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AGRICULTURE: TOWARDS 2010

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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DIRECTOR-GENERAL'S PREFACE

"Agriculture: Toward 2010": what it is and what it does

This report updates, amplifies and extends to the year 2010, the FAO global study "Agriculture: Toward 2000", last issued in 1987. This new edition assesses the prospects, worldwide, for food and agriculture, including fisheries and forestry, over the next 20 years.

The two most important underlying themes of the study, which are also at the very heart of FAO's activities, concern the prospects for enhanced **food security and nutrition** *and for improved* **sustainability of agricultural and rural development**. *These themes were also the focus of the two major international conferences held in 1992: the United Nations Conference on Environment and Development and the FAO/WHO International Conference on Nutrition. Both conferences provided important signposts for the preparation of the present study, as did the Den Bosch Conference on Sustainable Agriculture and Rural Development held in 1991.*

In assessing the prospects for progress towards improved food security and sustainability, it was necessary to analyse in detail many contributory issues. These range from the factors affecting rural poverty and the development of human resources, to those pertaining to the overall economic and international trading conditions, to the status and future of agricultural resources and technology. To facilitate such analysis, FAO's experience and expertise in all of the relevant disciplines, from the broad socio-economic to the very specialized and technical ones, have been brought to bear, together with its extensive knowledge of local, national and international situations and policies.

The findings of the study aim to describe the future as it is likely to be, not as it ought to be, and do not aim to wish away problems and challenges. As such they should not be construed to represent goals of an FAO strategy. It is therefore hoped that the findings will contribute to increased awareness of what needs to be done to cope with the problems likely to persist and new ones that may emerge, to guide policies at both national and international levels, and to set priorities for the years ahead.

Some progress in food security and nutrition likely

The world as a whole has been making progress towards improved **food security and nutrition**. *This is clear from the substantial increases in per caput food supplies achieved globally and by many developing countries covering a significant proportion of the population of the developing world. But, as the 1987 edition of the study had warned, progress has been slow and uneven. Indeed, many countries and population groups have failed to make significant progress and some of them have even suffered setbacks in their already fragile food security and nutrition situation. Humanity is thus still faced with the stark reality of chronic undernutrition affecting some 800 million people, 20 percent of the population of the developing countries, as many as 37 percent in sub-Saharan Africa and still more in some individual countries. The notion that the world would by now be on a firm path towards eliminating the scourge of hunger and undernutrition by the end of this century has so far proven overly optimistic.*

The present study predicts that this uneven path of progress is, unfortunately, likely to prevail also beyond the end of this century. But it also indicates some significant enhancement of food security and nutrition by the year 2010, mainly resulting from increased domestic production but also with some additional growth in food imports. However, food exporting countries should face no major problem in supplying the envisaged additional imports, particularly if, as predicted, the former centrally planned developed countries become smaller net food importers than was the case until quite recently.

It can be expected that by the year 2010 per caput food supplies will have increased and the incidence of undernutrition will have been further reduced in most developing regions. However, parts of South Asia may still be in a rather difficult position and much of sub-Saharan Africa would probably not be significantly better off than at present. Therefore, the world must brace itself for continuing interventions to cope with the consequences of local food crises and for action to remove permanently their root causes. Nothing short of a significant upgrading of the overall development performance of the lagging countries, with emphasis on poverty reduction, will free the world of the most pressing food insecurity problems. Making progress towards this goal depends on many factors. However, experience amply demonstrates the crucial role of agriculture in the process of overall development, particularly where a large part of the population depends on the sector for employment and income.

Pressures on agricultural resources and the environment to continue

On the issue of sustainability, the study brings together the most recent evaluation of data on the developing countries' agricultural resources, how they are used now and what may be available for meeting future needs. It does the same for the forestry and the fisheries sectors. The study also provides an assessment of the possible extent and intensity of use of resources over the next 20 years. It concludes that pressure on resources, including those that are associated with degradation, will continue to build up.

More than the need to produce more food for growing populations, the pressures threatening sustainability are likely to be those emanating from the growth of rural poverty, as more and more people attempt to extract a living out of dwindling resources. When these processes occur in an environment of poor and limited resources and when the circumstances for introducing sustainable technologies and practices are not propitious, the risk grows that a vicious circle of poverty and resource degradation will set in. Poverty-related environmental pressures are, however, only part of the story. Agricultural practices, consumption patterns and policies on the part of the rich also contribute to the problem. Responding to environmental pressures from this origin will depend on changes in policies to remove incentives for environmentally damaging practices and indeed to introduce disincentives for controlling them.

But the poverty-related part of environmental degradation is unlikely to be eased before poverty-reducing development has advanced sufficiently to the stage when people and countries become significantly less dependent on the exploitation of agricultural resources. The key concern, therefore, will be how to ensure transition from a world of rapidly growing population and many people chronically undernourished to one of slow or very low demographic growth free from chronic undernutrition, with the least possible adverse effects on resources and the

environment. There is considerable scope for improvements in this direction and the study explores a range of technological and other policy options. Provided such improvements are put in place, the prospects are for an easing of pressures on world agricultural resources in the longer term and for minimal further build-up of pressures on the environment caused by agriculture.

Edouard Saouma
Director-General

EXPLANATORY NOTES

Like Agriculture: Toward 2000 (Revised Version 1987), this perspective study of the likely course of events in the sectors of food and agriculture for the next 20 years should not be taken as a blueprint for food and agricultural development. The study aims at alerting people and governments to take early action to reverse some of the predicted negative trends and thus avoid emerging problems. FAO, for its part, will continue through its policy advisory services, field programmes and projects to assist its member countries in supporting the positive aspects of this assessment and to strive to prevent the projected negative ones.

Symbols and units

ha	hectare
kg	kilogram
$	US dollar
ton	metric ton (1000 kilograms)
mln.	million
billion	thousand million
p.a.	per annum
calories	kilocalories (kcal)
mm	millimetre
m3	cubic metre

Time periods

1990	calendar year
1988/90	average for the three years centred on 1989, except if specified otherwise
1970-90	period from 1970 to 1990
1988/90-2010	period from the three year average 1988/90 to 2010

Growth rates

Annual growth rates for historical periods are computed from all the annual data of the period using the Ordinary Least Squares (OLS) method to estimate an exponential curve with time as the explanatory variable. The estimated coefficient of time is the annual growth rate. Annual growth rates for projection periods are compound growth rates calculated from values for the begin- and end-point of the period.

Abbreviations

AEZ	Agro-Ecological Zone
BMR	Basal Metabolic Rate
CAP	Common Agricultural Policy
CPEs	Centrally Planned Economies
EC	European Community
ECDC	Economic Cooperation among Developing Countries
ECU	European Currenty Unit
EEZ	Exclusive Economic Zone
EFTA	European Free Trade Association
FOR90	Forest Resources Assessment 1990 for the Tropical World
GDP	Gross Domestic Product
GNP	Gross National Product
HFCS	High Fructose Corn Syrup
ICA	International Commodity Agreement
ICN	International Conference on Nutrition
IPNS	Integrated Plant Nutrition System
IPM	Integrated Pest Management
LGP	Length of Growing Period
MTNs	Multilateral Trade Negotiations
MV	Modern Variety
NGO	Non-Governmental Organization
PSE	Producer Subsidy Equivalent
SARD	Sustainable Agricultural and Rural Development
SSR	Self-Sufficiency Ratio = Production as Percent of Total Domestic Use
UNCED	United Nations Conference on Environment and Development
WCARRD	World Conference on Agrarian Reform and Rural Development

(Note: other abbreviations are explained in the text).

Countries and country groups

See the Appendix for a list of countries and the standard country groups used in this report. In the text, the term ex-Centrally Planned Economies of Europe or ex-CPEs is sometimes used to refer to the group "Eastern Europe and former USSR". The historical data and projections are presented for the aggregate of the countries of the former USSR because the data for the individual countries available at the time this study was being prepared (1992) were inadequate for a systematic analysis. Data availability at the country level has in the meantime improved. The term "All Other (or Other) Developed Countries" is used for the countries referred to formerly as "Developed Market Economies", comprising all the developed countries shown in the Appendix, except the ex-CPEs.

Commodities

See the Appendix for a list of the standard commodities used in this report.

Land definitions

The arable area is the physical land area used for growing crops (both annual and perennial). In any given year, part of the arable area may not be cropped (fallow) or may be cropped more than once (double cropping). The area actually cropped and harvested in any given year is the harvested area. The harvested area expressed as a percentage of the arable area is the cropping intensity. Land with crop production potential consists of all land area which is at present arable or is potentially arable, i.e. is suitable for growing crops when developed (see Chapter 4).

Data sources

All data are derived from FAO sources unless specified otherwise.

CHAPTER 1

INTRODUCTION AND OVERVIEW

1. INTRODUCTION

1.1 This Study assesses prospects for world food and agriculture to the year 2010, with special focus on the developing countries. The findings indicate that progress towards increasing production and per caput food supplies will continue to be made. However, such progress would be very slow for many countries and population groups. As a consequence chronic undernutrition would persist and its incidence would continue to be significant. Agriculture would be more intensive and more land would be brought into agricultural use. Pressures on agricultural resources and the environment would continue to build-up. The results of the Study present the situation as it is likely to develop and several chapters are devoted to the discussion of ways of tackling both persisting and newly emerging problems.

2. FOCUS ON NUTRITION/FOOD SECURITY AND AGRICULTURAL RESOURCES/SUSTAINABILITY

1.2 The Study covers a wide array of issues in varying degrees of detail as regards their geographic, commodity, resources, technology, and other dimensions as well as related policies. The overall framework for the assessment of prospects is provided by two related major issues in world food and agriculture:

(a) making progress towards elimination of undernutrition and food insecurity of the significant part of the population of the developing countries still subject to these conditions, and

(b) safeguarding the productive potential and broader environmental functions of agricultural resources for future generations, the very essence of sustainability, while satisfying food and other needs.

The importance of these issues was underlined by the major international conferences of recent years: the United Nations Conference on Environment and Development (UNCED) and the FAO/WHO International Conference on Nutrition (ICN).

Food and Nutrition: Progress and Failures in the Historical Period

1.3 World per caput food supplies are today some 18 percent above what they were 30 years ago. The majority of the developing countries participated in this progress and improved nutrition. However, impressive as this progress has been, it has bypassed a large number of countries and population groups. Many countries continue to have very low per caput food supplies and have hardly made any progress. Indeed, sub-Saharan Africa, is

today worse off nutritionally than 30 or 20 years ago. In parallel, continuous population growth has meant that the declines in the percentage of the population chronically undernourished did not lead to commensurate declines in the absolute numbers affected. The latter have fallen only modestly and remain stubbornly high at some 800 million persons.

1.4 It is now well recognized that failure to alleviate poverty is the main reason why undernutrition persists. This realization, together with the evidence that the world as a whole faced no major constraints in increasing food production by as much as required to meet the growth of effective demand (as shown by the long-term trends for food prices not to rise in real terms, and indeed to decline on balance), contributed to focus attention on ways and means to alleviate poverty and improve the "food entitlements" of the poor, while downplaying the role of increasing per caput food supplies. However, the two aspects cannot be separated in the quest for policy responses to the problem of undernutrition. In the majority of the developing countries, increasing food production is among the principal means for combating poverty. This follows from the fact that the majority of the poor depend on agriculture for employment and incomes. So long as this dependence continues to be high, the growth of food production and of agricultural productivity in the countries with high concentrations of rural poverty will continue to be among the principal means for alleviating poverty and improving nutrition.

The Role of World Food Markets

1.5 But global food production capabilities will continue to be important, even if the focus is on the nutrition problem in the developing countries. The fact that success in a number of countries was based on rapidly growing food imports, particularly in the 1970s following the growth of export earnings from the oil boom and easy access to external finance, underlines the role of world food markets in the nutritional developments of the developing countries. In the past, world markets were abundantly supplied by the main cereal exporters, mainly the Western developed countries. This evidence suggests that the world as a whole had sufficient production potential to respond to spurts in import demand without raising prices, apart from occasional shocks. Whether this will be so in the longer term future is another question, which is addressed later on, drawing on the analyses of this study.

The Significance of Agricultural Resources in the Food Security *Problematique*

1.6 In the quest for solutions to the problem of food security and undernutrition, concerns are often expressed about the capability of the world's agricultural resources, technology and human ingenuity to increase food supplies by as much as required to ensure to all people adequate access to food. However, the adequacy of agricultural resources to produce more food is only one part of the resources/environment/sustainability nexus having a bearing on the food problem. Agricultural resources are not only an input into food production but also the major economic asset on which depends a good part of the population in the developing countries for employment and income. Thus, even if the world's resources were adequate to underpin continued growth in food production, the solution of the food problem would still be constrained if the agricultural resources of the poor were insufficient

to ensure their livelihood. From this standpoint, the relevant dimension of the perceived growing global imbalance between population and agricultural resources is not so much the need to produce more food for more people but rather the fact that the population dependent on agriculture for a living continues to grow.

1.7 Some developing countries have made the transition to reduced dependence on agricultural resources for their total employment and income. They include countries which have achieved medium-high levels of per caput food availabilities, even though their agricultural resources per caput (of the total population) have declined to very low levels. Some of them have come to depend increasingly on food imports. For them, the agricultural resource constraints most relevant to their food welfare are those impinging on the global capabilities of the world to produce more food. However, many developing countries are far from this transition. For these latter countries, local agricultural resource constraints will continue to be a major factor in the prospects for solving their food problem. This is because a high proportion of their population, often growing in absolute numbers, depends on these very agricultural resources. Moreover, efforts of growing numbers to make a living out of dwindling resources per caput are sometimes associated with degradation and reduction of the productive potential of these resources. In such cases, there is a high risk that a vicious circle between increasing poverty and resource degradation may be established.

1.8 However, it would be incorrect to assume that agricultural resource degradation is exclusively a poverty-related phenomenon. There is sufficient evidence of resource degradation associated with agricultural practices in areas which are certainly not poor, e.g. overuse of agrochemicals in Europe, soil erosion associated with part of grain production in North America and effluents from intensive livestock operations in many countries. Some of these effects are generated or strengthened by policies which provide incentives for unsustainable practices, e.g. support and protection policies which make profitable the excessive use of agrochemicals. Thus, devising policies to safeguard agricultural resources, reduce more general adverse environmental impacts and make progress towards sustainability requires taking account of the factors that determine behaviour vis-à-vis the resources of both the poor in the developing countries and the non-poor everywhere.

1.9 Notwithstanding the above-mentioned occurrences of increased pressures on agricultural resources generated by the actions of the non-poor, poverty reducing development remains the main hope for easing such pressures in the long term. In the first place, overall population growth slows down with development and agricultural population declines; and secondly, there is less scope for further increases in per caput food consumption when people are well fed. The pressures for increasing food production and for extracting incomes out of agricultural resources in non-sustainable ways become accordingly less intense at higher levels of development. In addition, the objective of resource conservation and environmental protection ranks higher with development in society's hierarchy of preferences, while the means to pursue this objective are also less scarce.

1.10 In this context, the question of primary interest for policy is not only how to break the vicious circle between increasing poverty and resource degradation but also how to manage the process of development in ways which minimize the trade-offs between it and the environment. Later sections in this chapter summarize, and other chapters discuss more fully, the environmental pressures likely to emerge in the next 20 years as they can be

deduced from the production, resource use and technology projections of this study. They set the stage for examining the options offered by technology and other policies to respond to this challenge.

3. PROSPECTIVE DEVELOPMENTS TO YEAR 2010

Continuing, but Slower, Growth in World Population

1.11 Over the time horizon of the study the world population may grow to 7.2 billion, up from the 5.3 billion of 1990 and the 3.7 billion of only 20 years earlier. 94 percent, or 1.8 billion, of the total increment in world population will be in the developing countries. Moreover, the regional patterns of population growth are very disparate, e.g. 3.2 percent p.a. in sub-Saharan Africa, 1.5 percent p.a. in East Asia. These demographic trends in the developing countries, in combination with their still low levels of per caput food consumption, would require continued strong growth in their food supplies. Not all these additional needs will be expressed as effective market demand. The aggregate increase in the food supplies of the developing countries is likely to be less than required to raise average per caput supplies to levels compatible with food security for all. This is because the general development scene is likely to leave many developing countries and population groups with per caput incomes and potential for access to food not much above present levels.

Better Prospects for Overall Economic Growth in the Developing Countries but with Significant Exceptions

1.12 In the crisis decade of the 1980s, all developing regions experienced declines in per caput incomes, with the important exception of Asia, both East and South. It is likely that these trends will be reversed in the future. The latest World Bank assessment indicates that Asia would continue to perform at fairly high rates of economic growth while the prospects are for modest recovery in both Latin America/Caribbean and the Near East/North Africa. Sub-Saharan Africa would also shift to higher economic growth rates compared with the disastrous 1980s but its per caput income would grow only slightly. These developments in the overall economy already foreshadow the prospect that some regions will continue to make progress towards food security and that others may not make much progress.

1.13 The Western developed countries are likely to continue to perform as in the past. The prospects for the ex-Centrally Planned Economies (CPEs) of Europe are shrouded in uncertainty. Their combined GDP is likely to be by 1993 one-third below that of the pre-reform period. The decline will probably bottom-out in the near future, but it may take a long time before sustained growth re-establishes per caput incomes at the pre-reform levels.

World Agricultural Growth will Continue to Slow Down

1.14 The detailed assessments of this Study indicate that the growth rate of world agricultural production will be lower in the next 20 years compared with that of the last 20 years, perhaps 1.8 percent p.a. compared with 2.3 percent p.a. This is largely a continuation

of long-term trends. The slowdown is not a negative outcome *per se* to the extent that it reflects some positive developments in the world demographic and development scenes. In the first place, and as noted above, world population growth has been on the decline. Secondly, more and more countries have been raising their per caput food consumption to levels beyond which there is limited scope for further increases. Most developed countries are in this class and they are being gradually joined by some developing countries. To put it in plain language, people who have money to buy more food don't need to do so, though they will probably continue to increase their expenditure on food to pay for the ever-increasing margins of marketing, processing, packaging and the services that go with them.

1.15 The negative aspect of the slowdown has to do with the fact that it has been happening and will continue to happen while many countries and a significant part of the world population continue to have totally inadequate consumption levels and access to food, with consequent persistence of high levels of undernutrition. In short, the slowdown in world agricultural growth is also due to the fact that people who would consume more do not have sufficient incomes to demand more food and cause it to be produced. Undoubtedly, world output could expand at higher rates than envisaged in this study if effective demand were to grow faster.

1.16 There is in the preceding discussion a notional separation between demand and supply: demand expands independently of supply and causes production to respond. If the additional production is forthcoming at non-increasing prices, one cannot speak of constraints to increasing output. This description fits fairly well the situation in the more advanced countries where incomes and demand originate predominantly in sectors other than agriculture. But it applies much less to many developing countries where incomes of large parts of their population depend, directly and indirectly, on agriculture. In such situations, increasing demand and increasing production are in many respects two faces of the same coin. For if production constraints limit agricultural growth, they act as brakes on both incomes and demand as well as supply. In such situations, one can speak of production constraints limiting progress towards food security, even though such constraints may not apply at the world level.

1.17 The policy implication is that in countries with heavy dependence on agriculture, progress towards improved food security depends in major ways on making their own agriculture more productive, at least until such dependence is significantly reduced in the process of development. This self-evident conclusion is not new. It is restated here in order to dispel the notion that agricultural resource constraints do not stand in the way of improving world food security just because there is probably still ample potential for increasing food production in the world as a whole. This notwithstanding, as development proceeds and poor countries reduce their dependence on agriculture for income and employment, and become more integrated into the world economy, the issue of whether there are agricultural resource constraints to making progress towards food security for all will tend to shift from the local level to the global one.

Progress in Food and Nutrition, but Not for All

1.18 The implications of the demographic and overall development prospects, together with the assessments of this study for production, consumption and trade are that per caput food supplies for direct human consumption (as measured by the food balance sheets) in the developing countries as a whole would continue to grow, from nearly 2 500 calories today to just over 2 700 calories by the year 2010. It is likely that by the year 2010 Near East/North Africa, East Asia (including China) and Latin America/Caribbean regions will be at or above the 3 000 calorie mark, a significant progress particularly for East Asia. South Asia may also make significant progress but it will still be in 20 years time at a middling position. But the prospects are that per caput food supplies in sub-Saharan Africa will remain at very low levels.

1.19 Under the circumstances, the incidence of chronic undernutrition could decline significantly in the three regions with the better prospects. Progress will likely be made also in South Asia, though there could still be 200 million people undernourished in the region by the year 2010. Chronic undernutrition is likely to remain rampant in sub-Saharan Africa, with 32 percent of the population (some 300 million) affected. Thus, the scourge of chronic undernutrition in terms of absolute numbers affected will tend to shift from South Asia to sub-Saharan Africa. These estimates are broad orders of magnitude and relative trends rather than precise predictions of what may happen, subject to the necessary caveats (discussed in Chapter 2). They indicate that it is likely that chronic undernutrition in the developing countries as a whole will persist, perhaps at somewhat lower absolute levels, some 650 million people in the year 2010, against some 800 million people today. Therefore, there will be no respite from the need for interventions to cope with the problem, nor from that of seeking to eradicate poverty, the root cause of undernutrition.

World Production of Cereals to Continue to Grow, but not in Per Caput Terms

1.20 In the past 20 years, per caput production of cereals for the world as a whole grew from 305 kg in 1969/71 to 325 kg in 1979/81 and to 327 kg in 1989/91 (1988/90 was unrepresentative because of the North American drought of 1988). It is probable that the average may stop growing and it may fall a little to 325 kg by the year 2010. This is, however, no cause for general alarm for the reasons discussed earlier in connection with the progressive slowdown in world agricultural growth. In particular, the growth of consumption requirements for all uses in the developed countries (which have 635 kg of per caput total use of cereals and account for 46 percent of world consumption) grow only slowly and may fall in per caput terms. Therefore, these countries produce collectively as much as needed for their own consumption and to meet the increase in net exports to the developing countries. They could produce more, if more were demanded. These prospects are heavily influenced by possible developments in the ex-CPEs of Europe whose total domestic use of cereals would not only stop increasing rapidly as in the past but may actually fall slightly. This prospective development has its origin in the slower growth of their livestock sector, the more efficient use of cereals as feed and lower rates in post-harvest losses, all related to the radical reforms currently under way.

1.21 By contrast per caput production of cereals in the developing countries is foreseen to continue growing, from the 216 kg in 1988/90 to 228 kg in 2010. This is a smaller increment than was achieved in the past: 15 kg per decade in the 1970s and the 1980s. But their per caput consumption for all uses may grow faster than production, from 235 to 253 kg, most of it for feed to support the rapidly growing livestock sector. This will require further growth of net imports from the developed countries, which may grow from the 90 million tons of 1988/90 to about 160 million tons in 2010.[1] The implied rate of growth of the net import requirements is not particularly high judged by the historical record. It is more like that of the 1980s rather than the very rapid one of the 1970s. Financing increased food imports may be considered a normal feature of those developing countries in which both incomes and consumption, particularly of livestock products, grow and other sectors generate foreign exchange earnings. But those developing countries which cannot easily finance increased food imports from scarce foreign exchange earnings will face hardship. It is, therefore, reasonable to foresee a continued role for food aid for a long time to come. If policy reforms towards a more market oriented international agricultural trade system were to limit the scope for food aid from surpluses, alternative measures will be required to meet the needs. In this respect, the provisions contemplated in the Final Draft Act of the Uruguay Round of MTNs, about attenuating the effects on the food importing developing countries of an eventual rise in world market prices, creating conditions for food security stocks and continuation of food aid flows, assume particular importance.

Modest Growth in the Demand for Exports of Cereals from the Major Exporting Developed Regions

1.22 Although the prospects for further growth of exports of cereals from the major exporting developed countries to the developing countries offer some scope for further growth of production and exports of the former, the prospects are for their net exports to the rest of the world to grow by much less. This is because the group of the ex-CPEs of Europe would probably cease to be a large net importer in the future and there is a possibility that they could be 100 percent self-sufficient collectively.

1.23 There might be significant changes in the market shares in these total net exports of the three major exporting OECD areas, W. Europe, N. America and Oceania. The policy reforms under way and in prospect, if fully implemented and enshrined in an eventual GATT accord on farm trade, would probably lead to W. Europe being a smaller net exporter in the future, with all of the additional combined exports of the three groups, and some more, accruing to North America and Oceania. At least this is what is indicated by the results of most analyses concerning the possible effects of the policy reforms. These findings are, of course, subject to the many caveats attached to the assumptions and models on which these analyses are based.

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1 These are net imports of all the developing countries, after projected exports from the net exporting developing countries of some 30 million tons (up from 17 million in 1988/90 and 14 million tons in 1969/71) have been deducted from the projected imports of the net importing countries of some 190 million tons (106 million tons in 1988/90 and 34 million tons in 1969/71).

Continuing Strong Growth in the Livestock Sector

1.24 The past trends for the livestock sector in developing countries to grow at a relatively high rate are set to continue, though in attenuated form. Part of the growth in cereal imports of the developing countries will be for increased production and consumption of livestock products. However, the consumption of livestock products in the developing countries will still be well below that of the developed countries in per caput terms in the year 2010. These averages for the developing countries mask wide regional and country diversities, and in both South Asia and sub-Saharan Africa consumption will generally remain at very low levels. The disparities reflect those in incomes as well as production constraints. The latter are a factor in the unfavourable nutritional prospects of some countries in which livestock products, particularly milk, are a major staple food, e.g. in the pastoral societies.

1.25 The livestock sector of the developed countries may also grow, but at much slower rates compared with the past, with per caput consumption growing only for poultry meat. This would reflect the prospect that (a) in the ex-CPEs the production and per caput consumption of livestock products may take a long time to recover to near pre-reform levels after the sharp initial declines, and (b) the other developed countries have generally high levels of per caput consumption.

1.26 With the continued growth of the livestock sector in the developing countries, their use of cereals as feed will continue to grow fast and it may more than double by the year 2010 to some 340 million tons, about 23 percent of their total use. This increasing proportion of total cereals supplies used to feed animals in the developing countries may give rise for concern given the persistence of undernutrition. The concern would be well founded if the use of cereals for feed diverted supplies that would be otherwise available for use by the poor as direct food. This could happen but only in situations where the additional demand for feed would raise prices rather than supplies (whether from domestic production or imports) and price the poor out of the market. There are reasons to believe that this is the exception rather than the rule, as discussed in Chapter 3.

Roots, Tubers, Plantains: Continuing Importance in the Total Food Supplies of Countries in the Humid Tropics

1.27 Roots, tubers and plantains account for some 40 percent of total food supplies (in terms of calories) for about one-half of the population of sub-Saharan Africa, where overall food supplies are at very low levels. Other countries in both Africa and Latin America/Caribbean also depend significantly on these staples. Production could be increased, and will do, to meet future needs. However, the past trends have been for per caput consumption to decline, at least as far as it can be ascertained from imprecise statistics for this sector. The decline has reflected essentially trends towards urbanization where the high perishability and labour-intensive nature of preparation for consumption make them less preferred foods. With increasing urbanization, it can be expected that there will be further, though modest, declines in average per caput consumption. But dependence of these countries on these products for their total food supplies will continue to be high. The trend towards decline in per caput consumption may be attenuated if imported cereals were to become scarcer, which may well be the case if policy reforms in the developed countries were to raise prices and reduce supplies for concessionary sales and food aid. Likewise,

further research into converting starchy roots into less perishable and more convenient food products for the urban population could contribute to attenuate these trends.

The Oilcrops Sector of the Developing Countries: Continued Rapid Growth in Prospect

1.28 In the last 20 years the oilcrops sector of the developing countries grew fast and underwent radical structural change. The oil palm in East Asia and soybeans in South America exhibited spectacular growth. The shares of these products and regions in total oilcrop production increased rapidly and those of the other oilcrops of the developing countries (coconuts, groundnuts, cottonseed, sesame) and of the other regions declined accordingly.

1.29 The production growth of the sector will continue to be above-average compared with the rest of agriculture. Structural change will also continue, but at a much slower pace compared with the past. The expansion of the oilpalm sector will continue to be the most rapid, increasing its share to perhaps 38 percent, up from 32 percent at present and only 16 percent 20 years ago. Soybean production in South America will also continue to grow rapidly, but nothing like the 12-fold increase of the last 20 years, when growth had started from a very low base. The continuation of fairly high growth rates of the oilcrops sector reflect the rapid increase in consumption of the developing countries for both vegetable oils for food and oilseed proteins in support of their rapidly growing livestock sectors. They would also increase further their exports of oils and to a lesser extent those of oilmeals to the rest of the world.

Slower Growth in the Other Main Agricultural Exports of the Developing Countries

1.30 There are well-known reasons why the generally unfavourable trends in the net exports of the major export commodities of the developing countries to the rest of the world may continue. For *sugar*, the reason is mostly the probable continuation of support and protection policies, market access restrictions and subsidized exports of major developed countries. Then, the ex-CPEs are likely to be much smaller net importers in the future. Therefore, net exports to the developed countries will likely continue to fall. But the developing exporting countries are likely to continue to expand exports because there are growing markets in the net importing developing countries, which increased their net imports nearly fourfold in the last 20 years.

1.31 Unlike sugar and some other major export commodities, *coffee and cocoa* are produced only in the developing countries and consumed mostly in the Western developed countries, where per caput consumption levels are already generally high. Therefore, efforts by developing countries to increase supplies in competition with each other translates into small increases in the volume of exports and large declines in prices. For the longer term, there is scope for the situation to improve given the low consumption levels prevailing in the ex-CPEs and the developing countries themselves. But little of this scope may materialize in the form of increased consumption and imports in the next 20 years. Therefore, growth in net exports of about 25 percent, and somewhat higher in production, is a likely outcome.

The real value of export earnings is likely to grow at a rate not very different from that of volume, as some projections show that real international prices are not poised for any substantial recovery from the low levels of the late 1980s.

1.32 For *tea*, there are somewhat better prospects for production growth, though not for exports, because a good proportion of production is consumed in the developing countries themselves and per caput consumption will continue to increase. Finally, exports of *bananas* have better prospects than those of the tropical beverages since there is still scope for per caput consumption to increase in the developed countries.

1.33 In general, for the commodities produced only or mainly in developing countries competing with each other and consumed mostly in developed countries with nearly saturated consumption levels, the prospects for export earnings will continue to be dominated by movements in prices rather than volumes. The very long run remedy to declining prices may be found in the growth of consumption in yet unsaturated markets (ex-CPEs and developing countries themselves) and ultimately in the general development of the producing countries themselves. The latter factor is important because it will create alternative income-earning opportunities and put a floor to how low the returns to labour in these commodity sectors may fall before supply contracts and prices recover.

1.34 Finally, the prospects for some agricultural raw materials traditionally exported from the developing countries offer limited scope for growth in net export earnings, though for different, and not always negative, reasons. Thus, net exports of *tobacco* to the developed countries may not grow at all because their consumption is on the decline while it is on a rapid growth path in the developing countries themselves. For *cotton*, the developing countries have recently turned from being a net exporter to become a net importer and will further increase their net imports in the future. This is, on the whole, a positive development because it reflects their growing and increasingly export-oriented textiles industry. These trends could become even more pronounced if restrictions to textile exports become less stringent or are abolished. Similar considerations apply to the *hides and skins* sector and the associated expansion of exports of leather goods. Finally, *natural rubber* exports to the developed countries would continue to grow, but also here the developing countries will gradually increase their share in world consumption and may, by the year 2010, account for over one half of the world total, compared with less than one-quarter 20 years ago. Much of the expansion of consumption will be in East Asia.

The Developing Countries Likely to Turn from Net Agricultural Exporters to Net Importers

1.35 The prospective developments presented above for the major commodity sectors indicate that the net imports of the developing countries of the agricultural commodities for which they are or may become net importers will be growing faster than their net exports of their major export commodities. These trends in import and export volumes point firmly in the direction of the developing countries' combined agricultural trade account switching from surplus to deficit. The movement in this direction has been evident for some time in the historical period. The positive net balance of trade on agricultural account shrank rapidly in the 1970s when food imports from the developed countries exploded. Although the trend

was somewhat reversed in the 1980s the overall surplus was only $5.0 billion in 1988/90 compared with $17.5 billion in 1969/71 (both at 1988/90 prices).

1.36 The prospect that the developing countries may turn into net agricultural importers does not by itself say much about the welfare implications of this turnaround. It is certain that it will have a negative impact on the welfare of those countries which will continue to depend heavily on slowly growing agricultural exports to finance their food and other imports. There are many low-income countries in this situation and they include those which depend heavily on agricultural export commodities with limited growth prospects. However, for other countries these prospects are part and parcel of the development process. These are the countries whose increased imports or reduced exports of agricultural raw materials are more than compensated by growing exports of the related manufactures; and those in which the increased food imports reflect their growing incomes and food consumption and are financed from export earnings of other sectors.

4. FACTORS IN THE GROWTH OF AGRICULTURE IN DEVELOPING COUNTRIES

Further Intensification in Prospect, with Yield Growth the Mainstay of Production Increases

1.37 The production outcomes presented earlier will depend on further intensification of agriculture in the developing countries: yields will be higher, more land will be brought into cultivation and irrigated, and the existing land will be used more intensively (multiple cropping and reduced fallow periods).

1.38 Yield growth has been the mainstay of production increases in the past. It will be more so in the future, particularly in the land-scarce regions of Asia and Near East/North Africa. At present, average yields differ widely among countries. This indicates that there is considerable scope for the countries with low yields to increase production by adopting technologies already used in countries with higher yields. Progress would depend on policies and other conditions which provide incentives and make it possible for farmers to adopt known technologies and practices already used in other countries or by other farmers within the same country. However, comparisons of average yields convey only limited information about the potential for lagging countries to catch up with the ones achieving higher yields. This is because agro-ecological conditions differ widely among countries and farming environments. For example, the 5.0 tons/ha average wheat yield of Egypt reflects the fact that wheat is irrigated. This yield is not achievable by countries in which wheat is, and will continue to be, predominantly rainfed in adverse agro-ecological conditions.

1.39 Therefore, agro-ecological differences among countries must be taken into account before any judgement can be passed as to the potential for yield growth. It is for this reason that a painstaking assembly and collation of data on yields achieved in the different countries in six agro-ecological environments (five rainfed and one irrigated - hereafter referred to as "land classes"), was undertaken for this Study. The resulting data are not perfect and it has not been possible to assemble sufficient information for China. But for the other developing countries these imperfect data can go a long way towards permitting an assessment of yield growth potential which is far superior to that based only on average yields.

1.40 With these caveats in mind, the dependence of the production outcomes presented earlier on yield growth, and how credible the yield projections may be, can be illustrated as follows: the average irrigated rice yield in the developing countries is today 3.7 tons/ha, but some countries achieve only 1.0 ton and others 10.0 tons. The one-fifth of countries with the highest yields achieve an average of 6.7 tons. The country-by-country assessment of prospects for irrigated rice indicate that the average irrigated rice yield of all countries could be 5.2 tons/ha in year 2010. This means that in 20 years' time the average irrigated rice yield for all countries may be still below that achieved today by the top fifth of countries with the highest yields. This may appear conservative, but it is a "best guess" outcome of the judgements made for individual countries taking into account both differences among countries in the quality of irrigated lands as well in the socioeconomic environments which condition the pace of adoption of yield-increasing technologies. Similar considerations apply also to the rate at which average yields of other crops in each land class may edge upwards towards those achieved by the best performing countries today. Thus, the average yield of rainfed wheat in sub-humid land may grow from 1.7 to 2.1 tons/ha, compared with the 2.3 tons/ha achieved today by the top fifth of countries. For sub-humid rainfed maize the corresponding numbers are for the average yield to grow from 1.8 to 2.6 tons/ha compared with 2.8 tons/ha achieved by the top 20 percent of countries today. And so on for other crops and land classes (for more details see Tables 3.6, 4.3 and 4.7, in Chapters 3 and 4).

1.41 It all goes to demonstrate that the further spread and adaptation to local conditions of the technologies used today provide sufficient scope for further growth in average yields, even if no major new research breakthroughs raising the yield ceilings at experiment stations were to be forthcoming. But the research effort must go on in major ways to prepare for the longer term, adapt varieties to local conditions and exploit fully the breakthroughs of the recent past, e.g. enable farmers to retain hybrid rice seeds from their crops for many seasons rather than have to buy new ones for each planting. Further research in the hybrid rice technology based on apomixis-asexual reproduction holds promise in this respect. Moreover, continuing research effort is needed for the crops and unfavourable environments which had been neglected in the past, as well as for preventing declines and maintaining and perhaps increasing yields in those farming conditions where yields achieved are near the ceilings of experiment station yields.

Land in Crop Production to Expand and to be Used More Intensively

1.42 The developing countries (excluding China) have about 2.5 billion ha of land on which rainfed crops could achieve reasonable yields, depending on the technology used. Nearly 80 percent of it is in the two land-abundant regions of sub-Saharan Africa and Latin America/Caribbean. The differences in land/person ratios among regions are enormous, with South Asia and the Near East/North Africa region having particularly low land availabilities per caput. Of this total land, about 720 million ha are currently used in crop production and another 36 million ha of land so used comes from desert land which has been irrigated. The projections of this study would require increases in the different countries which sum up to about 90 million ha. Thus, by the year 2010, the total land in crop production could be some 850 million ha. The expansion would mostly be in sub-Saharan Africa and Latin America/Caribbean, some in East Asia (excluding China) and very little in the other two regions.

1.43 Of the some 760 million ha in agricultural use at present, only about 600 million ha are cropped and harvested in any given year. This is because land is being used at very different intensities in the different regions. Thus, it is estimated that only about 55 percent of the land in regular crop production is cropped and harvested in any given year in sub-Saharan Africa (the rest being fallow), while the average cropping intensity is about 110 percent in South Asia, reflecting mainly the multiple cropping in the region's substantial areas under irrigation as well as the region's more general land scarcity. It is foreseen that the land needs for crop production growth will come in part from further increases in cropping intensities, and the average for the developing countries as a whole could rise from 79 percent at present to 85 percent in the year 2010. Thus, land cropped and harvested in an average year would increase from 600 million ha at present to about 720 million ha in year 2010, or 120 million ha increase compared with the 90 million ha of new land to be brought in crop production.

1.44 Achievement of the increased intensities and higher yields depends crucially on maintenance of irrigation and its further expansion by 23 million ha or 19 percent in a net sense, i.e. on top of the expansion needed to offset losses of irrigated land due to salinization, etc. This is a lower rate of expansion than in the past because of the well known problems of increasing unit costs of irrigation investment and scarcity of water resources and suitable sites, as well as the enhanced attention paid to avoiding adverse environmental impacts. Given these constraints, but also for reasons of efficiency, the emphasis in the future will be more on making more efficient use of water and less on indiscriminate expansion of irrigated areas. The bulk of additional irrigation would be in South Asia, which now accounts for 52 percent of all irrigation of the developing countries (excluding China), a share it will maintain in the future.

Would Agricultural Expansion Encroach on the Forest?

1.45 The FAO Forest Resources Assessment 1990 (FOR90) produced data on the forest land of the tropical countries. Of the 91 countries for which the data on land with crop production potential were estimated, the forest area data are available for only 69 countries. The following comments examine the extent to which agricultural expansion may encroach on the forest. They, therefore, refer only to the subset of the 69 countries which account for all but 4 percent of the total tropical forest area in FOR90. They are also speculative because the extent of overlap between the forest and the land with agricultural potential is not fully known. Only some elements of such overlap can be deduced indirectly.

1.46 In the absence of more concrete information the situation in these 69 countries is one whereby 85 million ha are projected to be converted to agriculture in 20 years out of a total 1 720 million ha of land with agricultural potential but not in crop production use at present. The extent to which this land overlaps with the forest area is not fully known, but a minimum estimate (derived as explained in Chapter 4) is about 800 million ha and the real overlap is probably much larger.[2] Not much more can be said on this matter, except perhaps that if all the additional land for agriculture were to come from the forest areas, it

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2 It is noted that data on protected areas for 63 out of these 69 countries indicate that some 380 million ha are in this class, of which some 200 million are on land with agricultural potential but not in agricultural use.

would imply an annual rate of deforestation of 4.2 million ha, or 0.25 percent p.a. of the total forest area of these 69 countries of 1690 million ha. This compares with the some 15 million ha (0.8 percent p.a.) of annual deforestation estimated for the 1980s. This latter figure, however, includes deforestation from all causes, not only from formal expansion of crop production. In particular, deforestation results from expansion of grazing (not included in the estimates of this study) and informal, unrecorded, agriculture using much more land than considered necessary to achieve the crop production increases. It also includes deforestation from logging of areas not yet reforested by natural regrowth and from fuelwood gathering operations. To the extent that expansion of grazing and of informal agriculture and overcutting for fuelwood continue in the future it must be expected that deforestation will continue at a much greater rate than needed for expansion of formal agriculture.

Other Claims on Land

1.47 Land with agricultural potential is increasingly occupied by human settlements and infrastructure. Rough estimates for the developing countries (excluding China) indicate that such uses of land may be about 94 million ha, or 0.033 ha per caput (3 000 persons/km^2), but with this ratio varying widely among countries, depending on overall population densities. Not all human settlements are on land with agricultural potential, but about 50 million ha probably are in this category. With population growth, more land will be diverted to human settlements and infrastructure, though perhaps not in proportion, because with increasing population densities the land so used per person will tend to decline to perhaps 0.03 ha. This means that land in human settlements may increase to 128 million ha, of which perhaps some 70 million would be land with agricultural potential, an increase of the latter of 20 million ha. This potential use must therefore be added to that for the expansion of crop production proper, discussed above, to obtain an idea on future claims on the land with agricultural potential.

Further Growth in Fertilizer Use and Some in Pesticide Use in the Developing Countries

1.48 The developing countries (excluding China) use some 37 million tons of *fertilizer* (in terms of nutrients NPK). Such use increased fourfold in the last 20 years, though the growth rate of the 1980s was much lower than that of the 1970s. At present, the fertilizer use rates have reached 62 kg/ha of harvested area (about one-half the average of the developed countries), but with very wide differences, ranging regionally from 11 kg in sub-Saharan African to 90 kg in Near East/North Africa. The scope for further increases is much less than in the past. This, in combination with the lower rate of growth of agriculture, will tend to make for further declines in the growth rate of fertilizer consumption, to 3.8 percent p.a. in the period to 2010. Thus, projected fertilizer consumption in the developing countries (excluding China) may rise to some 80 million tons and the application rate to some 110 kg/ha. The environmental dimensions of this prospective development are discussed in Chapters 11-12. Here it is worth noting that while there are problems from excessive use in some irrigated areas of the developing countries, there are also problems from too little use in other areas, where it is associated with land degradation due to nutrient mining.

1.49 Traditional plant protection methods (tillage, burning, crop rotation) remain important in developing countries. However, methods based on the use of chemical *pesticides* have become widely used in recent decades. It is estimated that the developing countries used some 620 thousand tons of pesticides (active ingredient) in 1980. Such use then declined to 530 thousand tons (one-fifth of the world total) but then recently growth resumed at about 1 percent p.a., the same as that in the developed countries. The developing countries account for about 50 percent of world use of insecticides, but for much smaller proportions of fungicides and herbicides. This reflects both agro-ecological and economic factors, e.g. higher incidence of insects in the humid tropics and cheaper labour for weed control. With labour costs rising in some countries, it can be expected that chemical herbicides will be used more widely.

1.50 The intensification of production and the expansion of agriculture into new areas in the developing countries could translate into further growth of pesticide use. Such growth could be contained at fairly low rates, through a combination of technological change, improved management and incentives and increasing resort to methods of integrated pest management (IPM). These prospects for the developing countries contrast with those for the developed countries where the lower growth of agriculture and the policies for pesticides as well as further spread of IPM could eventually lead to absolute declines in total use.

5. FURTHER PRESSURES ON AGRICULTURAL RESOURCES AND THE ENVIRONMENT

1.51 The pressures for conversion to agricultural use and human settlements of land with agricultural potential were dealt with in the preceding section. On the whole such claims (110 million ha in all developing countries, excluding China) over the next 20 years would appear small when compared with about 1.8 billion ha of land with agricultural potential not occupied by either of the two uses. However, land scarcities are very acute in some countries and regions, viz. South Asia and Near East/North Africa. Even the small increases foreseen for them are a significant part of their still unused land. For example, the increments for these two uses would claim about 40 percent of the still unused land with agricultural potential in South Asia. There will be little land left for further expansion, at least for human settlements, beyond the year 2010. It is noted that additional land for agriculture in South Asia will be needed even after allowing for further intensification. The latter could raise cropping intensities from 110 percent to 120 percent and double the fertilizer use rate per ha.

1.52 Even though land constraints are severe in some countries and regions, those of *freshwater* supplies for agriculture are even more limiting for many more countries. The increasing claims on agricultural land for non-agricultural uses are minor when compared with those placed on water resources, because the per caput non-agricultural use of water tends to rise very rapidly with urbanization and industrialization. Competition between agriculture and the other sectors for dwindling per caput availabilities of freshwater will become more intense in the future and can only be accommodated by increasing the efficiency in water use.

1.53 *Degradation of soils* is estimated to affect some 1.2 billion ha of land worldwide, of which about 450 million ha is in Asia. Among the causes, deforestation and overgrazing

probably contribute one-third each, with the bulk of the balance due mostly to mismanagement of arable land. Soil (water and wind) erosion accounts for just over 1 billion ha of total degradation, with the balance due to chemical and physical degradation. Both man-made and natural processes (e.g. upward and ongoing movements in the earth's crust) cause soil degradation. Some degradation will continue to occur in the future but the relationship between soil erosion and productivity loss is complex and more work is needed before firm conclusions can be drawn about the impact of soil erosion on yields.

1.54 Degradation from nutrient mining is a serious problem, particularly in the semi-areas of sub-Saharan Africa where livestock manure is in short supply and the use of mineral fertilizer is seldom economic. The problem will probably continue to exist over the next 20 years, though perhaps in less intense form. Degradation from salinization of soils is primarily a problem of irrigated areas, but also occurs in hot dry zones. Estimates of irrigated land losses from this cause vary widely (from 0.2 million ha to 1.5 million ha annually, worldwide) while 10-15 percent of irrigated land is to some extent degraded through waterlogging and salinization.

1.55 *Desertification* (broadly: land degradation in dryland areas) is estimated to affect some 30 percent of the world's land surface. More recent thinking on desertification points to a growing consensus that the past estimates of area affected were greatly exaggerated. Some of the more extreme estimates were due to weaknesses in the methodology used to produce them. It is now recognized that drylands are much more resilient to drought and to man's abuse than previously thought. However, further expansion of agriculture into fragile soils in the dryland areas would contribute to increasing problems from this source.

1.56 *Water contamination* of agricultural origin (salt concentrations in irrigated areas, contamination from fertilizer and pesticides as well as from effluents of intensive livestock units and fish farms) will likely increase further because of the long length of time required for appropriate corrective action.

