 | 0.8 | .. | 2.4 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | 2.5 | 0.5 | 21.9 | -2.8 | .. | 0.8 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | -1.0 | 5.8 | 6.9 | -7.8 | .. | -1.5 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 1 | 10 | 16 | 14 | 0 | 2 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 4.0 | 4.6 | 1.2 | 5.8 | 4.8 | 4.0 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 3.6 | 2.3 | 4.1 | 3.1 | 1.0 | 3.5 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 14,529 | 530 | -22 | 3,504 | 883 | 19,424 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 94 | 63 | 295 | 82 | 45 | 93 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 4.2 | 2.2 | 2.4 | 3.5 | 1.1 | 4.1 |
| | 31. Net imports of barley, 1987-89 (000 t) | 152 | 0 | -30 | 9 | 297 | 427 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 3 | 29 | 33 | 13 | 15 | 4 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | -0.7 | 0.5 | 8.9 | -7.1 | 6.4 | -1.7 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 35 | .. | .. | 0 | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | 80 | .. | .. | 0 | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | .. | .. | 0 | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 100 | .. | .. | 100 | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | 100 | .. | .. | 0 | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | 100 | .. | .. | 100 | .. | 100 |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 200 | .. | .. | 764 | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | 200 | .. | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | 140 | .. | .. | 669 | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 2.6 | .. | .. | 0.7 | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | .. | .. | .. | 37 | .. | .. |

.. = Not calculable or not available.

| | | Producer | Consumers | | | | |
|---|---|---|---|---|---|---|---|
| | | Mexico | Costa Rica | Cuba | Dominican Republic | El Salvador | Guatemala |
| General indiactors | 1. Estimated population, 1990 (millions) | 88.1 | 3.0 | 10.3 | 7.1 | 5.2 | 9.2 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 1.9 | 2.0 | 0.9 | 1.8 | 2.1 | 2.8 |
| | 3. Per capita income, 1988 (US$) | 1,760 | 1,690 | .. | 720 | 940 | 900 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 249 | 110 | 59 | 88 | 148 | 179 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | 0.1 | 0.3 | 2.0 | 2.2 | 1.1 | 0.6 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 950 | 0 | 0 | 0 | 0 | 30 |
| | 7. Wheat yield, 1987-89 (t/ha) | 4.20 | .. | .. | .. | .. | 1.64 |
| | 8. Wheat production, 1987-89 (000 t) | 3,993 | .. | .. | .. | .. | 50 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | -1.6 | .. | .. | .. | .. | 4.9 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 3.3 | .. | .. | .. | .. | -5.3 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 3.1 | .. | .. | .. | .. | 1.1 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 1.4 | .. | .. | .. | .. | 4.1 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 1.4 | .. | .. | .. | .. | 6.0 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 4.8 | .. | .. | .. | .. | -1.4 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 10 | 0 | 0 | 0 | 0 | 4 |
| | 16. Barley area harvested, 1987-89 (000 h) | 274 | 0 | 0 | 0 | 0 | 1 |
| | 17. Barley yield, 1987-89 (t/ha) | 1.76 | .. | .. | .. | .. | .. |
| | 18. Barley production, 1987-89 (000 t) | 482 | .. | .. | .. | .. | .. |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | 0.8 | .. | .. | .. | .. | .. |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | 0.3 | .. | .. | .. | .. | .. |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | 6.0 | .. | .. | .. | .. | .. |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 0.8 | .. | .. | .. | .. | .. |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | 6.8 | .. | .. | .. | .. | .. |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | 1.1 | .. | .. | .. | .. | .. |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 3 | 0 | 0 | 0 | 0 | 0 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 2.2 | 2.4 | 2.6 | 3.7 | 1.8 | 1.9 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 2.2 | 2.2 | 3.7 | 3.0 | 1.5 | 3.5 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 549 | 140 | 1,425 | 219 | 121 | 178 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 54 | 49 | 140 | 32 | 24 | 26 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 1.4 | 0.5 | 2.4 | 1.4 | 1.8 | 1.5 |
| | 31. Net imports of barley, 1987-89 (000 t) | 44 | 0 | 44 | 0 | 0 | 0 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 6 | <1 | 4 | 0 | 0 | <1 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | 1.6 | 3.5 | -0.7 | .. | .. | 6.6 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 75 | .. | .. | .. | .. | 0 |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | 100 | .. | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | 30 | .. | .. | .. | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 95 | .. | .. | .. | .. | 90 |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | 100 | .. | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | 95 | .. | .. | .. | .. | |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 180 | .. | .. | .. | .. | 140 |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | 176 | .. | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | 217 | .. | .. | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 1.7 | .. | .. | .. | .. | 3.2 |
| | 44. Farm wage in kg of wheat per day, 1989-90 | 30 | .. | .. | .. | .. | 15 |

= Not calculable or not available.