1.57 As regards *pesticides*, it is assumed that greater emphasis on integrated pest management and concerns about health and ecosystem conservation will tend to reduce the growth rate of pesticide use. But the more intensive use of land (reduced fallows, more multiple cropping) as well as the higher than average growth of the vegetables sector will contribute to further, though modest, increases in pesticide use in the developing countries.

1.58 Further expansion and intensification of agriculture will also contribute to intensified *pressures on the environment of a global nature*. Deforestation will affect adversely the dual role of forests as habitats for biodiversity and as major carbon sinks. Biodiversity will also likely suffer from possible further draining of wetlands for conversion to agriculture, even though this conversion may affect only a minor proportion of total wetlands. Additionally, agriculture will continue to contribute to the growth of greenhouse gases in the atmosphere (biomass burning in the process of deforestation, and methane emissions from rice cultivation and from ruminant livestock).

1.59 The eventual impacts of climate change are still uncertain, but on present evidence they may affect particularly adversely those regions already vulnerable to present day climate variation, notably sub-Saharan Africa. The effects of an eventual rise in the sea level would also be severe for some countries and affect a good part of their high quality land resources.

For the present and more immediate future, increased CO_2 levels appear to have a positive effect on agriculture in general, because they contribute to higher yields through faster growth of plant biomass and better water utilization in many crops.

6. TECHNOLOGICAL AND OTHER POLICIES TO MINIMIZE TRADE-OFFS BETWEEN AGRICULTURAL DEVELOPMENT AND THE ENVIRONMENT

1.60 Existing and possible future technologies provide scope for responding, wholly or partially, to the increased pressures of agricultural origin on the environment. Exploring the potential for doing so requires shifting technology from "hardware" solutions requiring large inputs of fixed and variable capital, e.g. machine-made land terraces or pesticides, to solutions based on more sophisticated, knowledge and information-intensive resource management practices which can lower both off-farm costs and environmental pressures. This is not to suggest that a new technological approach is sufficient by itself. Much will depend on policies and institutional measures providing incentives needed for farmers, forest users and fishermen to adopt sustainable technologies and resource management practices. Institutional measures will include the establishment of well-defined property or user rights for public and private resources, as well as enhanced peoples' participation and decentralized resource management.

1.61 It is noted from the outset that the general debate regarding the merits of low or high external input technological development paths for agriculture has run its course, and there is growing acceptance that neither of the two approaches has the whole answer. What is required is a balanced integration of the two systems. For example, the use of mineral fertilizer will continue to grow (see Section 4.5), but it cannot in many situations provide all the inputs necessary to maintain soil fertility and must be associated with organic manures and other biological inputs as part of an integrated plant nutrition system (IPNS).

1.62 More generally, the extent to which countries will follow more environment-friendly practices depends on their socio-economic and natural resource situations. The developed countries are in a better position to do so, and are moving in this direction. In contrast, the developing countries are in much greater need to improve the management of their agricultural resources because their livelihoods depend crucially on them. At the same time, however, they are in greater need than the developed countries to increase production through intensification and have much less access to technologies and resources for more sustainable production. But there is much scope for improvement and for minimizing trade-offs between more production and the environment even under these unfavourable conditions. The important thing is for policies to recognize that the first priority of many farmers is household food security and family welfare. Thus efforts to minimize trade-offs between more production and the environment must be centred on actions that improve household food security and are profitable on time-scales which meet the farmers' differing circumstances or risk perceptions.

1.63 It is now well recognized that the past heavy dependence of the agricultural development of the developing countries on the transfer of technologies and management practices of the developed countries contributed to raise production and productivity, but it had some undesirable effects, e.g. discouragement of mixed cropping and minimal tillage

practices, dominance of mineral fertilizer, emphasis on engineering rather than biological approaches to soil stabilization, neglect of semi-arid areas and crops, etc. Corrective action would require a shift in national and international research priorities, with particular emphasis on technologies which are not too risky and are profitable at early stages in the adoption process. Efforts to build on indigenous technical knowledge hold promise, but there is no guarantee that they will be sufficient in isolation.

1.64 In the quest for limiting *land and water degradation*, the wider adoption of known techniques of soil conservation with low external capital requirements could help boost or stabilize yields in the first half of the projection period. Dryland areas in sub-Saharan Africa and Asia could benefit from such techniques, as would slopelands in the humid tropics. Likewise, efforts for dealing with the *salinization problem* could benefit from integration of the standard corrective action (drainage, canal lining) with a more holistic approach to water management, e.g. conjunctive use of surface and groundwater and parallel use of canal and tubewell systems. More generally, the increasing dependence on raising water use efficiency for coping with the growing water shortages will require some radical rethinking of policy approaches to pricing water and to needed institutional changes.

1.65 Wider adoption of *integrated plant nutrition,* its further development and improved management of input use provide the main technological way to meeting the challenge of required increases in nutrient supplies in support of more production while minimizing adverse effects on the environment. Likewise, *integrated pest management* is to be the mainstay of efforts in the plant protection area, with priority to the crops accounting for the bulk of pesticide use: cotton, maize, soybeans, fruit and vegetables.

1.66 In the *livestock sector*, there is much in the technological pipeline to meet the challenge of moving towards more sustainable production systems. Policies in this direction could have an impact well before 2010. The aims would be to compensate for the lack or poor quality of land through measures to raise pasture and rangeland output and improve management systems; to bring about a closer integration of crop and livestock production; to raise the supply and quality of supplementary feeds; to achieve genetic improvements from conventional breeding and modern biotechnical tools; and to complement these gains with cheaper and more effective animal health measures.

1.67 *Biotechnology* offers a range of applications for plant and animal production. Some are likely to have an increasing impact well before 2010; others in the longer term. The former include tissue culture of virus-free stocks of cassava and other root crops, and the introduction of microbial plant growth promoters e.g. mycorrhiza. The latter include cereals with the ability to fix some of their own nitrogen needs, and transgenic tree crops.

1.68 Making progress towards the adoption of technologies for sustainable agriculture will depend greatly on increased *agricultural research* efforts with emphasis on (a) improved management of biological systems, based on a better understanding of their feedback and balancing processes; (b) better information management, implying the need for sound data on natural resources, land use and farming systems etc, to improve environmental monitoring capability; and (c) better farm-household system management, in order to obtain a better integration of activities in the household and in the field, and on- and off-farm. At the operational level, the research effort should be directed at promoting sustainable increases in productivity in the higher potential areas as well as at targeting marginal and fragile

environments where current degradation must be reversed and production stabilized or raised. These thrusts must be supplemented by two cross-cutting and highly complementary approaches, that of rehabilitation and restoration of ecology, and that of exploiting the synergism of indigenous technical knowledge and modern science. All four actions must be supported by international efforts to strengthen the national agricultural research systems, both institutionally and financially.

1.69 Finally, *international agricultural trade* and policies affecting it can exert influences on the environment and the prospects for sustainable development. Trade may affect the environment if production shifts from places where it is less sustainable to places where it is more sustainable and vice versa. To the extent that trade contributes to shift production to more sustainable locations, more trade would tend to lower global pressures on resources and the environment. Such pressures would be minimized when all trading countries have environmental policies which embody the environmental externalities into the costs of production and the prices of the traded goods. However, environmental externalities need not be valued in the same way in countries with differing resource endowments and levels of development. In particular poor countries should not be denied opportunities for profitable trade because they do not meet the strict, and often inappropriate for them, environmental conditions reflecting values of much wealthier societies.

7. FOREST SECTOR PROSPECTS

1.70 With the exception of fuelwood, per caput consumption of *forest and forest-industry products* will continue to grow, particularly in the developing countries, with growth being highest for wood-based panels and paper. The developed countries as a whole should face no major problem in increasing production of wood in sustainable ways by as much as required for their own consumption and exports. The developing countries depend currently to a high degree on natural forests for the production of wood, for own consumption and exports. Such dependence and their higher growth of demand will make it more difficult for them to increase production in sustainable ways, unless greatly improved management measures are instituted and forest plantations greatly expanded.

1.71 Developing countries, particularly the poorest ones, depend on wood for a major part of their energy supplies. The shortages of *fuelwood* are likely to persist and become more acute as accessible forest and non-forest sources dwindle due to overexploitation and conversion of forest land to other uses. Although much of the growth in energy consumption of the population groups which depend on fuelwood will be met by the continuing trend towards substitution of alternative fuels for wood, some population groups (e.g. the urban poor or rural people in remote locations) are not likely to have ready access to such alternatives. For them, the future outlook is for more work to be put into procuring wood and making do with less energy.

1.72 Pressures on the forest for meeting often conflicting demands are bound to increase, mainly in the developing countries, and continue to imperil the forest's essential environmental functions. The highest risk is manifested in terms of *tropical deforestation*. It continued to advance in the 1980s at about 15 million ha p.a., or 0.8 percent of the total tropical forest area. The FOR90 Assessment documents that deforestation is observed to radiate out from the populated areas and that the higher the increase in population densities

the higher the rate of deforestation, other things being equal. It also notes that much of the deforestation is related to the expansion of agriculture, whether in the form of recorded conversion to arable land or, more often, unrecorded expansion. Fuelwood collection is also a contributing factor. Logging *per se*, on the other hand, need not lead to permanent loss of forest if soundly managed. It may, however, affect other vital environmental functions of the forest, e.g. biodiversity. Moreover, the opening-up of previously inaccessible forest areas by logging operations tends to facilitate settlement and conversion to agriculture.

1.73 These findings seem to confirm the common belief that there is a close association between population growth and deforestation. However, for policy purposes the mechanism connecting these two variables has to be understood. This is no simple matter, for the reasons discussed earlier in relation to the build-up of pressures on agricultural resources and the environment. In particular, it is noted that the most relevant aspect of population growth is the extent to which it is associated with increases in the number of people depending on agriculture, and more generally the rural poor. Many developing countries are far from having reached the stage when pressures from this kind of population growth are relaxed. Some of them are not even making progress towards it.

1.74 It follows that further deforestation is to be expected in the future. Some speculative comments on the possible deforestation impact of expansion of agriculture and human settlements for the year 2010 were made in Section 4. It was noted there that informal and disorderly expansion of agriculture may lead to a higher rate of conversion of land and forest areas than required by the projected growth in crop production. Expansion of grazing, fuelwood production and unsustainable logging may further contribute to deforestation. Under the circumstances, the key issue is how to minimize loss of forest during this rather protracted, though hopefully transitory, phase, until such time as the inherent forces (development, reduction in agricultural population and rural poverty, etc.) making for containment or reversal of deforestation come into play.

1.75 The preceding discussion is based on two premises: (a) that much of the deforestation is caused by expansion of agriculture, and (b) that it is closely related to the growth of population in poverty, and indeed that part which depends on agriculture for a living. True as these premises are, they tell only part of the story. In particular it may not be concluded that the rate of damage to the forest will slow down at the initial stage of accelerated economic growth and poverty reduction. There is evidence suggesting that the opposite may happen. This is explained in part by the fact that more intensified exploitation of forest resources and expansion of agriculture to exploit profitable opportunities are part and parcel of the very process of accelerated development and poverty reduction. In practice, countries tend to run down their natural capital to increase incomes as conventionally measured, i.e. without netting-out the income gains for the losses of natural capital. The other contributing factor has to do with the limited capabilities of countries to formulate and enforce rules for sustainable exploitation of the forest resources; and in some cases their own sector-specific or economy-wide policies translate into incentives for unsustainable exploitation. Ignoring other causes of deforestation, in particular the complex interactions of activities by both the poor and the non-poor, can lead to wrong policy conclusions as noted earlier.

8. INCREASING RESOURCE CONSTRAINTS IN FISHERIES

1.76 The historical developments as well as the future prospects of the fisheries sector are conditioned, to a significant extent, by the wild characteristic of the resource and the fact that, for most species, the levels of production are limited by nature. This has three important consequences. First, beyond certain levels, additional investment in fishing effort does not produce additional yields and, in many cases, actually leads to declines in total catch as well as to economic waste. Such an increase in fishing effort is inevitable in those, almost universal, situations where there is ineffective fisheries management. Second, with growing demand and limited supplies, the real prices of fish products inevitably increase. This has important and damaging consequences for low-income consumers, particularly those in the developing countries. The third major, and more positive, result is that limited natural supplies and high prices serve to stimulate increased production through the cultivation of those species that allow it.

1.77 World production of fish had been increasing up to 1989 to a peak of 100 million tons after which it declined to about 97 million in the three subsequent years. The share of culture fisheries in total production has been increasing rapidly and it currently accounts for about 12 percent of the total. Marine capture fisheries account for about 80 million tons of the total. It is now evident that the yield of this sector is adversely affected at extraction levels beyond about 80 million tons.

1.78 The natural resource constraints to increasing production in the capture fisheries sector mean that additional fishing effort and investment is unlikely to increase production and may well lead to declines. Better management and other interventions which would favour recovery of fish stocks could make it possible to increase somewhat capture fisheries production (marine and inland) from the present 85 million tons to perhaps 90-110 million tons. This estimate is hypothetical and subject to many uncertainties. Culture fisheries (marine and inland) have higher growth potential, but even here constraints are present (technology, environment, disease). There is scope for reducing these constraints, particularly for marine environment aquaculture, and it is possible that production could grow at a higher rate than that of capture fisheries, e.g. from the 12 million tons to 15-20 million tons by year 2010.

1.79 It follows that total fish production from all sources could be in year 2010 between 10 percent and 30 percent above present levels. Over the same period, world population is expected to grow by 36 percent. Therefore, per caput fish supplies will likely fall. Consumption by the poor may fall by more and shift in part to species currently used for reduction to fishmeal, as the species currently less preferred by high-income consumers are diverted to their segment of the market. These prospective developments can have serious nutritional consequences for the poor consumers in countries with high dependence on fish for protein supplies, e.g. many countries in Asia and Africa.

1.80 The increasing supply constraints and the associated rise in the real price of fish will tend to stimulate greater investment in fishing effort, thus establishing a vicious circle whereby stock depletion reduces supplies leading to additional price increases. This process has been aided by heavy subsidies granted to fisheries by major countries. With the reforms under way in the ex-centrally planned economies of Europe, a substantial part of their subsidized operations has become openly uneconomic. The consequent reductions in the

fleets of these countries are leading to significant structural change in the world fishing industry.

1.81 This vicious circle can partly be broken by the establishment of systems of exclusive use rights which provide the fishermen with a stake in the resource and an interest in future returns. However, as many governments have found, this is difficult to achieve. At national levels, fishery administrators generally do not have the mandate to make such decisions. In international areas or areas where stocks are shared by countries (e.g. the northeast Atlantic), negotiators cannot readily agree to controls which limit the rights of their own fishermen. But as the problems become increasingly severe, the issues are raised to higher political levels and, eventually, will force the necessary decisions. Several countries have already taken the basic steps to create exclusive use rights and have achieved significant benefits. Although the systems still contain many imperfections, the improvements that have been produced provide valuable lessons for other countries. There is some hope, therefore, that the management of fisheries will eventually improve. However, although the benefits will be significant in reducing biological and economic waste, they will still not be sufficient to overcome the limits on supply.

1.82 Finally, fisheries and more general policies must address the problems increasingly affecting small-scale fisheries: conflict with large-scale operations in the inshore waters and degradation of the coastal environment. This is necessary for social purposes, for shifting production on to a more sustainable base and for minimizing adverse effects on the environment. With regard to the latter, it is noted that the coastal zone receives large amounts of pollutants including: organic wastes from municipalities, chemical wastes from industries, pesticides and herbicides from agriculture and siltation from forest land clearing and road building. In addition, activities within the coastal zone also affect the environment. These include mining of coral reefs and destruction of mangrove swamps. Fishermen themselves contribute to these kinds of damage by converting mangrove swamps to mariculture ponds for shrimp; by excessive use of feed and antibiotics in cage culture; and by using dynamite, poison and other kinds of techniques that destroy coral reefs.

9. POLICIES FOR AGRICULTURE AND RURAL DEVELOPMENT IN DEVELOPING COUNTRIES

Policies for Agriculture in an Economy-Wide Context

1.83 It is now well accepted that policies for agriculture must be viewed as an important component and be an integral part of the wider policy environment. The initial approaches of the post Second World War period emphasized, at best, benign neglect of agriculture, extraction of a surplus from it and preference for, often import substitution-based, industrialization. Such approaches have often been proven counterproductive, though practices based on such perceptions persisted for a long time in several developing countries. It is now well recognized that agriculture's role must be upgraded in development strategies, notwithstanding the fact that in the process of development other sectors are bound to grow faster than agriculture.

1.84 The general policy thrust underpinning this study draws on the lessons of experience and current thinking, and may be summarized as follows:

(a) Contrary to the earlier thinking mentioned above, it is now well accepted that in the developing countries with a high weight of agriculture in the total economy and employment, overall development is impeded if agriculture is neglected, starved of resources or discriminated against by the use of policies which affect adversely producer incentives; and that such neglect is not only socially unacceptable, seeing that the majority of the poor, and often of the total population, depend on agriculture, but also economically inefficient.

(b) Farmers and agriculture do respond to incentives, and many of the successes and failures in getting agriculture moving can be explained by policies which permitted such incentives to manifest themselves or, on the contrary, affected them adversely, directly or indirectly. Incentives comprise not only better prices for outputs and lower ones for inputs but also the provision to agriculture of public goods such as infrastructure, education, research, etc.

(c) Agriculture's performance is affected not only by policies specifically designed for it (e.g. price supports, taxes, subsidies) but also, and often more deeply, by policies affecting the overall macro-economic environment (e.g. public sector deficits, inflation, interest rate, exchange rate) as well as policies for the other sectors (e.g. the rate of protection accorded to manufacturing if it makes more expensive the manufactured inputs and consumer goods purchased by agriculture). The lesson is that agriculture cannot prosper in an environment of high inflation, overvalued exchange rates and generally in conditions which turn incentives against it. The importance of the macro-economic factors came in stark evidence in the aftermath of the 1970s, a period of external shocks, easy borrowing and build-up of foreign debt, which was followed by the emergence of strong macro-economic disequilibria and ushered in the crisis decade of the 1980s. Policy responses to correct such imbalances (going under the generic name of structural adjustment) while restoring incentives to the sector may have also affected the sector negatively due to public spending cuts, less growth of the demand for agricultural produce and fewer opportunities for agricultural labour to move to other sectors. These reforms may not by themselves engineer resumption of growth but they are considered necessary as a step towards setting the economy on an even keel, in the absence of which strategies for long-term growth have a low probability of succeeding.

(d) Certain types of public sector involvement in economic life can be counterproductive. The analysis of experiences here draws heavily on examples from agriculture, as government involvement particularly in marketing of agricultural produce was very diffuse in some countries. The issues related to the proper role of the public sector have still to be settled (and certainly they cannot be settled on dogmatic grounds) as the expected benefits from reforms to correct these perceived structural shortcomings and the often associated macro-economic imbalances are in many cases slow in coming and of uncertain magnitude and duration. But some degree of consensus can be gleaned. It reaffirms and strengthens the case for an enhanced role of the public sector in agriculture in such areas as education (including technical education for agriculture) research and

technology development and transfer, etc., with the proviso, of course, that success or failure depend greatly on the organizational and managerial capabilities of governments. The case for this sort of public sector role is further strengthened by increasing evidence about the high rates of return to agricultural research and that what matters for development, together with, and perhaps more than, investment in physical assets, is investment in human capital and knowledge. In parallel, the consensus seems to lend support to the proposition that, in a general sense, governments should backstop rather than supplant the private sector in production and marketing by, mainly, creating the institutional framework and enforcing the rules for markets to work efficiently and for prices to play their vital role as incentives and disincentives for guiding such private sector activities.

1.85 In conclusion, it can be stated with confidence that the early post-war ideas of squeezing agriculture for the benefit of other sectors are dead and hopefully buried for good. This does not mean that agriculture's role as supplier of resources to the rest of the economy will cease. But it does mean that in many situations priority must be given to increasing agricultural productivity and the incomes of the rural people if markets for the domestic industry are to be expanded and if a surplus is to be created in agriculture and transferred, rather than extracted, to other sectors. Such transfers are seen primarily as spontaneous responses to the normal course of events whereby agriculture grows less rapidly than other sectors. In these conditions, other sectors offer generally higher rates of return and it is natural that resources are directed to them. Here again, the importance of public sector interventions to promote investment benefiting agriculture is emphasized, e.g. in research, education, infrastructure, etc., because the social rate of return on these investments can exceed by far the private rate of return. In the process of development and structural transformation, the initial conditions prevailing in some countries dictate that there is strong case for priority to agriculture in development strategies to enable the sector to play its vital role in poverty alleviation and in backstopping overall economic growth.

Policies for, or Affecting, International Agricultural Trade

1.86 A number of policy changes have been undertaken in recent years or are under consideration, at both the international and the national levels, which can have profound effects on international agricultural trade. All point to the direction of allowing an enhanced role for market forces to determine trade flows. The reforms in the ex-centrally planned economies of Europe belong in this category. Their potential trade effects were noted earlier (paragraph 1.22). Here belongs also the reform of the European Community's Common Agricultural Policy (CAP), with potential trade effects also noted in paragraph 1.23. These effects of the CAP reform would be for the major temperate commodities in the direction of those that could be forthcoming from an eventual agreement on the agricultural part of the Uruguay Round, if the latter were to be largely along the lines of the Draft Final Act.

1.87 Other developed countries are also introducing policy reforms that would reduce the level of support and protection of agriculture and allow an enhanced role for market forces. In parallel, the general thrust of policy reforms of the developing countries described in the preceding section is towards more open economies and structural adjustments which would create more favourable conditions for trade. However, some key problems faced by many developing countries in their agricultural trade relations are not being addressed with the

same urgency, if at all. These include issues of, among others, the falling and volatile prices of major tropical export commodities or market access restrictions and subsidized export competition for some of their commodities on the part of developed countries. Finally, the concerns for the environment and the related policies have helped bring into the international trade policy debate the issues concerning the interactions between trade and the environment. These issues were noted earlier (paragraph 1.69).

Issues of Rural Poverty and Rural Development

1.88 Over one billion people in the developing countries are poor, with a substantial majority of them living in rural areas. The development of agriculture may therefore play a direct role in rural poverty alleviation, since the majority of rural poor depend on agricultural activity for providing the main source of their income and employment. The projected growth rates of agricultural production presented earlier are generally above those of the population dependent on agriculture in all developing countries. The implicit growth rates of the average per caput incomes of the agricultural population are, however, modest, though they can be significant in those countries where the agricultural population is on the decline. Reductions in the incidence of rural poverty from agricultural growth depends not only on its rate per caput but also on its impact on distribution; and also on increasing opportunities for non-agricultural employment in rural areas in synergy with agricultural growth.

1.89 The impacts of agricultural growth on different socio-economic categories of rural producers and labourers, as well as the mechanisms through which these impacts are mediated, depend on the nature of the growth processes and the structural factors underlying the social organization in rural areas. The evidence seems to suggest that while, on balance, agricultural growth can be expected to bring about reductions in rural poverty, some parts of the rural population may become worse-off economically. The structural characteristics of the rural economy at the inception of agricultural growth play a predominant role in the distribution of benefits from higher production.

1.90 Access to land is a major factor determining the poverty alleviation effects of agricultural growth as well as conditioning the growth process itself. The most recent attempt to take stock of progress in redistributive *land reform* was undertaken in 1991 for the quadrennial FAO report on progress under the WCARRD Programme of Action. The report concludes that progress has been limited, mainly because the implementation of land distribution programmes was strongly affected by political realities. Yet the case for such reforms remains strong on both efficiency and equity grounds. It is further strengthened when linkages with the non-agricultural rural sector are considered, because a more equal distribution stimulates also rural non-farm employment. In general, the experience seems to suggest that political commitment and strong follow-up support from the public sector to beneficiaries of land reform are essential ingredients of successful land reform policies. Land reform will continue to be a relevant issue in the quest for rural poverty alleviation. This will be particularly so in countries with increasing agricultural population and poor non-agricultural growth prospects.

1.91 Beyond reforms affecting the distribution of land ownership, those of *tenancy arrangements* remain important. The lessons here are that past policies restricting

sharecropping contracts were sometimes counterproductive. The tenancy reforms pursued in the reforming centrally planned economies of Asia are proving increasingly successful as they shift from socialized farming to household-based arrangements with adequate security of tenure. It is also increasingly accepted that most traditional land tenure systems in Africa can adapt well to changing circumstances and the policy emphasis should be on providing an appropriate legal and institutional environment.

1.92 Limited access to *rural finance* by the poor in agriculture has been a major limiting factor in agricultural development and poverty alleviation. The policy orientation favouring provision of formal finance through specialized credit institutions has been often unsuccessful and there is increasing recognition of the need for less formal arrangements to enhance access to credit of the poor, e.g. Rotating Savings and Credit Associations (ROSCAs).

1.93 Concerning *marketing*, the attempts to provide marketing services to agriculture, including to the poor, often together with other services, through parastatals have proven generally, though not always, inefficient. Such inefficiencies are among the reasons why reform of the role of the public sector in agricultural marketing figures prominently in structural adjustment programmes. There is a well-recognized role for government in marketing by providing infrastructure, the legal framework and enforcement of rules and generally supporting the functioning of markets. However, the policy thrust is for direct involvement of the state in marketing to be curtailed and for the private sector to be allowed and encouraged to be the main vehicle for this function. The key issue is how to move smoothly from one organizational form to another, because the poor will suffer most if major disruptions in services occur.

1.94 In the longer term, the growth of agriculture and the overall economy would tend to alleviate the rural poverty problem, particularly if agricultural and rural development is directed towards more egalitarian patterns by policies like the ones described above. However, in the immediate future, and for some countries for a long time, rural poverty will continue to be a major problem. Therefore *direct interventions* will continue to be needed. *Rural public works* have long been used for this purpose, particularly in emergency situations. They form the core of government antipoverty strategies in South Asia and other countries. The experience is generally favourable, and antipoverty impacts are highest under community participation and careful selection and targeting of beneficiaries.

1.95 *Interventions in the food and nutrition* area will continue to have a place in the total arsenal of anti-poverty policies. The lessons here are that attempting to reach the poor through *general food subsidies* is a very costly policy and, in general, tends to benefit the non-poor more than the poor. More targeted schemes are generally superior in achieving their objectives, though often more difficult to administer. They include *ration schemes, food stamps and supplementary feeding programmes*.

10. EMPHASIS ON HUMAN RESOURCES DEVELOPMENT IN DEVELOPING COUNTRIES

1.96 As noted many times in the preceding discussion, intensification of agriculture will continue to be, and more so than in the past, the mainstay of production growth in the future. It is now well recognized that what matters for a successful transition to more intensive

agriculture, more than physical capital, is the capability of farmers to be energetic agents open to and eager to adopt profitable innovations in both technology and management practices. Moreover, the need to shift agriculture to more sustainable technologies and practices will attach an even higher premium to those capabilities. Therefore, a major thrust in policies for agricultural development must be directed to human resources development (HRD), involving all aspects from basic education to technical one, including formal and informal approaches to creating and transferring skills. HRD includes also the upgrading of health and nutrition. These, as well as education, are objectives of development in their own right and not only means for making people more productive economically.

1.97 The required HRD effort in agriculture in the developing countries is considerable because the population economically active in agriculture will continue to grow, albeit slowly. Moreover, there is a huge backlog to absorb, given the prevalence of high illiteracy rates in the rural areas, as well as scarcity of trained extension personnel. It is estimated that there is one extension agent per 2 500 people economically active in agriculture in the developing countries. The corresponding ratio is one to about 400 in the developed countries. In the latter, the private sector is also more active in providing extension services. Additionally, the proportion of females in the total extension activity of the developing countries is very low and out of all proportion to the relative importance of women in agriculture. There have been some encouraging trends in the developing countries, though not in all regions, as regards both the growth of the number of people involved in extension, and their quality, as more highly trained persons gradually replace those with fewer skills.

11. CONCLUDING REMARKS

1.98 There emerges a mixed picture about the future of the world food and agriculture from the assessments of this study. Overall, the world appears set on a path of declining growth rates of agriculture as more and more countries reach medium-high or high levels of per caput food supplies and population growth slows down. There appear to be no unsurmountable resource and technology constraints at the global level that would stand in the way of increasing world food supplies by as much as required by the growth of effective demand. And, on balance, there is scope for such growth in production to be achieved while taking measures to shift agriculture on to a more sustainable production path. However, the need to accept trade-offs between agricultural growth and the environment will persist in many local situations which combine adverse agro-ecological and socio-economic characteristics. The above global statements apply much less, or not at all, to marine capture fisheries. This latter sector provides perhaps the major example of global natural resource constraints which cannot apparently be relaxed through substitution by man-made resources and technology, at least not as far as one can tell on the basis of present knowledge. But substitution can and does take place at the consumption level, as more investment and technology produce substitutes of fish in consumption, albeit imperfect ones, e.g. poultry meat.

1.99 The findings of the Study imply that many countries and population groups will not be able to benefit in per caput terms more than marginally from the further growth in world food production, nor from the potential for this growth to be even higher than projected here. Only a combination of faster, poverty reducing, development and public policy, both national and international, will ultimately improve access to food by the poor and eliminate chronic

undernutrition. In the countries with high concentrations of poverty and high dependence on agriculture, success in this area will often require priority to be placed on agriculture for increasing incomes and food supplies locally. If local agricultural resource endowments are unfavourable, the task of bringing about development can prove very arduous indeed. It is in such contexts that one can speak of resource constraints being real obstacles to solving food and nutrition problems, even though resource constraints to increasing global food production may not be serious.

1.100 Finally, looking forward to the longer-term future beyond the year 2010, it can be expected that the annual rate of growth of world food production required to sustain the growing population will tend to continue to decline. This is because the growth rate of world population will be lower (world population could be 8.5 billion by 2025, but the annual growth rate may have fallen to 1.0 percent p.a. by then) while a higher proportion of world population will have per caput food consumption levels allowing little scope for further increases. The crucial issue is whether the world will succeed in making the transition to this state, while eliminating poverty and undernutrition in the not-too-distant future and placing agriculture on a sustainable footing.

CHAPTER 2

MAJOR THEMES IN WORLD FOOD AND AGRICULTURE AT THE BEGINNING OF THE 1990s

1. INTRODUCTION

1.1 A 20-Year Time Horizon: How Appropriate Is It?

2.1 This chapter sets the stage for discussing possible future developments in world food and agriculture. The future, as far as we can glean it, is the *twenty-year period 1990-2010* (in practice, and for most variables, the period from the three-year average 1988/90 to 2010). This period is perhaps *too long* for some purposes, in particular for defining with some acceptable degree of confidence the paths of some major "exogenous" variables that have a decisive influence on the development of things agricultural, e.g. how foreign debt issues may evolve or what would be the rate of success of the structural adjustment programmes, including their agricultural policy components, now in place in many developing countries. Both condition the prospects for resumption of sustained growth in these countries as well as the capability of governments to invest in agriculture. The situation is complicated further by the uncertainties surrounding the time profile of the reform process in the ex-centrally planned economies, e.g. when would the recession bottom out and growth be resumed? It is obvious that developments in this latter group of countries can exert a decisive influence on world markets of agricultural products (will they continue to be major net cereal importers or will their demand for tropical products expand, stagnate or continue on a slow path?)

2.2 In relation to the above, it is noted that this Study does not, in principle, formulate its own forecasts or assumptions of the overall development outlook for the different countries and regions. It rather relies on the work of other organizations for such forecasts and then attempts to define the probable evolution of food and agriculture, given such exogenously defined overall development environment. The exogenous assumptions used are presented in Chapter 3. Here, however, it must be noted that the evolution of the overall development outlook cannot be considered to be independent from the evolution of the agricultural sector. This applies particularly to the countries where agriculture has a large weight in the overall economy, in practice many developing countries. Indeed, the development literature tends to place increasing emphasis on the role of the agricultural and rural sector for promoting overall economic growth in these countries. This topic is discussed at some length in Chapter 7. There is, however, precious little by way of empirical estimates covering a large enough number of countries as to what the relevant relationships are, concretely how the rates and patterns of agricultural and overall growth influence each other. This being the case, the approach used in this Study, just as in many other studies of agriculture, accounts for influences from the overall economy to agriculture (mainly through the income growth-demand growth link) but not the other way round.

2.3 Returning to the issue of the 20-year period, it is noted that it is perhaps *too short* for addressing issues which have in recent years leapt to the forefront of the development debate: environment, sustainability, degradation of natural resources, climate change, longer-term capabilities of the earth to cope with increasing demographic pressures, etc. In particular, the period is too short for capturing significant changes in demographic trends and analysing what their effects could be on the rate at which pressure on agricultural resources for increasing production will be building-up in the longer-term future.

2.4 The time horizon of 20 years is *just about right* for addressing issues of the possible development of a number of variables most directly related to technical agriculture, e.g. the rate of diffusion of improved technology or changes in the natural resource environment of the sector, e.g. expansion of irrigation. The same goes for the time required to bring about significant upgrading of human resources in agriculture, e.g. through education and training. However, the rates of uptake by farmers of the opportunities offered by the evolution of agricultural technology or the rates at which the opportunities to augment resources through investment in physical assets and in human resources will be exploited are crucially conditioned by overall developments in the economy, society, politics and institutions. It follows that the higher confidence with which we can glean the potentials for technological and resource developments over a 20-year period is watered down when it comes to speculating about their impact on actual food and agriculture outcomes. The above are important caveats to be borne in mind when considering the conclusions of this Study.

1.2 Selecting Issues for Focusing the Study

2.5 What are the major issues in world food and agriculture that a 20-year study should address in priority? There is a multitude of interdependent issues and their relative weight in the total problematique varies greatly with the standpoint of the observer. In the *developing countries* the dominant issues relate to reducing undernutrition, enhancing food security, combating rural poverty and achieving rates and patterns of agricultural growth that would contribute to overall economic development. In the *developed countries* more relative weight is attached to managing the transition to a slow-growing agriculture, more responsive to market forces, while economizing on budget costs and safeguarding farm incomes and the livelihoods and life styles of rural communities. The lively debate on the regimes that should govern the conduct of agricultural trade must be essentially seen as a prime external manifestation of these underlying issues in the majority of the industrialized countries plus, of course, as reflecting the more conventional economic concerns (market shares, etc.) of the major exporting countries.

2.6 For the *ex-centrally planned countries* the dominant issues in the short to medium term relate mostly to the process of transition to market-oriented economies and are exemplified by such aspects as the reform of the land tenure systems and the shedding of excess labour while minimizing the adverse effects on the social situation associated with the changes affecting the large multi-function socialized units. Of more immediate concern is the need to ensure food supplies to consumers at affordable prices, overhaul the long neglected downstream sector of agriculture (transport, storage, processing, distribution) and halt the deterioration of the terms of trade of agriculture.

2.7 For the longer term, however, the dominant issues relate to the role visualized for agriculture in the post-reform market-oriented economies. In these countries, the "normal" pain of agricultural adjustment associated with the transition to mature or semi-mature industrial economies is magnified by the process of systemic reform. Policies to cope with this problem may well determine the kind of agricultural sector that will emerge as part of the post-reform situations. In this context, it is noted that the empirical evidence as to what the role of agriculture should be in a market-oriented economic system is not very helpful. In the great majority of the market-oriented developed countries, agriculture is far from being a market-oriented sector. And there are signs that some market-oriented developing countries making the transition to the status of developed countries are tempted to ease the problems of agricultural adjustment by adopting policies which make their agricultures less market-oriented. Should one draw the conclusion that this is the model these reforming countries should aspire to? Or should they rather learn from the current efforts of the industrialized countries to transit to an alternative model, which emphasizes pursuit of farm income and rural development objectives through policies (e.g. "delinked" income support) which minimize distortions of market signals to producers and consumers?

2.8 Cross-cutting over all country groups are issues relating to the use made of *agricultural and other environmental resources* in the development process and how such use relates to the objective of moving towards *long-term sustainability of economies and societies*. Universal as such issues are, they manifest themselves in very diverse forms in the different countries and societies and, what is more important, different people assign them widely differing weights in their hierarchy of objectives when it comes to considering development priorities. The wide ecological and socio-economic diversity existing in the world ensures that these issues present themselves in the form of a complex mosaic which can easily defy generalizations.

2.9 All the above issues and many more are addressed in this Study in varying degrees, some with the full backing of quantitative analysis, e.g. the evolution of food consumption and nutrition, others in more qualitative terms, e.g. the principles that may, or should, guide policy-making for agriculture in the future. In presenting the possible future paths of the main food and agriculture variables in Chapters 3 and 4 an attempt is made to compare them with their historical paths so that the reader may appreciate the extent to which, and as far as possible why, the future may or may not be like the past. Therefore, and in order to avoid duplication and economize on length, no attempt is made in this chapter to present a systematic and comprehensive picture of past trends in the many variables that compose the food in the agricultural universe. Thus, readers interested in, for example, the historical developments in cereal yields will find the relevant information in Chapters 3 and 4 where such historical developments are discussed together with those expected for the future. Similarly, the past history and future prospects for the developing countries' food deficits and self-sufficiency are discussed together in Chapter 3; and so on for other variables.

2.10 At the same time, it is recognized that a 20-year global study should endeavour to provide the reader with sufficient insights on the few issues in food and agriculture which are of truly global import. There are two such issues that would seem to dominate all others: (a) the persistence of undernutrition and food insecurity for large parts of the developing countries' population, and (b) the process of increasing scarcity and degradation of agricultural and other environmental resources as it relates, directly or indirectly, to the process of meeting the food and income needs of a growing world population.

2.11 The rest of this chapter is devoted to presenting the present understanding of the nature and significance of these two issues and, as far as possible, to an analysis of the historical developments that have given rise to the present situation. The intention is to give the reader an understanding of what are the real dimensions of these issues, analyse progress and failures in the historical period and identify the factors that may determine progress or failure in the future.

2. THE LONGER-TERM HISTORICAL EVOLUTION OF THE GLOBAL POPULATION-FOOD SUPPLY BALANCE AND FOOD AND NUTRITION IN THE DEVELOPING COUNTRIES

2.12 The evolution of the global population-food supply balance provides an appropriate background for reviewing the evolution of the food and nutrition situation in the developing countries. It must, however, be noted from the outset that examining developments at the global level, e.g. by juxtaposing the evolution of world food production and that of world population, offers few analytical insights for understanding the evolution of the food and nutrition situation in the developing countries.[3] This is evident from the fact that hunger persists in the developing countries at a time when global food production has evolved to a stage when sufficient food is produced to meet the needs of every person in the planet. Still, the issue of global balance is very alive in the minds of the public, particularly when issues of the capabilities of the earth to support the ever growing global population are considered. Such issues have recently assumed increasing importance in the context of perceived constraints to the global food production capabilities related to natural resource degradation and other environmental problems.

2.13 Concerning the evolution of the global population-food supply balance, it is noted that the last few decades witnessed unprecedented increases in world population. Only 30 years ago, world population was 3.0 billion; it was 5.3 billion in 1990. There have been ever increasing annual absolute increments in world population during this period. In the early 1960s, 63 million persons were added to world population every year. The annual increment rose to 76 million in the early 1970s, to 82 million in the early 1980s and is estimated to be some 94 million at present. It may not peak-off until the year 2000. Thereafter, the annual increment (not total population) is projected to start declining very slowly, e.g. it will be some 85 million by 2025, by which time world population will have reached 8.5 billion (the population projections used in this Study are shown in Chapter 3 and, in more detail, in the Statistical Appendix).

2.14 How has agriculture responded to these increases in world population? The global picture is shown in Figure 2.1. Production grew faster than population. Per caput production is today about 20 percent above that of 30 years ago. Food availabilities for the world as a whole are today equivalent to some 2 700 kilocalories per person per day

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[3] This is not to deny the fact that the global food demand-supply balance influences the incidence of undernutrition. It does so mainly through its impact on the price of food products bought and sold by the poor.

(referred to as simply calories in the rest of the text), up from 2 300 calories 30 years ago.[4] And this is counting only food consumed directly by human beings. In addition, some 640 million tons of cereals are fed to animals for producing the livestock products which people consume. Diversion of even one third of such animal feed of cereals to direct human consumption could raise per caput food availabilities to some 3 000 calories in a net sense, i.e. after adjusting for calorie losses due to consequent reductions in the production and consumption of livestock products. This is not to suggest that such potential diversion is a practical or even necessary proposition. But the example serves to illustrate the fact that the existing level of per caput food availabilities is considered sufficient for everyone on the planet to have adequate nutrition, provided it were distributed equally.

2.15 Yet such food availabilities are not distributed equally. At the one extreme, W. Europe's per caput food availabilities stand at some 3 500 calories. Those of North America at some 3 600 calories. At the other extreme they are only 2 100 calories in sub-Saharan Africa and 2 200 calories in India and Bangladesh together (see Statistical Appendix). Thus, for a large part of the developing world, food availabilities are far from being adequate for all people to have access to sufficient food at all times, in short for their food security. So long as this situation persists, a world food problem will continue to exist, notwithstanding adequate production at the global level. The notion that the problem is not one of production but of distribution is attractive. But while this notion is correct in a numerical and static sense, it is trivial and can be misleading. For one thing it entails the notion of drastic redistribution of static world food supplies as a possible solution. For another, it relegates the need to increase production to a subsidiary role.

2.16 It is increasingly recognized that people with inadequate food consumption levels are in that condition because they do not earn sufficient incomes to demand as much food as required to satisfy their needs. One should then be speaking not of food scarcity but rather scarcity of incomes or purchasing power, in short, poverty or lack of entitlements to food. This way of emphasizing entitlements to food rather than food supplies has come of recent to dominate thinking in efforts to understand and explain the prevalence of undernutrition and prescribe policies to overcome it. The entitlements approach correctly de-emphasizes the role of average per caput food supplies as an indicator for a complete understanding of issues of inadequate access to food by the poor. It should not, however, detract from the fact that ever increasing food supplies will be needed for solving the food problem in the future. Moreover, the level of per caput food production in the countries with high dependence on agriculture for employment and incomes is itself a major determinant of the food entitlements of the poor.

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4 The food available for direct human consumption (Food) is computed from the following food balance sheet equation for each country, food product and year:
Total Food Supply = Production + (imports - exports) + (beginning stocks - ending stocks), and
Food = Total Food Supply - Animal Feed - Industrial non-Food uses - Seed - Waste (from harvest to retail).
The resulting estimate of per caput food availabilities can differ from the amounts of food people actually ingest in a nutritional sense, e.g. because of further waste in the post-retail stage (e.g. at the household level). For discussion of this issue and comparisons see FAO, *A Comparative Study of Food Consumption Data from Food Balance Sheets and Household Surveys*, FAO Economic and Social Development Paper No. 34, 1983.

Figure 2.1: World Gross Agricultural Production, Population and Production per caput

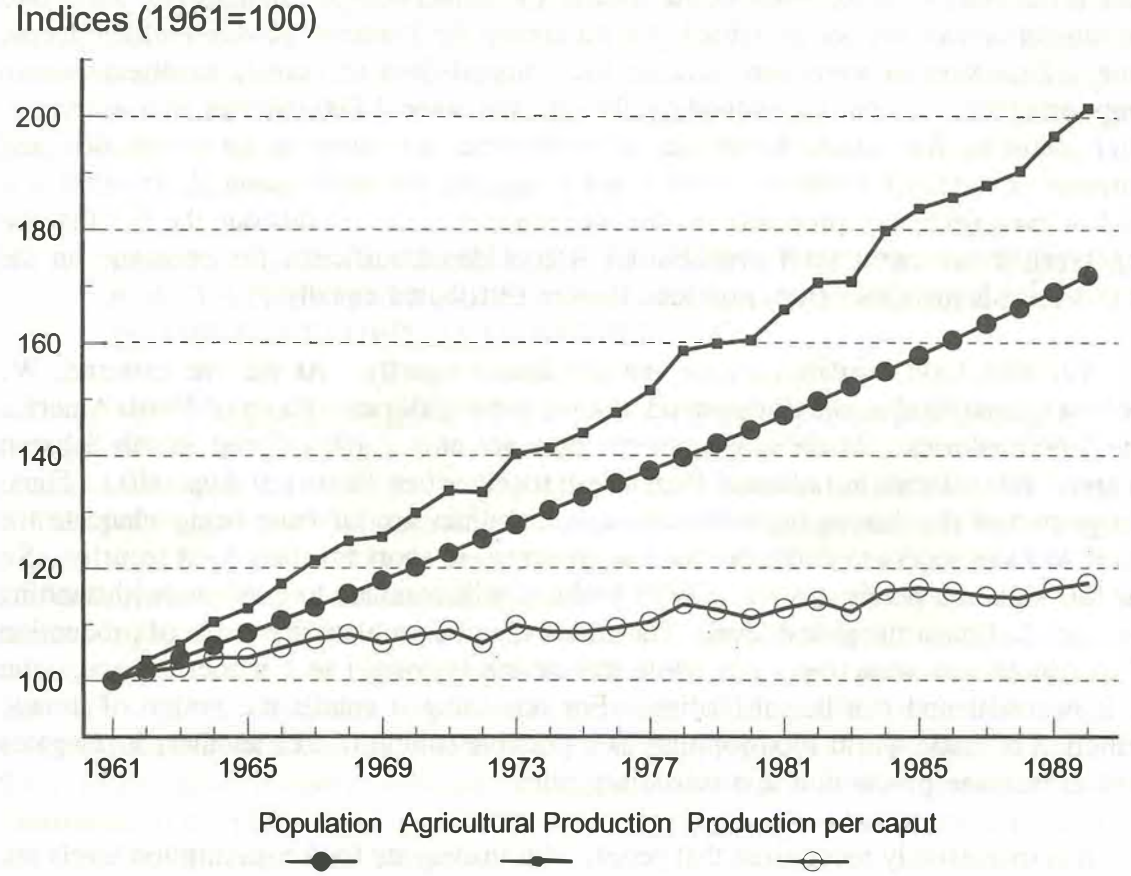
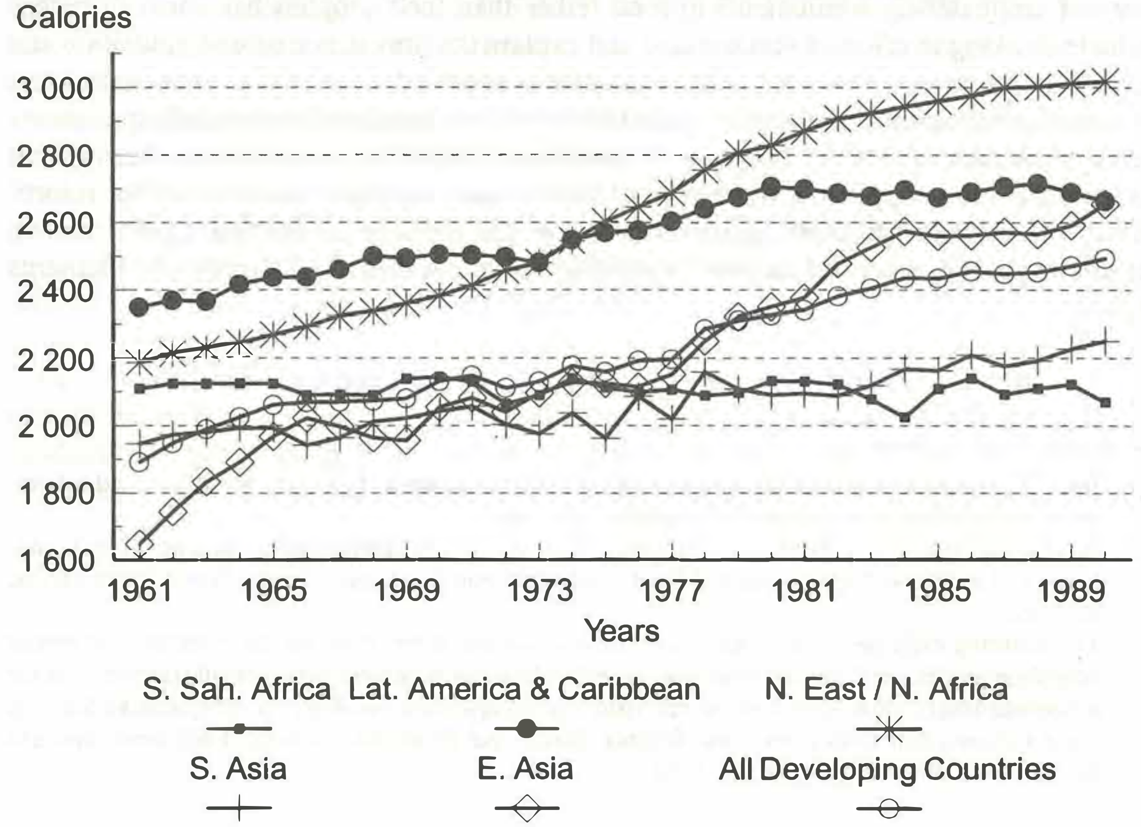


Figure 2.2: Developing Countries, per caput Food Supplies (cal/day)



2.17 On the issue of the role of a potential redistribution of the globally adequate food supplies, it is noted that if the poor countries' incomes were to increase to levels that would put them in a position to raise their solvable food demand significantly, massive transfers through the market to meet the increased demand would not be necessary, at least not at the scale suggested by present imbalances in inter-country food supplies. This is so because much of this additional demand would be met by increases in the poor countries' own production. This proposition follows from the fact that, with few exceptions, a more productive agriculture in the poor countries would be an integral part of the process of increasing their incomes. The majority of the world's poor earn their living by producing food and in most poor countries employment and income earning opportunities in all sectors, not just agriculture, are closely linked to how productive agriculture is (see Chapter 7). Therefore, in most poor countries, increases in incomes that would raise demand and the increases in food supplies generated locally from a more productive agriculture go in tandem.

2.18 In conclusion, the present relative abundance of food at the global level and the apparent potential for redistribution of static world food supplies are of more theoretical than practical significance when it comes to thinking of ways and means of improving the food welfare of the poor countries. This being so, policy responses to the food problem will have to address, among other things and in priority, the issue of growth and geographical distribution of food supplies in the future. That is, if consumption in the poor countries is to be raised to "acceptable" levels, additional food must be produced at the right places. In parallel, the scope and the need for transfers of food through trade and food aid will continue to grow.

3. THE DEVELOPING COUNTRIES: MAGNITUDE OF THE FOOD PROBLEM AND HISTORICAL DEVELOPMENTS

3.1 The Overall Picture

2.19 How big is the food availability problem in the developing countries? How has it developed over time? How many people suffer from undernutrition and how may the situation develop in the future? These are some of the questions addressed in what follows.

2.20 First, the magnitude of the problem and its evolution over time. Data in Table 2.1 group the developing countries according to their per caput food availabilities. The following comments may be made:

(a) Per caput food supplies in the developing countries as a whole have been increasing, from 1950 calories in the early 1960s to 2 475 calories at present. This happened while their population grew from 2.1 billion to nearly 4.0 billion. Therefore, significant progress has been made. This progress, or lack of it in some cases, can be seen visually in Figure 2.2 where the evolution is shown for the individual regions.

(b) The result of these developments has been that today only some 330 million people, or some 8.5 percent of the developing countries' population, live in countries where per caput food supplies are extremely low - under 2 100 calories. Thirty years ago these numbers were 1.7 billion or 80 percent of the total. The progress achieved

can also be seen by looking at the picture from the other end. Today some 650 million people, or 17 percent of the total population of the developing countries, live in countries with per caput food supplies over 2 700 calories. Again, 30 years ago these numbers were only 35 million or under 2 percent of the total.

(c) It is obvious, however, that, impressive as this progress has been, it has not been fast enough nor of a pattern that would have raised per caput food supplies in all countries to levels usually associated with significant reductions in the population suffering from serious problems of food insecurity and undernutrition. What is the size of the population in this category depends, of course, not only on national average per caput food supplies but also on how equally such supplies are distributed within each country. The empirical evidence here is scant. However, from the few countries with "good" quality distributional data it is found that on average (i.e. taking the simple average of high-inequality and low-inequality countries) the proportion of the population undernourished is around 10 percent when per caput food supplies are around 2 700 calories. It is typically in the range 15-35 percent when national average calories are in the range 2 200-2 500. The data in Table 2.1 indicate that some 3.3 billion people live in countries with under 2 700 calories and some 2 billion in countries with under 2 500 calories.[5]

2.21 The above numbers give an idea of the magnitude of the problem, if progress were to be measured in terms of national average per caput food supplies. However, not all people in countries with low national averages, even very low ones, are subject to undernutrition. And there are undernourished people even in countries with relatively high national averages. Therefore, a more appropriate estimate of the incidence of undernutrition can be obtained from a combination of the national average food supplies with a

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[5] These indicative numbers of per caput food supplies are distinct from the related concept of national average requirements for dietary energy. The latter are derived as the weighted average of the requirements of the individuals in a population group. Individual requirements vary widely with (mainly) age, sex, body weight and level of physical activity. For example, they are 1 900 calories/day for a woman in the 18-30 age bracket, with a body weight of 50 kg and light physical activity. They rise to 3 700 calories/day for a man of 70 kg in the same age bracket but with heavy physical activity (FAO/WHO/UNU, *Energy and Protein Requirements*, Report of a Joint FAO/WHO/UNU Expert Consultation, 1985, Tables 15, 42, 45). These are still averages, since requirements vary among persons of the same age, weight, etc. National average requirements have been computed for individual countries. For example, they were 2 130 calories/day for Haiti for moderate activity level (FAO, *Malnutrition in the Latin American and the Caribbean Region, Causes and Prevention*, document LARC 90/4, 1990). To make this estimate conceptually comparable to that used here for per caput food supplies it must be raised by a margin to account for food losses at the post-retail level. If the margin were 10%, Haiti would have a requirement at the retail level of some 2 350 calories/person/day. This would have been adequate for meeting the country's nutritional needs if food were distributed to individuals exactly according to their requirements. Since this is never the case in any country, it results that the national average must be still higher if enough food were to be available for people at the lower end of the distribution to have potentially access to food to meet their energy requirements. In the event, Haiti's per caput food supplies were 2 000 calories in 1988/90. The preceding discussion in no way implies that the solution to the food problem is to be pursued by means of policies aimed at raising per caput food supplies to whatever level is suggested by the above considerations. Such policies must be seen as a necessary complement to, not a substitute for, policies which address directly the root cause of the problem, the inadequate food entitlements of the poor. However, in countries where most of the poor are in agriculture, the two policies go in tandem.

distributional parameter and some notion of a nutritional threshold level, i.e. a level of food intake below which a person chronically subjected to it can be classified as undernourished. This method and data (supplemented in many cases by educated guesses for the value of the distributional parameter and the shape of the statistical distribution curve) have been used by FAO to derive rough estimates of the numbers of persons in the developing countries which can be classified as undernourished.

2.22 The estimates of the incidence of chronic undernutrition thus obtained were most recently published on the occasion of the International Conference on Nutrition (December 1992). They are shown in Table 2.2. Progress has been made, but the magnitude of the problem remains significant. The largest, though declining, numbers are to be found in Asia but those in sub-Saharan Africa have been increasing rapidly, both in absolute terms and as proportions of the region's total population.

2.23 The above two alternative approaches to gauging the magnitude of the food problem in the developing countries (population living in countries with given per caput food supplies, Table 2.1, or numbers of undernourished, Table 2.2), provide useful starting points for looking into prospects for the future which are addressed in the following Chapter 3. That is, one would need to speculate about how average per caput food supplies may develop in the different countries and what may happen to within-country distributions. Unfortunately, the historical data and ability to speculate on prospective changes in socio-economic and political structures having a bearing on within-country inequalities allow little scope for saying much on the distributional aspect.[6] It is a somewhat less arduous task to address the question how the per caput food availabilities may develop in the future in the different countries. For this purpose, the empirical evidence is analysed in order to, as far as possible, understand what have been the factors responsible for the fact that some countries have made progress in raising per caput food supplies and others have not, or experienced outright deterioration. One way of addressing this issue is to examine the historical developments in those countries which performed well in the past; and to do the same for those countries which failed to make any significant gains or experienced outright declines.

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6 Physiological considerations (i.e. a person needs a minimum food intake for survival and there is a upper physiological limit to how much food a person may consume) dictate that the scope for distributional inequalities is more limited in the case of food intakes than in other "unbounded" variables, e.g. income. Consequently, it may be hypothesized that very low or relatively high levels of average per caput food supplies will be associated with more equal distribution of food intakes compared with those that could prevail when the overall average is the middle range. This is a useful hypothesis for looking at the distributional issue when we know nothing about prospective developments in the other determining variables of the distribution of food intakes. Thus, it can be expected that the distribution of food intakes will tend to become more equal in those developing countries in which the average per caput food supplies will continue to edge upwards towards the 3 000+ calorie level. These considerations are taken into account in Chapter 3 when considering the issue of the possible evolution of the incidence of undernutrition in the future.

Table 2.1 Population Living in Developing Countries* with Given Per Caput Food Supplies, 1961/63 to 1988/90

Per Caput Food Supplies (Cal/Day)

Cal/Day	3-Year Averages				Population (million)			
	1961/63	1969/71	1979/81	1988/90	1962	1970	1980	1989
Developing Countries								
Under 2000	1 810	1 960	1 900	1 784	1 581 [1]	1 046 [2] [3]	197	123
2000 - 2100	2 045	2 030	2 100	2 040	114	746	771 [4]	211
2100 - 2300	2 210	2 200	2 180	2 225	176	338	483 [5]	1 425 [6]
2300 - 2500	2 400	2 395	2 345	2 405	196	230	1 234	212 [7]
2500 - 2700	2 655	2 560	2 655	2 635	38	176	103	1 327
2700 - 3 000	2 785	2 870	2 780	2 795	14	55	293	286
Over 3000	3 075	3 265	3 070	3 120	21	24	190	365
Total	1 950	2 120	2 330	2 470	2 141	2 616	3 271	3 950
Developed Countries	3 030	3 200	3 290	3 400	989	1 074	1 168	1 242
World	2 290	2 430	2 580	2 700	3 130	3 690	4 439	5 192

[1] Includes China (pop. 663 mln) and India (pop. 462 mln); [2] China (pop. 816 mln); [3] India (pop. 555 mln); [4] India (pop. 689 mln); [5] China (pop. 978 mln); [6] India (pop. 836 mln); [7] China (pop. 1 102 mln).

* All countries with Food Balance Sheet data.

Table 2.2 Estimates of Chronic Undernutrition in the 93 Developing Countries of the Study

	Year	Per Caput Food Supplies (Cal/Day)	Total Population (million)	Undernourished [1]	
				% of Total Population	Million
Africa (S. Saharan)	1969/71	2 140	268	35	94
	1979/81	2 120	358	36	129
	1988/90	2 100	473	37	175
N. East/N. Africa	1969/71	2 380	178	24	42
	1979/81	2 830	233	10	23
	1988/90	3 010	297	8	24
East Asia	1969/71	2 020	1 120	44	497
	1979/81	2 340	1 358	26	359
	1988/90	2 600	1 558	16	252
South Asia	1969/71	2 040	738	34	254
	1979/81	2 100	926	31	285
	1988/90	2 220	1 144	24	271
Latin America and Caribbean	1969/71	2 500	281	19	54
	1979/81	2 690	357	13	47
	1988/90	2 690	433	13	59
TOTAL	1969/71	2 120	2 585	36	941
	1979/81	2 320	3 232	26	843
	1988/90	2 470	3 905	20	781

[1] Persons who, on average during the course of a year, are estimated to have food consumption levels below those required to maintain body weight and support light activity. This threshold level (ranging from an average of 1 760 Cal/Person/Day for Asia to 1985 for Latin America) is set equal to 1.54 times the Basal Metabolic Rate. For more explanations see FAO, *World Food Supplies and Prevalence of Chronic Undernutrition in Developing Regions as Assessed in 1992* (Document ESS/MISC/1992).

3.2 The Correlates of Success

2.24 For the purposes of this discussion, the group of countries which performed well in the historical period includes those which, starting from low or very low levels of per caput food supplies 30 years ago (between 1 650 and 2 300 calories in 1961/63) had reached by the late 1980s high or medium high levels (between 2 600 and 3 300 calories in 1988/90).[7] The main characteristics of their historical evolution which probably explain much of their progress in raising per caput food supplies may be summarized as follows:

(a) All of them had above average economic growth rates, as evidenced by the growth rates in their per caput incomes. This seems to be the most prevalent common characteristic of these countries.

(b) In most countries, there was a spurt in the growth of food imports, particularly in the period of rapid gains in per caput food supplies, as evidenced by the increases in per caput net imports of cereals. This meant rapid declines in their cereals self-sufficiency. But there were exceptions. In particular, China and Indonesia did not follow this pattern as their own agricultures grew to provide the additional food supplies and, most probably, was a key factor in raising per caput incomes.

(c) A contributing factor to the nutritional improvement in this group of countries has been the fact that global agriculture provided readily and without much strain the food imports that underpinned the growth of their consumption, mostly in the 1970s. It is noted, however, that the historical experience of responsiveness of world agricultural production to increases in demand must be interpreted with care, in particular for drawing conclusions about the potential of world agriculture to respond to spurts in demand in the future. This is because the data showing that increasing quantities were forthcoming in the world markets at the same time as prices declined are vitiated by the agricultural support and protection policies of major countries (e.g. USA, EC, Japan). In practice, part of the costs of delivering the increased output were covered by the heavy subsidies granted to agriculture in these countries. It is not known how world agricultural production would have reacted to the increasing demand in the absence of such distortions. Some indications can be obtained from the trade liberalization studies which simulate world food markets with removal of such distortions. They generally indicate that world food prices would have been somewhat, but not much, higher.

(d) There emerges a mixed picture concerning the role of domestic agricultural growth in the process of increasing per caput food supplies. All sorts of situations are encountered, with per caput production declining in some countries while increasing in others at moderate or very high growth rates. Drawing the conclusion that agricultural growth does not matter would not be warranted, however. More likely,

[7] These countries are (in ascending order of their 1961/63 rank): Libya, China, Algeria, S. Arabia, Indonesia, Iraq, Korea (Rep.), Iran, Korea (DPR), Tunisia, Morocco, Egypt. Each of them had increased per caput food supplies by at least 40% over the historical period considered. Thus, countries which had in 1988/90 2 600 calories are included only if they started with less than 1 860 calories in 1961/63. Likewise, those with 3 300 in 1988/90 are included only if they started with less than 2 350 calories. Calorie data for all countries are given in the Statistical Appendix.

agricultural growth plays a largely subsidiary role in countries where agriculture is a small sector in the economy and much of the gains in economic growth and import capacity derive from the non-agricultural sector, particularly from non-agricultural commodity sectors. This seems to have been the case of many of the oil-exporting countries. But in countries where such conditions are not prevalent, agricultural growth seems to be an essential ingredient in the process of increasing per caput food supplies, through its role in the provision of supplies and in support of economic growth and the balance of payments. China's experience in the post-reform period after 1978 seems to conform to this pattern.

(e) In all countries, much of the quantum improvement in per caput food supplies was achieved in a relatively short period of time, in most cases around ten years. Judging the durability of such gains is more difficult. There are examples of countries where improvement and retrogression of per caput food supplies follow the commodity boom and bust cycles. It is, therefore, possible that the food and nutrition gains will tend to prove more durable in countries in which the circumstances that brought them about are part and parcel of wider economic and social transformations, e.g. China, Korea (Rep.). The same probably holds for countries in which the windfalls from commodity booms are put to good use to bring about such transformations, as indeed it happened in many of the countries in the group analysed here.

(f) Finally, the relationship between the growth rate of population and that of per caput food supplies does not produce any consistent pattern. Fast progress in the latter variable occurred in countries with very high rates of population growth, e.g. Libya, S. Arabia. Again, no hasty conclusions may be drawn. In particular the evidence from these countries may not be taken to mean that fast demographic growth is not an obstacle to improving welfare. All countries in this group with high population growth rates experienced special circumstances (the windfall income gains from the oil sector) and indeed in some cases the high demographic growth was partly the result of such special circumstances, e.g. due to labour immigration. The proposition that poor countries with high population growth face a more arduous task in improving welfare than those with lower population growth is in no way falsified by the experience of the above countries.

3.3 The Correlates of Failure and Retrogression

2.25 At the other extreme, the study of the experiences of the many countries which, starting from low initial conditions 30 years ago, failed to make progress or suffered outright declines, should provide some insights as to the reasons for failure. The study of the relevant data for a sample of these countries[8] leads to the following conclusions:

[8] All developing countries (among the 93 of this Study) with per caput food supplies under 2 100 calories in 1988/90 (19 countries, listed in ascending order of calories in 1988/90): Ethiopia, Chad, Afghanistan, Mozambique, Central African Rep., Somalia, Angola, S. Leone, Rwanda, Burundi, Namibia, Haiti, Bolivia, Zambia, Peru, Bangladesh, Sudan, Malawi, Kenya. All of them were in 1988/90 in the range 1 700 calories (Ethiopia) to 2 065 calories (Kenya). In 1961/63 the range was from 1 720 calories (Somalia) to 2 300 calories (Chad).

2.26 For the great majority of these countries one could have predicted that the food situation would be really bad even before looking at the data. Many of them are in sub-Saharan Africa, a fact which by itself tells a lot, given the overall economic and agricultural stagnation that has been plaguing the region for some time now. Add to this the fact that many of these countries, both in Africa and elsewhere, have suffered or are still going through severe disruptions caused by war and political disturbances and one has in a nutshell the explanation for failure and retrogression on the food and nutrition front.

2.27 The data do no more than confirm this impressionistic prediction. Indeed, the most common characteristics of these countries are declines in per caput incomes and per caput agricultural production. The two are not, of course, independent of each other. Their per caput food imports did increase, often by means of food aid. However, in contrast to the experiences of the countries in the preceding category, their per caput imports of cereals remained at generally modest levels, while the declines in cereals self-sufficiency were accordingly contained, at the cost, of course, of stagnant or declining per caput food supplies.

3.4 Some Generalizations and How They Can Aid the Assessment of the Future

2.28 The preceding discussion, based as it is on an impressionistic examination of the data for a restricted number of countries, is meant to provide some clues as to what have been the main correlates of success or failure in raising per caput food supplies in the different countries. However, it is far from a complete analysis. At best it indicates that success is commonly associated with sustained growth in per caput incomes and with varying combinations of growth in domestic agricultural production and import capacity.

2.29 A more complete and formal analysis of the data for all developing countries confirms that these findings hold in a general way, meaning that these three variables alone (per caput incomes, growth of agriculture, food imports) explain only partly the differentials among countries of per caput food supplies. For example, for the 75 countries thus analysed only 34 had per caput food supplies within a range ± 5 percent of those justified (or predicted) by their levels of the above three variables. Another 22 countries were within a range of between ± 5 percent and ± 10 percent. The deviations for the remaining 19 countries were outside the ± 10 percent range.[9] These findings do no more than confirm the well-known fact that some countries achieve relatively "satisfactory" levels of per caput food supplies at comparatively low levels of per caput income. And others have per caput food supplies lower than their per caput incomes would lead one to expect. Understanding (or hypothesizing about) the reason for these discrepancies is probably the most important

[9] The above findings which predict that for a given level of income, growth rate of production and food imports, a country could be expected to have, e.g. 2 100 calories, also indicate that the true value can be, with a 95% probability, anywhere in the range of 1 680-2 520 calories. This is an enormous range for a very slow moving variable like per caput food supplies which would normally move within physiological bounds of about 1 700-3 400 calories in terms of national averages. The values assumed by per caput food supplies within this range can make all the difference in the world between bare survival and middling prosperity. These findings are, therefore, to be taken as confirming the positive correlation between inter-country differences in per caput food supplies and differences in incomes etc., but are of much less use for making predictions (in this case projections) for individual countries.

insight for guiding the quest for policy responses to the problems of food and undernutrition. That is, if some countries have managed to make progress on the food front while remaining essentially poor on the overall income side, would not other countries with a food problem learn something from their experience?

2.30 Obviously, other factors beside per caput incomes, growth of production and food imports, such as food prices and the distribution of income or the incidence of poverty, are important determinants of the intercountry differences in per caput food availabilities. Moreover, some of the differences are explained by the fact that the conventional income statistics, expressed in a common currency, usually the dollar, can distort the relative positions of the different countries on the income scale because the internal purchasing power of this somewhat fictitious dollar can vary widely among countries. For example, Egypt, Honduras, Bolivia and Zimbabwe with reported per caput incomes in the range of $590-640 have per caput food supplies of calories 3 310, 2 210, 2 010 and 2 260, respectively. These differences are partly explained by the wide disparities in the purchasing power of the dollar in the different countries. When incomes are corrected for this factor and converted to dollars reflecting purchasing power parities, they become $3 100 (Egypt), $1 610 (Honduras), $1 910 (Bolivia) and $1 970 (Zimbabwe) (income data from World Bank, *World Development Report 1992*, Tables 1, 30). In addition, public policy which influences access to food, directly (e.g. through public food distribution schemes) or indirectly (e.g. through policies to alleviate poverty), can be an important factor in explaining the observed differences in per caput food supplies among countries.

2.31 Important as these other factors are, they are difficult to account for systematically in the assessment of the possible evolution of per caput food supplies in the future. The reason is that not enough is known, nor can it be deduced in any valid and systematic way, about how such things as the income distribution, the incidence of poverty and public policies affecting access to food may evolve in the individual countries, let alone the prospects that peaceful conditions will prevail and when in the countries plagued by war and other disturbances. This being so, the main guide for the projections are the effects of growth in per caput incomes (mostly obtained from other organizations), the evaluation of the agricultural production prospects undertaken for this Study and a notion of possible levels of food imports. Yet, the preceding discussion indicated that these three variables alone are not very good predictors of intercountry differences in per caput food supplies and that other country-specific factors must be taken into account. This apparent contradiction is bypassed by starting each country's projections of per caput food supplies from its own base year figure. The latter already embodies the effects on per caput food supplies of these "other" country-specific factors as well as the effects of per caput incomes, the growth rate of agriculture and the level of net food imports. Notionally, ignoring these "other" factors, means that they are assumed to continue to play in the future the same role as they played in determining the base year food supply levels. And, naturally, some of these factors, in particular the prevalence, or otherwise, of peace, are supposedly already incorporated in the income growth projections of other organizations which, as noted, are taken as exogenously given in the projections of per caput food supplies, as well as for providing the general overall economic background within which the production and food import prospects are evaluated. For example, it is difficult to assume that countries projected to be on a low

overall economic growth trajectory can mobilize the significant amounts of resources for investment in agriculture, rural infrastructure and human capital needed to underpin significant accelerations in agricultural production.

4. ISSUES OF AGRICULTURAL RESOURCES, ENVIRONMENT AND SUSTAINABILITY

4.1 General Considerations

2.32 Concern with the state of the environment and the dwindling quantity of land and water resources (per caput) as well as their degradation requires that the conclusions of the preceding section be amplified to address questions like the following: *to what extent may the resource and environmental constraints impinge on the prospects for increasing food supplies and assuring access to food by all, the very essence of food security? And can such progress be achieved while ensuring that the gains made and the potential for further gains are maintained for future generations, the very essence of sustainability?* The rest of this chapter endeavours to put the overall issue in a proper perspective. The reader is referred to other chapters for more specific discussion (Chapters 4, 11, 12, 13). These chapters provide estimates of the pressures that are likely to be put on agricultural resources in the process of increasing production over the next 20 years. They also explore the options for policy responses to minimize the unavoidable trade-offs between increasing production and pressures on the environment.

2.33 The preceding section singled out the rate of increase in per caput food supplies of countries and population groups with inadequate access to food as a practical proxy for measuring progress towards solving problems of undernutrition. It also highlighted a number of interdependent factors as being instrumental in increasing per caput food supplies: poverty-reducing economic growth; the multiple role of agricultural growth in the majority of the developing countries (increasing food supplies and providing employment and income-earning opportunities to the poor, both directly and indirectly via the growth linkages of agriculture); enhanced capacity to import food; and public policy.

2.34 It follows, therefore, that important as the agricultural resource constraints are in conditioning the prospects for food production and generation of incomes in agriculture, the wider environmental constraints can also affect in important ways the prospects of eliminating undernutrition because of their possible effects in restraining the overall economic growth rate and the potential for reducing poverty. For example, reducing emissions of greenhouse gases and the existence of non-agricultural resource constraints may cause the world economic growth rate to be lower than what would be otherwise.[10] The low-income countries which depend, actually or potentially, on a buoyant world economy for their development will find it more difficult to improve their economic growth rates and reduce poverty. Moreover, the adverse environmental impacts (local, but with global implications) which often accompany the accelerated growth in the use of energy in the transition from low to high economic growth rates in the low-income countries will tend to make such transition

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10 See, for example, OECD, "The Economic Costs of Reducing CO_2 Emissions", *OECD Economic Studies*, No. 19, Winter 1992.

more difficult.[11] These are examples of how the more general environmental and resource constraints, and not only the agricultural ones, may impinge on the prospects for reducing undernutrition.

2.35 Given the above considerations, the extent to which the agricultural resources are adequate or otherwise to produce as much food as required to increase per caput food supplies and generate incomes for the people dependent on them in sustainable ways must be examined in the context of these grander themes concerning the overall resource and environmental constraints. It may well be, for example, that at the global level the binding constraints would not be those impinging directly on the production of food but rather those standing in the way of achieving economic growth rates and patterns adequate to eliminate poverty in the not-too-distant future.

2.36 There is another sense in which the agricultural resources may not be the binding constraint to making progress towards elimination of undernutrition, at least not in a global context and in the longer term. It was noted in the preceding section that (a) progress achieved in the last few decades points to ever increasing per caput food consumption levels, (b) a considerable number of countries have made the transition from low and medium-low levels to medium-high ones, and (c) beyond these levels the growth of per caput consumption of food tends to slow down before stopping altogether when it reaches physiologically maximum levels.

2.37 It follows that a combination of continuation of these developments in per caput food consumption and the expected slowdown in population growth will eventually translate into a slowdown in the rate at which pressures are exerted on world agricultural resources for increasing food production. That is, the world may reach at some future date a stage when very little additional growth in global food production would be necessary to maintain adequate food supplies for all. The experience of many developed countries in which there is little scope for further expansion of aggregate agricultural output for domestic use, and in which land has often to be taken out of production, is telling. The gist of the matter is, therefore, whether this stage can be reached with the production potential of sufficient agricultural resources intact and with enough forest left to continue providing its essential environmental functions. In other chapters of this Study (see, for example, Chapter 11) an attempt is made to address this question for the limited time horizon of the next 20 years, a time by which the world will have moved closer to, but still be far away from, a stationary state when little further growth of global food output will be necessary. It is noted that, unlike food, the per caput consumption of other goods and services is a largely unbounded variable of changing composition. It is, therefore, possible to visualize the existence of environmental and resource constraints limiting the potential for ever increasing per caput production of all goods and services, though not food, production of which, as noted, is not required to continue to grow *ad infinitum*.

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11 See, for example, Kennedy, P., *Preparing for the 21st Century,* Random House, New York, 1993 (p. 192). A case can be made that some developing countries, but not all of them, would gain from policies to reduce GHG emissions if such policies removed economically wasteful energy market distortions; see OECD (1992), *op. cit.*

2.38 The preceding discussion provides the background for discussing in the next section the relative significance of agricultural resource constraints for making progress towards reducing undernutrition. This means essentially the prospects for increasing per caput food supplies for the population groups with inadequate access to food, taking into account both the *supply side* of the problem (e.g. can enough food be produced in sustainable ways?) as well as the *demand side* (e.g. in what ways may agricultural resource constraints play a role in the process of enhancing access to food by the poor?) The link between the two sides is provided by the fact that the great majority of the poor depend for employment and income on the exploitation of those very agricultural resources.

2.39 This being so, it may well be that even if the world as a whole faced no major agricultural resource constraints to producing more food, such resource constraints may still represent a formidable obstacle to eliminating undernutrition at the local level. This will be the case so long as the poor continue to depend on the exploitation of agricultural resources subject to constraints for their employment, incomes and access to food. In the end, it is the income-earning opportunities of the poor that matter for the elimination of undernutrition. If the agricultural resources at their disposal constrain progress towards this objective and they have limited alternative opportunities to make a living, it is entirely proper to speak of agricultural resource constraints to eliminating undernutrition, even if no such constraints existed in terms of global capacity to produce more food.

4.2 Land and Water Resources in the Quest for Sustainable Responses to the Food Problem

2.40 In the preceding Section 3, the food problem was defined in terms of a few measurable variables (per caput food supplies by country, incidence of undernutrition) and analysed in terms of others (agricultural production, per caput incomes, distribution, food imports). In this analysis, the possible role of agricultural resources was not considered explicitly. It can be hypothesized that such a role is subsumed in that of some of the variables considered, notably agricultural production and per caput incomes. The widespread concerns with agricultural resources, the environment and sustainability requires that an attempt be made to consider such a role more directly. This issue is addressed in terms of (a) what is known about the land and water resources, and (b) how the constraints relating to these resources may enter the determination of the rate of progress towards solving the food problem.

2.41 The state of knowledge on the extent and use of agricultural resources and the historical evolution of such use leaves much to be desired. For example, the data on cropping patterns by agro-ecological zones used in this Study had to be compiled from fragmented sources and supplemented by expert judgements. Likewise, the data on the state of degradation of irrigated lands or erosion of rainfed lands are limited and very little is known about how such states have been evolving over time. Furthermore, there is a dearth of systematic information on yet unexploited irrigation potential. The data on water resources (river flows, acquifers), such as they exist, need to be interfaced with those on land (terrain, soil, etc. characteristics) and analysed in the context of a host of socio-economic factors affecting their use, before comprehensive and credible estimates of the potential for irrigation expansion can be obtained.

4.2.1 Potential of Land and Water Resources for Rainfed Crop Production

2.42 Given these data shortcomings, resort may be made to the second best option offered by the rather more systematic data in the soil and climatic inventories used in FAO's Agro-ecological Zones (AEZ) work. These data (recently re-elaborated for this Study) permit the derivation of estimates of *land stocks of varying quality with potential for growing crops*. Examples of the kind of data thus obtained are given in the following Table 2.3 for South Asia and Tropical South America. (The data in Table 2.3 are partial and are used here to illustrate the issues. More comprehensive data for the developing countries are shown in Chapter 4.)

2.43 It is noted that such evaluation indicates the potential for rainfed crop production of land in its natural state, i.e. not taking into account improvements or deteriorations brought about by human activity. The results should, therefore, be read with this caveat in mind, because it is well known that much of the land in agricultural use has been modified in the course of time, for better or for worse, by human intervention. Some account of such alterations is taken in the process of accounting for irrigated land stocks, e.g. in the extreme, desert land with no agricultural potential in its natural state is added to the agricultural land if it has been irrigated.

2.44 The above data on land convey also significant information on *water resources for agriculture*. On the latter subject, a distinction is made between water supplies from rainfall, which are directly utilizable in rainfed agriculture if falling or ending up in soils with appropriate qualities, in particular the capacity to retain humidity in the root zone for the length of time required by the growth cycles of the different crops; and the part of rainfall which feeds into water bodies like rivers and acquifers and which, together with stocks of fossil water, can be used for agriculture only through human intervention (irrigation). As noted, the data on this latter resource are not adequate for a full evaluation. But the data on supplies from directly utilizable rainfall are part and parcel of the evaluation of the above mentioned AEZ data set on land resources for agriculture. This is because when evaluating any piece of land for its suitability to produce one or more crops at "acceptable" yields under alternative technologies, the rainfall regime and the soil's water-holding capacity are key elements in the solution.

2.45 In the end, declaring that, for example, South Asia has in crop production some 50 million ha of land with terrain/soil characteristics "very suitable" or "suitable" for agriculture, which receive rainfall and have waterholding characteristics sufficient for a growing period of 180-269 days (Table 2.3), is equivalent to making a statement on water availabilities for rainfed agriculture. This is counting not rainfall in abstract (e.g. in mm) but more precisely that part which ends up in soils with other desirable characteristics for farming. Barring changes in the rainfall regimes and the quality of soils, it can be assumed that this is a perennial resource. This estimate is perhaps more robust than those of water resources for irrigation. The latter are subject to greater uncertainty concerning their permanence over time because of (a) possible reduction of the water supplies due to overexploitation, (b) the risk of deterioration of the irrigated lands (waterlogging, salinization) and of infrastructure (siltation, etc.), and (c) possible diversion of water supplies to competing non-agricultural uses.

Table 2.3 Examples of Land Balance Sheet: South Asia and Tropical South America

(million ha)

	Moisture regime (LGP, days)[1]	Land quality[2]	South Asia Total	South Asia in Crop Prod. Use	South Asia Balance[3]	Tropical South America Total	Tropical South America in Crop Prod. Use	Tropical South America Balance[3]
Land with Crop Prod. Potential by Class								
1. Dry Semi-arid	75-119	VS,S,MS	30.4	22.1	8.2	9.8	3.5	6.3
2. Moist Semi-arid	120-179	VS,S	86.1	62.2	23.9	32.2	10.8	21.5
3. Sub-humid	180-269	VS,S	61.8	48.6	13.2	121.5	47.4	74.2
4. Humid	270+	VS,S	7.1		9.8	329.5	44.0	516.2
5. Marginal Moist Semi-arid, Sub-humid, Humid	120+	MS	29.8	27.1		230.7		
6. Fluvisols/Gleysols	Nat. Flooded	VS,S	27.1		3.3	65.2	8.1	99.1
7. Marginal Fluvisols/Gleysols	Nat. Flooded	MS	2.2	26.0		42.0		
A. Total 1 to 7			244.2	186.0	58.4	831.0	113.7	717.3
B. - of which irrigated				49.1			4.5	
C. Additional Irrig. from Hyperarid land			15.3	15.3		0.9	0.9	
D. Total land with Crop Prod. Potential (A+C)			259.5	201.3	58.4	831.9	114.6	717.3
E. Land without Crop Prod. Potential			240.9			532.7		
E.1 - Hyperarid			45.6			22.7		
E.2 - Other Constraints			195.3			510.0		
F. Total Forest Area [4]			90.0			802.9		
F.1 - Could be on Land without Crop Prod. Potential [5]			72.2			310.2		
F.2 - Minimum forest area on Land with Crop Prod. Potential [6]					17.8			492.7
G. Total in Human Settlements and Infrastructure[7]			27.3 (0.023 ha/person)			11.3 (0.046 ha/person)		
G.1 - on Land without Crop Prod. Potential			9.6			4.7		
G.2 - Balance on Land with Crop Prod. Potential					17.7			6.6
H. Protected Areas			15.7			143.6		
H.1 - On land without Crop Prod. Potential			10.1			52.1		
H.2 - Balance on Land with Crop Prod. Potential					5.7			91.5

1/ LGP = length of growing period is the number of days during the year when temperature and rainfed soil moisture permits plant growth.

2/ VS = very suitable, in the sense that obtainable yields can be 80 percent or higher of those obtainable in land without constraints; S = suitable, yields 40-80 percent of the constraint-free ones; MS = marginally suitable, yields 20-40 percent.

3/ Could be partly in grazing use; additional grazing land is the fallow part of the land used in crop production.

4/ Data from the FOR90 assessment (see chapter on Forestry).

5/ Maximum amount of land on which trees, but not crops, could exist.

6/ Balance of forest area (F2 = F-F1) which by necessity must be on land with crop prod. potential. As such, it is the minimum overlap between forest and agricultural land. It could be much larger in reality.

7/ For method of estimating land in human settlements and infrastructure see Chapter 4.

2.46 In practice, therefore, the LGP classification of land with agricultural potential goes some way towards defining the water constraints for agriculture. It has the added advantage that the estimates thus obtained are less subject to uncertainty compared with those referring to water resources for irrigation. With regard to the latter, it is noted that knowledge of the extent of water resources potentially usable for irrigation is only a first step towards assessing the existence or otherwise of water constraints for agriculture. Estimating future irrigation requires assumptions about the economic and social benefits and costs of irrigation investment, the policies and management affecting the efficiency of water use and the acceptable trade-offs with the environment. The importance of improving the data and knowledge about these aspects is evident from the fact that at present some 37 percent of the gross value of crop output (and 50 percent of that of cereals) of the developing countries comes from irrigated lands.

2.47 The estimates thus derived for the land and water availabilities for rainfed agriculture are supplemented with two pieces of additional relevant information, viz. (a) the extent to which they are irrigated, including an estimation of irrigation of land not suitable for rainfed production in its natural state (rows B, C in Table 2.3), and (b) if they are used currently for crop production (not including land used for fodder, whether cultivated or natural grass for grazing).

2.48 This estimate of the current use status makes it possible to obtain as residual the land with crop production potential of varying quality. However, its mere existence does not mean that it should be considered as available for expansion of crop production in the future (see below). The stark contrast between the situations in South Asia and Tropical South America is evident (Table 2.3). It becomes even starker when expressed in terms of population densities, given that South Asia's population is 1.2 billion and that of tropical South America only 250 million. Moreover, South Asia has 65 percent of its economically active population in agriculture (275 million), while tropical South America has only 25 percent and 22 million. There are, therefore, even starker differences in terms of agricultural land actually or potentially available per person in the agricultural labour force. This latter variable is the key one for understanding the forces that may shape the future in terms of the population-resources balance. As already noted, this balance has two main dimensions: (a) how much more food must be produced, which is directly linked to the growth of *total population* and the per caput consumption of food, and (b) how many people are, or will be, making a living out of the exploitation of agricultural resources. The relevant variable here is the size of the *population economically active in agriculture*.

2.49 As noted, the existence of land with crop production potential does not necessarily mean that such land may be so used. In the first place, part of it is used for *human settlements* (habitation, industry, infrastructures) and more of it will be so used in the future following population growth. There are no reliable data on how much land is occupied by human settlements. Sporadic data for some countries have been used to derive the estimates shown in the table (Row G, for methods of estimation see Chapter 4). These estimates are subject to an unknown, though probably very large, margin of error.

2.50 Secondly, part of the area with crop production potential overlaps with *forest*. The extent of this overlap is not precisely known. The table provides minimum estimates obtained by first deducting from the total forest area the part which, on agro-ecological

criteria, could exist on the land without agricultural potential (Row F.1 in the table). The balance of the total forest area must be by definition on the land with agricultural potential (Row F.2). This is a minimum estimate of overlap and the actual one is probably much larger. Considerations of environment and sustainability dictate that a good part of the land with forest should not be considered for prospective agricultural expansion. Indeed some areas, not always under forest, are legally protected (Rows H.1, H.2 in the table). Moreover, forest lands do contribute to food security and any gains in food production from conversion to agriculture must be netted out for the food security losses incurred. This is because significant numbers of people, much beyond the communities of forest dwellers, depend on sustainably managed forests and trees either as a source of complementary food supplies, or even more importantly, as a source of off-farm income.

2.51 It is evident from the preceding discussion that the question "How much more land can be drawn into crop production?" cannot be answered only or even predominantly, on the basis of the data presented here. For one thing, the extent of, perhaps multiple, overlap between land with crop production potential, forest, human settlements and protected areas is not known within an acceptable margin of error. For another, more of the land with crop production potential (whether presently used or not) will be occupied by human settlements following population growth. Further, a host of other factors (socio-economic, technological, etc.) will determine the combination of area expansion and growth of yields that will underpin the future growth of production. In the event, and as explained in Chapter 4, the additional land to come under crop production by year 2010 may be about 8 million ha in South Asia and 20 million ha in tropical South America. In addition, continued population growth would probably require additional land for human settlements and infrastructures of some 9 million ha and 3 million ha in the two regions, respectively.

4.2.2 Declining Land/Person Ratios

2.52 As noted, the continuous decline of agricultural resources per caput following population growth is one of the major reasons why concern is expressed in relation to the population-food supply balance. The other reason has to do with the deterioration of the quality and food production potential of the resources. The data discussed above may be used to shed some light on the nature and significance of the decline in the resources/person ratio (hereafter referred to as land/person ratios). The values of this latter ratio in the different developing countries span a very wide range, from the very low to the very high. For example, at the very low end are countries like Korea (Rep.), Mauritius, Rwanda, etc. with ratios of land-in-use of under 0.1 ha per person in the total population and virtually zero

reserves for further expansion. At the other extreme, countries like Argentina or the Central African Republic (CAR) have land-in-use ratios of close to 1 ha/person and considerable reserves.[12]

2.53 With population growth, more and more countries will be shifting closer to values of the land/person ratios typical of those encountered currently in the land-scarce countries. Does this matter for their food and nutrition? An approach to obtaining a first partial answer is to examine if the currently land-scarce countries are worse-off nutritionally (in terms of per caput food availabilities) compared with the more land-abundant ones. This is attempted in Table 2.4, with the land/person ratios adjusted as indicated in footnote 10. The picture emerging from the table just confirms what is known, i.e. there is no apparent close relationship between the land/person ratios and per caput food supplies. If anything, many land-abundant countries have low per caput food supplies, while most of the nutritionally better-off countries seem to be precisely those with the highest land scarcities. At the same time, most of these latter countries have considerable cereal imports.

2.54 Should this evidence be interpreted to mean that the perceived threat of ever declining land/person ratios is misplaced? Not necessarily. In the first place, the national land/person ratio, even if adjusted for land quality differentials, is just one of the many factors that determine per caput food supplies. Its importance cannot be evidenced without an analysis accounting for the role of these other factors (essentially respecting the clause "other things being equal"). Secondly, the high dependence of the land-scarce, good-nutrition countries on imported cereals means that the perceived threat of the declining land/person ratios must be understood in a global context. That is, a decline in an individual country's land/person ratio may not threaten its own food welfare provided there is enough land elsewhere (in the actual or potential exporting countries) to keep the global land/person ratio from falling below (unknown) critical minimum values; and, of course, provided that the people in the land-scarce country do not depend in a major way on the local land and water resources for a living. Countries like Korea (Rep.) and Mauritius are in this class.

2.55 It follows from the above that declining land/person ratios can threaten the food welfare of those land-scarce countries which depend on agriculture in a major way for a living. And this irrespective of the fact that their own population growth may not have a significant impact for the global land/person ratios. Most countries in this class are those in the upper left quadrant of Table 2.4. Only a combination of much more productive

12 A country may have plenty of land of poor agricultural quality, but not for this reason should it be classified as land-abundant. For example, it is estimated that Niger has land-in-use of 1.5 ha per person in the total population, but with 95% of it in the dry semi-arid category. Other countries have much less land-in-use per person but of better quality, including quality improvements brought about by irrigation. For example, Pakistan has only 0.16 ha/person but 86% of it is irrigated. The land/person ratios must, therefore, be adjusted before a meaningful comparison among countries can be attempted. Adjustments are made using the following weights: 1.0 for sub-humid; 0.81 for fluvisols/gleysols and 0.35 for marginally productive fluvisols/gleysols; 0.31 for dry semi-arid; 0.88 for moist semi-arid; 0.85 for humid; 0.35 for the marginal areas in the moist semi-arid, sub-humid and humid zones; and 2.2 for irrigated. These weights roughly reflect potential cereal yields. After such adjustments, Niger's land/person ratio falls to 0.50 ha and that of Pakistan rises to 0.31 ha. This is land of fairly comparable production potential after the adjustments. The comparisons in the following Table 2.4 are on the basis of the thus adjusted land/person ratios.

Table 2.4 Distribution of Developing Countries by Per Caput Land-in-Use and Food Supplies, Data for 1988/90

Land per Caput [1/] (ha)	Food Supplies per Caput (cal/day)					
	Under 2000	2000-2100	2100-2300	2300-2500	2500-2700	Over 2700
Under 0.10	Rwanda (8)[2/]				Jamaica (140)	T.Tobago (213) Jordan (338) Korea, Rep. (225) Mauritius (190)
0.10-0.19	Burundi (4) Somalia (29) Namibia (49)	Kenya (1) Bangladesh (20) Haiti (36)	Yemen (134) Lesotho (117) Sri Lanka (60) Vietnam (-11) Liberia (47) Guatemala (36) Honduras (33)	Venezuela (126) Dominican Rep. (94) El Salvador (36) Philippines (35) Colombia (27) Laos (14) Gabon (74)	Indonesia (10)	Egypt (163) Lebanon (188) S.Arabia (265)
0.20-0.29	Ethiopia (15)	Peru (65) Malawi (13)	India (1) Panama (53) Nepal (2) Nigeria (5) Ghana (20) Uganda (1) Congo (51)	Myanmar (-4) Ecuador (46)	Malaysia (140)	Costa Rica (120) Algeria (251) Korea, PDR (27) Libya (401)
0.30-0.39	Sierra Leone (37) Mozambique (30)		Tanzania (2) Gambia (97) Botswana (148) Pakistan (6) Nicaragua (46) Thailand (-113) Madagascar (9) Cambodia (8) Zaire (12)	Chile (14) Suriname (-60) Mauritania (117)	Swaziland (134)	Turkey (14) Cuba (235) Tunisia (219) Mexico (77) Iran (101) Syria (114)
0.40-0.50	Angola (49) Afghanistan (17)	Bolivia (19) Sudan (16)	Zimbabwe (-40) Togo (21)		Uruguay (-158) C.Ivoire (50)	Morocco (58) Iraq (223)
Over 0.50	Chad (8) CAR (15)	Zambia (15)	Niger (26) Cameroon (43) Guinea (40) Mali (10) Burkina Faso (17)	Senegal (82) Benin (22) Guyana (10)	Paraguay (-70)	Brazil (18) Argentina (-289)

1/ Land per caput adjusted to measure land of roughly comparable production potential (see text, footnote 10).
2/ Numbers in parentheses are net cereal imports in kg per caput. A minus sign denotes net exports.

agriculture (in practice, resort to land-augmenting technologies that would halt or reverse the declines) and vigorous non-agricultural growth will free them from the bondage of the ever declining land/person ratios.[13]

2.56 In conclusion, the declining land/person ratios do matter for per caput food supplies in two senses. In the *global context* and for countries with high actual or potential dependence on food imports they matter mainly if the declines threaten to push the global ratio below (unknown) critical values, even after allowing for the reprieve to be had from land-augmenting technologies. Should this happen, the effects would be manifested in terms of rising food prices which would affect mostly the poor. It has not happened so far despite continuous declines in the global land/person ratios. How close the world is to eventual critical values and whether such values are likely to be reached before the world achieves stationary population and acceptable per caput food supplies for all is a matter of conjecture.