# Mexico, Central America, and the Caribbean, continued

| | | Consumers | | | | Regional toral or average |
|---|---|---|---|---|---|---|
| | | Haiti | Honduras | Jamaica | Trinidad and Tobago | |
| General indiactors | 1. Estimated population, 1990 (millions) | 6.5 | 5.1 | 2.5 | 1.3 | 147.0 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 1.9 | 2.9 | 0.5 | 1.4 | 1.9 |
| | 3. Per capita income, 1988 (US$) | 380 | 860 | 1,070 | 3,350 | 1,538 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 58 | 123 | 2 | 8 | 189 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -3.0 | -1.2 | -3.7 | -2.4 | 0.3 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 0 | 1 | 0 | 0 | 982 |
| | 7. Wheat yield, 1987-89 (t/ha) | .. | .. | .. | .. | 4.12 |
| | 8. Wheat production, 1987-89 (000 t) | .. | .. | .. | .. | 4,044 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | -1.3 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | 2.9 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | 2.8 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | 1.7 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | 1.5 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | 4.6 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 0 | 0 | 0 | 0 | 8 |
| | 16. Barley area harvested, 1987-89 (000 h) | 0 | 0 | 0 | 0 | 275 |
| | 17. Barley yield, 1987-89 (t/ha) | .. | .. | .. | .. | 1.76 |
| | 18. Barley production, 1987-89 (000 t) | .. | .. | .. | .. | 483 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | 0.8 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | 0.4 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | 6.0 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | 0.8 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | .. | .. | .. | .. | 6.8 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | .. | .. | .. | .. | 1.2 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 0 | 0 | 0 | 0 | 2 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 1.1 | 1.1 | 1.4 | 2.6 | 2.1 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | -0.1 | 0.0 | 1.1 | -0.1 | 2.2 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 181 | 111 | 165 | 130 | 3,528 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 29 | 23 | 68 | 104 | 53 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 6.0 | 1.9 | -1.2 | 0.2 | 1.3 |
| | 31. Net imports of barley, 1987-89 (000 t) | 0 | 0 | 0 | <1 | 98 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 0 | 0 | 0 | -14.9 | 4 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | .. | .. | .. | .. | 1.5 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | .. | .. | .. | 30 |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | .. | .. | .. | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | .. | .. | .. | 95 |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | .. | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | .. | .. | .. | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | .. | .. | .. | .. | .. |

.. = Not calculable or not available.

| | | Producer | Consumers | | | | Regional total or average |
|---|---|---|---|---|---|---|---|
| | | Peru | Bolivia | Colombia | Ecuador | Venezuela | |
| General indiactors | 1. Estimated population, 1990 (millions) | 22.2 | 7.3 | 31.6 | 10.7 | 19.6 | 92.7 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 2.1 | 2.7 | 1.6 | 2.2 | 2.2 | 2.0 |
| | 3. Per capita income, 1988 (US$) | 1,300 | 570 | 1,180 | 1,120 | 3,250 | 1,597 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 112 | 115 | 115 | 132 | 117 | 121 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | 0.1 | 0.0 | 0.7 | 0.6 | 1.9 | 0.6 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 112 | 88 | 41 | 37 | 1 | 278 |
| | 7. Wheat yield, 1987-89 (t/ha) | 1.32 | 0.76 | 1.76 | 0.89 | .. | 1.15 |
| | 8. Wheat production, 1987-89 (000 t) | 147 | 67 | 72 | 33 | .. | 320 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | -3.0 | 3.3 | -8.5 | -9.3 | .. | -3.5 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 0.6 | -0.3 | 2.7 | 1.2 | .. | 0.6 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 1.3 | 0.4 | -0.3 | 0.3 | .. | -0.2 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 2.6 | 1.4 | 4.3 | -1.3 | .. | 2.4 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | -1.7 | 3.7 | -8.8 | -9.0 | .. | -3.7 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 3.2 | 1.0 | 7.1 | -0.2 | .. | 3.0 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 12 | 14 | 3 | 4 | <1 | 5 |
| | 16. Barley area harvested, 1987-89 (000 h) | 114 | 90 | 52 | 62 | 0 | 317 |
| | 17. Barley yield, 1987-89 (t/ha) | 1.10 | 0.76 | 1.87 | 0.76 | .. | 1.06 |
| | 18. Barley production, 1987-89 (000 t) | 124 | 68 | 97 | 47 | .. | 337 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | -1.3 | 0.4 | 1.7 | -11.2 | .. | -2.5 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | -3.2 | -0.4 | -1.9 | 4.2 | .. | -1.1 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | -0.4 | -0.8 | 1.3 | 1.6 | .. | 1.2 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 2.5 | 2.2 | 0.5 | 1.2 | .. | 1.3 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | -1.7 | -0.4 | 3.0 | -9.9 | .. | -1.4 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | -0.9 | 1.8 | -1.4 | 5.5 | .. | 0.1 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 12 | 14 | 4 | 8 | 0 | 6 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 2.5 | 1.3 | 2.5 | 1.6 | 2.0 | 2.1 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 2.3 | 0.8 | 2.5 | 2.9 | 2.5 | 2.3 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 868 | 257 | 671 | 405 | 1,062 | 3,356 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 48 | 47 | 24 | 43 | 57 | 41 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | -1.0 | -0.6 | 2.1 | 2.2 | -1.2 | -0.1 |
| | 31. Net imports of barley, 1987-89 (000 t) | 43 | 0 | 84 | 16 | 6 | 148 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 8 | 10 | 6 | 6 | <1 | 5 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | -2.8 | -1.9 | 0.4 | -3.9 | 18.8 | -1.8 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | .. | 0 | .. | .. | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | 0 | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | 0 | .. | .. | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | .. | 1 | .. | .. | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | 1 | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | .. | .. | .. | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | .. | 180 | .. | 215 | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | 225 | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | 152 | .. | 205 | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | .. | 5.5 | .. | 2.9 | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | .. | 17 | .. | 8 | .. | .. |

.. = Not calculable or not available.