2.57 In the *local context* declines in the land/person ratios do matter for food supplies, nutrition and incomes, mainly for the countries with limited access to imported food and high dependence on agriculture for the maintenance and improvement of living standards and, consequently, of food welfare. If and when such dependence is reduced, the pressures on the global land/person ratios will assume increasing importance also for them.

2.58 The possible role of land-augmenting (in practice, yield-increasing) technologies was referred to above for the reprieve such technologies can afford in relation to the consequences of the inexorable declines of the land/person ratios. However, some of the perceived threats to progress towards solving the food problem have precisely to do with the risks to the productive potential of the agricultural resources stemming from the application of these very technologies, e.g. loss of irrigated land to salination and waterlogging, loss of yield potential because of pesticide resistance, etc. In addition, efforts to bring new land into cultivation or to use existing agricultural land more intensively can be often associated with degradation (e.g. from reduced fallows, from exposure of fragile soils to erosion following deforestation) and may not add permanently to total productive potential. Chapter 11 presents some evidence of these processes. In the following section an attempt is made to address what are hypothesized to be the more fundamental processes driving human activity towards degradation of the productive potential of agricultural resources.

4.2.3 Agricultural Activity and Degradation of Agricultural Resources

2.59 As noted, there is sufficient (though not comprehensive, nor detailed) evidence establishing that the productive potential of at least part of the world's land and water resources is being degraded by agricultural activity (e.g. soil erosion, water-logging and

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13 Reference to land-augmenting technologies and the growth of other sectors just underlines the fact that aggregate resources for producing food and/or incomes cannot be considered as given. In the process of development scarce resources are substituted by less scarce ones and the total is augmented by additions of man-made capital, the most important component of which is human ingenuity. Whether there are ultimate limits to this process is another question (see, for example, Daly. H., *Steady State Economics*, Earthscan Publications, London 1992).

salinization of irrigated lands). In addition, agricultural activity generates other adverse environmental impacts (e.g. threat to biodiversity, pollution of surface and groundwater sources). Chapter 11 presents some evidence of these processes. While recognizing that agricultural activity often contributes to maintaining or restoring the productive capacity of land and water resources, this concluding section attempts to provide a framework of thinking through why human activity may end up destroying rather than preserving or enhancing this capacity.

2.60 The most commonly held view is that these processes are somehow related to continuing demographic growth, in two senses: (a) more food must be produced and this tends to draw into agricultural use land and water resources not previously so used and/or causes such resources to be used more intensively. Both processes may generate adverse impacts on the quality of the resources themselves as well as on the broader environment; and (b) in many developing countries population growth is accompanied by increases in the number of persons living off the exploitation of agricultural resources with the consequence that the amount of resources per person declines.

2.61 In the normal course of events the decline in per caput resources would tend to raise their value to the persons concerned (being often their main or only income-earning asset) and would lead to their more efficient use, including maintenance and improvement of their productive potential. The fact that much of the agricultural resource base has been improved for agricultural use by human activity in the historical period is testimony to this process. Yet it is often observed that under certain conditions this caring relationship tends to break down with the result that people destroy rather than conserve and improve the productive potential of the resources.

2.62 Understanding why this happens is the most important insight needed for policy responses to promote sustainable development. When this destructive relationship is observed in conditions of poverty, it is commonly taken for granted that poverty explains the behaviour of people vis-à-vis the resources. The hypothesized mechanism works (in economic parlance) via the shortening of the time horizon of the poor. In plain language, this means that in conditions of abject poverty the need for survival today takes high precedence over considerations for survival tomorrow. The poor simply do not have sufficient means to provide for today and also invest in resource conservation and improvement to provide for tomorrow.

2.63 However, this proposition is far from being a sufficiently complete explanation of processes at work useful for formulating policy responses. For one thing, there is plenty of empirical evidence that this process is not at work in many situations of poverty. For another, it is often observed that agricultural resource degradation occurs also when such resources are exploited by the non-poor (a matter discussed below). It also occurs, and often more so, in conditions where poverty is declining rather than increasing, e.g. when the opening up of income earning opportunities outside agriculture leads to the abandonment (because they are not any more worth it) of elaborate resource conservation practices, such as the maintenance of terraces to conserve small, poor quality, land patches on hillsides, etc.[14]

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[14] For examples from the Latin American Sierras, see De Janvry A. and R. Garcia, *Poverty, Public Policies and the Environment*, paper for IFAD, 1988 (mimeo).

Another example of degradation associated with alleviation rather than aggravation of poverty is given by the opening up of profitable opportunities to grow cassava in some Asian countries for export to the EC where it substituted high-priced cereals in the feed sector. It is thought that part of this expansion of cassava production had adverse effects on the land and water resources which were not "internalized" in the export price (see Chapter 13).

2.64 It follows from the above that more complex processes are at work and the simple correlation between poverty and environmental degradation can be an oversimplification. This is well recognized, and research work on understanding the role of other variables which mediate the relationship between poverty and environmental degradation can provide valuable insights. Such work emphasizes, for example, the vital importance of institutions governing access to resources (e.g. to common property or open access resources) and how such institutions come under pressure when population density increases; inequality of access to land and landlessness; policies which distort incentives against the use of technology that would contribute to resource conservation, e.g. by depressing the output/fertilizer price ratio and making fertilizer use uneconomic where increased use is vital for prevention of soil mining; and the knock-on effects of policies which facilitate interactions between the non-poor and the poor in ways which lead to degradation, e.g. when deforestation and expansion of agriculture are facilitated by incentives to logging operations which open access roads into previously inaccessible forest areas which may have soils that cannot easily sustain crop production.

2.65 Understanding the role of these and other mediating variables and getting away from the simple notion that degradation can be explained by poverty alone is important for formulating and implementing policies for sustainable agriculture and resource conservation. It is important because the policy environment in the future will continue to be characterized by pressures on agricultural resources related, in one way or another, to rural poverty. Indeed, the numbers of the rural poor depending on the exploitation of agricultural resources will probably increase further in some countries and decline in others. It was noted earlier that both processes can be associated with resource degradation. Therefore, the key policy problem is how to minimize adverse environmental impacts of both processes. Chapter 12 presents what are essentially technological options for policy responses; and Chapter 13 deals with policies that would contribute to minimizing the unavoidable trade-offs between agricultural development and the environment.

2.66 *Poverty-related degradation of agricultural resources is only part of the story.* It is well known that part of the degradation process is related to the actions of people who are not in the poor category. This issue has two aspects: *the first one* has to do with consumption levels and patterns of the non-poor, in both the developed and the developing countries. For example, some 30 percent of world cereals' output is used as animal feed and a good part of the production of soybeans and other oilseeds is also related to livestock production. Most of the livestock output produced in concentrate-feeding systems is consumed by the medium- and high-income people. To the extent that production of cereals and oilseeds causes degradation (as indeed it does in some places, though not in others) it can be said that part of the degradation is caused by actions of the rich, not the poor. It would perhaps be more correct to say that it is caused by *interactions between rich and poor,* e.g. when expansion of soybeans production in South America raised the price of land there. This induced small farmers to sell land to large soybean operations and move to other areas to colonize new lands. The example cited earlier concerning the expansion of cassava

production for export to Europe is another case. Both cases are to some extent related to policies of other countries which maintained artificially high prices for cereals used in livestock production and increased incentives for production and export of these cereal substitutes.

2.67 Many other cases could be cited to illustrate the complex interactions between the behaviour of the poor and the non-poor resulting in the building up of pressures on agricultural resources. Without a thorough understanding of such complex processes at work leading to resource degradation, it would be difficult to design and implement appropriate policy responses. Accounting for the factors which determine the actions of the poor and the non-poor alike is required even if, in a poverty-focused strategy, the priority objective were to minimize the degradation of the resources operated by the poor.

2.68 The *second aspect* has to do with the fact that resource degradation is also associated with agriculture practised by farmers who are not poor. Soil erosion believed to be associated with some of the grain production in North America is a case in point; excessive fertilizer and other agrochemical use in Europe is another; and effluents from intensive livestock operations are in the same category. These are all examples of actions by the non-poor with adverse environmental effects. It all goes to show that associating resource degradation with poverty addresses is only part of the issue.

2.69 In the end, the focus of policy has to recognize that resource degradation has different consequences for different countries and population groups. For the poor countries, the consequences can be very serious because their welfare depends heavily on the productive potential of their agricultural resources.[15] Therefore, from a purely developmental and conventional welfare standpoint, it is right that preoccupation with resource degradation problems focuses primarily on the developing countries. At the same time, it must be recognized that resource degradation not only in the developing countries, but anywhere in the planet, particularly in the major food exporting developed countries, can make more difficult the solution of the food security problems of the poor if it reduces the global food production potential. Therefore, controlling resource degradation in the rich countries assumes priority even in strategies focused primarily on the food security of the poor; and this irrespective of the fact that the welfare of the rich countries, as conventionally measured by, for example, per caput incomes, may not be seriously threatened by moderate degradation of their own resources. There are, of course, other compelling reasons why the rich countries give high priority to controlling degradation of their own resources, as an objective in its own right.

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15 See, for example, Schelling, T., "Some Economics of Global Warming", *American Economic Review*, March 1992.

CHAPTER 3

WORLD FOOD AND AGRICULTURE: A 20-YEAR PERSPECTIVE

1. INTRODUCTION

3.1 This chapter presents the likely developments in world food and agriculture over the period to 2010, in varying degrees of detail concerning commodities and country groups. It is emphasized that this Study attempts to sketch out the prospective developments and *give an idea of the future as it is likely to be rather than as it ought to be from a normative perspective*. For example, the conclusion that undernutrition is likely to persist results from this approach to looking into the future. Therefore, the prospective developments presented here are not goals of an FAO strategy. But they can provide a basis for action to cope with the problems likely to persist and new ones that may emerge. The major thrusts of policies required to respond to persisting and newly emerging problems are discussed mainly in Chapter 7 onwards, but also in other chapters. The alternative of sketching out a normative scenario in which all problems would be solved in the next 20 years would not be useful because it would have to be based on some totally unrealistic assumptions, e.g. very high economic and agricultural growth rates as well as rapid growth of food imports of sub-Saharan Africa.

3.2 Concerning the question how likely are the "probable" future developments presented in this Study, there is no scientific way of answering it. This is mainly because the summary quantifications presented here are the result of analyses conducted at a great level of detail concerning countries, commodities, technologies and resources. The final results as to how these different variables may develop have been heavily weighted by the views, knowledge and visions of a large number of technical experts in all the relevant disciplines and possessing varying degrees of knowledge of the local situations in the different countries. Thus, the methodology used in this Study is largely the same as that of the 1987 edition, with some refinements.[16] One way of judging the "credibility" of the prospective developments presented here is to examine how closely actual developments of major variables have been tracking the projections to 2000 of the 1987 edition of this Study. Some comparisons in this sense are presented in the Annex at the end of this chapter. This may help readers to form their own opinion on whether the future developments presented here may come true or otherwise.

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16 For a description and evaluation of the methodology see the published version of the 1987 study, *World Agriculture Toward 2000*, Belhaven Press, London and New York University Press, New York, 1988, and (in French) *Agriculture Mondiale: Horizon 2000*, Economica, Paris, 1989.

2. POPULATION GROWTH AND THE OVERALL ECONOMIC GROWTH OUTLOOK

Population

3.3 The world population is projected to grow to 7.2 billion by year 2010, up from 5.3 billion in 1990, an increase of 1.9 billion or 36 percent in 20 years (Table 3.1). This is a higher absolute increment than that of the last 20 years (1.6 billion) but a lower one in percentage terms. Indeed, the growth rate of world population seems to have peaked at 2.1 percent p.a. in 1965-70 and then declined progressively to the current level of 1.7 percent p.a. Further declines in the growth rate are foreseen for the future so that by the final five-year period of the Study's horizon (2005-10) growth will have fallen to 1.3 percent p.a. But the absolute yearly increments will continue to be large and growing. They are at present larger than at any time in the past, at about 94 million persons per year, and may not peak until the year 2000. The annual increment would still be some 95 million people by year 2010.

3.4 What matters most for food and nutrition is the population growth of the developing countries and indeed those regions with the highest incidence of poverty and undernutrition (sub-Saharan Africa and South Asia). The developing countries are still on a high demographic growth path (2.0 percent p.a.) and will account for over 90 percent of the additional world population in the projection period. But their growth rate is also on the decline, though slowly. Growth is expected to have fallen from 2.0 percent at present to 1.6 percent p.a. in the five-year period 2005-10. The only major region with a very high and still increasing population growth rate (over 3.0 percent p.a.) is sub-Saharan African, though also here the growth rate may peak during the projection period. Still, its population is projected to increase to some 900 million by the year 2010, an average growth rate of 3.2 percent p.a.[17] Making food availabilities grow at an equal rate would still be an achievement and a break from past trends, but even if achieved, it would only serve to prevent further deterioration of the already very inadequate nutrition levels.

Economic Growth Assumptions

3.5 The overall economic growth rates used in this Study (Table 3.1) are taken from other sources, mainly the work of other organizations, e.g. the World Bank, and supplemented by our own judgements only when no projections from other sources were available. The problems associated with the use of exogenous assumptions about the overall economic growth outlook in assessing the food and agriculture prospects were discussed in Chapter 2 (paragraph 2.2) and are not repeated here.

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17 The just released UN Population Assessment of 1992 (not used in this Study) indicates a lower projected population for the sub-Saharan region of this Study (874 million rather than the 915 million used here) and a growth rate of 3.0 percent p.a. rather than 3.2 percent. This is not necessarily an optimistic outcome because the projected lower population in some countries could reflect the increased mortality rates due to the AIDS pandemic. The projections for the other regions are also somewhat different (the new projections are shown in the Statistical Appendix).

Table 3.1 Population Projections and GDP Growth Assumptions

	Population						GDP Growth Rates		World Bank's Latest Baseline GDP Projections [1/]			
							1989-2010		Total		Per caput	
	1989	2010	70-80	80-90	90-2000	2000-10	Total	Per caput	82-92	92-2002	82-92	92-2002
	.... million		.... growth rates % p.a.				.... % p.a.		...... % p.a.			
World	5 205	7 209	1.9	1.8	1.7	1.4						
All Developing	3 960	5 835	2.2	2.1	2.0	1.7			3.8	5.3	1.7	3.4
93 Developing	3 905	5 758	2.2	2.1	2.0	1.7	5.3	3.4				
Africa (S. Saharan)	473	915	2.9	3.2	3.3	3.1	3.9	0.7	2.0	3.7	-1.1	0.6
N. East/N. Africa	297	493	2.7	2.8	2.6	2.2	4.4	1.9	1.6	4.5	-1.5	1.6
East Asia	1 558	2 001	1.9	1.5	1.5	0.9	7.0	5.7	8.0	7.3	6.4	5.9
South Asia	1 144	1 728	2.3	2.4	2.2	1.8	5.1	3.0	5.2	5.3	2.9	3.4
Lat. America + Carib.	433	622	2.4	2.2	1.9	1.6	4.0	2.3	1.9	3.9	-0.2	2.1
Developed Countries	1 244	1 373	0.8	0.7	0.5	0.4	2.6	2.1				
W.Europe	399	410	0.4	0.3	0.2	0.0	2.7	2.5				
N. America	274	311	1.0	0.9	0.6	0.5	2.2	1.6	2.7[3/]	2.7[3/]		
Others	182	214	1.4	1.0	0.9	0.7	4.2	3.4				
E. Europe and former USSR	387	435	0.9	0.8	0.6	0.5	0.5[2/]	0.0	-0.4	2.1		

Note: Population data and projections are from the 1990 UN Assessment. Country level data are shown in the Statistical Appendix, where regional totals from the 1992 UN Assessment are also shown.

1/ World Bank, *Global Economic Prospects and The Developing Countries, 1993.*

2/ The GDP growth rates 1989-2010 are lower than those of the World Bank because they include the deep GDP declines of 1990-92 and foreseen for 1993 (1990: -3.1, 1991: -10.1, 1992: -15.5, proj. 1993: -8.8; data from IMF, *World Economic Outlook*, April 1993).

3/ GDP projections for the G-7 countries.

3.6 For the developing countries the outlook is for economic growth to be much better in the 1990s than that of the "crisis" decade of the 1980s. In this latter period, all developing regions except Asia experienced declines in per caput incomes. In the projection period the prospects are for Asia to maintain its high growth rate and all the other regions to shift in varying degrees from negative to positive, though modest, growth rates in per caput incomes. But there are no Asia-type growth prospects for these regions, particularly not for sub-Saharan Africa. Although the region's economic growth rate could double compared with the dismal 1980s, this would still leave it with nearly stagnant and very low per caput incomes over the projection period, given its high population growth rate. These developments can hardly lay the foundation for significant improvements in its food and agriculture. Such prospects are indeed reflected in this Study's assessments for the region (see below).

3.7 The OECD countries are assumed to continue along their growth path of the 1980s, though their low population growth rate would make for rather respectable increases in per caput incomes. The OECD growth rate is an important parameter in the World Bank's assessment of the developing countries' growth prospects (see reference in Table 3.1). The direct link with the latter's agriculture is likely to be weak because of the low income and price elasticities of the OECD for the demand of their main traditional agricultural exportables, though the link can be significant for products like fruit and vegetables. However, the indirect links can be important, at least for some regions, if OECD growth stimulates their exports of manufactures and this contributes to higher incomes and agricultural demand in the developing countries themselves.

3.8 The uncertainties surrounding the prospects for recovery and long-term growth of the ex-Centrally Planned Economies (CPEs) of Europe, particularly those for the former USSR, are well known. Their combined GDP had fallen by about one-third between 1989 and (forecast) 1993. The working hypothesis in this Study is that growth could lead to restoration of their per caput income level to that of 1989 by 2010. The reforms and these growth prospects can be expected to have profound influences on their own food and agriculture and on world food markets. These are discussed later on in this chapter. Here it suffices to mention that world cereals markets may be affected by increased export availabilities from Eastern Europe and greatly reduced import requirements of the former USSR. Both will contribute to continued weakness in these markets as these developments will tend to offset part of the stimulus of continuing growth in import requirements of the developing countries. In parallel, the import demand of the ex-CPEs for the main traditional agricultural exportables of the developing countries is unlikely to be very buoyant, notwithstanding their still very low levels of per caput consumption of such products (coffee, cocoa, etc.) and the considerable potential for increases.

3. AGRICULTURE: PROSPECTIVE DEVELOPMENTS IN AGGREGATE PRODUCTION AND DEMAND

The World as a Whole

3.9 For the world as a whole, the prospects are that the growth of aggregate (gross) production will continue to slow down. This is in line with the longer-term historical developments when the growth rate fell from 3.0 in the 1960s, to 2.4 percent in the 1970s

to 2.2 in the 1980s. It is foreseen that the growth rate will fall further to 1.8 percent p.a. in the next 20 years (Table 3.2). A host of factors explain this progressive deceleration. It may not be interpreted to mean that the world as a whole is running out of potential to increase agricultural output, though production constraints at the local level do contribute to this outcome. This happens when the demand not met by local production cannot be expressed as effective demand for imports and induce production to increase in another part of the world.

3.10 The progressive slowdown in the growth of world production mirrors the similar slowdown in the growth of demand, itself resulting from the lower population growth and the progressive saturation of per caput food consumption levels for parts of the world population. The little scope for further growth in per caput consumption in most developed countries is a case in point. This has a major impact on the scope for further expansion of the world totals because the developed countries account for a high share of gross world consumption of agricultural products, 49 percent in 1988/90, notwithstanding their much lower share in world population (24 percent). At the same time, the considerable scope for further growth in consumption in most developing countries gets expressed as effective demand only gradually, for the well-known reasons of the slow growth in their per caput incomes and, in the countries facing production constraints, import financing capacity.

3.11 In conclusion, the further slowdown in world agriculture conveys a composite signal of positive and negative elements for the world's food and agriculture futures. On the negative side is the fact that the potential for producing more to increase food supplies to the people with low consumption levels will be utilized only in part. On the positive side is the slowdown in world population growth and the fact that more and more people attain satisfactory levels of food consumption; and, of course, the less the need for increasing output, the smaller the additional pressures exerted on resources and the environment. But this is not always so. In situations of poverty, a low growth rate of production may be associated with more resource degradation than a higher rate of production. This is because a low rate contributes to perpetuate poverty and sets in motion the vicious circle of poverty - degradation - poverty, as discussed in Chapter 2.

The Developing Countries

3.12 The preceding discussion on the possible outcomes at the world level (slower growth than in the past 20 years) applies largely also to the developing countries as a whole, though with less force and important exceptions (see Table 3.2). Also here, the gradual progress towards higher consumption levels in some countries and regions and the overall lower growth rate of population will lead to a slower growth in demand and production compared with the past. East Asia, and to a smaller extent Near East/North Africa, are the regions closest to this pattern of evolution. They had the highest growth rates of per caput aggregate demand in the past 20 years, though the sharp slowdown in the growth of per caput demand in the Near East/North Africa region was already evident in the 1980s. East Asia would continue to have the highest, though lower than in the past, growth of per caput demand and production of all regions, given its high projected economic growth. South Asia and Latin America should maintain their middling growth rates of the past 20 years in both per caput demand and production. This leaves sub-Saharan Africa as the only region that could have a higher growth rate compared with the past. This is a significant improvement, but only

relatively speaking, since it would only mean that per caput production and demand may just stop falling.

3.13 However, these prospective developments for aggregate agriculture cannot be appreciated without a closer look at the prospects for the major commodity sectors. Much of the remainder of this chapter is devoted to such an examination. But an initial idea of how the prospects for the different commodities enter the determination of the agricultural aggregates is given in the lower part of Table 3.2. In it, the projected growth rate of production for sub-Saharan Africa, which is lower than that of projected population, is broken down into three commodity sectors. It is clearly seen that when the sector of the non-food commodities (coffee, cocoa, tobacco, rubber, etc.), which grows slowly because of export market constraints, and that of the roots/tubers (growing less rapidly than population due to long-term declines in per caput consumption) are separated out, the rest of agriculture (essentially the other crop and livestock products, predominantly for domestic use), could grow at 3.2 percent p.a. This growth rate, if achieved, would match that of population and could even exceed it if the latter turned out to be lower as indicated by the latest demographic projections (see footnote 16). This is an optimistic assessment of sorts, given the long historical experience of much lower growth rates and falls in per caput production. Even so, it would only prevent further deterioration.

The Developed Countries

3.14 Much of what was said earlier on the world prospects for aggregate production and demand applies to the developed countries. In the OECD countries, there is limited scope for further growth in per caput consumption. The past policies of import substitution in some major countries and the export opportunities offered by the increasing net food deficits of the developing countries and the former USSR had contributed to relax the demand constraints and allow for moderate growth in production. The relief offered by these two factors, particularly that of the State-aided import substitution, had been largely exhausted by the mid-1980s. The scope for further import substitution is very limited for most commodities. Moreover, the thrust of policy reforms under way or under active consideration is likely to make virtually impossible any further State-aided import substitution in these countries. In parallel, the growth of net import requirements of the developing countries for the main agricultural exportables of the OECD area is likely to be slow. Furthermore, part of the associated expansion of the export markets is likely to be counterbalanced by reductions in the net import requirements of the former USSR and some expansion of export availabilities from E. Europe. Therefore, the likely outcome for the aggregate agricultural production of the OECD area is that the growth rate will be no higher than the 0.8 percent p.a. achieved in the 1980s, which itself was down from 2.0 percent p.a. in the 1970s.

3.15 The uncertainty concerning the prospects for the reforming countries of E. Europe and former USSR was underlined above. Their production fell sharply in the initial years of the reforms, with aggregate 1992 gross output being about 15 percent below that of the three-year average 1988/90. The recovery that will follow is expected to be slow and may lead to aggregate production growth in the next 20 years being only one-half that of the last 20 years (Table 3.2). The sharp reduction in per caput consumption in the initial years of the reforms will probably be reversed, but future levels are unlikely to be above those of the

pre-reform period. The commodity composition of consumption may change and the per caput domestic use of all agricultural products may be lower, due to lower waste rates and less cereals being fed per unit of livestock output (see Table 3.16).

4. PROSPECTIVE DEVELOPMENTS IN FOOD AND NUTRITION

3.16 The implication of the above-described prospects in the demand and production for the evolution of per caput food supplies and the associated possible effects on the incidence of undernutrition are summarized in Table 3.3. By and large, it can be expected that the trends towards increasing per caput food supplies in most developing countries will continue. In particular, the average food supplies for the projected 2 billion population of East Asia may reach just over 3 000 calories/day. Thus, this region will be edging towards the relatively high levels of Near East/North Africa, with the Latin America/Caribbean region following closely behind. In all three regions, though not in all countries in them, the incidence of undernutrition may fall by year 2010 to the fairly low level of 4-6 percent of the total population. This possible evolution will be helped by a probable fall in inequality of access to food supplies which, as noted in Chapter 2 (paragraph 2.23, footnote 6), may be expected to improve as average food supplies edge up towards the 3 000+ calorie level. Such an assumption is incorporated in the projections of undernutrition in Table 3.3.

3.17 South Asia may also be expected to make significant progress, but the initial conditions are such that by 2010 the per caput food supplies would still be in the low-middle level (2 450 calories/day). Accordingly, the incidence of undernutrition is likely to remain high, particularly if measured in terms of the absolute numbers of persons affected. Still, the possible halving of the percentage of the population chronically undernourished to 12 percent by year 2010 denotes significant, though not sufficient, progress.

3.18 Concerning sub-Saharan Africa, the discussion in the earlier sections on population, economic growth and aggregate agriculture already foreshadowed the conclusions shown in Table 3.3, i.e. that little progress can be expected to be made in raising per caput food supplies. Undernutrition will probably remain disturbingly widespread and still affect by year 2010 nearly one-third of the population (300 million people). Indeed, the region will take over from South Asia as the one with the highest number of persons chronically undernourished, no matter that its total population will be by then only half as large as that of South Asia.

3.19 Things may turn out otherwise if sub-Saharan Africa were to lift itself out of quasi perennial economic stagnation; and if its agriculture were to make even more progress than assessed as probable in this Study. In the quest for policy responses to the deteriorating nutritional situation of sub-Saharan Africa, the agricultural assessment of this Study indicates that there are certainly potentialities for higher growth than anticipated here in certain commodity sectors. But it would be far-fetched to assume that they would materialize in an environment of nearly stagnant per caput incomes which constrain effective demand domestically, while the demand for the main agricultural exportables will also be sluggish. These conditions are hardly propitious for providing incentives to stimulate introduction of feasible technologies and investments in resource improvements that would cause this productive potential to express itself. And stagnant economies will continue to constrain the

Table 3.2 Growth Rates of Gross Agricultural Production and Domestic Demand (All Uses)

(percent p.a.)

	Production				Domestic Demand (all uses)			
	Total		Per Caput		Total		Per Caput	
	70-90	88/90-2010	70-90	88/90-2010	70-90	88/90-2010	70-90	88/90-2010
World	2.3	1.8	0.5	0.2	2.3	1.8	0.5	0.2
93 Developing Countries	3.3	2.6	1.1	0.8	3.6	2.8	1.4	0.9
Africa (S. Sah)	1.9	3.0	-1.1	-0.2	2.6	3.3	-0.4	0.1
Near East/N. Africa	3.1	2.7	0.3	0.3	4.5	2.8	1.7	0.4
East Asia	4.1	2.7	2.4	1.5	4.1	2.8	2.4	1.6
South Asia	3.1	2.6	0.7	0.6	3.1	2.8	0.8	0.8
Latin America + Caribb.	2.9	2.3	0.6	0.6	2.9	2.4	0.6	0.6
Developed Countries	1.4	0.7	0.6	0.2	1.2	0.5	0.5	0.0
E. Europe + Former USSR	1.2	0.4	0.4	-0.1	1.4	0.2	0.6	-0.4
Other Developed Countries	1.5	0.8	0.7	0.4	1.2	0.7	0.5	0.2
Memo Item								
Africa (S. Sah)								
Non-Food Agric. (mainly exportables)	0.9	1.9						
Roots/Tubers	2.3	2.8						
Other Food Products	1.9	3.2						

Table 3.3 Per Caput Food Supplies for Direct Human Consumption (calories/day) and Possible Evolution of the Incidence of Chronic Undernutrition

	Per Caput Food Supplies (cal/day)			Chronic Undernutrition					
				Percent of Population			No. of Persons (million)		
	69/71	88/90	2010	69/71	88/90	2010	69/71	88/90	2010*
World	2 430	2 700	2 860						
93 Developing Countries	2 120	2 470	2 730	36	20	11	941	781	637
Africa (S. Sah)	2 140	2 100	2 170	35	37	32	94	175	296
Near East/N. Africa	2 380	3 010	3 120	24	8	6	42	24	29
East Asia	2 020	2 600	3 060	44	16	4	497	252	70
South Asia	2 040	2 220	2 450	34	24	12	254	271	202
Latin America + Caribb.	2 500	2 690	2 950	19	13	6	54	59	40
Developed Countries	3 200	3 400	3 470						
E. Europe + Former USSR	3 310	3 380	3 380						
Other Developed Countries	3 140	3 410	3 510						

* The projections assume modest declines in inequality of distribution of food supplies (technically speaking, the standard deviation of the distribution is assumed to remain constant rather than increase whenever the average per caput supplies increase - See reference given in Table 2.2).

resources of the public sector for investing in agriculture to boost its production performance (e.g. infrastructure, research, extension, education, etc.). As noted, there is scope for more optimistic outcomes in food and agriculture if the widespread policy reforms currently being implemented and the external environment, including resource flows, were to lead to faster overall development than indicated by the assessments of other organizations (see Table 3.1).

5. THE DEVELOPING COUNTRIES: PROSPECTS BY MAJOR COMMODITY GROUPS

5.1 Differing Prospects for the Individual Commodity Sectors

3.20 As noted, the prospective developments for the entire agricultural sector reflect the diverging growth prospects for the different commodity sectors. These are summarized in Table 3.4, while the prospects for each major sector are discussed in the subsequent sections.

Table 3.4 Major Commodity Groups in Total Gross Agricultural Production, 93 Developing Countries

Commodity Group	Share % in total value of gross production 1988/90	Growth Rates of Production*				
		61-70	70-80	80-90	70-90	88/90-2010
Cereals	30	4.1	3.0	2.8	3.1	2.0
Other Basic Food Crops (roots/tubers, plantains, pulses)	9	2.5	1.5	1.6	1.3	1.7
Other Food Crops	27	3.1	3.5	3.7	3.7	2.8
Livestock	27	3.9	3.8	4.6	4.3	3.4
Non-Food Crops (beverages, raw materials)	7	2.7	1.3	3.1	2.6	2.2
Total	100	3.5	3.0	3.4	3.3	2.6

* The growth rates of the historical period are obtained taking all the annual data into account (by statistically fitting exponential curves in the annual data as is the standard practice). It is, therefore, possible for the 20-year growth rate to result as lower or higher than the growth rates of the two component 10-year periods, or their average.

5.2 Cereals in the Developing Countries

Overall Prospects

3.21 The trend towards lower growth rates in cereals production is expected to continue (Table 3.5).[18] Notwithstanding this decline, the growth of production has been above that of population and should continue to be so in the future. Thus production per caput would continue to grow, but at a slower rate than in the past. For example, per caput production had increased by 30 kg in the last 20 years. It may increase by only 12 kg in the next 20 years.

3.22 This slowdown is the result of a mix of positive and negative factors. On the positive side, the per caput demand for direct food uses is already at relatively high levels in some countries and demand tends to shift to other food products. This is the case of rice in some East Asian countries. On the negative side, other countries with still low levels of per caput consumption levels may not make much progress because of a combination of low growth in per caput incomes and constraints on increasing production.

3.23 In parallel, the growth of per caput consumption for all uses (+18 kg) is likely to exceed that of per caput production (+12 kg) with the difference to be met by increasing net imports (Table 3.5). Much of the additional consumption per caput will be for non-food uses, essentially for feed. This reflects the continued growth in the production and consumption of livestock products (see below).

3.24 The result of these possible developments in production and consumption is that the net cereals import requirements of the developing countries would continue to grow, though slowly, more like the path of the 1980s than the explosive one of the 1970s. Thus, net cereals imports may grow from the 90 million tons of 1988/90 to some 160 million tons[19] in year 2010 and the aggregate cereal self-sufficiency ratio may decline a little to 90 percent by year 2010 (Table 3.5). About one-half of the total increment of the 93 countries would be for the Near East/North Africa region and the balance would be mostly for Latin America and sub-Saharan Africa, and only a minor part for South Asia and East Asia, assuming China (Mainland) would continue to be only a small net importer.

3.25 The prospect that sub-Saharan Africa's net cereal import requirements may more than double to nearly 20 million tons may be viewed with alarm given the region's difficult balance of payments situation and heavy dependence on food aid. This possible outcome suggests a continued and possibly expanded role for food aid in the future. Still, the region's net import requirements are, and will likely remain, a small part of the total cereals deficit of the developing countries. They are also entirely inadequate for its own needs as even if

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18 The projections presented here are not extrapolations of past trends. If the projections had been derived as mere extrapolations of the historical growth rates the resulting projected production would have been much higher. For an illustration, see Annex to this chapter, Figure 3.A.2.

19 These are *net* imports of all the developing countries, after deduction of projected net exports of the *exporting developing countries* of some 30 million tons (up from 17 million tons in 1988/90 and 14 million tons in 1969/71). The net imports of the *importing developing countries* are projected at some 190 million tons by the year 2010 (up from 106 million in 1988/90 and 34 million tons in 1969/71).

Table 3.5 All Cereals, 93 Developing Countries (including rice in milled form)

A. All 93 Countries

Year	Million Tons			Self-Sufficiency, %	kg/caput				Growth rate of production % p.a.	
	Production	Consumption	Net Imports*		Production	Consumption				
						All Uses	Direct Food	Other Uses		
61/63	350	357	16 (18)	98	165	169	131	38	60-70	4.0
69/71	480	492	17 (20)	98	186	190	145	45	70-80	3.1
79/81	650	709	59 (67)	92	201	220	162	58	80-90	2.8
88/90	845	918	80 (90)	92	216	235	170	65	88/90-2000	2.3
2010	1 314	1 460	146 (162)	90	228	253	173	80	2000-2010	1.9

B. By Region

	Demand				Production	Net Balance	SSR	Growth Rates, % p.a.		
	Food		Feed	Total use				Period	Demand	Production
	Per caput (kg)	Total	. . . . . .	(million tons)	. . . . . .	. . . . . .	%			
Sub-Saharan Africa										
1969/71	115	31	1	37	36	-3	97.4	61 - 90	2.6	1.9
1979/81	113	40	2	48	41	-8	85.5	70 - 90	2.9	2.1
1988/90	114	54	2	63	54	-8	86.4	80 - 90	3.2	3.4
2010	120	110	4	128	109	-19	85.5	88/90-2010	3.4	3.4
N. East/N. Africa										
1969/71	183	33	10	54	46	-6	86.9	61 - 90	4.0	2.4
1979/81	203	47	19	80	58	-23	72.6	70 - 90	4.3	2.4
1988/90	213	63	32	112	73	-38	65.4	80 - 90	3.9	2.9
2010	210	103	64	190	119	-71	62.7	88/90-2010	2.6	2.3
East Asia (incl. China)**										
1969/71	151	169	20	215	211	-7	97.9	61 - 90	4.1	4.0
1979/81	181	246	49	327	307	-19	94.1	70 - 90	3.7	3.6
1988/90	200	312	73	428	409	-20	96.2	80 - 90	2.8	3.1
2010	206	412	174	642	620	-22	96.6	88/90-2010	2.0	2.0
South Asia										
1969/71	148	110	1	124	121	-5	97.9	61 - 90	2.8	3.0
1979/81	154	143	2	161	156	-1	96.8	70 - 90	2.8	3.0
1988/90	158	180	3	205	209	-5	101.9	80 - 90	2.7	2.9
2010	164	284	5	317	307	-10	96.7	88/90-2010	2.1	1.8
Lat. America + Caribb.										
1969/71	119	33	22	63	66	+3	104.9	61 - 90	3.6	2.9
1979/81	128	46	38	94	87	-8	92.9	70 - 90	3.2	2.4
1988/90	129	56	45	113	99	-10	87.6	80 - 90	1.8	0.8
2010	139	87	79	184	159	-25	86.5	88/90-2010	2.4	2.3

* Numbers in parentheses are the net imports of all developing countries, i.e. including those not in the group of 93, some of which are sizeable importers though minor producers. For imports and exports of the developing countries see paragraph 3.24 (footnote 19).

** See paragraph 3.27 (footnote 21).

its production increased by 3.4 percent p.a. (as assessed by this Study) this rate would still be grossly inadequate to raise more than marginally the very low consumption levels. Thus, while it is a matter of concern that the region's net cereal imports may more than double in the next 20 years, the real concern should be how to define a superior outcome for the region, one that would be composed of higher growth of agriculture (though not necessarily of cereals), exports and overall incomes and would lead to higher demand despite, most likely, even higher net food imports.[20]

Production Perspectives for the Individual Cereals

3.26 Much of the projected slowdown in total cereals production of the developing countries is due to the prospective developments in wheat and rice, while production growth of coarse grains could be somewhat faster than in the past, though not fast enough to compensate for the slower growth of wheat and rice. This is mainly because the bulk of their wheat and rice crops is produced in the two land-scarce regions of Asia and the Near East/North Africa. These two regions account for 94 percent of total rice production in the developing countries and for 90 percent of that of wheat but for only 63 percent (51 percent, excluding China) of that of coarse grains (data for 1988/90).

3.27 It follows that the scope for increasing production of wheat and rice in the developing countries through area expansion is much more limited than that for coarse grains which have a larger weight in total cereals production in the less land-scarce regions of Latin America and sub-Saharan Africa. This leaves production growth of wheat and rice in the developing countries to depend mainly, and more than in the past, on the growth of yields. In this context, the quantum leaps of yields of these two crops, characteristic of the heyday of the spread of the green revolution, are unlikely to be repeated at the same rate in the future. A slowdown in yield growth is foreseen for both wheat and rice; from an average growth rate of 2.8 percent p.a. in the last 20 years to 1.6 percent p.a. in the next 20 years for wheat; and from 2.3 percent p.a. to 1.5 percent p.a. for rice. Why this would be so is explained in more detail in Chapter 4 where the issue is analysed in terms of the individual agroecological zones, ranging from semi-arid to fully irrigated. A preview of the main parameters of cereals production in the developing countries, excluding China,[21] is given in Table 3.6. The following comments should help the reader to grasp the reasons underlying the projections.

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20 Concern is often expressed at the burgeoning food deficits of "Africa". In practice most of the increases in net cereal imports originated in North Africa (Morocco, Algeria, Tunisia, Libya, Egypt) rather than in the sub-Saharan region. Thus, in 1988/90 net imports in North Africa were 19.4 m. tons (up from 2.7 m tons in 1969/71) and in sub-Saharan Africa 8.1 m. tons (2.7 m tons in 1969/71).

21 China is not included in this analysis of production prospects by agroecological zone because of lack of the relevant data, i.e. the breakdown of current crop production and of land reserves by zone. China (mainland)'s cereals production was 313 million tons in 1988/90, double that of 1969/71. The working assumption used in this Study is that the growth rate of production would be lower in the future and production in year 2010 would be about 50 percent above present levels. Cereals include wheat, coarse grains and milled rice.

Table 3.6 Area, Yield and Production by Major Cereal Crop, Developing Countries (excluding China)

	1969/71	1988/90	2010	Growth Rates, % p.a.	
				1970-90	1988/90-2010
Production (million tons)					
Wheat	67	132	205	3.8	2.1
Rice (paddy)	177	303	459	3.0	2.0
Maize	70	112	196	2.7	2.7
Other Coarse Grains	68	85	134	1.3	2.2
Total*	322	531	842	2.8	2.2
Yields (kg/ha)					
Wheat	1 150	1 900	2 660	2.8	1.6
- irrigated (49%)**		2 470	3 320		
- sub-humid (23%)		1 700	2 140		
- other rainfed (28%)		1 260	1 810		
Rice (paddy)	1 855	2 775	3 810	2.3	1.5
- irrigated (44%)		3 690	5 165		
- naturally flooded (27%)		2 415	3 125		
- other rainfed (29%)		1 745	1 950		
Maize	1 300	1 790	2 470	1.8	1.5
- irrigated (12%)		3 690	4 550		
- sub-humid (48%)		1 820	2 570		
- humid (24%)		1 280	1 735		
Other Coarse Grains	730	940	1 210	1.3	1.2
- dry semi-arid (27%)		480	660		
- moist semi-arid (29%)		810	1 045		
- sub-humid (23%)		1 210	1 600		
- humid (9%)		860	1 085		
- irrigated (9%)		2 220	2 750		
Total	1 270	1 910	2 560	2.2	1.4
Area (harvested, mill. ha)					
Wheat	58	70	77	0.9	0.5
Rice (paddy)	95	109	120	0.8	0.5
Maize	54	63	80	0.9	1.2
Other Coarse Grains	93	90	111	0	1.0
Total	300	331	389	0.6	0.8

* In the total production of cereals, rice is included in milled terms.

** Numbers in parentheses denote the area under the crop in each agroecological zone as % of the total harvested area under the crop for 1988/90.

3.28 For *rice*, a production growth rate of 2.0 percent p.a. would be obtained from a combination of growth in yields (1.6 percent p.a.) and harvested area (0.5 percent p.a.). These growth rates of all three variables are well below those achieved in the last 20 years. Some 58 percent of rice production in the developing countries (excluding China) comes from irrigated land. It is foreseen that present irrigated yields of 3.7 tons/ha (in paddy) could increase to 5.2 tons/ha by year 2010, while the irrigated paddy area could expand from

47 m.ha to 58 m.ha.[22] Currently only few of the major rice-producing developing countries achieve irrigated yields of over 5 tons. The projections imply that by the year 2010 most countries could have irrigated yields over 5 tons/ha, while the others would not be much below the 5-ton mark. Thus, most of the increase in rice production would come from the growth of production under irrigation. Similar rates of yield increases (from 2.42 tons/ha to 3.1 tons) are projected for the other major component of the rice production system in naturally flooded land, though here the harvested area may decline somewhat partly due to its conversion to controlled irrigation.

3.29 For *wheat* the production growth rate of 2.1 percent p.a. could be achieved from a combination of harvested area expanding at 0.5 percent p.a. and yields rising by 1.6 percent p.a. As in the case of rice, these growth rates are well below those of the last 20 years (see Table 3.6) and indeed more so compared with rice. Again, increases in irrigated production would provide much of the increment in total wheat production. Year 2010 irrigated wheat yields could be 3.3 tons/ha on the average, up from some 2.5 tons currently. The bulk of the developing countries' irrigated wheat is in South Asia and the prospects of these projections materializing depends greatly on this region raising its irrigated yields from the currently relatively low level of 2.29 tons/ha to 3.22 tons/ha. This would still be below the yields of over 4.0 tons achieved currently in other countries, though on much smaller areas, such as Mexico, Egypt and Saudi Arabia. The prospects for rainfed wheat yields are that they could increase to some 2.14 tons/ha in the sub-humid areas and to 1.81 tons/ha in other rainfed areas.

3.30 These results indicate that it will be much more difficult in wheat, compared with rice, to keep up the high growth rates of yield achieved in the past. The implication is that some major wheat producing developing countries[23] would become more dependent on wheat imports even to achieve meagre increases in their per caput consumption. It is true that their net imports increased also in the past 20 years but then their per caput food consumption of wheat had increased significantly, from 55 to 74 kg. The new element in the projections is that their net imports would continue to grow for no significant gains in per caput consumption. This is unlike what may happen in the rice sector in which the major producing countries as a whole would continue to be net exporters while some of them would still increase their per caput consumption.

3.31 Unlike wheat and rice, the production growth rate of *maize* in the developing countries could be maintained at the rate of 2.7 percent p.a. achieved in the last 20 years. This growth rate of production could be achieved from a combination of higher growth in harvested area (1.2 percent p.a.) and somewhat lower growth in yields (1.5 percent p.a.) compared with the historical record. In practice, maize could be the fastest growing cereal crop in the developing countries in the next 20 years. This partly reflects the increasing role of the feed sector in total cereals demand but also the better area and yield growth prospects for maize compared with other cereals. Some two-thirds of all maize in the developing countries (excluding China) is produced in Latin America and sub-Saharan Africa where

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22 Data and projections are for harvested area. Part of the increase will come from increased cropping intensity, not from expansion of physical area under irrigation (see Chapter 4).

23 Data on areas, yields and production by country and cereal crop are shown in the Statistical Appendix.

there is still scope for increasing production through area expansion. Indeed, harvested area under maize could expand faster than in the last 20 years and could account for some 40 percent of the total increment in production. Moreover, the bulk (70 percent) of maize output is grown in agro-ecological conditions (sub-humid and irrigated land) in which it is possible to exploit existing technological potential to continue to raise yields. Such yield growth for maize would not, however, replicate the spectacular advances in the past for rice and wheat. It is more likely that growth in yields would maintained at a rate somewhat below the relatively modest rate of the past 20 years.

3.32 Finally, it is possible that production of other *coarse grains (barley, millet, sorghum, others)* could grow faster than in the past, but the growth rate would still be a modest 2.2 percent p.a. Such growth would depend more than for the other cereals on area expansion, because much of the increase would be in sub-Saharan Africa (almost all of the increase in millet production and one half of that in sorghum) and Latin America (the other half of the increase in sorghum production) where area expansion is likely to predominate as a source of growth, given the adverse rainfed conditions in which these crops are grown, particularly in sub-Saharan Africa. By contrast, increases in barley production could come mostly from yield growth in the Near East/N. Africa region where the bulk of the developing countries' barley output is produced.

Food and Feed Uses of Cereals

3.33 Currently total domestic use of cereals in the developing countries amounts to 930 million tons (with rice included in milled terms) of which 90 million tons comes from net imports from the developed countries. *Direct food* consumption absorbs some 670 million tons (72 percent of the total, but with wide regional differences, e.g. from 88 percent in South Asia to 56 percent in Near East/North Africa). *Animal feed* accounts for some 160 million tons (17 percent of the total, again with wide regional differences), while the remaining 100 million tons is used for seed and industrial non-food uses or represents waste (post harvest to retail).