# Southern Cone, South America

| | | Producers | | | | | Regional total or average |
|---|---|---|---|---|---|---|---|
| | | Argentina | Brazil | Chile | Paraguay | Uruguay | |
| General indicators | 1. Estimated population, 1990 (millions) | 32.2 | 149.7 | 13.1 | 4.3 | 3.1 | 202.4 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 1.1 | 1.8 | 1.3 | 2.7 | 0.6 | 1.7 |
| | 3. Per capita income, 1988 (US$) | 2,520 | 2,160 | 1,510 | 1,180 | 2,470 | 2,160 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 654 | 302 | 229 | 408 | 404 | 358 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | -0.5 | 1.4 | 0.8 | 6.0 | 1.2 | 0.6 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 4,891 | 3,418 | 598 | 216 | 190 | 9,312 |
| | 7. Wheat yield, 1987-89 (t/ha) | 1.83 | 1.68 | 3.00 | 1.85 | 2.09 | 1.85 |
| | 8. Wheat production, 1987-89 (000 t) | 8,933 | 5,731 | 1,791 | 400 | 398 | 17,254 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | -2.3 | 11.8 | -2.0 | 2.6 | -3.3 | 1.0 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 0.9 | 0.5 | 0.1 | 19.1 | -4.0 | 0.8 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 3.0 | -1.3 | 0.4 | 0.8 | 0.3 | 0.8 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 1.3 | 7.9 | 5.5 | 5.3 | 8.7 | 3.8 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 0.7 | 10.4 | -1.6 | 3.5 | -3.0 | 1.8 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 2.2 | 8.4 | 5.6 | 25.5 | 4.3 | 4.5 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 55 | 15 | 73 | 25 | 36 | 27 |
| | 16. Barley area harvested, 1987-89 (000 h) | 137 | 108 | 22 | 0 | 78 | 345 |
| | 17. Barley yield, 1987-89 (t/ha) | 2.26 | 1.68 | .. | .. | 2.23 | 2.14 |
| | 18. Barley production, 1987-89 (000 t) | 310 | 182 | .. | .. | 174 | 737 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | -4.8 | 9.7 | .. | .. | 3.5 | -2.1 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | -7.7 | 1.9 | .. | .. | 4.9 | -3.7 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | 1.8 | 4.0 | .. | .. | 1.9 | 1.6 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 5.2 | 2.9 | .. | .. | 6.8 | 4.2 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | -3.1 | 14.1 | .. | .. | 5.5 | -0.6 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | -2.9 | 4.9 | .. | .. | 12.1 | 0.4 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 2 | <1 | 3 | 0 | 15 | 1 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 2.3 | 1.9 | 3.5 | 1.9 | 2.4 | 2.1 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 2.2 | 1.7 | 3.3 | 2.2 | 5.0 | 1.9 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | -4,093 | 1.673 | 38 | 3 | -18 | -2,396 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 153 | 51 | 144 | 100 | 124 | 76 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | -1.2 | 1.5 | -0.8 | 3.5 | -0.8 | -0.1 |
| | 31. Net imports of barley, 1987-89 (000 t) | -74 | 199 | 41 | 0 | -39 | 126 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 7 | 3 | 9 | 0 | 44 | 4 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | -4.3 | 6.7 | -1.8 | .. | 6.7 | -0.6 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 1 | 1 | 40 | 0 | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | .. | 100 | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | 0 | 40 | .. | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 15 | 95 | 75 | 90 | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | .. | 100 | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | 100 | 100 | .. | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 74 | 152 | 123 | 75 | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | .. | 135 | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | 152 | 130 | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 7.6 | 4.5 | 3.7 | 8.5 | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | 84 | 16 | 29 | 50 | .. | .. |

.. = Not calculable or not available.