3.34 As noted (Table 3.5) the *direct food* part of total cereals use is expected to grow at a rate just above that of population and show only marginal increases from the present per caput level of some 170 kg for the developing countries as a whole. The perspectives for the different regions differ from each other and often from their own historical experiences. *Sub-Saharan Africa* could see some modest increase in per caput consumption, though this would be far from adequate for nutritional improvement. Still, it would be an improvement following two decades of no growth, and indeed some decline, in per caput consumption. This "optimistic" outcome for the region depends essentially on the prospect that domestic cereals production (mostly of coarse grains) would grow in the next 20 years at 3.4 percent p.a. This is well above that achieved in the past 20 years (2.1 percent) but equal to that of the 1980s. Likewise, growth in per caput consumption in the *Latin America and Caribbean* region could resume after the no-growth decade of the 1980s. *South Asia* and *East Asia* (excluding China) could continue on their past slow and decelerating growth in the per caput direct consumption of cereals, though, as noted, for different reasons. The saturation/diversification effect will likely dominate the developments in East Asia, while low incomes and supply constraints will be more decisive for South Asia.

3.35 The end result is that demand for cereals for direct food consumption may grow at only 1.9 percent p.a. while that for feed would grow nearly twice as fast (3.7 percent p.a.). Why *feed use* should grow at this relatively high rate is explained below in the discussion of the prospective developments of livestock production and consumption. It is noted, however, that this growth rate is below that of earlier periods, when feed use of grains started from a low base and reached peak growth rates of 7.2 percent p.a. in the 1970s, before slowing down to 3.6 percent p.a. in the 1980s.

3.36 Still, feed use may account in year 2010 for some 22 percent of total use, up from 17 percent today, which itself was up from 11 percent twenty years ago. This prospect for an ever-increasing share of cereal supplies of the developing countries to be used in the feed sector may give rise for concern in a situation where many countries and population groups are still far from having met their needs for direct food consumption of cereals.[24] The relevance, or otherwise, of this concern depends essentially on the extent to which it can be considered that the use of cereals for feed diverts supplies which would otherwise be accessible to the poor. The answer is less straightforward than would appear at first glance. Increased demand for feed has traditionally originated in the middle- and high-income countries in which both feed and direct food use of cereals have been increasing and the latter is near "satisfactory" levels, though not for all population groups. By contrast, the need to increase per caput direct food use of cereals is to be found predominantly in the low-income countries, where feed use of cereals accounts for only a tiny proportion of total availabilities.

3.37 Under these circumstances, the link between the two, often spatially separate, categories of demand (of the middle-income countries for both food and feed, of the poor countries for food) and eventual diversion from the latter to the former could occur, in the first instance, through the operation of the world markets. But the conditions for this to happen are rather stringent: either (a) global supplies are quasi-constant in which case the additional demand for feed would raise prices with the result that part of the demand of the poor for direct consumption would be priced out of the market, or (b) supplies can be increased but only at prices which are above those that would otherwise prevail.

3.38 The empirical evidence from the world markets shows that increasing supplies to meet increments in demand (partly originating in the feed sector) have been forthcoming at declining, or non-increasing, real prices, except for occasional short-term shocks. There is, therefore, a *prima facie* case that increasing demand for feed has not raised permanently world cereal prices. The key question is, of course, whether prices would have been even lower but for the demand for feed. On this, it is more difficult to have firm views. It is noted, however, that one of the key factors behind the declining, or non-increasing, real prices in the presence of increasing demand has been the lowering of production costs following the diffusion of productivity-increasing technology. It is possible that this technological progress was partly linked to the expansion of demand of cereals by the feed sector.

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24 It is reminded that this Study attempts to assess how the situation may develop in the future rather than how it ought to be from a normative standpoint.

3.39 The above considerations seem to suggest that, in a global context, increasing use of cereals for feed was most likely met from additional supplies which were forthcoming at prices not significantly above those that would otherwise have prevailed. There is, however, reason to believe that such food-feed competition can be a significant factor in diverting supplies away from the poor at the level of individual countries or regions within countries. This would be the case of countries which face stringent production constraints and have little scope for increasing supplies through imports; or regions within countries which, because of local production constraints, low incomes or bottlenecks in transport, can be considered in a similar position. Such cases have characteristics closely resembling those of the "closed economy" paradigm. In such cases, an increase in the demand for feed would raise prices rather than production and reduce the direct food consumption of the poor.

3.40 The key issue is, of course, whether this process actually happens in poor countries in those conditions. It is noted that in the low-income regions of South Asia and sub-Saharan Africa the feed use of cereals remains a minuscule proportion of total use. Moreover, the projections show that this situation would not change much in the future, as nearly all their increases in demand for cereals would be for direct food purposes. Therefore, there is a *prima facie* case that the food-feed competition may not really be a significant factor in preventing progress towards raising the per caput direct consumption of cereals in the many countries with such consumption still at inadequate levels. If anything, the historical experience of many middle-income developing countries demonstrates that increases in the feed use of cereals occurred in parallel with increases in the per caput consumption for direct food purposes. The general underlying factor has been the growth in per caput incomes in combination with the growth of domestic cereals production and/or improvements in the import capacity. It is the absence of these factors that stand in the way of increasing per caput direct consumption in many low-income countries rather than the fact that feed use may be increasing in the middle- and high-income countries.

5.3 Livestock Products in Developing Countries

3.41 Structural change in the food consumption of the developing countries towards more livestock products will continue. However, their per caput consumption of such products[25] will still be well below those of the high-income countries twenty years from now. For some developing countries, the consumption of livestock products may not advance even in the longer-term future to the stage when it would match the consumption levels of the developed countries, for various reasons including those of ecology and culture. It is noted, however, that in some, though not all, high-income developing countries, meat consumption levels comparable to or little below those of the developed regions have been attained, e.g. Taiwan (province of China), Singapore, Hong Kong, the United Arab Emirates and Kuwait. Another factor in considering the livestock sector developments is that in some developing countries, including very poor ones, livestock products (mostly milk) are staples, not luxury foods, e.g. in the predominantly pastoral societies of the Sahel.

[25] Only meat, milk and eggs are considered here. Other livestock products are not analysed separately in the Study, e.g. wool, hides and skins and animal fats, though the latter are included in the demand and nutrition analysis.

3.42 For *meat* there may be a slowdown in the growth of per caput demand (from 2.6 percent p.a. in 1970-90 to 2.0 percent p.a. in 1988/90-2010), total demand (from 4.8 percent to 3.9 percent) and production (from 4.6 percent to 3.8 percent). The relevant data are shown in Table 3.7. The slowdown would occur in the regions of Near East/North Africa and East Asia. Prospective developments in China decisively influence the total outcome because this country accounts for 40 percent of total meat consumption of the developing countries.[26] For the developing countries without China, the growth rate of per caput demand for meat is likely to be maintained at 1.1 percent p.a., while the growth of their total demand and production is somewhat less than in the past because of the lower growth of population. In addition, there might be a net import of about 1 million tons, mostly reflecting growing net imports into the Near East/North Africa region, partly offset by increased net exports from Latin America.

Table 3.7 Meat Production and Consumption, 93 Developing Countries

	69/71	79/81	88/90	2010	Growth Rates, % p.a.	
					70-90	88/90-2010
Consumption/Demand						
Total (mill. tons)	27.0	42.2	64.0	143	4.8	3.9
Per caput (kg)	10.5	13.0	16.4	25	2.6	2.0
Production (mill. tons)	28.5	42.6	64.8	143	4.6	3.8
By species (mill. tons)						
Cattle	12.1	14.6	18.6	32	2.2	2.7
Sheep/goat	3.0	3.6	4.9	10	2.8	3.1
Pig	9.7	16.8	28.3	64	6.1	4.0
Poultry	3.7	7.6	12.9	37	7.0	5.1

Note: Meat is in carcass weight, excluding offals. Production is that of indigenous meat, with live animal exports counted as domestic meat production and live animals imports as meat imports, in their carcass weight equivalent.

26 There are a number of reasons for the projected slowdown in China. In the first place, rapid growth in per caput meat consumption in the historical period started from very low levels of 30 years ago (4.5 kg in 1961/63) and received new impetus after the reforms of the late 1970s, to reach 23.5 kg in 1988/90. The growth rate of per caput consumption was 5.7 percent in 1970-90. If growth were to continue as per trend, it would reach 75 kg in year 2010. This is nearly the European level and unlikely for a country at the level of development that China may reach in the next 20 years. Moreover, a continuation of trends of meat production at the rate of the last 20 years would probably put an intolerable strain on the cereals and oilseeds sectors, with feed demand translating into large import requirements. Feed now takes 53 million tons of cereals in China, or 17% percent of total use. The per caput meat consumption projected in this Study would still be a respectable 49 kg/caput in year 2010. It would translate into a production growth rate of 4.6% p.a.

3.43 Concerning *the milk sector*, there is likely to be a drastic slowdown in the rate of increase in consumption. In contrast to the prospective developments for the meat sector, the solwdown is generalized ans all regions may be affected. The reasons for these prospective developments are to be found in a combination of production constraints and reduced availabilities of exports at highly subsidized prices (including food aid) from the main exporting developed countries. It can be seen from the historical data in Table 3.8 that the slowdown has been under way already in the 1980s. In the decade of the 1970s, the growth of net imports provided one quarter of the increment in consumption. By contrast, there was no growth in net imports in the 1980s, and only slow growth in such net imports is foreseen for the next 20 years.

Table 3.8 Milk Production and Consumption, 93 Developing Countries

	69/71	79/81	88/90	2010	Growth Rates, % p.a.	
					70-90	88/90-2010
Consumption/Demand						
Total (mill. tons)	84.7	122.8	164.0	273.4	3.7	2.5
Per caput food (kg)	27.4	32.1	35.9	41.7	1.7	0.7
Production (mill. tons)	78.0	107.3	147.3	247.6	3.5	2.5
Net Trade (mill. tons)	-6.8	-16.2	-16.2	-25.8	5.8	2.2

Note: All data and projections are for all milk and dairy products in liquid whole milk equivalent. Consumption and trade of butter is not included in the dairy products but in the animal fats. This means that, e.g. a country importing or consuming milk powder or cheese is shown as importing or consuming the liquid whole milk equivalent; but if it imports/exports only butter it is not shown as importing/exporting milk or dairy products.

3.44 The trade picture is likely to be dominated by (a) the reduced scope for subsidized production and exports from the main developed exporting countries, a policy trend likely to hold in the future and be reinforced by developments following the eventual conclusion of the Uruguay Round with consequent upward pressure in world market prices, and (b) the limited import capacity, already apparent in the 1980s, of those countries which fuelled the growth of consumption and imports in the 1970s.[27]

3.45 An additional factor in the slowdown of consumption and trade growth is the fact that in the fastest growing region, East Asia, the rapid economic growth will be less of a stimulus for increased milk consumption compared with other products because of the dietary habits of the region (presently consuming 6.5 kg per caput compared with 55 kg in the other developing countries). Finally, of particular concern is the prospect that production constraints would permit little growth in per caput consumption in the regions in which milk is a staple food for large parts of the poor population, e.g. in the pastoral societies of sub-Saharan Africa and, to a lesser extent, South Asia.

[27] For example, in the Near East/North Africa region the growth of imports in the 1970s provided 55% of the growth of consumption and the region accounted for nearly 40% of the increment in total imports of the developing countries.

Implications for the Cereals Feed Sector

3.46 As noted in the preceding section, feed use of cereals in the developing countries is becoming an increasingly important component of total cereals use. It grew at 5.6 percent p.a. in the last 20 years (7.2 percent p.a. in the 1970s, 3.6 percent p.a. in the 1980s); this is nearly double the growth rate of the use of cereals in direct food consumption. This growth of the cereals feed use has been one of the main factors behind the rapid increase in the developing countries net cereal imports, particularly during the 1970s. With the exception of China, the middle-income developing countries account for the bulk of cereals feed use. This is, of course, related to their above-average per caput consumption of livestock products. China also shares this characteristic, even though the criterion of per caput income puts the country in the low-income group.

3.47 The general mechanism which drives the growth of the cereals feed sector can be simply stated: growth of incomes increases demand for livestock products. The latter causes production to increase, with the bulk of the additional production in most countries coming from the pig and poultry sectors, as discussed in the preceding section. Unlike the case of the ruminant animal sector in the developing countries, substantial increases in pig and poultry depend heavily on the expansion of the grain-fed production systems. This general pattern would translate into the feed use of cereals growing faster than the volume of livestock output. In parallel, however, gains in feed use productivity would tend to attenuate this pattern. Moreover, this pattern is less pronounced or entirely absent in those countries (both developed and developing) with relatively high shares of the cattle/sheep sector in the total growth of livestock production and ample grassland and other non-grain feed resources.

3.48 The historical experience of comparative growth rates of cereals feed use and livestock output in the last twenty years (Table 3.9) broadly conforms to the above-discussed considerations. In both sub-Saharan Africa and South Asia and to a lesser extent Latin America feed use of cereals grew at or below the growth rate of total livestock output, with the latter measured by aggregating the different livestock products using weights reflecting the differences in their cereals feed intensity (see footnote to Table 3.9). At the other extreme, the experiences of both Near East/North Africa and East Asia (excluding China) seem to conform to a pattern of increasing cereal feed intensity of their livestock sectors, though at varying rates in different periods.

3.49 Concerning the future, by and large, and unless there are special country-specific circumstances, the use of cereals feed is likely to grow at roughly the same rate as that of total livestock output, with the latter measured as indicated in the footnote to Table 3.9. This pattern may deviate in some cases from the historical relationships which have often been unstable over time. For example, the data for East Asia show that feed use grew twice as fast as livestock output in the 1970s but half as fast in the 1980s. Moreover, the historical statistics of feed use are often a poor guide to what may happen in the future because they are very unreliable for many developing countries.

Table 3.9 Use of Cereals and Oilseed Proteins for Animal Feed, Developing Countries

					Growth Rates				Ratios of Growth Rates	
					Cereal Feed or Oilseed Proteins		Livestock Output 1/			
	69/71	79/81	88/90	2010	70-90	88/90 -2010	70-90	88/90 -2010	70-90	88/90 -2010
	.... million tons				.... % p.a.					
All Developing Countries										
All Cereals	56	114	160		5.6					
Maize	34	74	104		5.9					
Other Coarse Grains	16	28	36		4.5					
All Cereals										
93 Developing Countries	55	110	154	327	5.5	3.7	5.3	3.7	1.0	1.0
92 Countries (excl. China)	39	71	101	198	5.4	3.2	4.3	3.2	1.3	1.0
Sub-Sah. Africa	1.3	1.6	1.8	4.3	1.3	4.2	3.2	3.5	0.4	1.2
N. East/N. Africa	10.0	18.6	31.6	64.5	7.2	3.5	4.6	3.7	1.6	0.9
East Asia	20.5	49.4	73.0	174	6.5	4.1	7.0	4.3	0.9	1.0
South Asia	1.3	2.2	2.9	5.3	4.4	2.9	4.5	3.2	1.0	0.9
Lat. America + Caribb.	21.8	37.7	44.6	78.9	3.8	2.8	3.8	2.8	1.0	1.0
Others (non-Study Countries)	1.2	4.0	5.7							
Oilseed Proteins 2/										
93 Developing Countries	5	9	14	39	6.0	5.0	5.3	3.7	1.2	1.3

1/ Growth rates computed from a special, feed-specific volume index of livestock output taking into account the fact that in the developing countries much of the beef, mutton and milk production comes from non-grainfed animals, while pigmeat, poultrymeat and eggs come predominantly from grain-fed production systems (for relevant data see Tyers and Anderson, *Disarray in World Food Markets*, Cambridge UP, 1992, p. 386). The feed-intensity weighted livestock production index is computed as follows: 0.3 (Beef + Mutton) + 0.1 (Milk) + 1.0 (Pig + Poultry + Eggs).

2/ 100% crude protein equivalent.

3.50 The projections of cereals feed use are shown in Table 3.9, together with those of livestock production. A growth rate of 3.7 percent for the next 20 years is well below that of the last 20 years (5.5 percent p.a. in 1970-90) though equal to that of the 1980s. Still, feed use will continue to be the dynamic element in total use of cereals in the developing countries. Its share in total use would increase further, to some 22 percent by year 2010 compared with 17 percent at present and only 11 percent twenty years ago. Finally, it must be noted that cereals feed is only one component, and in many developing countries a minor component, of the (largely unknown) total balance between feed resources and livestock production. Wider issues of livestock production taking into account all sources of feed are discussed in Chapter 4.

Use of Oilseed Proteins in the Livestock Sector

3.51 The 93 developing countries of this Study use oilseed proteins in their livestock production to the tune of some 14 million tons.[28] In addition, they use some 1.2 million tons of fishmeal protein. Such use grew rapidly in the past two decades at a rate above that of livestock production (see Table 3.9), though such growth has tended to slow down in the 1980s. A few developing countries account for some two-thirds of total consumption (China, India, Mexico, Turkey, Pakistan).

3.52 The livestock production projections presented here imply that feed consumption of oilseed proteins would continue to grow at rates somewhat above those of total livestock output. The implications of this growth in the livestock sector and the domestic consumption of oilseed proteins is that by the year 2010 the developing countries as a whole would have a net export surplus of oilmeal proteins below present levels. Their present production of oilseeds, after deduction for uses not contributing to actual or potential feed protein supplies (e.g. oilseeds consumed directly as food, seed, etc.), amounts to some 24 million tons, i.e. it exceeds their consumption as feed by some 10 million tons, in crude protein equivalent. By the year 2010, production (discussed later in this chapter) would reach some 46 million tons, leaving some 6 million tons for net exports. Latin America would continue to be a large net exporter but at the same time the import requirements of the other regions, particularly East Asia and the Near East/North Africa, would grow rapidly, thus reducing the net export availabilities of the developing countries as a whole.

5.4 Other Basic Food Crops (Roots, Tubers, Plantains, Pulses)

Roots, Tubers, Plantains

3.53 This category of basic foods comprises a variety of products, the main ones being cassava, sweet potatoes, potatoes, yams, taro and plantains (hereafter referred to as "starchy foods"). For some of them, much of the production and apparent consumption are at the subsistence level. Moreover, they are produced and consumed predominantly in countries with poor statistical services and are subject to above-average rates of waste/post-harvest losses. For these reasons, the data on production and apparent consumption are subject to margins of error which are thought to be much larger than those for other food products.[29]

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[28] Feed use of oilseeds and their meal/cakes converted to crude protein equivalent, e.g. soybeans at 35.6% and soybeanmeal at 45%, cottonseed at 21.1% and 40%, respectively, and so on.

[29] In particular, the inclusion of plantains in this group creates problems. It is meant to capture the similarities with roots and tubers in food consumption and nutrition in several countries in the humid tropics. However, it not always easy to distinguish between the role of plantains in food consumption and nutrition from that of bananas proper consumed as fruit. For the purpose of food consumption analysis, plantains may be considered to be bananas that are picked green and cooked before eating (see FAO, *Human Nutrition in Tropical Africa,* 1979 and FAO, *Roots, Tubers, Plantains and Bananas in Human Nutrition*, 1990). Several countries, particularly in Central America are reported as having fairly high levels of per caput consumption of bananas (40-50 kg). The picture is further complicated by the consumption of both bananas and plantains after fermentation in the form of alcoholic beverages.

3.54 There are two dimensions of the starchy foods economy which seem to dominate all others when it comes to viewing developments in this sector: ecology and per caput incomes. In other words, these products are the mainstay of diets of poor people in countries characterized by ecological conditions (mainly the forest zones in the humid tropics) making them the predominant subsistence crops. It is precisely in the countries which combine both these characteristics and also have a low per caput level of aggregate food supplies that very high levels of apparent per caput food consumption of roots are encountered. There are 15 countries in sub-Saharan Africa (group "Africa-high" in the attached table) each with over 200 kg of apparent per caput consumption (in fresh product weight), but with some having levels of 350-400 kg (Ghana, Gabon, Congo, Uganda) and others above 400 kg (Zaire). Together these countries account for 55 percent of sub-Saharan Africa's population and they depend on roots for some 40 percent of their food supplies. Smaller country groups in both sub-Saharan Africa and the Latin America/Caribbean region have a "medium" level dependence on roots for their total food supplies (100-200 kg per caput) while all the other developing countries have consumption levels well below 100 kg (40 kg on the average), including some with very low levels (typically 5 kg) in sub-Saharan Africa itself, e.g. Mali, Somalia.

3.55 It is obvious that the high dependence of diets on these products in some of the poorest countries with high incidence of undernutrition makes this group of crops of prime importance in any assessment of future prospects in nutrition and of policies to improve it. It is also a reminder that the analysis of issues of food security, poverty and undernutrition should not be unduly limited to cereals. At the same time, the poor quality of data on this most important source of energy in diets makes difficult the analysis of the food problem and the assessment of the future precisely in some of the countries in which the problem is most acute. The prospects for roots in food consumption are, therefore, presented here for these specific root-dependent countries together with those for cereals and for total food (Table 3.10).

3.56 The prospects are that per caput food consumption of starchy roots will continue to decline, partly as a result of continuing urbanization (though its effect will be mainly limited to cassava and yams), but no radical structural change of diets away from the high dependence on these products is to be expected in the African countries. The expected little growth in per caput incomes and the difficulties in increasing supplies of cereals will permit little improvement in total food supplies and will ensure continued high dependence of the diets of these countries on starchy foods. In the end, countries accounting for over 50 percent of sub-Saharan Africa's population would still depend on starchy foods for some 36 percent of their total food supplies (calories). This assumes that production can grow at rates somewhat above those of the last twenty years, an outcome which is considered feasible. Overall, however, the production of this group of crops in the developing countries as a whole is expected to grow at a rate below that of the population, a pattern well established historical period. This reflects essentially the change in diets resulting from urbanization which tends to favour foods (e.g. cereals) which are often cheaper and more convenient for preparation and consumption in urban environments compared with the rural ones. Given the potential for increasing production, policies to stimulate consumption could be important for improving nutrition. Such policies may include research to develop new root-based food products, such as composite flours, noodles, chips, dehydrated products, etc.

Table 3.10 Roots, Tubers and Plantains (Starchy Foods) in the Developing Countries

	Groups with High/Medium Consumption of Starchy Foods			Other Developing Countries	93 Developing Countries
	Africa		Latin America		
	High[1]	Medium[2]	Medium[2]		
Per Caput Food Supply of Starchy Foods (kg)					
1969/71	336	205	162	62	80
1988/90	332	174	135	40	63
2010	313	171	125	36	64
Per Caput Food Supply of Cereals (kg)					
1969/71	88	121	88	150	145
1988/90	87	119	96	179	170
2010	96	121	112	183	173
Per Caput Supplies, All Food (calories/day)					
1988/90	2 160	2 190	2 280	2 500	2 470
% from Starchy Foods	40	21	13	4	6
% from Cereals	34	49	36	63	61
2010	2 230	2 240	2 540	2 790	2 730
% from Starchy Foods	36	20	11	3	6
% from Cereals	35	47	38	58	56
Production Growth Rates, Starchy Foods					
1970-90 % p.a.	2.4	1.8	1.7	1.0	1.4
1988/90-2010 % p.a.	2.8	3.3	1.9	0.9	1.6
Population (million)					
1988/90	262	33	88	3522	3905
2010	509	65	132	5051	5758

1/ Over 200 kg/caput in 1988/90 (fresh product weight): Benin, Ghana, Côte d'Ivoire, Nigeria, Togo, Angola, Central African Republic, Congo, Gabon, Zaire, Burundi, Mozambique, Rwanda, Tanzania, Uganda.

2/ 100-200 kg/caput, Africa: Guinea, Liberia, Cameroon, Madagascar, Namibia; Latin America/Caribbean: Dom. Republic, Haiti, Bolivia, Colombia, Ecuador, Paraguay, Peru.

3.57 No discussion of the starchy roots sector of the developing countries would be complete without a brief examination of the future of *cassava exports*, mainly to Europe for animal feed. Such exports, almost entirely from Thailand and to a lesser extent Indonesia, experienced phenomenal growth in the past, from 5 million tons in 1969/71 to 24 million tons in 1988/90 in net terms (fresh product equivalent of dried cassava) at which level they peaked in the late 1980s. The reasons for these historical developments are well known: imported cassava and oilmeals captured an increasing share of the European feed market substituting for cereals which were uncompetitively priced by the domestic support policies. The situation may change in the future following policy reforms in Europe which would lower cereal prices to the feed sector. It is, therefore, probable that the net exports of the developing countries would decline from the present level of 24 million tons.

Pulses (Dry)

3.58 This group of basic foods, often included in the statistics together with cereals in the foodgrains group, comprises a variety of products (beans, peas, chickpeas, lentils, etc; soybeans and groundnuts are included in the oilseeds in this Study, not in pulses) which form an important component of the diet, particularly those of the low-income population groups, in many developing countries.[30] Average per caput apparent food consumption of pulses in the developing countries as a whole is some 7.5 kg and it has been falling (it was 12 kg in the early 1960s). There is, however, still a large number of developing countries with relatively high levels (10-20 kg), e.g. Burkina Faso, Uganda, India, Nicaragua, Brazil, etc., and a few with very high ones, e.g. Rwanda, Burundi. With few exceptions (e.g. Brazil, Mexico), these countries have low per caput total food supplies and particularly of livestock products. Pulses are, therefore, an important source of protein, particularly in countries with low livestock/fish consumption levels. Thus, they provide 45 percent of total protein availabilities in Rwanda and Burundi, 25 percent in Uganda, 20 percent in Haiti and 14 percent in India.

3.59 The trend towards decline in per caput consumption of the developing countries as a whole was halted in the 1980s, particularly if China is excluded from the total. For the future it is estimated that per caput food consumption may remain at about present levels (9.0-9.5 kg on the average, or 7.5-8.0 kg if China is included). In practice, this is saying that the experience of the 1980s rather than that of the longer historical period may be representative of likely developments in the next 20 years. The dependence of the above-mentioned countries on pulses for their total protein supplies will remain relatively high. The growth rates of total demand (all uses) and production are shown in Table 3.11.

Table 3.11 Pulses in the Developing Countries: Growth Rates of Production and Demand (% p.a.)

	1970-80	1980-90	1988/90-2010
Demand (all uses)			
Developing Countries	0.4	1.8	2.1
Developing Countries (excl. China)	0.4	2.8	2.2
Production			
Developing Countries	0.2	1.6	2.0
Developing Countries (excl. China)	0.2	2.4	2.2

30 FAO, *Legumes in Human Nutrition*, 1981.

5.5 Oilcrops

3.60 The world produced in 1988/90 oilcrops which corresponded to some 71 million tons of oil equivalent. Actual production of vegetable oil is, however, smaller, 60 million tons, because some oilseeds are also used for purposes other than oil extraction, e.g. direct food, feed, seed, etc. This latter figure includes some 2 million tons of vegetable oil produced from crops (maize) and residues (rice bran) not in the oilcrop category.

3.61 In the last 20 years the sector experienced above-average growth in production (4.0 percent p.a.) as well as radical structural change as concerns the shares in total production of the individual oilcrops and regions. The rapid expansion of oilpalm products in East Asia, soybeans in South America and sunflowerseed and rapeseed mostly in W. Europe and to a lesser extent North America have been the most characteristic signs of this important structural change. Over the same period, some traditional oilcrops (mainly groundnuts, coconuts, sesame and cottonseed) have fallen behind as major sources of world vegetable oils production (their share - in oil equivalent - declined from 38 percent in 1969/71 to 26 percent in 1988/90).

3.62 There are a number of characteristics of the oilcrops sector that make its analysis and assessment of future prospects a rather complex undertaking. On the production side, there are both tree crops (oilpalm, coconut, olive trees) characterized by slow supply response to changing market conditions and annual ones with high rates of substitutability with other annual crops (e.g. soybeans for maize) and consequently high supply responses. Then, cottonseed is really a byproduct of cotton lint production, whose production response is little affected by oil market conditions. Further, most oilcrops produce joint products of oil and protein meals for livestock.

3.63 The demand side is characterized by the fact that for each of these joint products there is a high degree of substitutability in consumption. In addition, the use of vegetable oils in non-food industrial uses (paints, detergents) in which they compete with petroleum products as well as the competition in the food markets with animal fats further complicates the picture; and so does the competition of oilmeals with fishmeal and other protein crops in the animal feeds sector. The possibility of substituting in consumption one product for another has been increasing over time with the evolution of technology. The practical implication is that market forces ensure that prices of the different oils tend to move in unison, and so do the prices of the different oilmeals.[31] At the same time, the prices of the joint products of any particular oilseed (e.g. of soybean oil and meal) may follow diverging paths.

3.64 Oils and fats are a high-income elasticity food commodity in the developing countries. Their per caput consumption of vegetable oils (including both oil proper and the oil equivalent of oilcrop products consumed as food in forms other than oil, e.g. groundnuts as pulses) is around 8 kg, compared with some 16 kg in the developed countries. There is, therefore, considerable scope for further expansion in consumption, though future growth can be expected to be slower than that of the last twenty years when the developing countries had started from very low levels. The relevant projections are shown in Table 3.12.

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31 See World Bank, *Price Prospects for Major Primary Commodities 1990-2005*, 1993.

3.65 The demand of the developing countries for oilseed proteins, the joint product of oilcrops, is expected to grow faster than that for vegetable oils, reflecting the rapid growth of the livestock sector, as discussed earlier. This will be a continuation and accentuation of the past pattern of the differentials in the two growth rates, as follows (percent p.a.):

	1970-90	1988/90-2010
Vegetable Oils	5.3	3.4
Oilseed Proteins	6.0	5.0

3.66 As discussed in the section on livestock, these developments are likely to lead to a situation whereby the developing countries will continue to be large and growing net exporters of vegetable oils (oils plus the oil equivalent of net oilseed exports) but their net surplus of oilseed proteins (from oilmeals and oilmeal equivalent of oilseeds) would decline. Latin America would continue to be a large net exporter, but the growth in the net deficits of East Asia and Near East/North Africa will lead to shrinking net exports of oilseed proteins from the developing countries as a whole. This possible outcome reflects also the prospect that palm oil (whose production generates little oilmeal in the form of the palm kernel cake) is likely to continue to expand its share in total oilcrop production in the developing countries.

3.67 The further structural change in the oilseeds sector of the developing countries that may occur in the future is depicted in Table 3.13. The past trend for the share of soybeans to increase rapidly could come to a halt, though total production would still more than double, down from a 12-fold increase during the last 20 years when it had started from a very low base and expanded rapidly in South America. The coconut sector will probably see little growth (1.3 percent p.a.) and this is probably too optimistic. This reflects, among other things, the increasing competition from palm kernel oil in the lauric oils market. Most other oilseeds could maintain their shares at present levels, after the decline they had suffered in the past under the impact of the rapid expansion of the palm oil and soybeans sectors.

Table 3.12 Vegetable Oils: Summary Data and Projections, 93 Developing Countries

(All oilcrops in oil equivalent)

	Demand			Production	Net Balance	Growth Rates (% p.a.)		
	Food		Total use			Period	Demand	Produc-tion
	Per caput	Total						
	(kg)	.... (million tons)						
93 Developing Countries								
1969/71	4.7	12.3	15.8	18.8	2.4			
1988/90	8.2	31.8	39.9	44.8	3.7	1970-90	5.3	4.8
2010	11.3	64.9	80.8	86.9	6.2	88/90-2010	3.4	3.2

Table 3.13 Production of Oilcrops: 92 Developing Countries (excluding China)

Thousand tons, oil equivalent

By Major Oilseed		By region						Share by Oilseed (%)
		Africa (Sub-Saharan)	Near East/ North Africa	East Asia (excl.China)	South Asia	Latin America + Caribbean	Total	
Palm oil +	1969/71	1 487		745		270	2 502	16
Palmkernel oil	1988/90	1 951		8 990	2	806	11 749	32
	2010	3 370		22 020	90	1 640	27 120	38
Soybeans	1969/71	16	3	179	4	372	574	4
	1988/90	46	66	470	318	5 959	6 859	19
	2010	120	200	740	510	12 790	14 350	20
Groundnuts	1969/71	1 562	33	251	1 889	401	4 136	27
	1988/90	1 377	51	467	2 729	228	4 852	13
	2010	2 120	100	1 090	5 170	580	9 050	13
Sunflower	1969/71	12	173		17	425	627	4
	1988/90	58	499		270	1 441	2 268	6
	2010	130	1 020		450	2 070	3 670	5
Sesame	1969/71	235	47	23	265	155	725	5
	1988/90	207	57	40	404	82	790	2
	2010	320	100	100	840	220	1 580	2
Coconuts	1969/71	138		1 806	920	250	3 114	20
	1988/90	207		2 985	1 292	335	4 820	13
	2010	410		3 350	1 900	480	6 140	9
Cottonseed	1969/71	225	385	9	497	440	1 556	10
	1988/90	273	369	22	1 016	470	2 150	6
	2010	560	700	35	2 320	580	4 200	6
Other	1969/71	192	341	45	992	641	2 211	14
	1988/90	226	549	79	2 105	450	3 409	9
	2010	280	880	110	3 640	960	5 870	8
Total	1969/71	3 867	982	3 058	4 584	2 954	15 445	100
	1988/90	4 345	1 591	13 053	8 023	9 771	36 900	100
	2010	7 310	3 000	27 440	14 920	19 320	72 000	100
Share by	1969/71	25	6	20	30	19	100	
regions (%)	1988/90	12	4	35	22	26	100	
	2010	10	4	38	21	27	100	

5.6 Major Agricultural Exportables of the Developing Countries, in Brief

5.6.1 Sugar

3.68 Sugar consumption in the developing countries as a whole is still well below that of the developed countries, 18 kg and 37 kg respectively.[32] In the former, the highest levels are in Latin America/Caribbean and Near East/N. Africa (43 kg and 29 kg, respectively) and the lowest in sub-Saharan Africa and East Asia (8-9 kg). In this latter region, particularly in China, alternative sweeteners account for a good share of total sweetener consumption. It is foreseen that per caput sugar consumption in the developing countries would grow by about 1 kg per decade to reach some 20 kg by year 2010, but with the above-indicated wide regional differentials being maintained, though somewhat less pronounced than at present. Overall there would be a slowdown in the growth rate of food consumption of sugar in the developing countries compared with the past (2.5 percent p.a. for 1988/90-2010, compared with 4.1 percent p.a. in the 1970s and 2.8 percent p.a. in the 1980s).

3.69 Sugar is a major export commodity of many developing countries. As a whole, the developing countries are large but declining net exporters. Part of the overall decline in their aggregate net exports has been due to the support and protection policies of most major developed countries,[33] and part is due to the emergence of many developing countries as growing net importers. The two developments are not, of course, independent from each other. The lower world market prices resulting from the access restrictions to the import markets of major OECD net importers, including the emergence of the EC as one of the largest net exporters, have probably contributed to the growth of imports into the developing countries. These developments can be appreciated from the data in Table 3.14.

3.70 It is expected that there will be continued strong growth of import requirements of the importing developing countries while the OECD area as a whole would continue to be a net exporter, unless policies were to change radically.[34] Developments in the former

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32 The OECD developed countries as a whole have gone through a phase of declining per caput consumption. Both health reasons and policies of high sugar prices in many countries have contributed to shift demand to alternative sweeteners, e.g. HFCS in the USA and non-caloric sweeteners in most countries. It is expected that the phase of declining per caput consumption is coming to an end and per caput consumption in the developed countries as a whole would tend to stabilize at about present levels of 37 kg.

33 For a succinct description and analysis, see Borrell, B. and R. Duncan, "A Survey of Costs of World Sugar Policies", *World Bank Research Observer*, July 1992.

34 The prospects for the sugar sector discussed here are mainly based on work by FAO and the International Sugar Organization and assume no major Uruguay Round-type policy changes (FAO, "The World Sugar Market: Prospects for the Nineties", document ESC/M/92/3). If there is significant reduction in support and protection of the sugar sector in major OECD countries, it can be expected that increased sugar production and exports from the low-cost producers (developing countries, but also Australia and South Africa) will tend to substitute for some of the production in the highly protected markets. If reforms changed preferential market access arrangements (e.g. under the EC's ACP sugar protocol or the USA's Caribbean Basin Initiative), some of the benefiting countries would be adversely affected (see, Borrell and Duncan, *op. cit.*, and Lord R. and R. Barry, *The World Sugar Market, Government Intervention and Multilateral Policy Reform*, USDA, 1990).

Table 3.14 Sugar: Net Trade Positions, 5-year averages

(million tons, raw sugar equivalent)

	1967/71	1977/81	1987/91
Developing Countries	9.3	8.5	3.7
Net Exporters (in 87/91)	12.1	17.0	15.3
- Cuba	5.5	6.7	6.8
- Brazil	1.1	2.4	1.7
- Thailand	0.1	1.1	2.5
- Mauritius	0.6	0.6	0.6
- Dominican Rep.	0.7	0.9	0.4
- Others	4.1	5.3	3.3
Net Importers (in 87/91)	-2.8	-8.5	-11.6
- China	-0.2	-1.0	-1.4
- Algeria	-0.2	-0.5	-0.9
- Egypt		-0.4	-0.7
- Iran	-0.1	-0.6	-0.6
- Iraq	-0.3	-0.5	-0.5
- Korea, Rep.	-0.2	-0.4	-0.8
- Malaysia	-0.3	-0.4	-0.6
- Others	-1.5	-4.7	-6.1
Developed Countries	-9.1	-7.6	-2.8
- EC-12	-2.3	1.7	3.1
- Other W. Europe	-0.8	-0.4	-0.3
- E. Europe + Former USSR	-0.6	-4.7	-4.2
- USA	-4.5	-4.0	-1.1
- Canada	-0.9	-0.9	-0.8
- Japan	-2.0	-2.3	-1.8
- Australia	1.7	2.3	2.7
- Others	0.3	0.7	-0.4

CPEs of Europe will play a role in limiting the growth of their aggregate consumption and import demand. Their per caput consumption may decline for some time before it recovers. It is likely that in the future more of their consumption will be supplied from domestic production. This means that although the exporting developing countries could expand further their exports, the developing countries as a whole would probably see their net exports to the developed countries decline further from the present level.

3.71 The sugar sector provides one example of the increasing role of the developing countries in world commodity markets formerly dominated by the developed countries on the import demand side. If this is considered by some to contain positive elements, it is being brought about for the wrong reasons, e.g. protectionism in these latter markets and to some extent the supply constraints of some developing countries which can ill afford sugar imports, e.g. some countries in sub-Saharan Africa. But it does contain positive elements to the extent that the growth of the import requirements of the developing countries reflects the improvements in incomes, increased consumption of sugar and comparative advantage of the exporting versus the importing countries.

3.72 Concerning production of sugarcane and beet in the developing countries, the growth rate (in raw sugar equivalent) is likely to be well below that of the past, perhaps 2.2 percent p.a. to 2010 compared with 3.5 percent p.a. in the last 20 years. This reflects partly the slowdown in the growth of their own consumption of sugar and the likely continued decline in net exports to the developed countries. But it also reflects the fact that the high production growth rates of the past were related to the sizeable production increases of sugar cane for ethanol production in the world's largest sugar cane producer, Brazil.[35] Such use is unlikely to continue to grow at anything like the past rate when it had started from nearly zero base. No further significant growth or some decline is a more probable outcome.

5.6.2 Tropical Beverages (Coffee, Cocoa, Tea)

3.73 Of these three major export commodities of the developing countries, coffee and cocoa share with some other commodities (e.g. rubber) the characteristic that they are produced exclusively in the developing countries and consumed mainly in the developed countries. The latter account for 71 percent of world consumption of coffee (the same as 20 years ago) and 83 percent of that of cocoa (87 percent in 1969/71). The case of tea is different as the developing countries account for 70 percent of world consumption. Moreover, the developing countries have increased significantly their share in world consumption of tea, but there has been only modest movement in this direction for cocoa and none for coffee.

3.74 It follows that for coffee and cocoa the production and export prospects will continue to be determined for a long time by developments in the consumption of the developed countries. The prospects are that there will be only modest further growth in per caput consumption in the main developed country markets for coffee and cocoa and, with the exception of the former CPEs, none for tea (Table 3.15). In parallel the protracted recession and foreign exchange shortages in Eastern Europe and the former USSR are unlikely to permit growth in their per caput consumption, notwithstanding their generally very low levels and considerable scope for increases. Under the circumstances the growth of production and exports of the developing countries are likely to be very slow. However, things may turn out otherwise if the reforms were to lead to a sizeable part of the population moving towards consumption patterns more closely resembling those of Western Europe. Therefore, the consumption projections for these countries may be on the pessimistic side, though the recovery from the recent declines may be slow and protracted.

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35 Currently only about one-third of Brazil's sugar cane output is used for sugar production. See discussion in Borrell, B. and R. Duncan, *op. cit.*, and Buzzanell, P., *Latin America's Big Three Sugar Producers in Transition: Cuba, Mexico, Brazil*, USDA, 1993.

Table 3.15 Tropical Beverages and Bananas

	Per Caput Consumption (kg)				Net Trade (th. tons)			
	Coffee	Cocoa	Tea 1/	Bananas	Coffee	Cocoa	Tea 1/	Bananas
Developed Countries								
E. Europe and Former USSR								
1969/71	0.3	0.5	0.3	0.2	-120	-180	-33	-64
1988/90	0.6	0.7	0.9	0.4	-233	-260	-230	-165
2010	0.6	0.7	1.1	0.7	-270	-280	-290	-330
Others								
1969/71	4.0	1.4	0.7	7.0	-2 940	-1 040	-415	-4 940
1988/90	4.6	1.9	0.6	8.7	-3 910	-1 610	-390	-7 140
2010	5.3	2.5	0.6	10.8	-4 980	-2 330	-490	-9 600
Developing Countries								
1969/71	0.5	0.1	0.3	7.2	3 185	1 210	460	5 300
1988/90	0.4	0.1	0.5	7.3	4 240	2 100	670	7 500
2010	0.5	0.1	0.7	9.0	5 250	2 610	800	10 000
	Growth Rate of Demand % p.a.				Growth Rate of Production % p.a.			
Developing Countries								
1970-90	1.8	4.7	4.6	2.3	2.2	2.7	3.7	2.1
1988/90- 2010	2.6	2.5	3.3	2.7	1.6	1.4	2.8	2.5
Developed Countries								
1970-90	1.6	2.0	1.6	1.5			2.4	1.8
1988/90-2010	1.1	1.7	1.1	1.5			0.8	1.6

1/ Including mate.

3.75 The preceding discussion indicates that the growth of production and exports of the developing countries in these commodities is likely to be slow and below that of the past 20 years. It is noted, however, that producing and exporting more of them, particularly coffee and cocoa, would not lead to commensurate gains in export earnings and welfare if prices were to continue falling. Indeed, the experience of the recent years has amply demonstrated that falls in prices led to disastrous declines in the real value of export earnings (see Figures 3.1, 3.2). There have been periods when exporting more did not bring benefits to the producing exporting countries as a whole, though individual countries did benefit at a cost to others. Competition among exporting countries turned out to be a negative sum game for them.

Figure 3.1: Coffee - Net Trade Positions and Real Export Earnings, 1961-1991

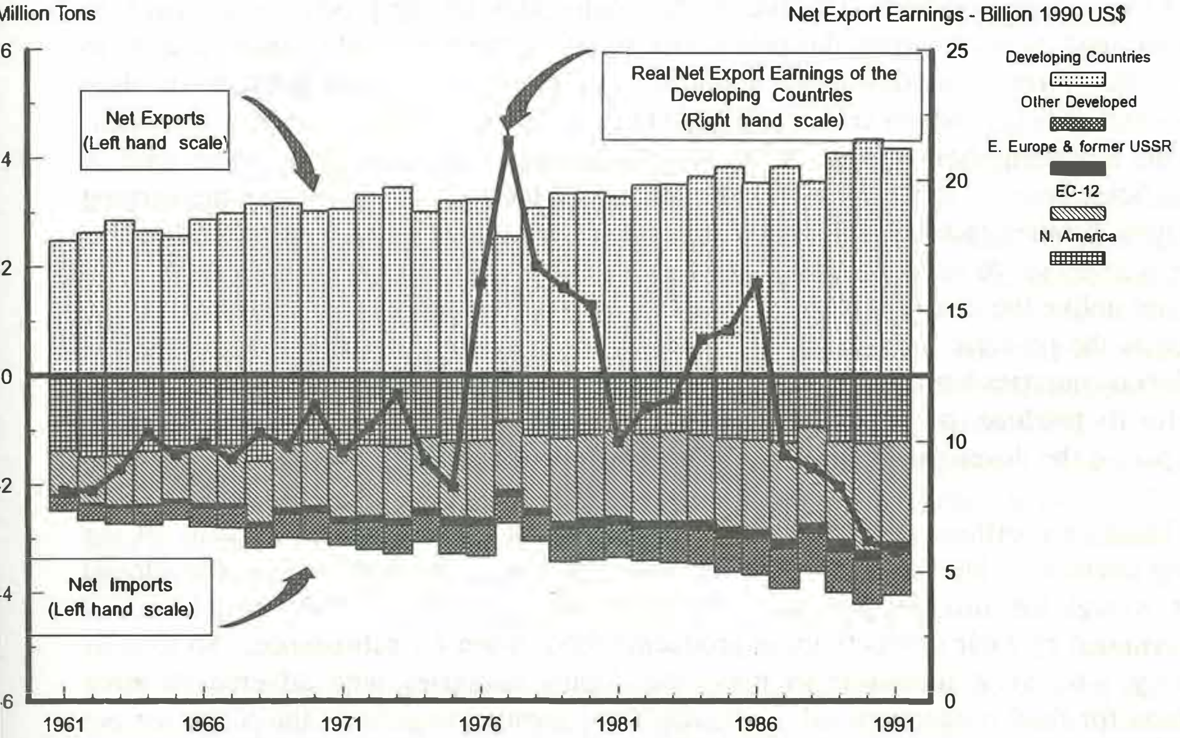
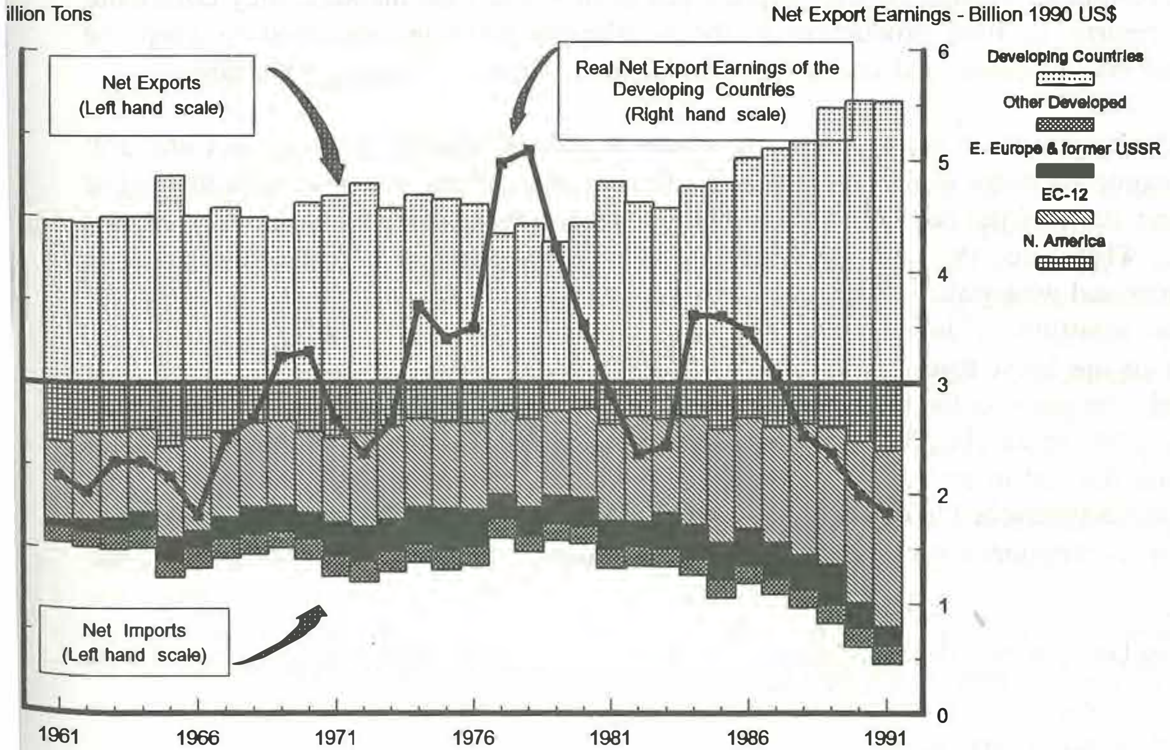


Figure 3.2: Cocoa - Net Trade Positions and Real Export Earnings, 1961-1991



ote: Real Net Export Earnings: Value of Net Exports of developing countries at current prices deflated by the unit
lue index of G-5 exports of manufactures to the developing countries.