| | | Producers | | | | | | | | Regional total or average |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Bulgaria | Czechoslovakia | East Germany[a] | Hungary | Poland | Romania | U.S.S.R. | Yugoslavia | |
| General indicators | 1. Estimated population, 1990 (millions) | 9.0 | 15.6 | 16.7 | 10.6 | 38.2 | 23.3 | 286.0 | 23.8 | 426.4 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 0.1 | 0.0 | 0.0 | -0.2 | 0.5 | 0.5 | 0.6 | 0.6 | 0.5 |
| | 3. Per capita income, 1988 (US$) | .. | .. | .. | 2,460 | 1,860 | .. | .. | 2,520 | .. |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 919 | 763 | 636 | 1,400 | 684 | 871 | 689 | 653 | 717 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | 1.8 | 2.6 | 2.5 | 3.0 | 1.3 | 1.6 | 0.9 | 0.7 | 1.2 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 1,135 | 1,230 | 763 | 1,274 | 2,169 | 2,500 | 47,459 | 1,495 | 58,222 |
| | 7. Wheat yield, 1987-89 (t/ha) | 4.20 | 5.16 | 4.90 | 5.06 | 3.69 | 2.80 | 1.81 | 3.85 | 2.21 |
| | 8. Wheat production, 1987-89 (000 t) | 4,764 | 6,352 | 3,738 | 6,444 | 7,995 | 7,000 | 86,086 | 5,749 | 128,749 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | -1.2 | 2.0 | 2.5 | -0.1 | -0.5 | -2.4 | -0.9 | -2.0 | -0.9 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 2.0 | 0.1 | 0.7 | 0.1 | 2.2 | 1.2 | -2.5 | -0.8 | -1.9 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 3.2 | 2.9 | 1.2 | 4.1 | 2.2 | 4.0 | 2.9 | 3.0 | 3.0 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 1.4 | 2.6 | 1.3 | 2.6 | 2.2 | 0.7 | 0.9 | 1.9 | 1.6 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 2.0 | 5.0 | 3.7 | 4.0 | 1.7 | 1.5 | 1.9 | 0.9 | 2.1 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 3.4 | 2.7 | 2.0 | 2.8 | 4.4 | 1.9 | -1.6 | 1.1 | -0.4 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 55 | 49 | 31 | 45 | 26 | 39 | 44 | 36 | 42 |
| | 16. Barley area harvested, 1987-89 (000 h) | 333 | 793 | 887 | 250 | 1,237 | 633 | 29,332 | 226 | 33,705 |
| | 17. Barley yield, 1987-89 (t/ha) | 3.97 | 4.42 | 4.77 | 4.42 | 3.25 | 3.05 | 1.76 | 2.69 | 2.03 |
| | 18. Barley production, 1987-89 (000 t) | 1,324 | 3,504 | 4,226 | 1,105 | 4,016 | 1,933 | 51,624 | 607 | 68,380 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | 2.0 | 2.4 | 5.2 | -5.2 | 6.8 | 9.3 | 5.5 | -0.9 | 5.3 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | -3.8 | -1.5 | -1.1 | 0.5 | -0.5 | -1.0 | -1.7 | -2.5 | -1.6 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | 3.2 | 2.4 | 0.9 | 3.1 | 1.5 | 4.3 | 1.0 | 2.9 | 1.1 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 2.6 | 1.6 | 2.5 | 3.7 | 1.7 | 0.3 | 1.2 | 2.4 | 1.4 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | 5.3 | 4.8 | 6.2 | -2.3 | 8.4 | 14.1 | 6.6 | 2.0 | 6.4 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | -1.3 | 0.1 | 1.3 | 4.3 | 1.1 | -0.7 | -0.5 | -0.1 | -0.2 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 16 | 32 | 36 | 9 | 15 | 10 | 27 | 5 | 25 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 4.0 | 4.8 | 4.3 | 5.2 | 3.1 | 3.2 | 1.8 | 3.7 | 2.2 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 1.9 | 2.7 | 1.6 | 3.4 | 2.0 | 2.4 | 1.7 | 2.0 | 1.9 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 18 | 156 | 398 | -1,474 | 2,152 | -178 | 16,475 | -237 | 17,347 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 533 | 417 | 248 | 469 | 268 | 296 | 359 | 234 | 344 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 2.7 | 1.7 | 1.3 | 1.8 | 2.2 | 1.9 | 0.4 | -0.2 | 0.7 |
| | 31. Net imports of barley, 1987-89 (000 t) | 119 | 8 | 885 | 110 | 393 | 5 | 2,950 | 38 | 4,509 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 161 | 225 | 307 | 115 | 117 | 84 | 191 | 27 | 171 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | 1.9 | 1.7 | 4.6 | 1.0 | 3.2 | 5.7 | 2.4 | 0.7 | 2.6 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | .. | 5 | 1 | .. | 0 | 40 | .. | 0 | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | .. | .. | .. | .. | .. | .. | 0 | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | 3 | 1 | .. | 0 | .. | .. | 0 | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | .. | 100 | 100 | 100 | 95 | 80 | .. | 100 | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | 100 | .. | 100 | .. | .. | .. | 100 | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | 100 | 100 | 100 | 95 | .. | .. | 100 | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | .. | 144 | .. | 108 | 74 | 95 | .. | 169 | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | 225 | .. | 125 | .. | 143 | .. | 253 | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | 108 | .. | 117 | 53 | 90 | .. | 160 | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | .. | 2.6 | .. | 2.4 | 2.1 | 1.0 | .. | 12.8 | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | .. | 42 | .. | 46 | 57 | 60 | .. | 100 | .. |

.. = Not calculable or not available.

[a] Statistics for Germany remain divided between East and West Germany, as in the original source.