Table 3.15 Tropical Beverages and Bananas

	Per Caput Consumption (kg)				Net Trade (th. tons)			
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1988/90	0.6	0.7	0.9	0.4	-233	-260	-230	-165
2010	0.6	0.7	1.1	0.7	-270	-280	-290	-330
Others								
1969/71	4.0	1.4	0.7	7.0	-2 940	-1 040	-415	-4 940
1988/90	4.6	1.9	0.6	8.7	-3 910	-1 610	-390	-7 140
2010	5.3	2.5	0.6	10.8	-4 980	-2 330	-490	-9 600
Developing Countries								
1969/71	0.5	0.1	0.3	7.2	3 185	1 210	460	5 300
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	Growth Rate of Demand % p.a.				Growth Rate of Production % p.a.			
Developing Countries								
1970-90	1.8	4.7	4.6	2.3	2.2	2.7	3.7	2.1
1988/90- 2010	2.6	2.5	3.3	2.7	1.6	1.4	2.8	2.5
Developed Countries								
1970-90	1.6	2.0	1.6	1.5			2.4	1.8
1988/90-2010	1.1	1.7	1.1	1.5			0.8	1.6

1/ Including mate.

3.75 The preceding discussion indicates that the growth of production and exports of the developing countries in these commodities is likely to be slow and below that of the past 20 years. It is noted, however, that producing and exporting more of them, particularly coffee and cocoa, would not lead to commensurate gains in export earnings and welfare if prices were to continue falling. Indeed, the experience of the recent years has amply demonstrated that falls in prices led to disastrous declines in the real value of export earnings (see Figures 3.1, 3.2). There have been periods when exporting more did not bring benefits to the producing exporting countries as a whole, though individual countries did benefit at a cost to others. Competition among exporting countries turned out to be a negative sum game for them.

Figure 3.1: Coffee - Net Trade Positions and Real Export Earnings, 1961-1991

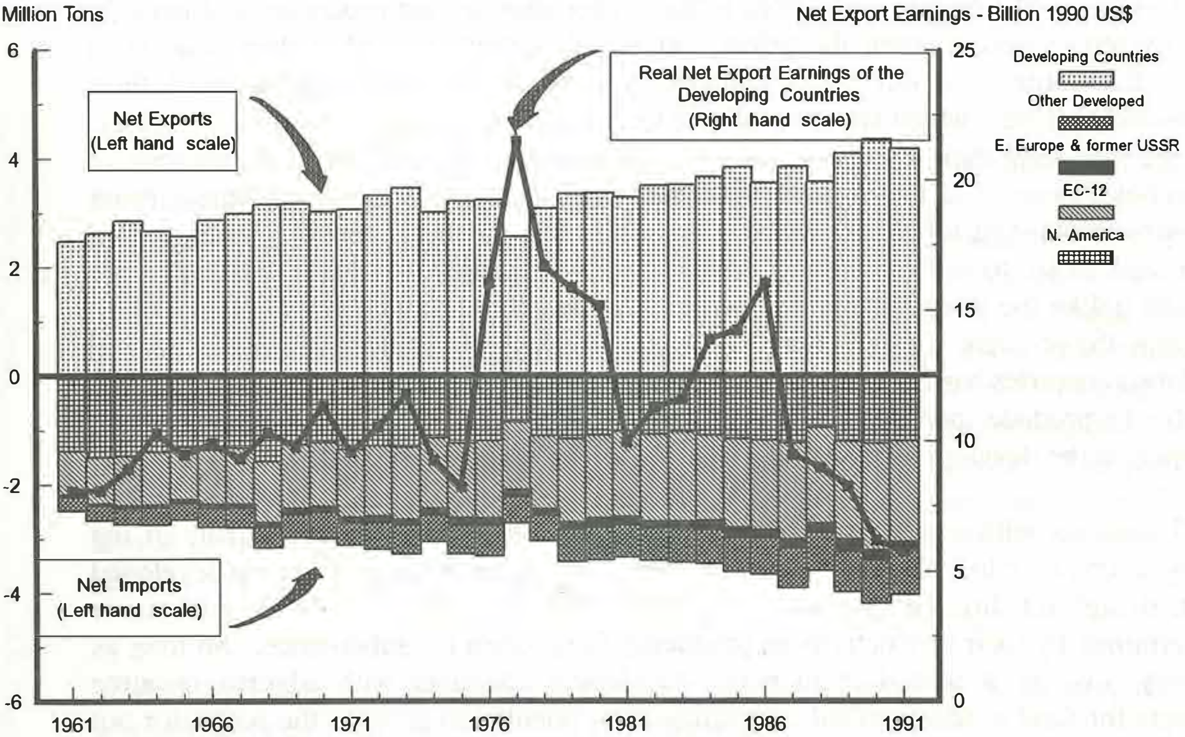
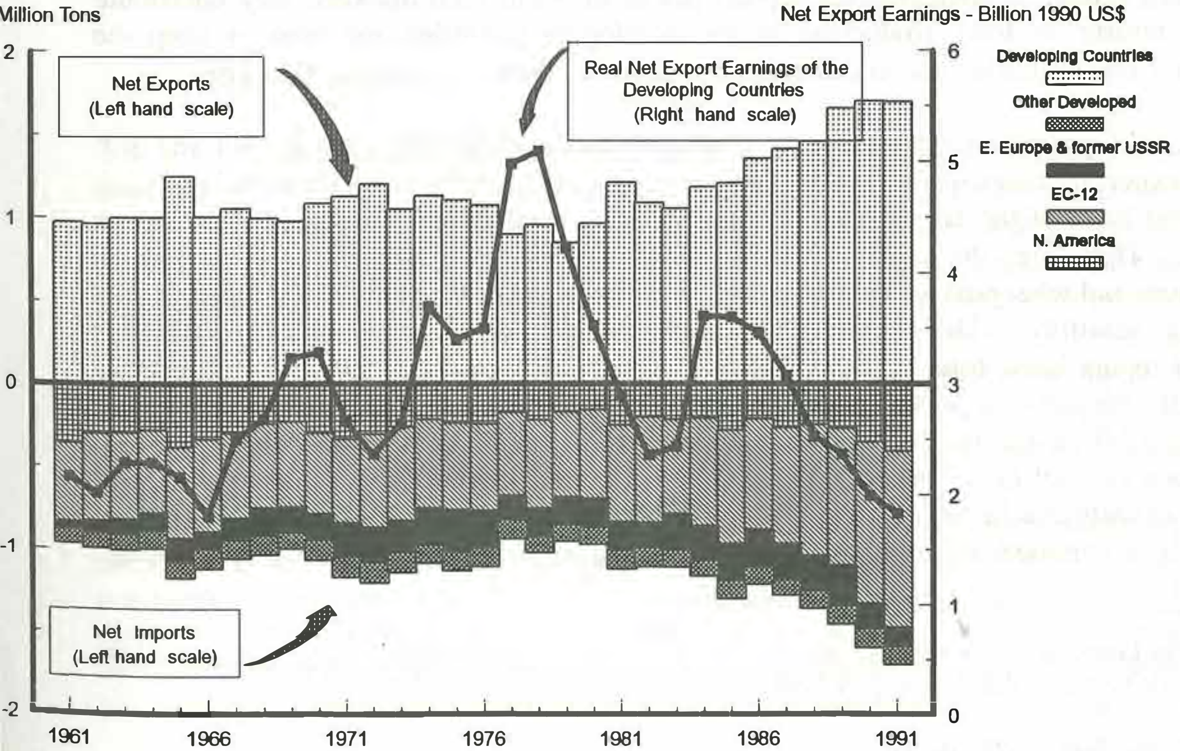


Figure 3.2: Cocoa - Net Trade Positions and Real Export Earnings, 1961-1991



Note: Real Net Export Earnings: Value of Net Exports of developing countries at current prices deflated by the unit value index of G-5 exports of manufactures to the developing countries.

3.76 In many ways the origins of the problems facing the producers and exporters of these commodities are not unlike those facing the farmers in the developed countries. Both sell the bulk of their output to markets with low price and income elasticities of demand and slow growth of overall consumption. This means that competition among producers and gains in productivity tend to drive down the prices and benefit consumers rather than raise farm incomes. But farmers in developed countries can benefit from two features of their economies and societies, which are not available to the producers in the developing countries. First, in the long-term their incomes cannot be suppressed too much even in the absence of support policies because of the high opportunity cost of their labour, given income-earning opportunities in other sectors; and second, the society and governments have the means to intervene, and do so, to support farm prices and ease the process of labour transfer to other sectors; and unlike the situation in many developing countries, the virtually zero population growth eases the pressure for agriculture to provide more jobs. In addition, agriculture in the developed countries has been aided heavily to seek outlets in the more price elastic export markets for its produce, precisely those of the developing countries. Again, this is not an avenue open to the developing countries, at least not for these products.

3.77 Things are different for the farmers producing these commodities in many of the developing countries which depend on the very same markets as the farmers in the developed countries, though for different products. For them, the opportunity cost of their labour is often determined by their productivity in producing food, often for subsistence. So long as this is very low, as it indeed is in many developing countries with adverse resource endowments for food production and continuing rural population growth, the scope for not profiting from increased export crop productivity and production remains limited.[36] And, of course, the scope for government intervention to support incomes is also very limited, no matter that some developing countries have attempted to do so at heavy cost to their macro-economic equilibria. To some extent, the above considerations can be seen as establishing an indirect link between agricultural policies in developed countries and the vicissitudes of these commodities. If such policies depress prices in world food markets, they contribute to lower returns to food production in the developing countries and tend to keep the opportunity cost of coffee and cocoa farm labour lower than it would be otherwise.

3.78 Developments in export volumes and earnings are depicted in Figures 3.1 and 3.2. The real export earnings of the developing countries from coffee and cocoa were in 1991 at their lowest level of the last 30 years notwithstanding significant increases in the volumes exported. Therefore, the key question is what may happen to the real prices of these commodities and what policies can be put in place to halt and reverse price declines and deal with price volatility. These issues are discussed in Chapter 8. Here it is noted that according to the latest forecasts of the World Bank,[37] real coffee prices could be in year 2005 nearly the same as the three-year average 1989/91, though higher than those recorded in the post-1991 years. For cocoa the price prospects are only slightly better while tea prices may remain flat, all in real terms. Price projections are, of course, to be interpreted with the many caveats attached to them. But they do indicate the likelihood that the price declines that hit these commodities may not be reversed. Indeed, year 2005 real prices could be,

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36 See Lewis, W.A., "Developed and Developing Countries", in Rosenblum, J. (ed), *Agriculture in the 21st Century*, Wiley, New York, 1983.

37 World Bank (1993), *op. cit.*

according to these projections, still well below those prevailing as recently as in the 1986/88 three-year average, e.g. about 45-55 percent below for coffee and cocoa. It is noted that 1986/88 prices were already lower than those of earlier years.

5.6.3 Bananas

3.79 The developing countries produced some 45 million tons of bananas in 1988/90 and their net exports to the developed countries were 7.5 million tons. The bulk of production and exports is in the Latin America/Caribbean region which accounts for 80-85 percent of all exports. There is still scope for growth in consumption in the developed countries, in particular the ex-CPEs where consumption levels are under 0.5 kg compared with nearly 9.0 kg in the other developed countries. Only a small part of this growth potential may materialize and imports into the ex-CPEs may only double. The developing countries' exports will continue to depend almost entirely on the growth of consumption in the other developed countries which account for 90 percent of world imports. The prospects for further growth in their consumption are fair and their net imports may grow from 7.1 million tons at present to 9.6 million tons by the year 2010, a growth rate of 1.5 percent p.a., the same as that of the last 20 years.

3.80 Per caput consumption should also continue to grow in the developing countries themselves, particularly in the fast growing region of East Asia. It is likely that the importing developing countries will increase their imports at a high rate and their share in world imports may more than double from the present level of about 7 percent. This notwithstanding, the high dependence of the developing exporting countries on the import markets of the western developed countries and on policies affecting such imports will remain overwhelming.

5.6.4 Cotton

3.81 Trading patterns in the major non-food agricultural commodities have been undergoing significant changes. These have been due to the diverging trends in consumption of the developed and the developing countries, as well as to changes in the trade of manufactures based on these commodities. Developments in the cotton sector illustrate this process of structural change. The developed countries used to be by far the major importers of cotton 20 years ago with a share of 75 percent of world gross imports and net imports from the developing countries of 1.6 million tons. But their mill consumption remained virtually static (about 6.5 million tons) while their production of cotton continued to increase. The result has been that in recent years they turned into small net exporters.

3.82 In parallel, mill consumption in the developing countries grew fairly rapidly (3.5 percent p.a. in 1970-90). Their production of raw cotton grew at a slower rate (2.4 percent p.a.) and their sizeable net exports of raw cotton turned into small net imports. The above discussion refers to production, mill consumption and trade of raw cotton. The underlying developments in the final consumption and trade of cotton manufactures have been different and have been instrumental in causing the diverging trends in mill consumption and trade of

the raw material.[38] Part of the trends in raw cotton reflect the rapid expansion of exports of cotton manufactures from the developing to the developed countries following the migration of the textiles industry from the latter to the former. This process would have been even more pronounced but for the restrictions in the trade of textiles.

3.83 The above-described trends would continue, with world production and consumption of cotton growing at about 2.5 percent p.a., to some 31 million tons by the year 2010. Although production would continue to rise also in the developed countries and they would still process about 8 million tons, mill consumption will be increasingly concentrated in the developing countries, doubling to some 23 million tons by the year 2010. The end-result would be that the developing countries would produce some 20 million tons but nonetheless would turn into major net importers of raw cotton of about 2.5 million tons (and growing exporters of cotton goods). Cotton thus provides an example of transformation of world industrial and trading relationships largely along the lines dictated by comparative advantage.[39] To an increasing extent raw materials from the developed (and developing) countries are being combined with low-cost labour from the developing countries to generate industrial development in the latter and cheaper labour-intensive manufactures everywhere.

5.6.5 Natural Rubber

3.84 Natural rubber, produced exclusively in the developing countries, may be following a similar footpath as cotton. However, for natural rubber the pace of change is likely to be much slower. The main underpinning factor for rubber would be somewhat different, namely the rapid consumption growth of rubber manufactures in the developing countries.

3.85 The share of natural rubber in world consumption of all rubber (natural and synthetic) had fallen to an all-time low of about 30 percent in 1980, but has since recovered to 36 percent, mostly due to the spread in the use of radial tyres and faster consumption growth in developing countries. This trend is expected to continue, and world consumption of natural rubber may grow at 2.6 percent p.a. over the time horizon of the Study, nearly the same growth rate as in the last 20 years. By the year 2010 the developing countries (mainly in Asia) may have overtaken the developed countries as the major industrial consumer of natural rubber, with their share rising to 55 percent of world consumption, up from 43 percent in 1988/90 and 24 percent 20 years ago. These developments will essentially reflect the faster growth of the automobile industry and use in the developing compared with the developed countries (tyre production accounts for some 50 percent of world natural rubber use.)

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38 For most commodities in this Study, the consumption and trade data of processed products were converted into primary product equivalent in order to establish the link between agricultural production and final consumption and trade of each commodity in both primary and processed form. Unfortunately, the complexity of the data referring to consumption and trade in textiles (e.g. the fact that cotton is used in widely differing mixes with other fibres, both natural and synthetic) has precluded a similar conversion of the data. Therefore, the only valid statement for final consumption (= production) of cotton can only refer to world level totals, as follows: 1980-90: 2.5% p.a., projected 1988/90-2010: 2.6 % p.a.

39 See Anderson, K. (ed). *New Silk Roads, East Asia and World Textile Markets*, Cambridge U.P., 1992.

3.86 Unlike cotton, however, the developing countries will remain growing net exporters, as they are the only producers in the world and the consumption (and net imports) of the developed countries would continue to grow at about 1.3 percent p.a. (against 3.8 percent p.a. in the developing countries). World production of natural rubber may continue to grow at the average rate of the past 20 years (2.5 percent p.a.). Production in East Asia will continue to dominate world production, but its share in the projected world output of 8.6 million tons may decline from 84 percent at present to 77 percent in 2010. This would reflect the increasing scarcity of labour in Malaysia and of land in both Malaysia and Thailand. Faster expansion in Indonesia will turn the country into the largest world producer and help keep East Asia's share from declining substantially. These developments may give sub-Saharan Africa one of the few opportunities to expand its share in world exports of a major agricultural commodity, from the present 7 percent to about double that by the year 2010. Rubber production in the main African producing countries (Cameroon, Côte d'Ivoire, Nigeria and Liberia) may increase threefold, the fastest growing single agricultural product of the region.

5.6.6 Tobacco

3.87 Consumption of tobacco in the developed countries has been declining, both total and per caput, with the latter having fallen particularly in the 1980s, from 2.0 kg in 1979/81 to 1.5 kg at present. It may fall further to nearer 1 kg by year 2010. By contrast, the developing countries have been increasing their tobacco consumption relatively rapidly, with per caput consumption having reached 1.1 kg and perhaps growing to 1.4 kg by the year 2010. Growth has been fastest in East Asia. It is ironic that tobacco is the one consumption item in which the developing countries are catching up fast with the developed ones and are slated to surpass them in the future. Apparently, things must get worse (on the consumption and health side) before they can get better. There is perhaps a parallel here with the process of environmental degradation (noted in Chapter 2) which seems to accelerate in some cases at the early stages of development and people endeavour, and can afford, to adopt policies to halt or reverse it only when development has advanced well beyond these early stages.

3.88 The end result of these prospective developments is that in developed countries both consumption and production of tobacco would probably continue to decline by about 1.0 percent p.a. and their net imports from the developing countries could remain constant at just over 200 thousand tons (they were 440 thousand tons ten years ago). World consumption will be increasingly shifting to the developing counties. They may account for about 80 percent of the world consumption in the year 2010, compared with 70 percent now and only 55 percent ten years ago. This implies a growth rate in their consumption of 2.3 percent p.a. (lower than in the past) and, given likely stagnant net exports to the developed countries, a growth rate of 1.9 percent p.a. for their production (also lower than in the past).

5.7 Conclusions

3.89 The preceding review of possible developments by major commodity sector has endeavoured to document the extent to which the diverging trends for each of them are likely to shape the future for total food and agriculture. Perhaps the major conclusion is that the developing countries are likely to change from their traditional position of net exporters of

agricultural (crop and livestock) products into net importers. This issue is discussed in the final section of this chapter, after a brief review of likely developments in the major commodity sectors of the developed countries.

6. THE DEVELOPED COUNTRIES: PROSPECTIVE DEVELOPMENTS IN BRIEF

6.1 General Considerations

3.90 The demographic and overall economic growth prospects of the developed countries, as well as those for aggregate food and agriculture were presented in sections 2 to 4 of this chapter. Possible developments for some commodities were also presented in connection with the discussion of the prospects for the major export commodities of the developing countries. What remains to be reviewed here are the prospects in developed countries for their other major commodity sectors. Cereals and livestock products account for 75 percent of their gross agricultural production, in value terms. Prospective developments in these two sectors are reviewed briefly in the rest of this section.[40]

3.91 It is noted that some of the forces that shaped the historical evolution of food and agriculture in most developed countries are likely to persist, e.g. slow growth in domestic consumption and trends towards higher productivity. But there are also major changes under way, or in prospect, which are likely to change the policy environment and affect the individual country groups in very different ways.

3.92 These changes have to do with the prospect that in the future there will be much less scope for trade-distorting policies or other interventions to determine the production, consumption and trade outcomes in food and agriculture. Such outcomes will be determined increasingly by market forces or, at least, by less trade-distorting policies. The first impetus in this direction comes from the systemic reforms under way in the ex-CPEs of Europe; and the second from the policy reforms in major western countries, particularly in Europe (see Chapter 8). Additional impetus and consolidation of these reforms will be provided by the eventual conclusion of the Uruguay Round of Multilateral Trade Negotiations. It is noted, however, that the reforms currently under way, if fully implemented, would probably generate results for the major temperate zone commodities in the direction of those that would be generated from the eventual application of the provisions of the agricultural part of Draft Final Act that has been proposed for concluding the agricultural part of the Uruguay Round. These questions are discussed further in Chapter 8, where it is noted that the findings of analytical work attempting to predict the impact of the reforms are subject to many uncertainties.

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40 The quantifications and policy discussion concerning the prospects for the cereals and livestock sectors draw partly on work of outside institutes specializing in policy analysis and long-term agricultural projections for the developed countries. Senior researchers in these Institutes cooperated by extending their analyses and medium-term (10-year) projections to year 2010 (Frohberg, K., "The Trade Potential of the Industrialized Countries over the Next Two Decades: Western and Eastern Europe and Japan", Institut für Agrarpolitik, Universität Bonn, 1993; Meyers, W., "Trade Outlook for North America and Oceania to 2010", and Johnson, S., "Former Soviet Union", both of the Centre for Agriculture and Rural Development, Iowa State University, USA, 1993. All in mimeo).

6.2 The Cereals Sector in the Developed Countries

3.93 The possible developments to year 2010 are summarized in Table 3.16 and interfaced with those for the developing countries. Total cereals production in the developed countries may grow by some 180 million tons, a 21 percent increase (or 0.9 percent p.a.) over the 850 million tons of 1988/90. This is a lower rate of growth than the average achieved in the last 20 years (1.5 percent p.a.). However, it is noted that most of the past increase had occurred in the 1970s and the growth rate had fallen to 0.8 percent p.a. in the 1980s. Thus, the trends established in the more recent past may prevail in the next 20 years, but with significant differences among the major groups of countries. In particular North America is likely to see a reversal from the trend for its share in the total production of the developed countries to decline (it was 42.5 percent in 1979/81 and had declined to 37 percent in 1988/90; it may be back to over 40 percent in 2010). In contrast, Western Europe's total cereals production in year 2010 may be no more than 7 percent above the 1988/90 levels (probably after a decline in the initial years of the EC policy reforms), compared with an increase of 43 percent between 1969/71 and 1988/90. The past experience of the region reflected the high support prices which resulted in a rapid process of import substitution and subsequent expansion of largely subsidized exports. The scope for further expansion along this path is virtually nil. In practice, additional output in Western Europe may be limited to somewhat less than the increase in the region's domestic demand, as net exports may fall a little. The region's domestic use of cereals may grow in the future, all of it for feed, compared with the decline experienced in the 1980s, because cereals would become more competitive with cereal substitutes, if the reforms under way were to be fully implemented.

3.94 One of the major forces that might shape the future is the possibility that total domestic use of cereals in the ex-CPEs of Europe may be somewhat below that of the pre-reform three-year average 1988/90, for a number of reasons: slightly lower per caput direct food consumption due to higher relative prices of cereals compared with the pre-reform period and diversification of diets; a slight decline in the per caput consumption of livestock products and only little growth in livestock production; more efficient use and overall decline in the cereals for feed use in the livestock sector (Table 3.17); and lower rates of post-harvest losses. These developments in the total use of cereals in the ex-CPEs of Europe, in combination with recovery and resumption of modest growth in their production, are likely to have profound implications for world food markets. Eastern Europe will most likely be a progressively growing net exporter of cereals, and the former USSR will probably be a much smaller net importer and could progressively become 100 percent self-sufficient or even turn into a net exporter. Given the uncertainties concerning the possible developments in this group of countries, the working assumption used in this Study is that net export availabilities of Eastern Europe could be some 5 million tons while the net import requirements of the former USSR could be in the range from zero to 5 million tons. These assumed net trade outcomes for the ex-CPEs, together with those of the developing countries and the other Western countries (Japan, Israel, South Africa) define the scope for the growth of net cereal exports from the three major net exporting regions (Western Europe, North America, Oceania). Their combined net exports may grow from 158 million tons in 1988/90 to

Table 3.16 Total Cereals, Possible Developed Country Outcomes in a World Context (million tons, with rice milled)

	Main Net Exporting Regions				Other Western Countries	E. Europe + Former USSR			All Developed	All Developing	World
	W. Europe	N. America	Oceania	Sub-total		E. Europe	Form. USSR	Sub-total			
Production											
1969/71	143.6	243.3	14.6	401.5	21.2	55.1	168.9	224	647	482	1 129
1979/81	178.5	341.9	21.7	542.1	24.3	68.3	169.6	238	804	652	1 457
1988/90	206.4	313.5	22.9	542.8	22.8	80.5	204.0	285	850	847	1 698
2010				679-684[1]	31.0			313-318[1]	1 028	1 314	2 342
Total Domestic Use											
1969/71	166.3	191.6	6.3	364.2	35.5	58.0	169.2	227	627	498	1 125
1979/81	189.1	202.3	7.3	398.8	46.8	77.6	214.7	292	738	720	1 458
1988/90	182.6	227.3	8.6	418.5	52.0	81.3	238.8	320	791	931	1 721
2010				490.0	63.0			313	866	1 476	2 342
Net Trade											
1969/71	-23.8	49.6	9.0	34.8	-14.6	-3.0	5.4	2.4	22.5	-20.4	
1979/81	-11.4	129.4	14.7	132.6	-22.9	-9.2	-31.1	-40.3	69.4	-66.8	
1988/90	24.4	118.7	14.5	157.5	-28.6	-2.2	-34.2	-36.4	92.6	- 90.0	
2010				189-194[1]	-32.0			0 to +5.0[1]	162	-162[2]	

[1] Assuming year 2010 net imports of the former USSR zero or 5.0 million tons and net exports of Eastern Europe of 5.0 million tons.

[2] Net imports of all developing countries after deducting 30 million tons of net exports from the exporting developing from the net imports of the importing developing countries (see paragraph 3.24 footnote 19).

190-195 million tons by year 2010. It is noted that only about one-half of the growth of net-import requirements of the developing countries will appear as increasing the demand for net exports, the other half being cancelled by the assumed disappearance of the ex-CPEs as a major net importer.

3.95 There is uncertainty as to how the shares of the three exporting regions in the above-indicated increment in the net import requirements of the rest of the world may evolve. Most studies that have addressed this question suggest that the outcome will depend on the implementation of the reforms under way and their consolidation in the context of an eventual GATT accord. As noted, policy reforms point to the direction of an enhanced role for market forces and less scope for export subsidies. If fully implemented, the net result is likely to be a decline in the net cereal exports of W. Europe. Therefore, the above-mentioned increment in the combined net exports of the three country groups, and some more, will likely accrue to North America and Oceania.

6.3 Livestock Sector Prospects in the Developed Countries

3.96 There are two major factors that may influence outcomes in this sector. In the ex-CPEs of Europe, the reported per caput consumption of meat had reached levels which were not much below those encountered in other developed countries with much higher incomes. With the price reforms and falls in purchasing power, the per caput consumption is going through a process of decline which may not bottom out for some time. For the longer term, the somewhat optimistic assumption used here is that per caput consumption may just revert to near the reported pre-reform levels of about 70 kg, but with more poultry meat and less beef. It is an optimistic assumption because even by 2010 the per caput incomes of the region are likely to be well below those of other countries with meat consumption at that level.

3.97 For the other developed countries as a whole, the only likely significant change is that further growth in the per caput consumption of meat will come from the poultry sector, while per caput consumption of pork could stabilize after the rapid expansion of the past, which took place mainly in Western Europe. In parallel, per caput consumption of beef would probably remain constant on the whole, with the main shifts comprising expanded consumption in Japan and a reduction in Oceania.

3.98 For the milk and dairy sector the most likely outcome is that per caput consumption levels would not change much (all dairy products, in fresh whole milk equivalent). In parallel, there is some scope for further growth of net exports to the developing countries (see Table 3.8) with most of these additional exports supplied (in a net sense) by Eastern Europe and Oceania.

Table 3.17 Summary Livestock Sector Data and Projections, Developed Countries

	E. Europe + ex USSR			All Other Developed Countries			Total		
	69/71	88/90	2010	69/71	88/90	2010	69/71	88/90	2010
Food/caput (kg)									
Beef	20	27	24	28	28	28	26	27	27
Mutton	3	3	3	3	3	3	3	3	3
Pork	21	29	28	25	31	31	24	31	30
Poultry	5	12	15	12	23	32	10	19	27
Total	49	71	70	69	85	94	63	80	86
Milk	189	179	176	188	208	208	188	200	198
Feed use of Cereals									
(mill. tons)	115	189	172	271	294	355	386	482	527
Growth Rates % p.a.	1970-90	88/90-2010		1970-90	88/90-2010		1970-90	88/90-2010	
Feed use of Cereals	2.2	-0.4		0.7	0.9		1.2	0.4	
Livestock Production [1/]	2.1	0.3		1.7	0.8		1.8	0.7	

[1/] Growth rates computed as indicated in Table 3.9.

7. CONCLUSIONS ON POSSIBLE DEVELOPMENTS IN THE AGRICULTURAL TRADE BALANCE OF THE DEVELOPING COUNTRIES

3.99 Historical developments in the aggregate agricultural trade values of the developing countries are shown in Table 3.18. The quantity indices of total imports and exports indicate that between 1961/63 and 1988/90 imports in real terms increased by 284 percent and exports by only 146 percent. The net export balance in real terms was in 1988/90 less than one-third of its level 30 years ago. There was a reversal of these trends in the 1980s because of the abrupt slowdown in the growth of the agricultural imports in the crisis decade of the 1980s.

3.100 The projected developments in import requirements and export availabilities of the major crop and livestock products indicate that it may not be long before the developing countries as a whole turn from net agricultural exporters to net importers. This would happen if values of exports and imports of the individual commodities were to change *pari passu* with the changes in volumes discussed in the preceding sections. There is nothing in the price trends that would suggest that the average price of the commodities for which they are net exporters would rise faster, or to fall less, than that of the commodities for which they are and will remain net importers. As noted, there is no reason to expect an upward movement in the real prices of major tropical exportables. By contrast, real prices of cereals and dairy products, the main agricultural commodities imported by the developing countries, are not likely to fall and could well rise in the context of policy reforms towards more trade liberalization.

Table 3.18 Values of Agricultural Trade,* All Developing Countries, 1961/63 to 1988/90

	1961/63	1969/71	1979/81	1988/90
Current Prices ($ billion)				
Exports	13.8	18.7	69.8	87.5
Imports	7.2	10.7	66.0	82.5
Net Balance	6.6	8.0	3.8	5.0
Index of Volume (79/81=100)				
Exports	55.3	69.7	100	135.8
Imports	34.1	43.5	100	131.0
Implied Values at 88/90 Prices ($ billion)				
Exports	35.6	44.9	64.4	87.5
Imports	21.5	27.4	63.0	82.5
Net Balance	14.1	17.5	1.4	5.0

* All crop and livestock products, including both primary and most processed products, but not manufactures based on agricultural raw materials, e.g. textiles or leather goods.

3.101 Quantitative and qualitative elements pointing towards the likely turnaround of the developing countries from net agricultural exporters to net importers, are given in Table 3.19. The upper part of the table shows all the commodities with positive net balances in 1988/90, totalling $ 32 billion. The lower part does so for the commodities with negative net balances, summing up to $ 27 billion. The likely developments for the future indicate that the negative balances will grow much faster than the positive ones. These likely outcomes point firmly in the direction of the net agricultural trade balance of the developing countries (crop and livestock products) turning from positive to negative.

3.102 As noted in the earlier discussion, some of the increases in net imports of the developing countries, particularly of raw materials, are likely to be more than compensated by growth in the positive net balance of trade in manufactures based on these products. And part of the increased net imports of cereals and livestock products reflect developments in those developing countries which could finance them with export earnings from other sectors. However, these prospective developments are likely to be a heavy burden for those countries which must continue to finance growing net food imports from export earnings which are unlikely to be forthcoming at the required rate from other export sectors.

Table 3.19 Developing Countries, Probable Evolution of Net Agricultural Trade Balance

	1988/90			Likely changes in net balance, in real terms, 88/90-2010
	Exports	Imports	Net Balance	
	.... million $			
Coffee	8 110	566	7 544	+24%
Oilseeds, veg. oils, oilmeals	13 416	9 776	3 640	+50%
Sugar	7 636	4 392	3 244	decline
Rubber	4 382	1 458	2 924	+35%
Cocoa	2 871	660	2 211	+24%
Citrus	2 257	598	1 659	+10-20%
Bananas	2 091	164	1 927	+33%
Other fruit	4 086	2 097	1 989	+100-150%
Vegetables	3 676	1 920	1 756	+50-70%
Tea	2 163	1 108	1 055	+20%
Spices	1 150	580	570	increase, modest
Cassava/Other roots	1 424	525	899	-40%
Veg. Fibres, excl. cotton	208	117	91	zero or decline
Tobacco	3 696	3 688	8	perhaps zero
Other products (unspecified)	10 495	7 997	2 498	
Sub-total	67 661	35 646	32 015	
Cereals	5 977	21 939	-15 962	+80%
Dairy products	457	5 805	-5 348	+55%
Meat, eggs	6 025	7 162	-1 137	+100% or more
Animal fats	40	729	-689	increase
Hides+Skins, excl. leather prod.	745	2 292	-1 547	
Wool, excl. wool textiles	504	1 421	-917	increase, probably
Cotton, excl. cotton textiles	3 797	4 062	-265	large
Beverages (mostly alcoholic)	1 377	2 329	-952	
Pulses	926	1 120	-194	+100%
Sub-total	19 848	46 859	-27 011	
Grand Total	87 509	82 505	5 004	

ANNEX TO CHAPTER 3

Comparisons of the Projections of the AT2000/1987* Study with Actual Outcomes

Figure 3.A.1: World Production of Cereals

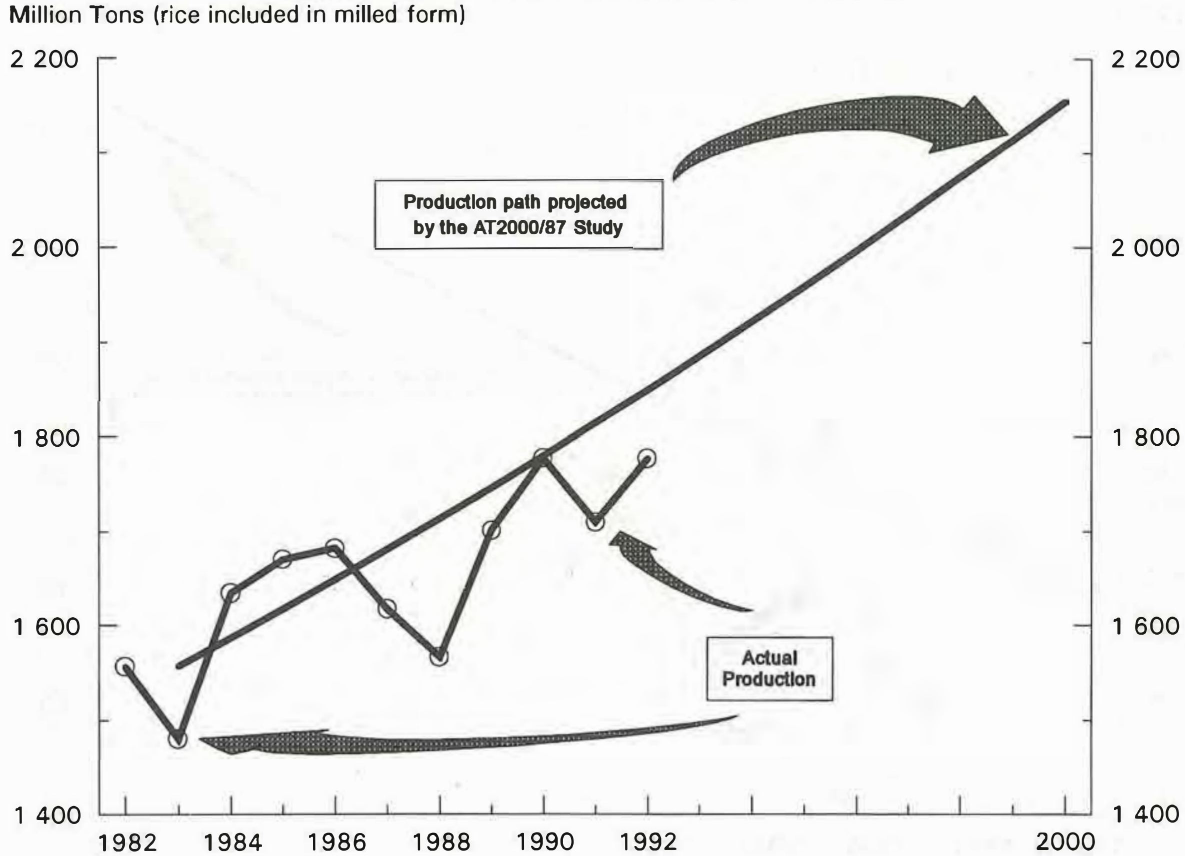
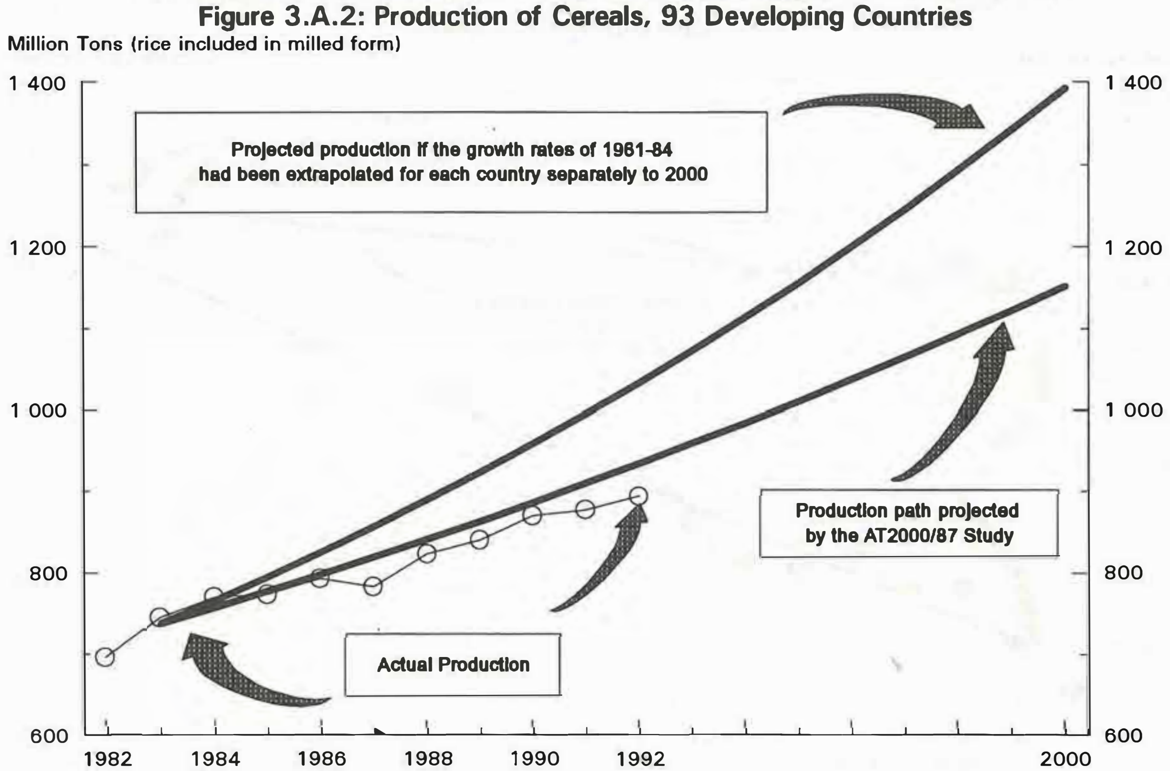


Figure 3.A.2: Production of Cereals, 93 Developing Countries



*The base year of the study was the 3-year average, 1982/84

ANNEX TO CHAPTER 3 (cont.)

Comparisons of the Projections of the AT2000/1987* Study with Actual Outcomes

Figure 3.A.3: Net Cereals Imports, All Developing Countries

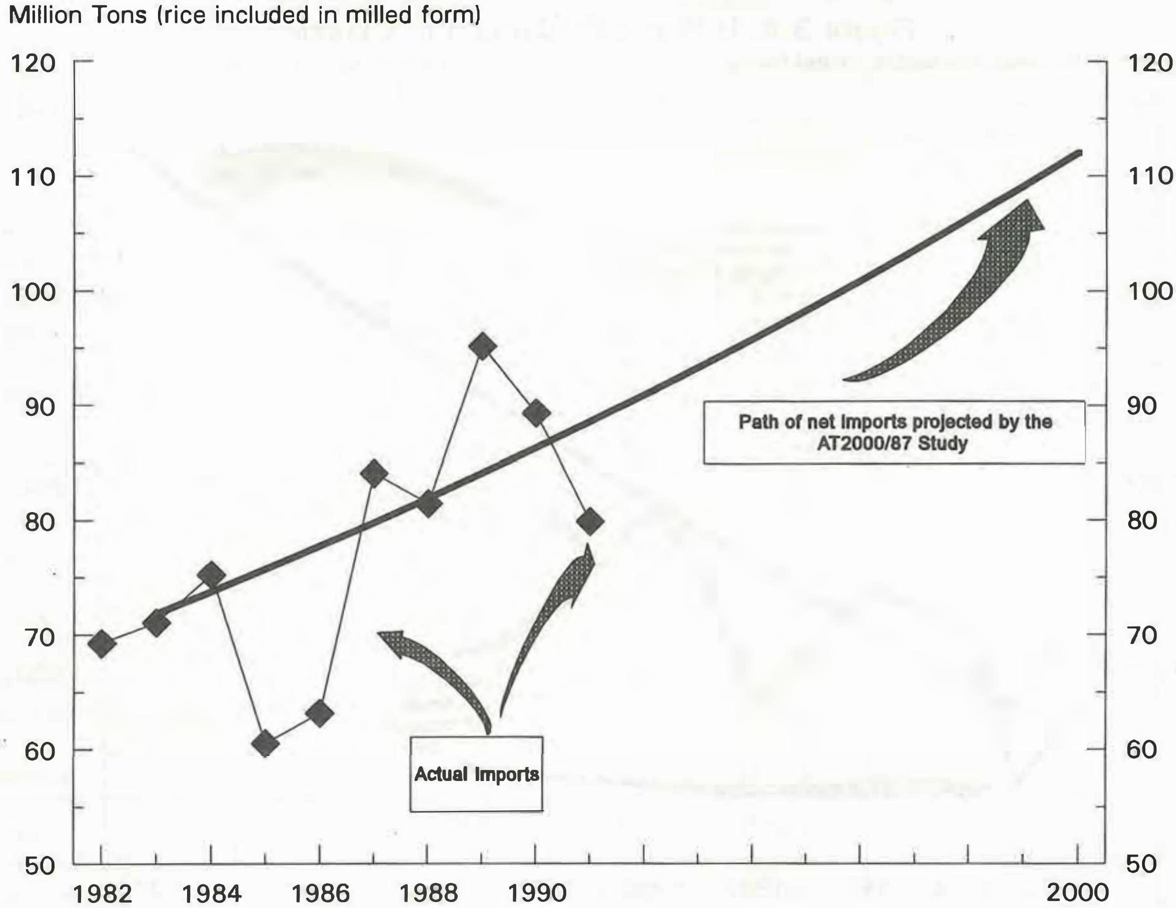
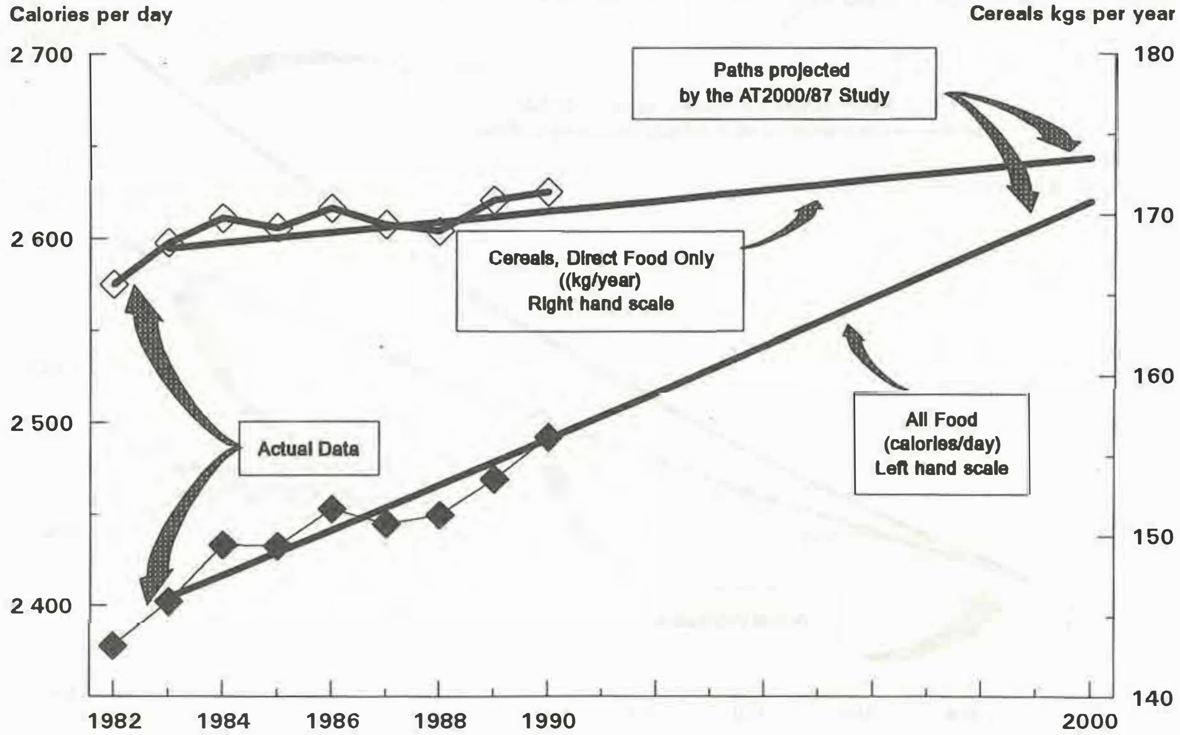


Figure 3.A.4: Per Caput Food Supplies for Direct Human Consumption, 93 Developing Countries



*The base year of the study was the 3-year average, 1982/84

CHAPTER 4

GROWTH OF AGRICULTURAL PRODUCTION IN DEVELOPING COUNTRIES

1. INTRODUCTION

4.1 As discussed in the preceding chapter, production growth rates are in general expected to slow down. But investment requirements in land development, marketing infrastructure and human resources will be substantial. The remaining opportunities for agricultural expansion are typically in areas more difficult and expensive - in terms of labour and capital - to develop. Furthermore, pressure to reduce negative environmental impacts associated with agriculture make development an increasingly difficult challenge. Current agricultural practices are unsustainable in many parts of the developing world, with arable land being mined of nutrients and eroded of topsoil, irrigated areas salinized, and rangelands overstocked. As discussed in Chapters 11 to 13, to arrest and reverse degradation of agricultural resources, farming systems will have to become more sophisticated, requiring higher levels of management and more judicious use of off-farm inputs.

4.2 This chapter discusses the expected sources of growth for agricultural production in the developing countries covered by this Study. Unfortunately, China could not be dealt with in the same detail as the other developing countries since data on land with crop production potential and on cropping patterns by agro-ecological land class are missing.[41] China therefore is covered in the same detail as other countries only in section 3 on livestock production.

2. CROP PRODUCTION

The aggregate picture

4.3 Developing countries' crop production is projected to increase by 66 percent (an annual rate of 2.4 percent) from 1988/90 to 2010. This compares with 69 percent (2.9 percent annually) over the last two decades. In aggregate, the sources of crop production growth in developing countries over the projection period are expected to show a

[41] There are a number of indications that data on cultivated area in China underreport land actually in use (e.g. see USDA, *China Agriculture and Trade Report*, ERS, RS-91-3, Washington, D.C., July 1991). Some sources indicate that underreporting amounts to about 30 percent, i.e. instead of a cultivated area of about 96 million ha (official data), actual cultivated area would be 125 million ha. Data on average cropping intensity (151 percent) seem to be fairly accurate as are data on production. If correct, this would imply a harvested area of 189 million ha instead of 145 million ha and yields and input use per harvested ha would be lower than official data show. Until such uncertainties about the actual data on area and yield by crop are resolved, it is difficult to make meaningful projections for such variables.

consolidation of developments over the past twenty years with, in particular, a larger proportion of the increase in output to come on account of higher yields. Around two-thirds of production growth would come from yield increases, while one-third would come from harvested area expansion (see Table 4.1).

4.4 Harvested area may increase either through expansion of arable land or through increases in cropping intensity, i.e. using the same piece of agricultural land more frequently through multiple cropping or reducing fallow periods. Some developing countries are following a similar pattern to that established earlier this century by developed countries, with higher yields the main or only source of production increase. Indeed, in some Asian countries the arable area could shrink slightly in the near future because of pressure to put land into non-agricultural uses.

Table 4.1 Sources of Growth in Crop Production and Total Land Use, Developing Countries (excl. China)

	Sources of growth over 1988/90 to 2010			Land			
				Arable		Harvested	
	Yield	Arable land	Cropping intensity	1988/90	2010	1988/90	2010
	.... percent contribution			.... million ha			
Developing Countries	66	21	13	757	850	598	723
Africa (sub-Saharan)	53	30	17	212	255	118	158
Near East/N. Africa	71	9	20	77	80	63	75
East Asia	64	27	9	77	88	81	97
South Asia	80	7	13	201	210	221	248
Latin America/Caribb.	53	28	19	189	217	116	145

4.5 The absolute increase in average yield over all crops could be around 37 percent over the projection period, growing at an average annual rate of 1.5 percent. This is somewhat lower than that in the past two decades, when it grew at 2.0 percent per year. Harvested area would expand by 21 percent, an annual rate of 0.9 percent. The expected net expansion in harvested area amounts to some 125 mln ha, made up of a 93 mln ha expansion in arable land (a 12 percent increase over arable land in use at present) and of an increase in its average annual use (cropping intensity) from 79 to 85 percent. Section 4 on the expansion of agricultural land elaborates on this.

4.6 The relative importance of yield, arable land and cropping intensity in increasing production will vary widely between countries and agro-ecological zones. There are marked contrasts between the five geographical regions (see Table 4.1). In Near East/North Africa and in many countries of other regions, especially in South Asia, the frontiers of land currently considered suitable for rainfed crop production have nearly been reached. The major expansion in arable land in absolute terms is expected to occur in Latin America and sub-Saharan Africa. In some countries, the abundance of land and/or the high costs of inputs would exert pressure for increasing areas as opposed to increasing yields.

4.7 Green revolution technologies were introduced in the 1960s and 1970s but their influence has continued in the 1980s and will continue in the 1990s and beyond. The diffusion of improved technology - including locally adapted modern varieties - more than raising the ceilings of yield potentials will determine the growth in average yields for particular developing countries in the next 20 years. In general, research station yields and those achieved by top farmers are much higher than the average national yields for any given agro-ecological situation. As will be illustrated in some of the sections on individual crops, while for some countries this gap may be narrowed somewhat, the yields achieved at the current "leading edge" of technology are generally well in excess of average yields expected by 2010.

4.8 At the sub-regional level and for most countries, yields of most crops continue to increase but the rates of growth do not appear to be increasing. Average cereal yield growth in developing countries has levelled off in the 1980s. While annual growth was around 1.5 percent per year in the 1960s and accelerated to 2.1 percent in the 1970s, it remained at 2.1 percent in the 1980s. The use of modern varieties and associated inputs is still spreading, and will contribute to maintaining and increasing average cereal yields, which over the projection period would grow at 1.4 percent annually.

4.9 In the past two decades, some distinct trends have emerged in the shares of total harvested land area occupied by the different crops. The share of cereals declined (from 61 to 55 percent): the proportion of rice has fallen slightly and wheat has roughly maintained its share, while the increase in the proportion of maize has been more than offset by falling shares of the sorghum and millet areas. At present, rice accounts for a third of the aggregate cereal area, wheat for 21 percent and maize for 19 percent. Oilcrops have substantially increased their share (from 10 to 14 percent) due to dramatic increases in the areas of soybeans (mainly in Latin America) and sunflower. The area allocated to fruit and vegetables has grown quickly and occupies an increasing proportion of the total land (from 3.9 to 7.3 percent). The shares of the main non-food crops (11 percent), pulses (9 percent) and roots and tubers (4 percent) have remained constant. These changes in the cropping patterns would continue in an attenuated manner over the projection period (Table 4.2).

In what follows the details of the expected production growth are discussed for a number of crops.

Cereals

4.10 Rice (in terms of paddy) is the most important cereal crop in developing countries, excluding China (48 percent of total cereals production in 1988/90), followed by wheat (21 percent), maize (18 percent), sorghum (6 percent) and barley and millet (each less than 4 percent). For reasons set out in the preceding chapter, production growth of wheat and rice is expected to slow down considerably over the projection period as compared with growth in the last two decades. Coarse grains would maintain their past annual growth in the future reflecting in part the strong growth of demand for cereals used for feed (see Table 3.9). Past and future growth rates for area, yield and production are shown in Table 3.6. The growth rates by major agro-ecological land class underlying the average growth rates are discussed below (Table 4.4). First, however, two more general observations will be made.

Table 4.2 Area and Yields for Major Crops: Developing Countries (excl. China)

	Production (P) (million tons)			Harvested area (A) (million ha)			Yield (Y) (tons/ha)			Growth rates (% p.a.) 1970-90			Growth rates (% p.a.) 1988/90-2010		
	1969/71	1988/90	2010	1969/71	1988/90	2010	1969/71	1988/90	2010	P	A	Y	P	A	Y
Wheat	67	132	205	58	70	77	1.2	1.9	2.7	3.8	0.9	2.8	2.1	0.5	1.6
Rice (paddy)	177	303	459	95	109	120	1.9	2.8	3.8	3.0	0.8	2.3	2.0	0.5	1.5
Maize	70	112	196	54	63	80	1.3	1.8	2.5	2.7	0.9	1.8	2.7	1.2	1.5
Barley	16	22	35	15	17	19	1.1	1.3	1.8	1.8	0.8	1.0	2.3	0.6	1.8
Millet	19	22	32	35	32	38	0.6	0.7	0.8	0.4	-0.6	1.0	1.8	0.9	1.0
Sorghum	28	37	62	38	37	50	0.7	1.0	1.2	1.7	0.3	1.5	2.5	1.4	1.1
Total Cereals	381	631	995	299	331	389	1.3	1.9	2.6	2.8	0.6	2.2	2.2	0.8	1.4
Cassava	95	153	223	11	15	18	8.3	10.1	12.2	2.4	1.3	1.1	1.8	0.9	0.9
Sugarcane	486	882	1 365	9	15	18	52.0	59.6	75.4	3.4	2.5	0.8	2.1	1.0	1.1
Pulses	24	30	48	46	52	61	0.5	0.6	0.8	1.3	0.7	0.6	2.2	0.7	1.5
Soybeans	3	38	79	3	22	33	1.0	1.7	2.4	11.8	9.4	2.1	3.6	1.9	1.7
Groundnuts	14	16	30	17	17	21	0.8	1.0	1.4	0.4	-0.4	0.9	3.0	1.2	1.7
Coffee	4	6	8	9	11	12	0.5	0.5	0.7	2.2	1.5	0.7	1.5	0.1	1.4
Seed cotton	16	21	42	22	19	22	0.7	1.1	1.9	1.3	-0.9	2.2	3.2	0.7	2.5

Note: Sometimes the changes in the annual growth rates between the historical and projection period appear to be large. Often this is a continuation of a change already begun in the historical period or an expected change in one country which has a large weight in the total. For example, annual growth in sugar cane production in the developing countries excluding Brazil is projected to remain the same as in the historical period, namely 2.2 percent. Likewise, the area allocated to soybeans in Brazil (currently more than half of total soybean area in developing countries) grew at 21.2 percent annually in the 1970s, but this growth rate fell to 3.5 percent in the 1980s.

4.11 First, as already noted in Chapter 3, by far the greater part of the production of wheat and rice is located in Asia and Near East/North Africa. Similarly, barley is mainly produced in Near East/North Africa. These are land-scarce regions and production increases therefore will predominantly originate in higher yields. Indeed the overall estimate is that for each of these crops yield increases will contribute more than three-quarters of the total production increase. The other cereals, maize, sorghum, millet and others, are mainly produced in the countries of Latin America and sub-Saharan Africa which are in general less land-scarce. For these crops, therefore, a large part of production increases is expected to come from increases in harvested area (46 percent for maize, 63 percent for millet and sorghum). Yield increases are derived in part from shifts in allocation of cropped area to land classes with higher yield potential (e.g. irrigated land). However, in general, the contribution to yield increases due to a change in the land class mix is of minor importance for all cereal crops.

4.12 The second observation relates to expected yield increases. Wheat and rice yields have shown spectacular growth over the last three decades. Although yield growth over the next two decades is expected to slow down considerably (see Table 3.6), the question arises whether there is still potential left for further increases given existing technology. Some countries have indeed reached very high average yield levels (e.g. irrigated rice in Egypt and Korea, DPR), and raising such yields much further will be difficult. Yet there exist wide inter-country yield differentials and most countries at present have yield levels well below those of the better performers. The extent to which yields will increase in the future, given existing technology, will depend on physical factors such as agro-ecological conditions and economic ones such as appropriate policies. An indication of the potential to increase yields can be obtained from the table below in which current cereal yields are compared over countries, controlling for agro-ecological conditions by assuming that these for each land class distinguished will be fairly similar. For example, for rice on irrigated land present day yields vary widely from 1 to 10 tons/ha. Average yield (over all countries included) is today 3.7 tons/ha and is projected to reach 5.2 tons/ha by 2010. This would still be well below the 6.7 tons/ha yield achieved today by the best performing countries (the top 20 percent of countries for 1988/90 yield levels). As can be seen from Table 4.3, in all cases the average yields projected for 2010 would be below levels reached by best performers today, in some cases even considerably so. Although no definite conclusions can be drawn given the many factors involved, this would suggest that even with existing technology (and further adaptive research) in most countries there is still considerable scope for increasing yields, assuming that appropriate policies will be adopted. However, the fact that current average yield levels are well below yields of the best performers (both between and within countries) indicates that raising average yields is not an easy process.

Rice

4.13 *Rice* production is projected to increase by 51 percent in the next two decades in the developing countries, excluding China. Growth in yields has underpinned much of the increase in rice production in the past twenty years. Rice yields rose sharply in the 1980s: production in these years increased over one-third, with yields increasing 29 percent and harvested area expanding by nearly 5 percent. In the 1970s, yields increased 16 percent while area expanded 10 percent. The scope for increases in area have been limited and much of the recorded increases in harvested area of rice reflected increasing cropping intensities

rather than expansion of cultivated land. The pattern of growth in the next 20 years is expected to be a continuation of the lower rate of land expansion established in the past decade but with growth in yield falling back to the levels of the 1970s (1.5 percent per year). With production concentrated in land-scarce Asian countries (90 percent of developing countries' (excluding China) rice is produced in Asia) relatively little further area expansion is expected. Yield gains will account for most (75 percent) of the future increment in production with the remaining contribution coming from expansion of harvested area, mainly due to increasing cropping intensity. In South and East Asia (excluding China) the expansion of harvested area in rice is expected to be less than 5 percent. Only in Latin America and sub-Saharan Africa will growth in area be substantial and these two regions together account for little over one-tenth of the rice area of the developing countries (excluding China).

Table 4.3 Cereal Yields in Major Agro-ecological Land Classes, Developing Countries (excluding China)

Product/Land Class	1988/90			Year 2010
	Range over all countries included*	Average of top 20%	Average over all countries included*	Average over all countries included*
Rice				
Irrigated	1.0 - 10.0	6.7	3.7	5.2
Fluvisols and Gleysols	0.8 - 4.6	3.2	2.4	3.1
Wheat				
Irrigated	1.1 - 5.7	4.6	2.4	3.3
Rainfed, sub-humid	0.7 - 3.1	2.3	1.8	2.2
Maize				
Irrigated	1.5 - 8.4	7.3	3.8	4.6
Rainfed, sub-humid	0.3 - 5.6	2.8	1.9	2.6
Rainfed, humid	0.2 - 4.6	2.6	1.3	1.7
Millet				
Rainfed, dry semi-arid	0.1 - 0.7	0.6	0.4	0.5
Rainfed, sub-humid	0.5 - 1.9	1.7	1.1	1.4
Sorghum				
Rainfed, dry semi-arid	0.3 - 1.1	1.0	0.5	0.6
Rainfed, sub-humid	0.5 - 3.6	3.2	1.5	1.9

* Countries with less than 50 000 ha of the specified land class under the crop have been excluded.

4.14 Part of the increase in the average yield will be derived from a change in the type of land upon which rice is grown. In particular, the share of irrigated rice in total rice area will continue to increase. Table 4.4 shows area, yield and production data for the base year and year 2010. The harvested irrigated area in rice is expected to increase by 21 percent over the projection period. About 44 percent of the harvested area of rice is now irrigated and

Table 4.4 Production of Major Cereals by Land Class in Developing Countries (excl. China)*

	All land classes**			dry semi-arid (AT1)			moist semi-arid (AT2)			sub-humid (AT3)			humid (AT4 + AT5)			fluvisols and gleysols (AT6+AT7)			irrigated		
	A***	Y	P	A	Y	P	A	Y	P	A	Y	P	A	Y	P	A	Y	P	A	Y	P
Wheat																					
1988/90	69.7	1.9	132.4	3.1	0.7	2.2	10.0	1.2	12.3	16.0	1.7	27.3	6.2	1.6	10.3	0.5	0.7	0.4	33.8	2.4	80.0
2010	77.1	2.7	205.0	3.2	1.0	3.3	11.0	1.8	20.3	17.4	2.1	37.1	5.2	2.3	12.1	0.5	1.0	0.5	39.7	3.3	131.7
Rice (paddy)																					
1988/90	109.2	2.8	302.7							10.5	2.1	22.4	21.4	1.6	33.3	29.7	2.4	71.7	47.5	3.7	175.3
2010	120.5	3.8	458.7							5.7	2.4	13.4	24.5	1.9	45.4	32.6	3.1	101.9	57.7	5.2	297.9
Maize																					
1988/90	62.6	1.8	112.2	0.8	0.6	0.5	7.6	1.2	9.0	30.1	1.8	54.9	15.3	1.3	19.5	1.6	1.0	1.7	7.2	3.7	26.7
2010	79.6	2.5	196.6	1.0	0.9	0.9	8.8	1.5	13.6	38.1	2.6	97.7	19.3	1.7	33.5	1.6	1.2	1.9	10.8	4.5	49.0
Millet																					
1988/90	31.9	0.7	21.7	10.2	0.4	3.9	9.8	0.6	6.4	6.3	0.9	5.8	2.9	0.5	1.5	0.9	0.8	0.8	1.7	1.9	3.3
2010	38.2	0.8	31.7	12.1	0.5	6.1	12.1	0.8	9.9	7.2	1.1	8.1	3.7	0.6	2.4	1.3	1.2	1.6	1.8	2.0	3.5
Sorghum																					
1988/90	37.1	1.0	36.9	8.8	0.5	4.1	11.3	0.8	8.9	9.4	1.3	11.9	2.5	0.7	1.9	2.0	0.8	1.7	3.0	2.8	8.4
2010	49.7	1.2	61.8	11.7	0.6	6.9	14.5	1.0	14.2	12.7	1.7	21.5	4.3	0.9	3.9	2.8	1.1	3.1	3.8	3.3	12.3

* Note: data on land and yields by land class at the country level do not exist in any systematic form. They have been assembled based on whatever information was available (country/project reports, expert judgement, etc.). They should therefore be interpreted with care.

** For a definition of the land classes see section 4.

*** A, Y, P: area in million ha; yield in tons/ha; production in million tons.

this proportion is likely to increase to 48 percent. About 27 percent of the rice area is on naturally flooded fluvisols and gleysols[42] and this is projected to increase slightly. Rice in other rainfed land[43] accounts for around 29 percent of the harvested area with about half of this being upland rice. Rainfed rice is likely to be reduced in relative terms as some of these areas become equipped for greater water control. Irrigated rice shows a yield advantage of 75 percent over non-irrigated one and this is projected to widen to around 100 percent by 2010. Controlled water environments continue to show most promise for productivity gains, with irrigated yields anticipated to grow 40 percent by 2010. Irrigation allows the full benefits of other inputs to be expressed, particularly from fertilizer and modern varieties. Moreover, the investment risk associated with input use is diminished. Naturally flooded areas do not always permit the full synergy of farm inputs to be realized. Such land is subject to inadequate or excess water and, from a much lower base, yield improvements of only 30 percent are likely. Upland rice yields are less than half those in irrigated areas and only limited progress in raising yields (10 to 20 percent) is expected.

4.15 At regional and most national levels, rice yields have continued to increase, with the diffusion of semi-dwarf varieties and associated inputs lifting average yields. This process will continue: yields achieved by farmers remain low in many countries and the adoption of modern varieties is still only partial. Difficulties remain in using modern higher yielding varieties in unfavourable environments or where traditional varieties retain price premiums. Nevertheless, progress is being made by breeders and the diffusion of hybrid rice will have a profound influence on production before 2010 (see section 5.4 on modern varieties and Box 4.1 on hybrid rice).

Wheat

4.16 As discussed in Chapter 3 (Table 3.6), growth in production of *wheat* in the developing countries (excluding China) could slow down substantially. This would be a continuation of a trend set in the 1980s. Aggregate area expansion is expected to continue at a low rate, similar to that of the 1980s (0.5 percent p.a.), with declining growth in South Asia being offset by increased growth in Latin America. The irrigated sector is expected to show more growth (18 percent increase in harvested area) than the rainfed one (5 percent, Table 4.4). This will be mainly from growth in Asia, where irrigation will partly substitute existing rainfed wheat. Of the rainfed wheat, most of the growth is expected in sub-humid areas, much of it in Latin America. Wheat in semi-arid zones is expected to increase in

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42 Rice on naturally flooded fluvisols and gleysols covers a wide range of ecologies but the main distinctions are based upon the depth of flooding: "rainfed lowland" and "deepwater". Rainfed lowland rice has shallower levels of flooding. In its most favourable form, conditions can be similar to irrigated rice. Less favourable environments are subject to drought or excessive water. Yields are generally lower where water depth exceeds 25cm or in areas prone to submergence. Where flooding depth is more than 50cm, potential yields are markedly lower; such deepwater environments are normally low-lying lands on river deltas where flooding only occurs during part of the season.

43 This comprises upland rice and lowland rice on naturally flooded soils other than fluvisols and gleysols. Upland rice is rainfed, in naturally well-drained soils with bunds or unbunded fields without surface water accumulation. Where the growing season is long and soils favourable, yields can be high and there is potential to develop improved varieties. Drought and soil constraints - particularly acidity - currently limit the potential in most upland areas.

Near East/North Africa, though in South Asia, conversion to irrigation is likely to reduce the wheat area on such marginal rainfed land. The proportion of irrigated wheat in total wheat area would increase from about 45 percent at present to 48 percent by 2010. The increased share under irrigation would be at the expense of higher rainfall land, over which irrigated wheat has a yield advantage of around 50 percent.

4.17 Growth in yield will contribute most (76 percent) of the increase in output, though average wheat yield will grow at a lower rate compared to the recent past. Wheat yield gains have been impressive and, at over 2.5 percent per year in developing countries (excluding China) during the past three decades, are the highest of any staple crop. The use of semi-dwarf varieties has given large benefits in yield, mainly because of their high responsiveness to fertilizer. However, modern semi-dwarf varieties are now sown on over two-thirds of the wheat area and fertilizer dressings are already high, particularly in Asia. Furthermore, nearly half the area is already irrigated and only limited expansion of this sector is expected. Thus the major sources of growth have been largely exploited in the last two decades and no technical breakthrough, such as the release of hybrid wheat, is likely to allow a quantum leap in yield. Improvements in input use, together with modest gains in genetic potential, are expected to increase yields by an average 1.6 percent per year, 40 percent in total, to 2010. Still, in 2010 average yields would be below those achieved by best performing countries today (see Table 4.3).

Maize

4.18 The growth of *maize* area is likely to show a reversal of the pattern observed in previous decades, when production growth resulted primarily from yield increases. Area expansion recovered in the 1980s and much of it has been a result of expansion of maize through displacement of other crops or insertion into new crop rotations. For example, maize is replacing sorghum and millet in some dryland areas in sub-Saharan Africa. In parts of India, maize is now grown as a winter crop. Improved varieties adapted to a wide range of agroclimatic conditions have made it possible for maize to grow in areas where it could not grow before. Relative to other cereals, maize is expected to show a greater increase in area in the future, with faster growth of harvested area likely for the period to 2010 than in the past 20 years (1.1 percent per year, 27 percent in total), mainly due to expansion in Latin America, sub-Saharan Africa and Southeast Asia.

4.19 Irrigated maize production is projected to show the fastest growth, with a likely expansion of 50 percent to 2010. Only 12 percent of the harvested area of maize is currently under irrigation and this share is expected to increase to 14 percent, mainly from expansion in Asia. Most of the area increase is likely to be in good rainfall (sub-humid) areas with suitable soils, which account for nearly half the harvested area; these are expected to increase by nearly a third, mainly due to expansion in the better-watered areas of Latin America, sub-Saharan Africa and Asia. The maize area in more marginal conditions (in terms of rainfall and soils) is likely to expand by a fifth. The yield advantage of irrigated and good rainfall land compared with more marginal areas is on average over 80 percent.

4.20 Higher yields would contribute nearly half of the increase of maize production over the projection period. Growth in yields in developing countries slowed in the 1980s to 1.0 percent per annum but is expected to recover in the coming years to 1.5 percent per

year, close to levels achieved in the 1970s. Hybrid and composite types are established as higher-yielding varieties and though no other breakthrough is likely to shift the yield plateau of this crop in the short term, improved varieties have not yet been adopted everywhere. Only half the area in developing countries is sown with modern germplasm and improved seeds and inputs are likely to spread further, increasing production, particularly in sub-Saharan Africa, where yields are still very low. Maize is generally highly responsive to fertilizer and dressings are likely to increase in developing countries.

Sorghum and Millet

4.21 Yield increases in *sorghum and millet* have been disappointing and show the problems of raising output of staple crops other than rice, wheat and maize. For both sorghum and millet, areas have stagnated in the last decade. Sub-Saharan Africa's modest expansion in these cereals has been offset by the continuation of the long-term decline in South Asia. This reflects substitution of higher-yielding crops such as maize, especially in more favourable areas. Thus sorghum and millet, due to their tolerance of low moisture and nutrient regimes, have become concentrated onto more marginal lands and this has contributed to restraining yield growth. In the past decade, millet has shown small yield gains while sorghum yields have declined, due to sharply lower harvests in sub-Saharan Africa in years of severe drought.

4.22 For sorghum and millet, the release of higher-yielding strains (including hybrid sorghum) and, more importantly, of lines tolerant to weed, insect and diseases is expected to make a modest contribution to raising average yields. Coupled with better crop husbandry, including attention to rainfed water management and plant nutrition, yields could rise at a rate at least as high as that in the past, at around 1 percent annually. However, area could increase at about 1.3 percent annually and the larger part of production growth is therefore expected to be derived from area expansion. With no significant shift from more marginal land to good rainfall or irrigated areas, changes in the land mix will make a negligible contribution to increased production.

Non-cereal Crops

4.23 The growth in area of *roots and tubers* is anticipated to expand more than that for cereals but yields will not increase to the same degree. The value of roots and tubers lies much in the stability of production in conditions where other crops may fail. They are adapted to a wide range of adverse conditions such as acid soils, fluctuating soil moisture content, high rainfall and infertile marginal lands.

4.24 Dramatically higher yields can be achieved even with non-improved cultivars through better soil management and crop husbandry. Yields have been shown to double or triple by introducing a single factor such as fertilizer, though fertilizers are not commonly used on

such crops despite demonstrated gains with moderate doses of nutrients.[44] Stagnant or even declining yields in developing countries have resulted not only from the lack of high-yielding cultivars and poor cultural practices but also from rapid degeneration due to diseases, especially viruses. With healthy planting material, large yield increases could be realized. Production increases of under 2 percent annually are expected, with area making a slightly larger contribution than yield. As noted in Chapter 3, a contributing factor to the slow growth of production is the shift of demand towards more convenient, and often cheaper, substitutes, due mainly to urbanization. Production growth could be higher if the demand constraints were relaxed.

4.25 After little growth in the in the 1960s and 1970s, *pulses* production has grown more quickly in the past decade, stemming from a boost in both area and yields in the 1980s. About half the developing countries' pulses production is in South Asia and in the 1980s government support in a number of countries in the region contributed to increase production by expanding the area irrigated, promoting intercropping, and raising fertilizer use.

4.26 Pulses are grown mainly on rainfed and marginal land with limited use of inputs. Though pulses fix nitrogen biologically, they generally respond to nitrogen fertilizers, as well as to phosphate and potash. New varieties, recently produced by national and international centres, have given higher yield potential to pulse crops. These are expected to permit yields to grow at somewhat higher rates (1.5 percent per year) than those attained in the 1980s. Nearly two-thirds of increased production will be derived from higher yields; there is little change expected in the land mix and just over a third of extra production will be from area expansion, which is expected to grow at a similar rate to the past 20 years (0.7 percent annually).

4.27 *Oilcrops* production has expanded sharply in the past three decades mainly due to rapid gains in soybean, palm oil and sunflower, with average annual growth rates of 15 percent, 7 percent and 7 percent, respectively. The most important element of growth has been the massive expansion in soybeans in Latin America. The region now accounts for over 85 percent of developing countries' production (excluding China). Soybean output grew at an annual rate of 11 percent in the 1960s and 21 percent in the 1970s. Growth slowed in the 1980s but was still 7 percent per year, most of which came from area expansion (over 9 percent annually from 1970 to 1990), while yield increases were 2.1 percent annually over the same period. Sunflower production is also concentrated in Latin America (61 percent of developing countries' production, excluding China), with the 1970-90 annual growth rate of 8 percent mainly coming from area expansion. Growth was also substantial for oilpalm. Over 75 percent of developing countries' oilpalm production is concentrated in East Asia. Groundnuts account for nearly a quarter of the aggregate oilseeds area but growth of this crop has been modest (only 0.5 percent annually 1960-90) while harvested area has contracted slightly.

4.28 Growth in oilseeds was strongest in the 1970s and the rate of gain has slowed in the 1980s. A further deceleration is expected to 2010. Nevertheless, incremental production

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[44] FAO's fertilizer programme (1961-86) shows productivity indices (extra kg product per kg fertilizer nutrient) of 30 or more for roots and tubers. The Value Cost Ratio (VCR) reported were in excess of two (considered the minimum needed to justify application by farmers in developing countries), with more than two-thirds of VCRs in excess of five.

will be high relative to other major crops and oilcrops will claim an increased share of harvested area by 2010. Future increases in oilcrop production are expected from roughly equal proportional gains in yield and area harvested.

4.29 The main *non-food crops* (cocoa, coffee, tea, tobacco, cotton, other fibre crops, and rubber) have shown modest growth in the past three decades, with their aggregate share of harvested area shrinking slightly. Beverage crops (coffee, cocoa and tea) have been increasing their areas but future growth in area is expected to be very small for coffee and limited for cocoa. In contrast, the tea area is likely to grow even faster than in the past. Yield increases have been modest for the beverage crops and slightly lower rates of gain are anticipated for the future. The fall in cotton area in the last two decades has been offset by increases in yields, especially in the 1980s and further yield increases and some area expansion are expected. Tobacco's area expansion of the 1960s and 1970s has been followed by a shrinkage in the 1980s. A recovery in area growth is however expected over the projection period. Yields of other fibre crops have shown only marginal gains in the past and little progress is expected in the next two decades.

4.30 *Fruit and vegetables* have claimed an increasing share of harvested area in developing countries and this trend is expected to continue. From under 5 percent in the 1970s and 1980s, fruit and vegetables could account for over 8 percent of the area by 2010. With many different individual crops in this category, generalizations are difficult to make. Area expansion of vegetables is expected to slow down somewhat, while fruit area is likely to continue expanding at a similar rates to the last 20 years. Vegetable and fruit yield gains have been steady with many species showing high responsiveness to irrigation and fertilizer. With new varieties and intensive cultivation techniques emerging, similar productivity gains are anticipated in the future as in the past two decades. Increased productivity is only expected where water management is under good control and little or no change is likely in rainfed areas.

3. LIVESTOCK PRODUCTION[45]

4.31 The rate of expansion in livestock output is expected to slow somewhat in the immediate future. Comparing projected annual growth rates for the two decades to 2010 with those of the last two decades, the rate for meat production would fall from 4.6 percent to 3.8 percent and for milk production from 3.5 percent to 2.5 percent. This slowdown will in part come on account of expected changes in the level and structure of demand in the developing countries as discussed in Chapter 3. But even at these lower growth rates, the pressure on livestock systems to increase production will be considerable because the expected absolute changes imply a 120 percent in aggregate meat production and a nearly 70 percent increase in milk production (see Figures 4.1 and 4.2).

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45 The discussion of livestock sector production prospects refers to all 93 developing countries of this Study, i.e. including China which was not covered in the discussion of crop production in the preceding section.

Figure 4.1: Meat Production in Developing Countries (incl. China)

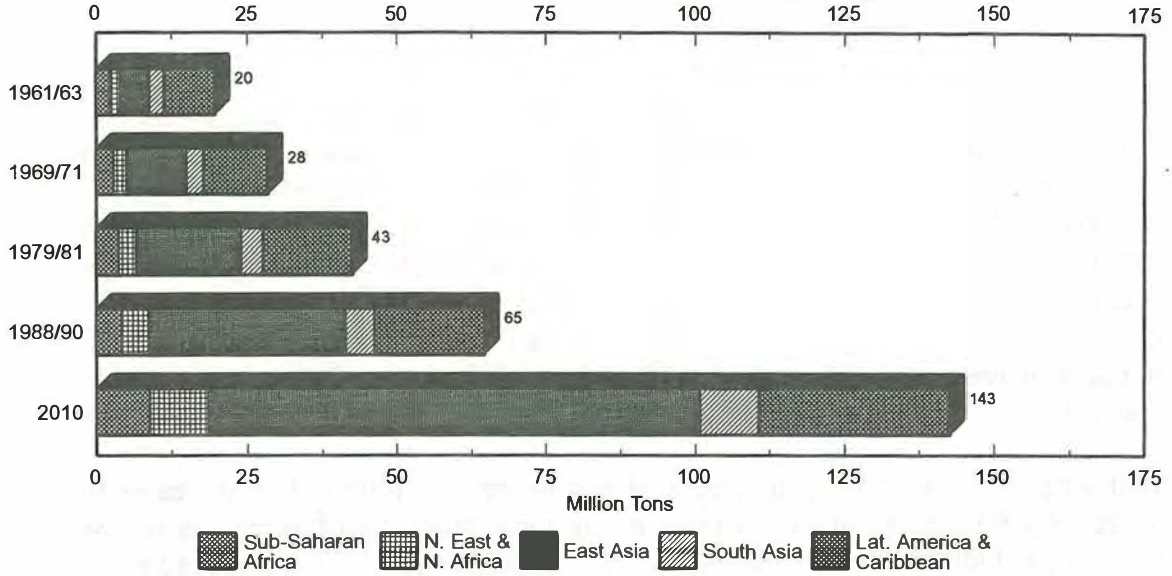


Figure 4.2: Milk Production in Developing Countries (incl. China)

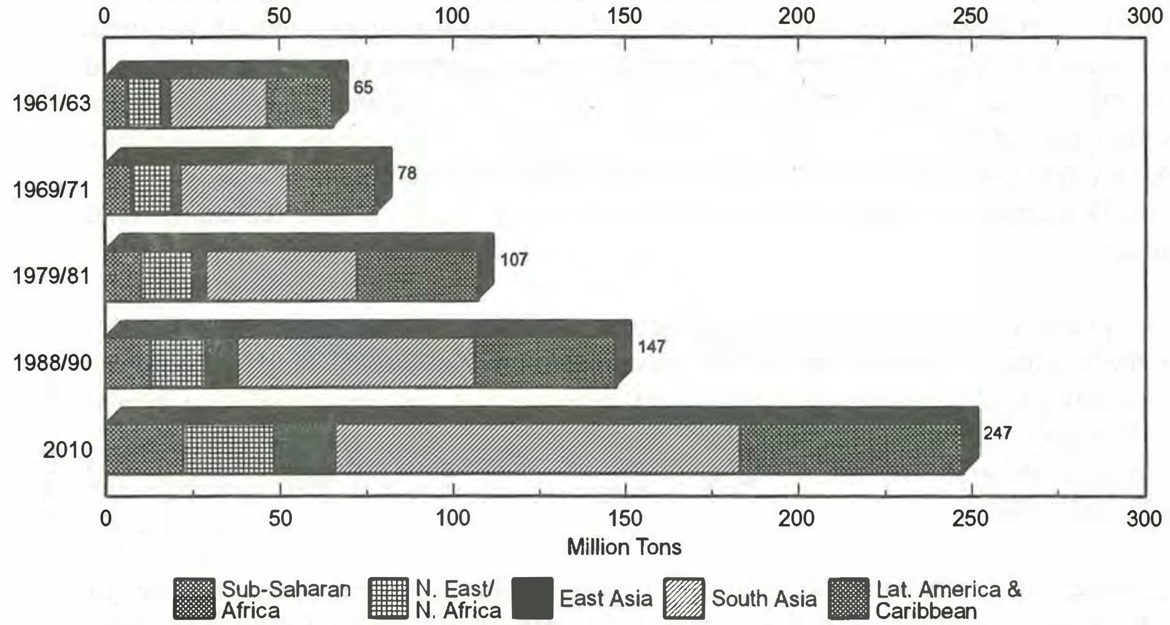
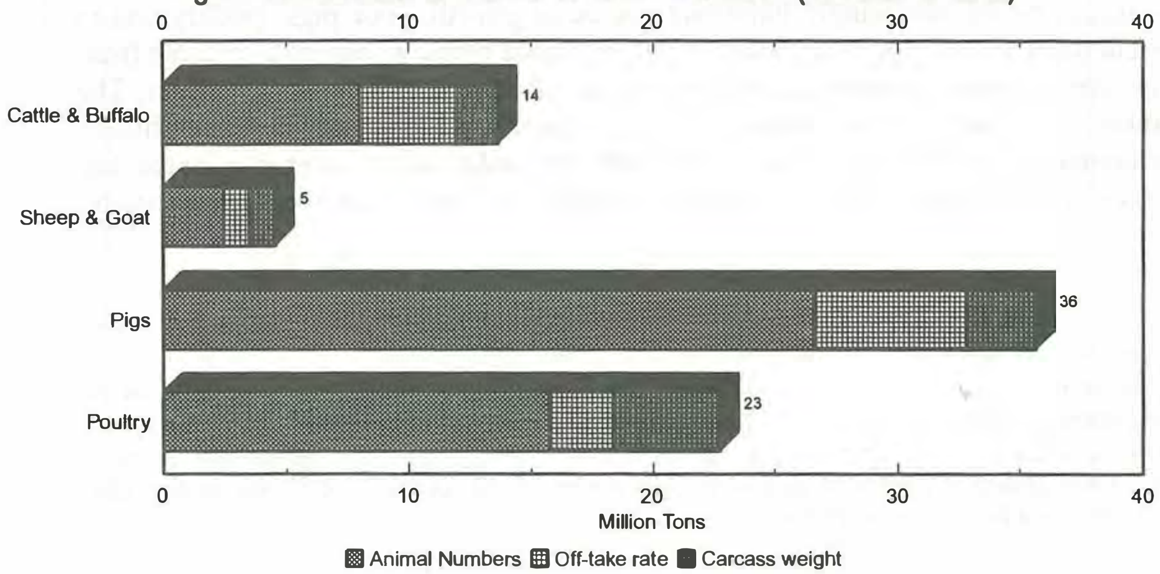


Figure 4.3: Sources of Growth in Meat Production (1988/90 to 2010)



4.32 Despite the projected increases in the annual growth rates of meat production in sub-Saharan Africa and South Asia (from 2.3 percent and 3.0 percent during 1970-90 to 3.5 percent and 3.4 percent over the projection period for the two regions respectively), the slow-downs foreseen for the other regions, which account for more than 80 percent of the aggregate meat production in the base period (Table 4.5), dominate the envisaged changes in the aggregate meat production. For milk production, the lower expected annual growth is the result of a slow down in all regions, except in Near East/North Africa, where the annual growth rate could increase from 1.6 percent in the period 1970-1990 to 2.4 percent over the projection period.

4.33 Poultry meat production is projected to rise most rapidly, followed by increases in pigmeat. More than 90 percent of the increase in pig meat production however is in one region, East Asia (including China), while the increase in poultry production is spread more evenly over all regions. These changes indicate that pigmeat will continue to be the most important source of meat in the developing countries (see Table 4.5), and that poultry meat will replace cattle and buffalo meat as the second largest source of meat by 2010.[46] There are some differences between the major regions in the structural changes, though the main trends are common to all. The proportion of poultry meat in total meat output is expected to continue to increase in every region while the contribution of cattle and buffalo meat would decline; that of pig meat would fall in East Asia but will increase slightly in sub-Saharan Africa (pig production is negligible in Near East/North Africa). Sheep and goat meat will likely maintain its share except in Near East/North Africa, where the share could decline further.

4.34 Two primary sources of production growth in livestock can be distinguished. Firstly, increasing the number of animals which are slaughtered, either through expansion in the absolute livestock population or increasing the off-take rate (i.e. the proportion slaughtered per year). Secondly, animal productivity can increase with higher output of meat, milk or eggs per animal through improved management, feeding, breeds, animal health and husbandry technologies.

4.35 Increases in livestock numbers and off-take rates have been the dominant sources of growth in developing countries, and this is expected to prevail also in the future, especially in extensive livestock production systems. However, there are many countries where the lack of potential to either expand the grazing area or raise its productivity will require that higher yields per animal be an increasingly important source of growth. For pigs, poultry and to a lesser extent dairy cattle, moreover, much of the increased output is expected to come from intensive or semi-intensive commercial production with the use of supplementary feeds. The overall pattern is that most of the additional meat production will be derived from a higher number of animals. However, yields per animal are expected to grow faster than in the past twenty years as a consequence of improvements in health, feed and pasture carrying capacity.

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46 Comparing annual growth rates of the last two decades (1970-90) with those expected over the projection period (Table 4.5), the change in growth rates sometimes appears to be large. This however often is a continuation of a change already set in over the historical period. For example, the annual growth of poultry production in Latin America/Caribbean was 9.4 percent in the 1970s, but fell to 4.7 percent in the 1980s.

Table 4.5 Meat Production in Developing Countries*

		Meat production					Livestock numbers				
		million tons			annual growth (%)		million			annual growth (%)	
		1969/71	1988/90	2010	1970-90	1988/90-2010	1969/71	1988/90	2010	1970-90	1988/90-2010
93 Developing countries	cattle and buffaloes	12.1	18.6	32.3	2.2	2.7	798	1 005	1369	1.3	1.5
	sheep and goats	3.0	4.9	9.5	2.8	3.1	869	1 129	1578	1.5	1.6
	pigs	9.7	28.3	64.0	6.1	4.0	291	486	860	2.2	2.8
	poultry	3.7	12.9	36.9	7.0	5.1	2 504	6 469	12 318	5.4	3.1
Sub-Saharan Africa	cattle and buffaloes	1.6	2.2	4.1	1.7	3.0	129	159	200	1.2	1.1
	sheep and goats	0.7	0.9	1.8	1.5	3.4	203	259	344	1.4	1.4
	pigs	0.2	0.3	0.8	3.3	4.3	6	11	16	3.8	1.8
	poultry	0.3	0.9	2.2	5.0	4.6	339	630	1097	3.5	2.7
Near East/North Africa	cattle and buffaloes	0.8	1.4	2.4	3.1	2.6	37	37	52	-0.1	1.7
	sheep and goats	1.0	1.4	2.7	2.2	3.0	203	240	326	1.2	1.5
	pigs						0.1	0.1	0.2	1.4	1.2
	poultry	0.4	1.6	4.6	8.1	5.1	206	677	1 125	6.9	2.5
East Asia (incl. China)	cattle and buffaloes	0.8	2.2	6.2	4.9	5.1	110	141	319	1.4	4.0
	sheep and goats	0.3	1.1	2.0	7.4	3.0	156	219	369	1.5	2.5
	pigs	7.3	24.5	57.0	7.0	4.1	215	386	724	2.4	3.0
	poultry	1.6	5.0	17.1	6.4	6.1	1 161	3 303	7 360	6.1	3.9
South Asia	cattle and buffaloes	1.9	2.7	4.7	2.1	2.6	302	347	432	0.9	1.0
	sheep and goats	0.6	1.1	2.3	4.0	3.5	149	248	338	2.9	1.5
	pigs	0.3	0.5	0.8	2.8	2.6	8	14	17	3.1	1.0
	poultry	0.2	0.6	2.2	6.3	6.1	252	603	913	4.9	2.0
Latin America/ Caribbean	cattle and buffaloes	6.9	10.0	14.8	1.9	1.9	218	319	364	1.9	0.6
	sheep and goats	0.5	0.4	0.7	-0.6	2.7	152	153	187	0.2	1.0
	pigs	1.9	3.0	5.3	2.3	2.8	63	75	103	0.8	1.5
	poultry	1.2	4.8	10.8	7.8	3.9	546	1 256	1 822	4.5	1.8

* For definition of meat production, see Table 3.7.

4.36 Figure 4.3 presents the sources of growth for different types of meat in developing countries, broken down into its component parts: the animal numbers, the off-take rates and the carcass weight. For each product, the biggest contribution to growth is expected to be made by the increases in animal numbers. Increases in off-take rates make the second largest contribution to growth in all products except poultry, where higher bird weights in South and East Asia and Latin America/Caribbean are likely to be the second largest contribution to growth.

4.37 There is a common trend among the diverse production systems, though slow in some countries, towards intensification. Intensification is aided by improvements in range management of extensive livestock production and through more rational use of local feed resources and animals kept in confinement. Improved management, in turn, reduces the non-productive stages of animals, increases feed conversion efficiency and reduces overgrazing.

4.38 Livestock production systems, however, differ in their ability to respond to changing market conditions. The differences in responsiveness are primarily due to the biological characteristics of the production process. With industrial-type systems being increasingly employed in developing countries, poultry production can respond relatively quickly to changing market conditions because of fast reproduction cycles and their proximity to urban markets. A wide range of commodities in elastic supply can be used to provide the required feed. Thus, compared with ruminants, poultry has a flexible feed resource base, and feed conversion efficiencies are high. However, the production systems of developing countries are usually highly dependent on imported technology and inputs. Eggs, pork, and, to a lesser extent, dairy production systems tend also to be relatively responsive to changing market forces. Due to the technological characteristics of intensive production, poultry, pig and most dairy systems cannot be gradually transformed from traditional to intensive production. Thus, at the level of the individual farm, the growth process tends not to be evolutionary but discontinuous.

4.39 In contrast, due to long reproduction cycles, low feed conversion efficiencies and low degree of specialization in beef, mutton and goat meat, and, to a lesser extent, dairy production, the responsiveness of red meat supply to higher demand tends to be slower. Thus, movements away from traditional systems toward more intensive methods tend to be correspondingly slower and of an evolutionary character.

4.40 Integrated mixed farming systems are also unlikely to be highly responsive to growing demand for livestock products, simply because of the other functions that livestock have to fulfil at the farm. Potential in the form of productivity increases and expansion through a gradual transformation of traditional farming systems is usually insufficient to respond effectively to growing consumer demand. Consequently, modern production systems, similar to those in the developed countries, have emerged in almost all developing countries alongside traditional systems. As the latter systems prove increasingly unable to meet the rising demand, a larger share of total supply is likely to come from more intensive systems.

4.41 Some countries however, will be excluded from any significant intensification and resulting productivity gains in the foreseeable future. For example, the low feed resource base and the import requirements for intensification of production would not allow most

Sahelian countries to make substantial progress in this direction, although they still could increase productivity.

4.42 The difficulties in the transition from extensive to more intensive livestock production has also led to increased environmental degradation. The greatest threat is from overgrazing and in many countries, especially in semi-arid ones, livestock numbers already exceed the carrying capacity of unimproved natural grassland. Balancing livestock numbers with forage and feed availabilities confronts major political, institutional and economic difficulties. These problems will be difficult to overcome in the short to medium term and are likely to grow rather than diminish in scope and gravity.