# Developed Market Economies

| | | Producers | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Australia | Austria | Belgium/ Luxembourg | Canada | Denmark | France | West Germany[a] | Greece | Italy |
| General indicators | 1. Estimated population, 1990 (millions) | 16.8 | 7.6 | 10.3 | 26.4 | 5.1 | 56.3 | 61.4 | 10.0 | 57.6 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 1.4 | 0.1 | 0.0 | 0.9 | 0.0 | 0.4 | 0.0 | 0.2 | 0.1 |
| | 3. Per capita income, 1988 (US$) | 12,340 | 15,470 | 14,779 | 16,960 | 18,450 | 16,090 | 18,480 | 4,800 | 13,330 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 1,307 | 673 | 214 | 1,740 | 1,563 | 993 | 419 | 477 | 306 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | 1.1 | 3.1 | 0.2 | 0.6 | 0.9 | 2.5 | 2.0 | 1.9 | 0.4 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 8,930 | 297 | 202 | 13,370 | 384 | 4,923 | 1,732 | 887 | 2,971 |
| | 7. Wheat yield, 1987-89 (t/ha) | 1.52 | 4.91 | 6.35 | 1.65 | 6.59 | 6.02 | 6.33 | 2.41 | 2.78 |
| | 8. Wheat production, 1987-89 (000 t) | 13,541 | 1,458 | 1,283 | 22,124 | 2,529 | 29,636 | 10,973 | 2,134 | 8,247 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | 0.6 | -0.8 | -1.1 | -0.9 | 2.1 | 0.3 | 1.0 | -1.0 | -2.5 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | -1.6 | 0.6 | 0.3 | 2.5 | 12.6 | 1.8 | 0.7 | -0.9 | -0.9 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 2.2 | 1.0 | 1.8 | 2.0 | 1.3 | 2.6 | 1.6 | 3.8 | 0.9 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 0.9 | 2.9 | 2.8 | -1.2 | 2.4 | 2.5 | 2.7 | 0.2 | 1.0 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 2.9 | 0.2 | 0.7 | 1.1 | 3.4 | 2.9 | 2.7 | 2.8 | -1.7 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | -0.7 | 3.4 | 3.1 | 1.3 | 15.2 | 4.4 | 3.5 | -0.7 | 0.1 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 66 | 31 | 54 | 62 | 24 | 53 | 37 | 63 | 64 |
| | 16. Barley area harvested, 1987-89 (000 h) | 2,274 | 292 | 133 | 4,953 | 1,033 | 1,913 | 1,813 | 229 | 457 |
| | 17. Barley yield, 1987-89 (t/ha) | 1.47 | 4.53 | 5.61 | 2.41 | 4.74 | 5.30 | 5.13 | 2.36 | 3.63 |
| | 18. Barley production, 1987-89 (000 t) | 3,340 | 1,322 | 747 | 11,947 | 4,898 | 10,128 | 9,305 | 540 | 1,658 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | 5.1 | 3.6 | 0.3 | 1.8 | 2.4 | 0.1 | 3.6 | 1.3 | 5.3 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | -1.7 | -1.9 | -2.6 | 1.5 | -4.1 | -3.9 | -0.6 | -4.6 | 4.4 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | 4.0 | 0.7 | 2.1 | 2.2 | 0.3 | 1.3 | 1.4 | 2.3 | 4.9 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 1.6 | 2.4 | 1.9 | 0.0 | 1.6 | 3.3 | 1.9 | 0.7 | 3.5 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | 9.2 | 4.3 | 2.4 | 4.0 | 2.7 | 1.4 | 5.1 | 3.6 | 10.5 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | -0.1 | 0.5 | -0.7 | 1.6 | -2.6 | -0.8 | 1.4 | -3.9 | 8.0 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 17 | 30 | 36 | 23 | 64 | 20 | 39 | 16 | 10 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 1.6 | 5.3 | 5.9 | 2.1 | 5.0 | 5.9 | 5.5 | 3.4 | 3.8 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 2.0 | 2.2 | 2.1 | 0.9 | 1.2 | 2.6 | 2.0 | 3.4 | 1.9 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | -12,581 | -579 | 528 | -18,143 | -564 | -16,521 | -1,791 | -304 | 2,938 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 59 | 116 | 177 | 153 | 383 | 235 | 150 | 183 | 195 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | -8.9 | -0.9 | 1.3 | -4.6 | 7.3 | 0.7 | 1.1 | 0.0 | 0.0 |
| | 31. Net imports of barley, 1987-89 (000 t) | -1,723 | -110 | 623 | -4,020 | -1,104 | -4,208 | -459 | 125 | 862 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 99 | 160 | 134 | 306 | 739 | 106 | 144 | 67 | 44 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | 0.5 | 1.0 | 0.8 | 0.2 | -1.5 | -1.1 | 1.6 | 0.5 | 3.1 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 2 | 0 | 0 | <2 | 10 | 10 | .. | 5 | 0 |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | 0 | 0 | .. | <2 | .. | .. | .. | 15 | 0 |
| | 36. Percent of total barley area irrigated, 1989-90 | 0 | 0 | 0 | <1 | 20 | 10 | .. | 0 | 0 |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 90 | 99 | 100 | 75 | 99 | 100 | .. | 95 | 90 |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | 100 | 100 | .. | 70 | .. | 100 | .. | 95 | 80 |
| | 39. Percent of total barley area which receives fertilizer (%) | 80 | 100 | 100 | 75 | 99 | 100 | .. | 90 | 60 |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 104 | 276 | 180 | 100 | 226 | 169 | 214 | 237 | 279 |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | 127 | 362 | .. | 91 | .. | 277 | 325 | 313 | 342 |
| | 42. Farm price of barley, 1989-90 (US$/t) | 96 | 242 | 168 | 58 | 212 | 156 | 195 | 224 | 225 |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 5.4 | 4.7 | 2.9 | 5.3 | 2.7 | 3.6 | 3.6 | .. | 5.1 |
| | 44. Farm wage in kg of wheat per day, 1989-90 | 356 | 141 | 228 | 366 | 381 | 262 | 295 | 105 | 358 |

.. = Not calculable or not available.

[a] Statistics for Germany remain divided between East and West Germany, as in the original source.

| | | Producers | | | | | Consumers | | |
|---|---|---|---|---|---|---|---|---|---|
| | | South Africa | Spain | Sweden | United Kingdom | United States | Japan | Netherlands | Portugal |
| General indiactors | 1. Estimated population, 1990 (millions) | 35.3 | 39.4 | 8.5 | 57.6 | 250.1 | 123.6 | 14.9 | 10.3 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 2.3 | 0.4 | 0.4 | 0.3 | 0.8 | 0.4 | 0.5 | 0.4 |
| | 3. Per capita income, 1988 (US$) | 2,290 | 7,740 | 19,300 | 12,810 | 19,840 | 21,020 | 14,520 | 3,650 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 375 | 546 | 610 | 379 | 1,046 | 116 | 84 | 163 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | 0.3 | 2.8 | 0.6 | 2.2 | 0.6 | -2.2 | -2.7 | -0.4 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 1,914 | 2,283 | 287 | 1,995 | 23,107 | 279 | 121 | 319 |
| | 7. Wheat yield, 1987-89 (t/ha) | 1.64 | 2.59 | 5.37 | 6.26 | 2.34 | 3.43 | 7.28 | 1.61 |
| | 8. Wheat production, 1987-89 (000 t) | 3,135 | 5,923 | 1,539 | 12,494 | 54,024 | 957 | 881 | 512 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | 3.7 | -4.0 | 1.7 | 3.0 | 1.5 | -9.8 | -1.8 | -5.0 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 0.6 | -1.6 | -0.5 | 4.9 | -0.8 | 9.2 | -0.7 | 0.5 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 0.7 | 2.2 | 0.4 | 2.8 | 1.3 | 1.5 | 2.7 | -4.1 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 4.6 | 4.9 | 2.4 | 2.0 | 0.8 | 0.4 | 2.1 | 6.9 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 4.5 | -1.8 | 2.0 | 5.9 | 2.8 | -8.4 | 0.9 | -8.8 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 5.3 | 3.2 | 1.9 | 7.0 | 0.0 | 9.6 | 1.4 | 7.5 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 28 | 29 | 22 | 51 | 39 | 11 | 63 | 31 |
| | 16. Barley area harvested, 1987-89 (000 h) | 92 | 4,278 | 521 | 1,790 | 3,507 | 113 | 54 | 81 |
| | 17. Barley yield, 1987-89 (t/ha) | 2.50 | 2.43 | 3.63 | 4.82 | 2.53 | 3.32 | 5.00 | 0.89 |
| | 18. Barley production, 1987-89 (000 t) | 231 | 10,405 | 1,892 | 8,632 | 8,876 | 374 | 272 | 72 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | 7.0 | 6.5 | 1.6 | -0.2 | -0.7 | -11.2 | -4.4 | -3.0 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | -0.6 | 2.2 | -2.3 | -2.7 | -0.2 | 1.6 | -2.0 | 0.8 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | 5.2 | 1.3 | 1.6 | 1.6 | 1.1 | 0.7 | 1.8 | -2.7 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 7.7 | 1.8 | 0.6 | 1.3 | -0.2 | 0.2 | 0.7 | 4.9 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | 12.6 | 7.9 | 3.2 | 1.4 | 0.3 | -10.6 | -2.7 | -5.6 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | 7.1 | 4.0 | -1.7 | -1.5 | -0.3 | 1.8 | -1.3 | 5.7 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 1 | 55 | 40 | 46 | 6 | 4 | 28 | 8 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 1.9 | 2.7 | 3.9 | 5.5 | 4.3 | 5.6 | 6.4 | 1.6 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 2.3 | 2.9 | 1.2 | 2.1 | 1.3 | 0.4 | 2.3 | 1.7 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | -484 | 89 | -454 | -1,793 | -37,293 | 5,188 | 1,118 | 508 |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 79 | 154 | 128 | 187 | 68 | 50 | 135 | 100 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 1.0 | 0.8 | 1.2 | 1.4 | -2.8 | 0.1 | 1.6 | -0.2 |
| | 31. Net imports of barley, 1987-89 (000 t) | 15 | -1,027 | -78 | -2,770 | -2,065 | 1,303 | 576 | 84 |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 7 | 240 | 215 | 102 | 28 | 14 | 57 | 15 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | 7.3 | 4.4 | 0.7 | -2.0 | -2.2 | -0.7 | 2.3 | 2.7 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | 18 | 10 | 1 | 0 | .. | 29 | .. | 2 |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | 100 | 1 | .. | .. | .. | .. | .. | 0 |
| | 36. Percent of total barley area irrigated, 1989-90 | 0 | 10 | 2 | 0 | .. | 2 | .. | 0 |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | 80 | 95 | 100 | 100 | .. | 10 | .. | 100 |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | 100 | 95 | .. | .. | .. | .. | .. | 100 |
| | 39. Percent of total barley area which receives fertilizer (%) | 80 | 95 | 100 | 100 | .. | <1 | .. | 90 |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | 173 | 245 | 211 | 160 | 96 | 1,103 | .. | 318 |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | 192 | 298 | .. | .. | 156 | .. | .. | 408 |
| | 42. Farm price of barley, 1989-90 (US$/t) | 118 | 202 | 256 | 149 | 98 | 1,141 | .. | 292 |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | 4.2 | 1.9 | 5.3 | 3.5 | 4.3 | 0.7 | .. | 1.7 |
| | 44. Farm wage in kg of wheat per day, 1989-90 | 27 | 100 | 400 | 317 | 448 | 36 | .. | 55 |

.. = Not calculable or not available.

# Regional Aggregates

| | | Less Developed Countries | Developed Market Economies | Eastern Europe and USSR | World |
|---|---|---|---|---|---|
| General indiactors | 1. Estimated population, 1990 (millions) | 4,025.0 | 819.4 | 426.4 | 5,270.7 |
| | 2. Estimated growth rate of population, 1988-2000 (%/yr) | 2.0 | 0.6 | 0.5 | 1.6 |
| | 3. Per capita income, 1988 (US$) | 677 | 16,427 | .. | 3,551 |
| | 4. Per capita cereal production , 1987-89 (kg/yr) | 249 | 653 | 717 | 352 |
| | 5. Growth rate of per capita cereal production, 1961-65 to 1987-89 (%/yr) | 0.8 | 1.0 | 1.2 | 0.6 |
| Production of wheat, barley and all cereals | 6. Wheat area harvested, 1987-89 (000 ha) | 98,982 | 64,486 | 58,222 | 221,691 |
| | 7. Wheat yield, 1987-89 (t/ha) | 2.18 | 2.69 | 2.21 | 2.34 |
| | 8. Wheat production, 1987-89 (000 t) | 216,151 | 173,401 | 128,749 | 518,301 |
| | 9. Growth rate of wheat area, 1967-69 to 1977-79 (%/yr) | 1.6 | 0.2 | -0.9 | 0.4 |
| | 10. Growth rate of wheat area, 1977-79 to 1987-89 (%/yr) | 0.5 | 0.2 | -1.9 | -0.3 |
| | 11. Growth rate of wheat yield, 1967-69 to 1977-79 (%/yr) | 3.5 | 1.8 | 3.0 | 2.6 |
| | 12. Growth rate of wheat yield, 1977-79 to 1987-89 (%/yr) | 3.7 | 1.7 | 1.6 | 2.4 |
| | 13. Growth rate of wheat production, 1967-69 to 1977-79 (%/yr) | 5.1 | 2.0 | 2.1 | 3.0 |
| | 14. Growth rate of wheat production, 1977-79 to 1987-89 (%/yr) | 4.2 | 1.8 | -0.4 | 2.1 |
| | 15. Wheat area as percent of total cereal area, 1987-89 (%) | 24 | 45 | 42 | 32 |
| | 16. Barley area harvested, 1987-89 (000 h) | 17,159 | 24,721 | 33,705 | 75,585 |
| | 17. Barley yield, 1987-89 (t/ha) | 1.43 | 3.19 | 2.03 | 2.27 |
| | 18. Barley production, 1987-89 (000 t) | 24,520 | 78,846 | 68,380 | 171,746 |
| | 19. Growth rate of barley area, 1967-69 to 1977-79 (%/yr) | -1.1 | 1.9 | 5.3 | 2.6 |
| | 20. Growth rate of barley area, 1977-79 to 1987-89 (%/yr) | 0.4 | -0.5 | -1.6 | -0.8 |
| | 21. Growth rate of barley yield, 1967-69 to 1977-79 (%/yr) | 1.4 | 1.1 | 1.1 | 1.3 |
| | 22. Growth rate of barley yield, 1977-79 to 1987-89 (%/yr) | 1.5 | 0.9 | 1.4 | 1.2 |
| | 23. Growth rate of barley production, 1967-69 to 1977-79 (%/yr) | 0.3 | 3.0 | 6.4 | 3.9 |
| | 24. Growth rate of barley production, 1977-79 to 1987-89 (%/yr) | 2.0 | 0.4 | -0.2 | 0.3 |
| | 25. Barley area as percent of total cereal area, 1987-89 (%) | 4 | 17 | 25 | 11 |
| | 26. Average yield of all cereals, 1987-89 (t/ha) | 2.3 | 3.7 | 2.2 | 2.6 |
| | 27. Growth rate of yield of all cereals, 1967-69 to 1987-89 (%/yr) | 2.6 | 1.5 | 1.9 | 2.1 |
| Trade and utilization | 28. Net imports of wheat, 1987-89 (000 t) | 59,922 | -78,489 | 17,347 | .. |
| | 29. Per capita total wheat consumption, 1987-89 (kg/yr) | 71 | 117 | 344 | 101 |
| | 30. Growth rate of per capita wheat consumption, 1967-69 to 1987-89 (%/yr) | 2.3 | -0.7 | 0.7 | 0.7 |
| | 31. Net imports of barley, 1987-89 (000 t) | 8,326 | -13,741 | 4,509 | .. |
| | 32. Per capita total barley consumption, 1987-89 (kg/yr) | 8 | 80 | 171 | 33 |
| | 33. Growth rate of per capita barley consumption, 1967-69 to 1987-89 (%/yr) | 0.3 | 0.0 | 2.6 | 0.2 |
| Productivity factors | 34. Percent of total bread wheat area irrigated, 1989-90 | .. | .. | .. | .. |
| | 35. Percent of total durum wheat area irrigated, 1989-90 | .. | .. | .. | .. |
| | 36. Percent of total barley area irrigated, 1989-90 | .. | 4 | .. | .. |
| | 37. Percentage of total bread wheat area which receives fertilizer (%) | .. | .. | .. | .. |
| | 38. Percentage of total durum wheat area which receives fertilizer (%) | .. | .. | .. | .. |
| | 39. Percent of total barley area which receives fertilizer (%) | .. | 88 | .. | .. |
| Prices | 40. Farm price of bread wheat, 1989-90 (US$/t) | .. | .. | .. | .. |
| | 41. Farm price of durum wheat, 1989-90 (US$/t) | .. | .. | .. | .. |
| | 42. Farm price of barley, 1989-90 (US$/t) | .. | .. | .. | .. |
| | 43. Ratio of farm-level nitrogen price to wheat price, 1989-90 | .. | .. | .. | .. |
| | 44. Farm wage in kg of wheat per day, 1989-90 | .. | .. | .. | .. |

.. = Not calculable or not available.

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# Annex 1: Regions of the World

**Eastern and Southern Africa**
Botswana
Burundi
Comoros
Djibouti
Ethiopia
Kenya
Lesotho
Madagascar
Malawi
Mauritius
Mozambique
Namibia
Rwanda
Seychelles
Somalia
Sudan
Swaziland
Tanzania
Uganda
Zambia
Zimbabwe

**Western and Central Africa**
Angola
Benin
Burkina Faso
Cameroon
Cape Verde
Central African Republic
Chad
Congo
Côte d'Ivoire
Equatorial Guinea
Gabon
Gambia
Ghana
Guinea
Guinea Bissau
Liberia
Mali
Mauritania
Niger
Nigeria
Reunion
Sao Tome
Senegal
Sierra Leone
St. Helena
Togo
Zaire

**North Africa**
Algeria
Egypt
Libya
Morocco
Tunisia

**West Asia**
Afghanistan
Bahrain
Cyprus
Iran
Iraq
Jordan
Kuwait
Lebanon
Oman
Qatar
Saudi Arabia
Syria
Turkey
United Arab Emirates
Yemen Arab Republic
Yemen Democratic Republic

**South Asia**
Bangladesh
Bhutan
India
Maldives
Myanmar
Nepal
Pakistan
Sri Lanka

**Southeast Asia and the Pacific**
American Samoa
Brunei
Cook Islands
East Timor
Fiji
French Polynesia
Guam
Hong Kong
Indonesia
Kampuchea Republic
Kiribati
Laos
Macau
Malaysia
Nauru
New Caledonia
Niue
Norfolk Island
Pacific Islands
Papua New Guinea
Philippines
Samoa
Singapore
Solomon Islands
Thailand
Tokelau
Tonga
Tuvalu
Vanuatu
Vietnam
Wallis and Futuna Islands

**East Asia**
China
Korea, North
Korea, South
Mongolia
Taiwan

**Mexico, Central America, and the Caribbean**
Antigua
Bahamas
Barbados
Belize
Bermuda
Cayman Islands
Costa Rica
Cuba
Dominica
Dominican Republic
El Salvador
Grenada
Guadeloupe
Guatemala
Haiti
Honduras
Jamaica
Martinique
Mexico
Montserrat
Netherlands Antilles
Nicaragua
Panama
St. Christopher and Nevis
St. Lucia
St. Pierre and Miquelon
St. Vincent Grenadine
Trinidad and Tobago
UK Virgin Islands
US Virgin Islands

**Andean Region**
Bolivia
Colombia
Ecuador
French Guiana
Guyana
Peru
Surinam
Venezuela

**Southern Cone, South America**
Argentina
Brazil
Chile
Paraguay
Uruguay
Falkland Islands

**Eastern Europe and USSR**
Albania
Bulgaria
Czechoslovakia
Germany, East
Hungary
Poland
Rumania
USSR
Yugoslavia

**Developed Market Economies**
Australia
Austria
Belgium-Luxembourg
Canada
Denmark
Faeroe Islands
Finland
France
Germany, West
Greece
Greenland
Iceland
Ireland
Israel
Italy
Japan
Malta
Netherlands
New Zealand
Norway
Portugal
South Africa
Spain
Sweden
Switzerland
United Kingdom
United States

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