4.43 Only in very few developing countries have meat and dairy industries developed to the stage where they can provide safe and regular supplies to their rapidly expanding urban populations. Over 90 percent of the livestock in developing countries is owned by rural smallholders with inadequate links to urban markets. The failure of existing structures and organizational patterns to cope with present and future demand for livestock products is evident in a number of aspects. First, demographic expansion has increased technical and infrastructural difficulties in meeting the effective demand, which are sometimes reflected in high price differentials between rural and urban areas. Second, environmental pollution, mainly waste from industrialized livestock production units and processing (in particular, slaughterhouses) is becoming ever more serious because of insufficient structures and the absence of adequate regulations or the lack of their enforcement. Lastly, insufficient food safety standards, because of technical and institutional constraints, are a continuous and growing human health hazard.

4. EXPANSION OF AGRICULTURAL LAND

4.44 For developing countries as a whole, the estimated rainfed land with crop production potential is still considerably in excess of land presently cultivated, 2 540 and 720 million ha, respectively, excluding China. However, land resources are unevenly distributed to such an extent that some countries have vast areas of rainfed land with crop production potential while other countries have already exhausted theirs and have been forced to expand cultivation into land unfit for cultivation. Moreover, even in countries with large land resources, the latter are not readily accessible for agriculture for a variety of reasons (infrastructure and resettlement costs, prevalence of disease, etc.) Moreover, a good part of the land with agricultural potential should not be considered as available for agricultural expansion because it must be retained for other uses, e.g. preservation of forest (see Chapter 2, paragraphs 2.48 - 2.50). Therefore, in many countries part of crop production may have to take place on areas marginal for farming even where enough favourable arable land is available elsewhere within the national boundary. Examples of complete land balance sheets for South Asia and Tropical South America were presented in Chapter 2 (Table 2.3). In what follows more detailed data for all regions are presented and explained.

4.1 Estimates of Rainfed Land with Crop Production Potential

4.45 An integral part of the assessment of future crop production growth was an assessment of the availability of land resources with crop production potential. The feasibility of increasing harvested areas and yields has to be measured in the context of the quantity and the quality of land available. The geo-referenced agro-ecological zones (AEZ) data base of FAO has been used to obtain a detailed assessment of such land potentials for each developing country covered in this Study (excluding China).[47] The analysis is based on assessment of suitability for 21 crops[48] under different technologies. It provides estimates on quantity and quality of available land resources that have a potential for rainfed cultivation.

4.46 Soils and climate data were used to generate a land resources inventory for all developing countries by superimposing three main layers of information: (i) a soil and terrain inventory, the FAO/Unesco Soil Map of the World (SMW); (ii) an inventory of major temperature regimes; and (iii) an inventory of moisture regimes, providing the time period during the year when moisture is available for crop growth, referred to as the Length of Growing Period (LGP expressed in number of days).[49] [50]

4.47 Estimates of the extents of rainfed land with crop production potential were made for each country and expressed in seven rainfed land classes, defined according to moisture regimes, soil and terrain suitability and attainable yields. All areas assessed as at least marginally suitable (attainable yields of at least 20 percent of the maximum constraint-free yield) for one or more of the crops at any of three input levels[51] qualify as rainfed land with a potential for crop production.

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47 Though the FAO AEZ methodology has produced a similar inventory for China, the absence of detailed data on present cropping patterns by AT2010 land classes made it impossible to include China in this section.

48 These crops include millet, sorghum, maize, spring wheat, winter wheat, barley, bunded rice, upland rice, sweet potato, cassava, white potato, phaseolus bean, groundnut, soybean, cowpea, chickpea, oil palm, sugar cane, banana, olive and cotton.

49 The soils database used for the present assessment was derived from the SMW (FAO-Unesco, 1972-78). More recent data for some countries indicate that the data in the SMW are in need of revision. The results reported here should be read with this caveat in mind. For the climate resources inventories, use has been made of inventories produced under FAO's agro-ecological zones project. See FAO (1978-81), *Reports of the Agro-Ecological Zones Project*, World Soil Resources Report 48.

50 The attributes of land resources were matched with soil, terrain and climatic requirements for the 21 crops. Suitability classes used are related to attainable yields as a percentage of the maximum constraint-free yields. The latter are the yields attained under optimum agro-climatic, soil and terrain conditions and optimum inputs and management. Four suitability classes have been used: VS - very suitable (80-100%), S - suitable (40-80%), MS - marginally suitable (20-40%) and not suitable (< 20%).

51 The procedure ensures that the best suited crops are selected to maximize the extent of land with crop production potential. This test was carried out at three levels of farm inputs. These management/technology levels are: a low level, using no fertilizers, pesticides or improved seeds, equivalent to subsistence farming; an intermediate level, with some fertilizers, pesticides and improved seeds, and a high level with full use of all inputs comparable to developed countries. See FAO (1978-81), *op.cit.* and FAO (1982), *Land Resources for Populations of the Future*.

4.48 The seven rainfed land classes distinguished in this Study are defined as follows:

Land class "AT 1" *Dry semi-arid land*: productive and marginally productive rainfed land, with attainable yields greater than 20 percent of potential constraint-free yields, in zones with 75-119 growing days (which corresponds to annual rainfall of approximately 300-500 mm). The soil and terrain conditions are very suitable, suitable or marginally suitable.

Land class "AT 2" *Moist semi-arid land*: productive rainfed land, with attainable yields greater than 40 percent of potential constraint-free yields, in zones with 120-179 growing days, with very suitable or suitable soil and terrain conditions.

Land class "AT 3" *Sub-humid land*: productive rainfed land, with attainable yields greater than 40 percent of potential constraint-free yields, in zones with 180-269 growing days, with very suitable and suitable soil and terrain conditions.

Land class "AT 4" *Humid land*: productive rainfed land, with attainable yields greater than 40 percent of potential constraint-free yields, in zones with more than 270 growing days, with very suitable and suitable soil and terrain conditions.

Land class "AT 5" *Marginal moist semi-arid, sub-humid and humid land*: marginally productive rainfed land, with attainable yields of 20-40 percent of potential constraint-free yields, in zones with more than 120 growing days, with only marginally suitable soil and terrain conditions.

Land class "AT 6" *Fluvisols and Gleysols (Naturally Flooded Land - NFL)*: productive lowlands, flooded or water-logged for part of the year with attainable yields greater than 40 percent of potential constraint-free yields.

Land class "AT 7" *Marginal Fluvisols and Gleysols (Marginal NFL)*: marginally productive lowlands, flooded or water-logged for part of the year with attainable yields of 20-40 percent of potential constraint-free yields.

4.49 Land with attainable yields of less than 20 percent of the maximum constraint-free yield was considered non-suitable. In some countries however, very marginally suitable lands with attainable yields of less than 20 percent are presently cropped, typically in ways that partially overcome the severe constraints, without resorting to irrigation (this is further discussed below in the section on land balances).

4.50 Table 4.6 presents for the developing regions of this Study the extents of rainfed land with crop production potential. It shows that the shares of this type of land in total land area are in the range 38 percent to 52 percent in all regions, except in Near East/North Africa where only 6 percent of the land area can be used for rainfed crops. The maps on the following pages present the dominant land classes for Africa, South America, Central America, Near East, South Asia and Southeast Asia. The detailed legend for the maps is given below.

Table 4.6 Rainfed Land with Crop Production Potential

(million ha)

Land class	SSA*	LA&C*	NENA*	EA*	SA*	TOTAL
AT 1	89	16	19	0	30	154
AT 2	179	60	22	4	86	351
AT 3	294	183	17	38	62	594
AT 4	171	383	0	37	7	598
AT 5	155	278	10	43	30	518
AT 6	105	91	10	25	27	258
AT 7	15	44	1	2	2	65
Total AT 1 to AT 7	1 008	1 054	78	153	244	2 538
Total Land Area	2 214	2 038	1 223	380	489	6 390
(AT 1 to AT 7)/Total land	46%	52%	6%	38%	50%	40%

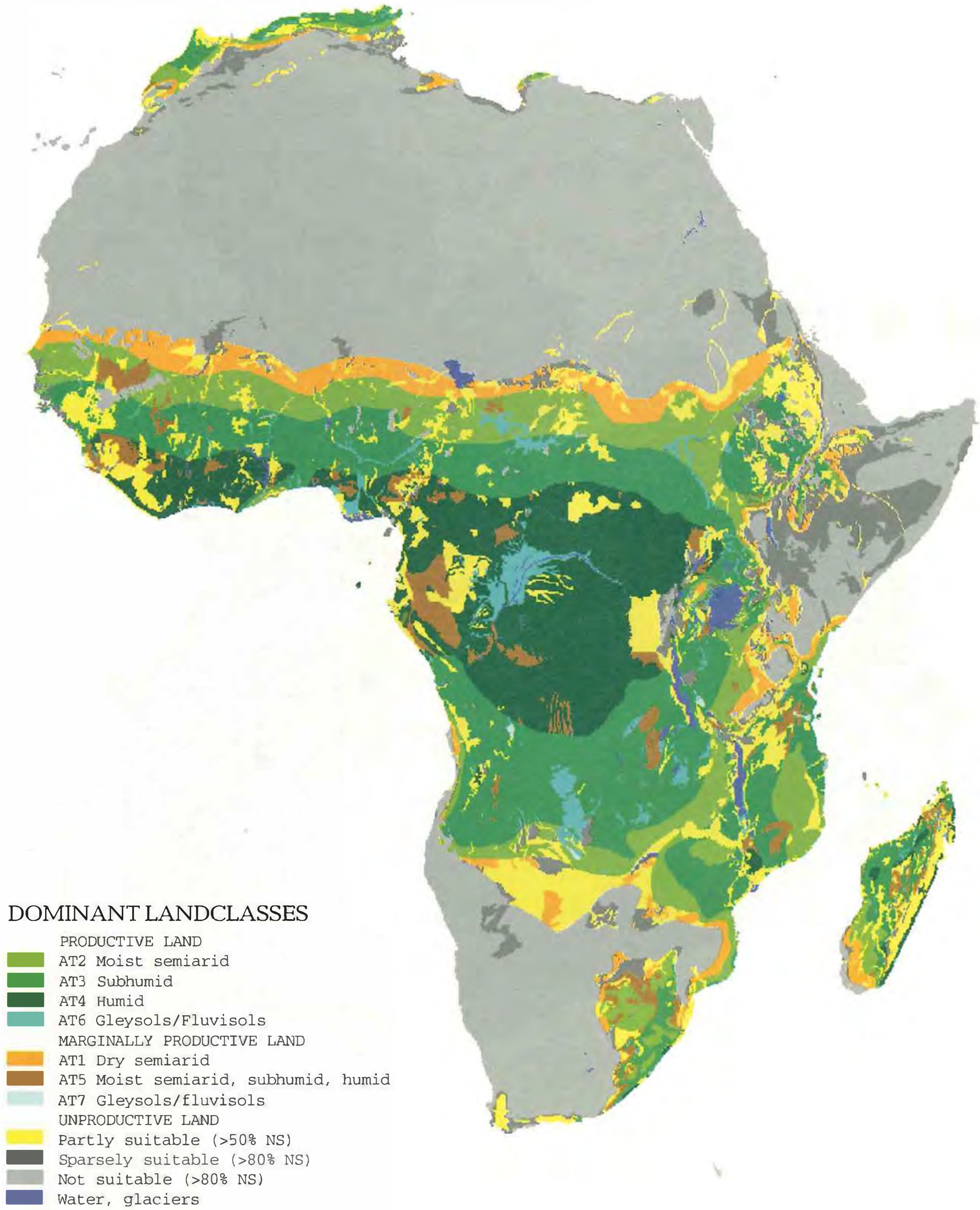
* Note: in all tables used in this section the following abbreviations are used: SSA: Sub-Saharan Africa. LA&C: Latin America/Caribbean. NENA: Near East/North Africa. EA: East Asia (excluding China). SA: South Asia.

MAPS

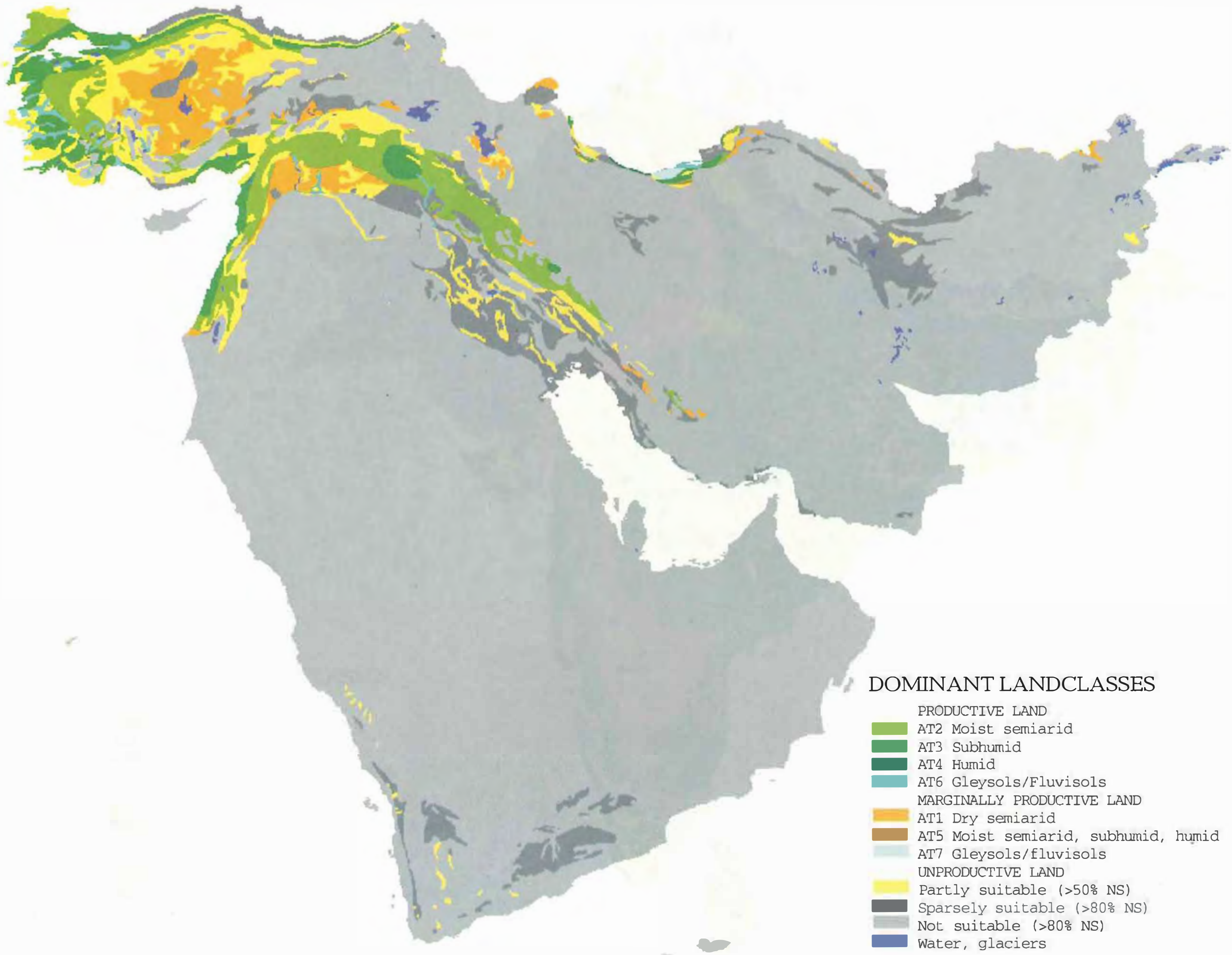
Full legend for maps of dominant land classes

Dominantly Productive Land			
AT 2	Moist semi-arid	LGP 120-179 days	> 50% of area VS+S land
AT 3	Sub-humid	LGP 180-269 days	> 50% of area VS+S land
AT 4	Humid	LGP 270-365 days	> 50% of area VS+S land
AT 6	Fluvisols and Gleysols	Naturally flooded land (NFL)	> 50% of area VS+S land
Dominantly Marginally Productive Land			
AT 1	Dry semi-arid	LGP 75-119 days	> 50% of area VS+S+MS land
AT 5	Moist semi-arid, sub-humid and humid	LGP 120-365 days	> 50% of area MS land
AT 7	Fluvisols and Gleysols	Naturally flooded land (NFL)	> 50% of area MS land
Dominantly Unproductive Land			
Partly suitable		LGP 75-365 or NFL	20-50% of area VS+S+MS land
Mostly not suitable		LGP 75-365 or NFL	0-20% of area VS+S+MS land
Not suitable			n.a.
Water, Glaciers			n.a.

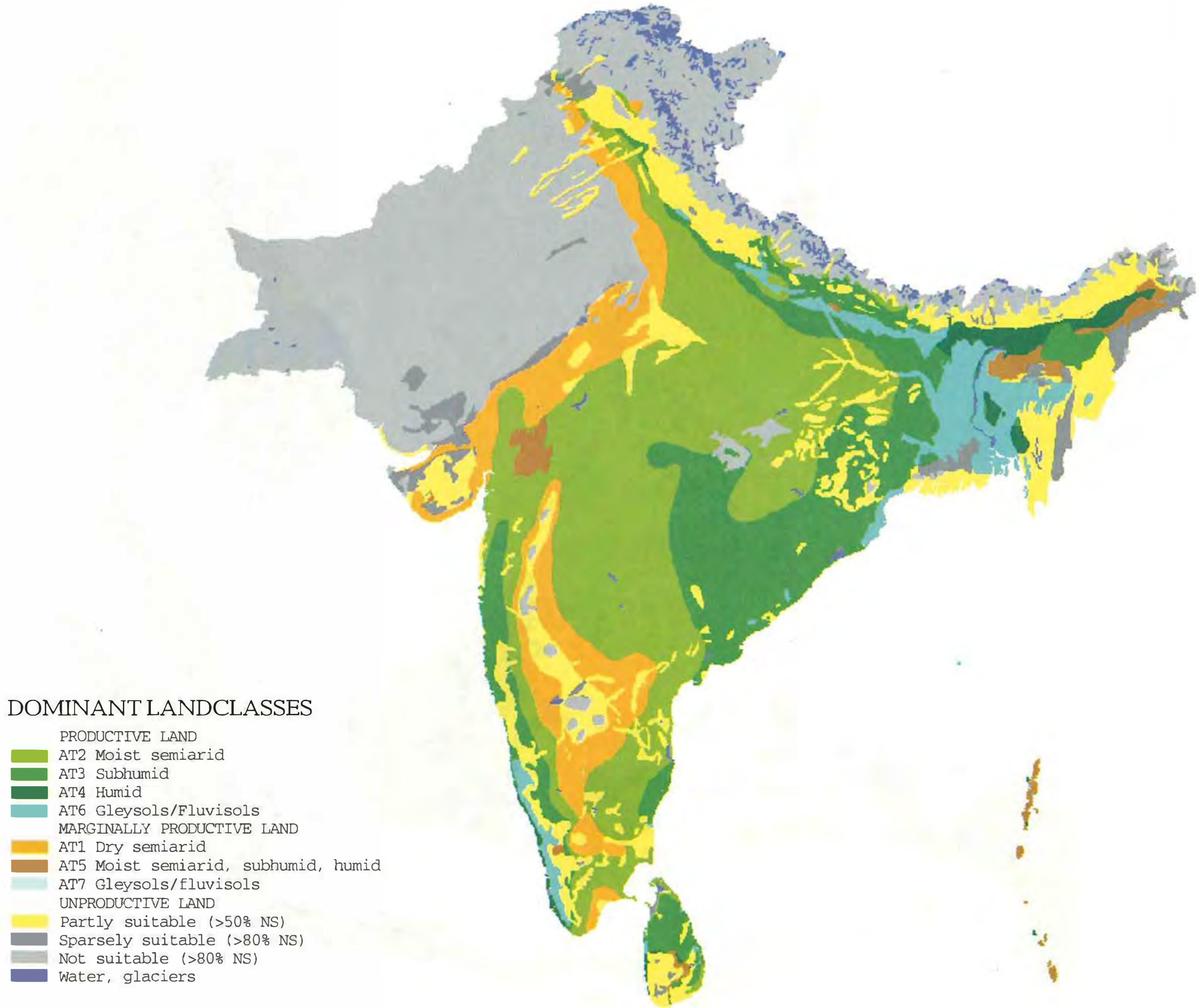
AFRICA


DOMINANT LANDCLASSES
PRODUCTIVE LAND
AT2 Moist semiarid
AT3 Subhumid
AT4 Humid
AT6 Gleysols/Fluvisols
MARGINALLY PRODUCTIVE LAND
AT1 Dry semiarid
AT5 Moist semiarid, subhumid, humid
AT7 Gleysols/fluvisols
UNPRODUCTIVE LAND
Partly suitable (>50% NS)
Sparsely suitable (>80% NS)
Not suitable (>80% NS)
Water, glaciers

NEAR EAST

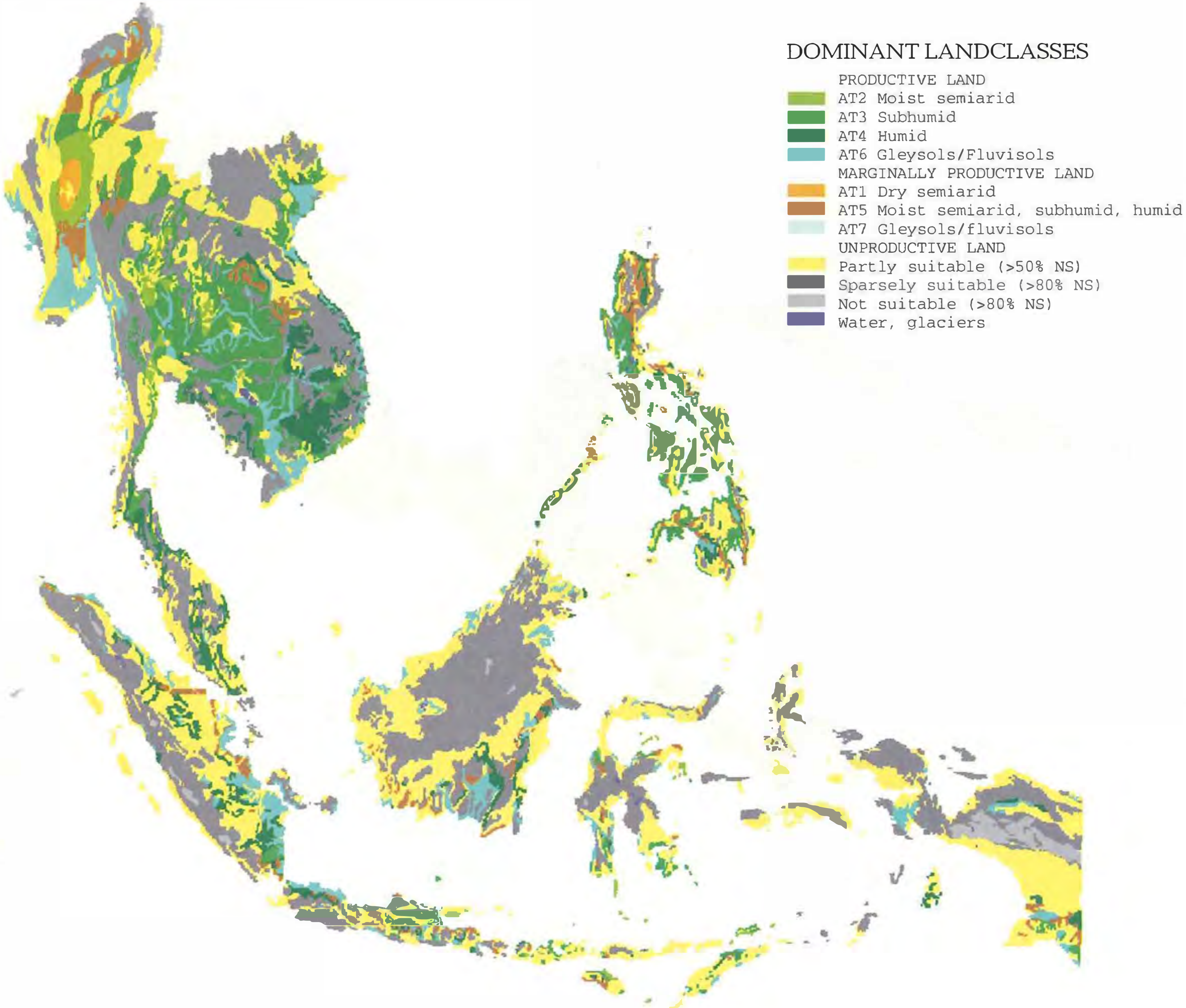

DOMINANT LANDCLASSES
PRODUCTIVE LAND
AT2 Moist semiarid
AT3 Subhumid
AT4 Humid
AT6 Gleysols/Fluvisols
MARGINALLY PRODUCTIVE LAND
AT1 Dry semiarid
AT5 Moist semiarid, subhumid, humid
AT7 Gleysols/fluvisols
UNPRODUCTIVE LAND
Partly suitable (>50% NS)
Sparsely suitable (>80% NS)
Not suitable (>80% NS)
Water, glaciers

SOUTH ASIA



DOMINANT LANDCLASSES
PRODUCTIVE LAND
AT2 Moist semiarid
AT3 Subhumid
AT4 Humid
AT6 Gleysols/Fluvisols
MARGINALLY PRODUCTIVE LAND
AT1 Dry semiarid
AT5 Moist semiarid, subhumid, humid
AT7 Gleysols/fluvisols
UNPRODUCTIVE LAND
Partly suitable (>50% NS)
Sparsely suitable (>80% NS)
Not suitable (>80% NS)
Water, glaciers

SOUTHEAST ASIA



CENTRAL ALMERICA

SOUTH AMERICA

4.51 Significant parts of the rainfed land with crop production potential are subject to terrain and soils constraints for crop production (Table 4.7). It can be seen that different constraints are dominant, depending on the region. For example, in Near East/North Africa the rainfed land with agricultural potential is largely in the mountain ranges, where precipitation is sufficient for cultivation. This causes a relatively high share (24 percent) of constraints related to steep slopes. Also in East Asia and South Asia, steep slopes constitute a substantial portion of the land with agricultural potential. In sub-Saharan Africa and Latin America/Caribbean about half of the rainfed land with crop production potential has soils with low natural fertility, in contrast to the Near East/North Africa region where this constraint is important for only 1 percent of the land. Furthermore, in sub-Saharan Africa, the share of area with agricultural potential constrained by soils with unfavourable sandy textures or frequent occurrence of stones and rocks is more than twice that of other regions.

Table 4.7 Share of Land with Terrain and Soil Constraints in Total Rainfed Land with Crop Production Potential

(percent)

Constraints	Regions					
	SSA	LA&C	NENA	EA	SA	Total
Steep slopes 16-45%	11	6	24	13	19	10
Shallow soils <50 cm	1	10	4	1	1	1
Low natural fertility	42	46	1	28	4	38
Poor soil drainage	15	28	2	26	11	20
Sandy or stony soils	36	15	17	11	11	23
Soil chemical constraints *	1	2	3	1	2	1
Total AT1 to AT7 land constraints**	72	72	43	63	42	67

* Salinity, Sodicity and Gypsum.
** Individual constraints are non-additive, i.e. they usually overlap.

4.52 Current and projected *irrigated land* has been allocated to the rainfed classes AT1 to AT7 and arid and hyperarid land (see section 4.2 below). However, while estimates were obtained for some countries, no recent systematic data for total areas which could potentially be irrigated could be obtained. Assessing water resources for irrigated agriculture on a geographic basis is fraught with conceptual difficulties. The definition of water resources and its quantification is subject to widely differing interpretations. Precipitation could be considered as the maximum available volume of water for a given area, but only a small fraction is readily available for use by agriculture and other sectors (urban, industries, navigation and fisheries). Water in river systems and infiltrating to aquifers can be available but most rainwater is lost in evaporation.

4.53 A commonly accepted measure of irrigation potential is that of renewable water resources, i.e. the volume of surface and ground water available within the area and being renewed on a yearly basis. However, water resources can be computed meaningfully only on the basis of physical hydrological units (watersheds) which can cut across international boundaries. Even within a watershed water resources cannot easily be allocated to land, as rivers can carry it considerable distances. Furthermore, since surface and ground water are linked, it is difficult to assess these two resources independently, and ground water is not adequately known for assessment on a regional basis. The assessment of available water resources is complicated further by inter-basin transfers, inter-annual variability of water resources, the use of fossil water (ground water resources which are not renewable) or shared water resources. In arid and semi-arid areas, where water resources availability is most critical, these elements are even more important.

4.2 Arable Land in Use

4.54 This section presents the estimated rates of expansion of land in crop production in the next 20 years, both in terms of arable land (physical area) and harvested land. The expansion of arable land is in net terms, i.e. over and above that needed to replace land lost to agriculture for various reasons. For example, degraded land can be withdrawn from farming either temporarily or permanently. Often this is as a result of desertification or waterlogging and salinization in irrigated areas (for a discussion of land degradation see Chapter 11).

4.55 Harvested area expanded at an annual rate of 1.0 percent in the 1960s, 1.4 percent in the 1970s and 1.0 percent in the 1980s. However, arable areas have been expanding at a lower rate because of increases in cropping intensity.[52] Arable land was estimated at about 760 million ha in developing countries (excluding China) in the base period and the harvested area at some 600 million ha, implying an average cropping intensity of about 79 percent. The harvested area is projected to increase by some 125 million ha and it would account for about a third of the growth in crop production, the other two-thirds being derived from higher yields (Table 4.1). Some 93 million ha of this would be supplied by expansion of the arable land area, of which about 2 million ha could be from irrigation of arid/hyperarid land (Table 4.8). This would imply a fall in the annual growth of arable land to around 0.6 percent in the next two decades. Cropping intensity could increase to 85 percent.

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[52] Cropping intensity (or index) is a measure of the frequency with which a piece of arable land is cropped. If two crops are harvested per year, the cropping intensity is 200%; if two crops are harvested in two years followed by a year of fallow the intensity is 66%. Thus cropping intensity increases as a result of multiple-cropping, when rainfall or irrigation allow more than one crop to be harvested in a year, or where - in more extensive farming systems - fallow periods are reduced.

Table 4.8 Land in Crop Production in 1988/90,[53] and Increments to 2010*

(million ha)

Land class	SSA	LA&C	NENA	EA	SA	TOTAL
AT 1	43 (4)	7 (0)	15 (1)	0 (0)	22 (0)	86 (6)
AT 2	44 (8)	23 (2)	18 (1)	1 (1)	62 (2)	148 (13)
AT 3	59 (11)	81 (13)	15 (0)	17 (4)	49 (0)	221 (28)
AT 4+5	58 (15)	64 (5)	10 (0)	43 (6)	27 (4)	202 (31)
AT 6+7	8 (3)	10 (7)	5 (0)	15 (1)	26 (2)	64 (13)
AT1 to AT7	211 (42)	184 (27)	62 (3)	77 (11)	186 (7)	721 (91)
Irrigated arid/hyperarid	1 (0)	5 (0)	15 (1)	0 (0)	15 (1)	36 (2)
Total	212 (42)	190 (27)	77 (4)	77 (11)	201 (8)	757 (93)

* Expected increments over 1988/90 to 2010 are given in brackets. Each land class also includes land irrigated in that class.

4.56 The increase in arable area would be mainly in sub-Saharan Africa (45 percent) and Latin America/Caribbean (29 percent), while some 12 percent would be in East Asia and only 9 percent in South Asia. Near East/North Africa's share in the increment is expected to be small (less than 5 percent). Nearly two-thirds of the increase in the arable area is expected to be in the sub-humid and humid landclasses, and of this some 75 percent is in sub-Saharan Africa and Latin America/Caribbean. Expansion in dry semi-arid land is expected to be relatively small and almost entirely within sub-Saharan Africa. The overall increments of arable area in moist semi-arid land and in fluvisols and gleysols are similar, each accounting for under 15 percent of the total expansion.

4.57 The arable land expansion described above includes irrigated areas located on rainfed arable land. Irrigated land in developing countries (excluding China) is expected to increase in a net sense by 19 percent (23 million ha), most of this being on rainfed land with crop production potential, with much of it substituting current rainfed cropland rather than constituting new additions to arable area. In some countries, part of the expansion of irrigated area will be in arid and hyperarid lands (i.e. not suited for rainfed crop production). This would amount to 2 million ha, 67 percent of which in Near East/North Africa and 26 percent in South Asia.

4.58 In some countries in South Asia and East Asia, there are only few opportunities to expand the arable area further due to the limited availability of rainfed land with crop production potential. Much of the irrigated land will have to be developed from rainfed land and fluvisols and gleysols already cropped, but the higher cropping intensities that can be realized on irrigated land would allow the harvested area to increase. In South Asia, the expansion in irrigated area is expected to more than offset a decline in rainfed arable land of around 4 percent, and harvested area would increase by 12 percent. In East Asia, arable area is expected to increase by 14 percent and harvested area by 20 percent.

4.59 In Near East/North Africa, rainfed land with crop production potential is almost totally utilized. Irrigation has expanded the arable area into land without rainfed potential,

53 In the discussion on land in use, the classes AT4, AT5 and AT6, AT7 were lumped together since no information on land in use for these classes separately could be obtained.

which together with higher cropping intensities, has permited increases in harvested area at a rate of 1.2 percent per year in the 1980s. Future growth in harvested area is expected to be lower, at around 0.8 percent to 2010, with the total arable area expanding by about 5 percent over the projection period. Increasing concern about overexploitation of non-renewable aquifers is expected to limit irrigation expansion in this region.

4.60 In sub-Saharan Africa, harvested area could grow by 34 percent and arable area by 20 percent. Almost all of the increase in arable land would be for rainfed crop production. The low reliance on controlled water supplies for arable crops in this region would continue. Irrigation will also continue to be a relatively small share of cropland in Latin America/Caribbean. Harvested area is expected to increase by 25 percent and the arable one by 14 percent.

4.61 Most countries in Near East/North Africa and to a lesser extent in South Asia, have used almost all their available rainfed arable land, but some countries can increase their arable area through irrigation of arid and hyperarid lands. However, both Near East/North Africa and South Asia will have to rely more heavily on increasing cropping intensities than on expanding arable land, despite their already high cropping intensities (Table 4.9). For developing countries as a whole (excluding China), average cropping intensity is estimated to increase from 79 to around 85 percent. This would contribute some 32 million ha to the harvested area.

Table 4.9 Current and Projected Cropping Intensities

	SSA	LA&C	NENA	EA	SA	Total
1988/90	55	61	83	105	110	79
2010	62	67	93	110	119	85

4.3 Land Balances

4.62 Using the estimates of rainfed land with crop production potential and arable areas in use, the "balance" of uncropped area could be obtained as the difference between the two (see Table 4.10). As bare statistics, uncropped land with rainfed crop production potential in developing countries appears large: in 2010 only one-third of land with crop production potential is expected to be in use. At the regional level, however, the projected expansion of arable land would take cultivated land toward theoretical limits in Near East/North Africa and South Asia, especially when non-agricultural land uses are taken into account (see below Section 4.4). Much of the land balance is concentrated in Latin America/Caribbean and sub-Saharan Africa. These regions are estimated to use only around a fifth of their total land with crop production potential. However, a few countries hold much of the balance, such as Brazil and Zaire. Several countries within these regions are encountering difficulties raising food production due to arable land shortages at national level and most countries have some areas where the opportunity to expand cropped land is limited.

Table 4.10 Land Balances, 1988/90 and 2010

(million ha)

Land class		SSA	LA&C	NENA	EA	SA	Total
AT1	1988/90	46	9	4	0	8	67
	2010	42	9	3	0	8	62
AT2	1988/90	135	37	4	3	24	203
	2010	127	35	3	2	22	189
AT3	1988/90	235	102	2	20	13	372
	2010	224	89	2	16	13	344
AT4 + AT5	1988/90	268	596	0	40	10	914
	2010	253	591	0	33	6	883
AT6 + AT7	1988/90	112	125	6	13	3	259
	2010	109	118	6	12	2	246
Total	1988/90	796	870	16	76	58	1 816
	2010	755	842	14	65	51	1 725
Total (ha/person)	1988/90	1.691	2.005	0.053	0.167	0.051	0.648
	2010	0.828	1.354	0.027	0.103	0.029	0.393

4.63 The tendency of farmers has been to settle on the best arable land, thus in some countries the existing uncropped land is of poorer quality than cropped land for reasons of climate, soil or topography. Factors indirectly related to farming may also prevent land being used for arable activity. Poor roads can make land inaccessible and severe challenges of disease (e.g. tsetse fly) faced by humans and animals may preclude its use.

4.64 It is noted that some countries in dryland zones, notably in Near East/North Africa appear to be using more land for crop production than their total rainfed land with crop production potential estimated from the data and methodology used in this Study (see Table A.5 in the Appendix for countries with a negative balance). This suggests that farmers are cultivating land considered unsuitable for agriculture because they are prepared to accept extremely low yields or the high risk of low yields.[54] However, special methods of water capture and use, as well as contingency planning, allow adaptation of farming to low rainfall and its erratic nature in dryland areas[55] (see also Chapter 12). Moreover, that such land is utilized is often a result of past investments in soil and water conservation which have converted marginal and unsuitable land into arable land which is effectively "suitable". Steep slopes preclude some arable field operations but in some countries (especially in Near East/North Africa) farmers have modified their fields over centuries to allow more area to be cultivated, building bunds or terraces on steeper slopes. Water conveyance systems also

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[54] The yield which classifies the Agro-ecological Zone cell as "Not Suitable" for a crop is set at below 20 percent of the maximum attainable yield. For example, sorghum would not be suitable at a yield below 0.2 t/ha. Some farmers in developing countries are clearly harvesting crops with lower yields than this. For example, in 1988/90 national average yields were 0.33 t/ha in Botswana, 0.35 t/ha in Niger, 0.38 t/ha in Jordan; with the normal variability in yields, much of these areas must have yielded much less than the average and are probably located on land considered unsuitable for sorghum in the methodology used in this Study.

[55] Such as spate irrigation, start-irrigation for olives, use of short-cycle varieties, wide spacing and using cereal crop for grain or fodder depending on rainfall in a given year.

allow areas to be cultivated where rainfall alone would not be sufficient, such as the qanat systems of Iran and Afghanistan.

4.65 The use of apparently unsuitable agricultural land is most obvious in Near East/North Africa, but there are many developing countries where "unsuitable" land is being cultivated within the same national boundary while some very good land is not. For example, in Ethiopia, "unsuitable" land (either too steep, too infertile or too dry) is cultivated in the north while "very suitable" arable land lies unutilized in the south-west. In Indonesia, available land on Java has been exhausted while islands with much crop potential lie almost uninhabited.

4.66 Table 4.10 also shows the per caput areas of uncropped rainfed land with crop production potential for the base period and as expected for 2010. By this indicator, land scarcity is shown to be equally severe in South Asia and Near East/North Africa, where the balance per person is only 30 percent of that of East Asia, and around 3 percent of those of sub-Saharan Africa and Latin America/Caribbean.

4.4 Restrictions on Expansion of Arable Land

4.67 Legally protected areas and non-agricultural land uses for human settlements occupy rainfed land with crop production potential and are expanding, thus restricting expansion of arable land. Furthermore, extending of the arable frontier is in competion with forest and rangeland. Arable cropping in areas of only marginal suitability for annual crop production carries a high risk of land degradation, which can be practically irreversible. That this will continue to occur seems almost as inevitable in the future as it has been in the past, unless fragile ecosystems (such as tropical rainforests and fragile rangelands) can be protected more successfully than they have been and alternative employment and income earning opportunities are available to the rural population.

4.68 Some developing countries, such as China, Republic of Korea and Syria, have followed the pattern established in industrialized countries, with land taken out of agriculture exceeding new land brought into cultivation. With high-quality arable land often lost unnecessarily, some countries protect their most fundamental agricultural resources through strict planning laws. In part, however, decreases in arable land are due to increased land productivity: higher yields have resulted in cropping being concentrated on the better land, with marginal lands being put to alternative uses. For example, in China, less favourable deep water rice land is being converted to aquaculture because it is more profitable.

4.69 Buildings, roads and reservoirs often take up land of the highest agricultural quality. For developing countries (excluding China), human settlement areas are estimated [56] at 94 million ha for 1990 or 1.4 percent of their total land. Of this, some 50 million ha are estimated to be located on land with crop production potential. Human settlements occupy large shares of this land in Asia, especially South Asia, due to high population density. By 2010, human settlements are expected to occupy 128 million ha, of which 69 million ha would be on land with crop production potential, an increase of 19 million ha. Thus losses of potential cropland in developing countries due to expanding human habitation would be around 1 million ha per year during the next two decades.

4.70 More important, however, is the fact that expansion of human settlements would tend to absorb a good part of the uncropped land balance. Currently human settlements occupy perhaps one-third of the uncropped land balance in South Asia, and around 12 percent of that in Near East/North Africa. By 2010, they may expand to occupy 45 percent of the uncropped land balance of South Asia and one-fifth of that in Near East/North Africa (Table 4.11).

Table 4.11 Estimated Human Settlement Areas as Share of Land Balance

(percent)

	SSA	LA&C	NENA	EA	SA	Total
1988/90	1.9	1.1	11.8	9.0	31.0	2.8
2010	2.9	1.5	20.0	14.5	45.1	4.0

4.71 Data on forest areas and protected areas were not available for all the developing countries covered in this Study. However, using available information for 63 developing countries for which data were available both for forest areas[57] and protected areas, and where data could be integrated with the estimates of potential arable land, some rough estimates on the share of the uncropped land balance which is currently protected or forested could be obtained.

56 Human settlement areas were estimated as follows: the only country for which systematic data were available was China, for which there were data on both population density and non-agricultural land use per person (residence and infrastructure areas) for about 2000 counties. Based on these data a function was estimated linking non-agricultural land use per person to population density (the higher this density, the lower area per person used for non-agricultural purposes). This function was subsequently used for all countries and all agro-ecological zones in each country. Estimates of population by agro-ecological zones were adapted from estimates used in the FAO/UNFPA/IIASA 1978-82 project "Land Resources for Populations of the Future". All these estimates are tentative and probably subject to large margins of error.

57 For four countries in sub-Saharan Africa and 3 countries in Latin America, data on forest extents but no data on protected areas were available. See the list of countries in the Appendix.

4.72 For the 63 developing countries considered, some 384 million ha of land are designated as protected areas, in which arable agriculture, among other economic activities, is prohibited by law.[58] Normally these areas are national parks, conservation forest and wildlife reserves. Of such protected areas, some 200 million ha are located on land which was estimated with the methodology of this Study to be technically suitable for rainfed crop production, but should be excluded from the evaluation of available land with crop production potential [59] (Table 4.12). With protected areas on average covering an estimated 12 percent of the land balance, such areas are an especially large share of uncropped land with crop production potential in East Asia (28 percent). Protected areas are legally recognized but law enforcement is weak in some countries with the result that many protected areas are subject to farming activity, though the degree of encroachment is not well known. As the protected areas have increased rapidly in the past and are likely to continue to grow, an evaluation of land with crop production potential should ensure that protected areas are distinguished. Land use planning could serve to protect land that is marginal for agriculture but provides valuable environmental services, e.g. protecting watersheds and biodiversity.

Table 4.12 Protected Areas (PA)

(million ha)

Number of countries	SSA (32)	LA&C (18)	EA (7)	SA (6)	Total (63)
PA on total land (%)	151 (8%)	155 (10%)	63 (17%)	16 (3%)	384 (9%)
PA on land with crop production potential (%)	78 (8%)	97 (11%)	20 (14%)	6 (2%)	201 (9%)
PA as % of land balance					
1988/90	10.0	12.6	28.2	9.8	12.0
2010	10.5	13.0	33.3	11.2	12.6

4.73 Unlike the data on protected areas, those on the forest cover could not be georeferenced and overlayed on those of the land with agricultural potential. Therefore, to estimate how much forest area may be on land with rainfed crop production potential, an

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58 Classes I, II, III, IV of the Categories for Conservation Management, IUCN (1990), *1990 United Nations List of National Parks and Protected Areas*, IUCN, Gland, Switzerland, and Cambridge, UK.

59 The "exclusion" of protected areas from the estimates for rainfed land with crop production potential was not possible for all the developing countries of this study because of the absence of information on the precise location of protected land for some countries. Maps and inventories of National Parks, Conservation Forest and Wildlife Reserves were made available by the World Conservation Monitoring Centre, Cambridge, United Kingdom.

assessment of land suitability for forests was made.[60] The areas unsuitable for crop production were first tested for forest suitability.[61] This resulted in an estimate of the forest area which could be on land without crop production potential. The balance of the forest area must by definition be on land with rainfed crop production potential. As such, the thus obtained estimate of agricultural land with forest cover is a minimum estimate. The real overlap is probably much higher. It should be noted that the protected areas and forest areas considered here are not mutually exclusive, as much of the protected area is forested. These estimates indicate that at least 47 percent of the uncropped rainfed land with crop production potential is now under forest (Table 4.13).

Table 4.13 1990 Forest Areas and Related Estimates: 63 Developing Countries with Data on Forest Areas and Protected Areas

Number of countries	SSA (32)	LA&C (18)	EA (7)	SA (6)	Total (63)
A. Total forest area (% of total land)	498 (26%)	876 (55%)	181 (48%)	90 (18%)	1 645 (38%)
B.*	284 (31%)	349 (51%)	160 (69%)	70 (29%)	862 (42%)
C.**	214 (22%)	527 (58%)	21 (15%)	20 (8%)	783 (34%)
D. C as % of land balance 1990	28%	68%	29%	34%	47%
2010	29%	70%	34%	39%	49%

* B: Area non-suitable for crop production, but suitable for forest, in million ha and as percentage of total area not suitable for crop production.

**C: Minimum estimate of forest area on land with crop production potential, in million ha and as percentage of total land with crop production potential. C is the difference between A and B.

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60 Data on forest extents are from the 1990 Forestry Resources Assessment (FAO (1993), *Summary of the Forest Resources Assessment 1990 for the Tropical World*). The definition of forest is as follows: "Forests are ecological systems with a minimum crown coverage of the land surface (here assumed as 10 percent) and generally associated with wild flora, fauna and natural soil conditions; and not subject to agronomic practices. For the present assessments a tree is defined as woody perennial with a single main stem (except in coppice crops where multiple stems replace a single stem) a more or less definite crown and a minimum height of more than five metres on maturity. Only forest areas of more than 100 ha (minimum area) are considered." *Guidelines for Assessment, Forest Resources Assessment July 1990*, FAO.

61 Assessments were carried out for three types of forest: open, transitional (open and closed) and closed. The areas considered were areas declared not suitable for crop production because of steepness of slopes or other obstacles severely constraining rational crop production. This land was rated for suitability for natural forest assuming the species most adapted in each environment. The logic of the procedures is similar to the crop suitability methodologies used for the definition of the arable land classes. Thus requirements for forest in terms of temperature, moisture, soil and terrain characteristics have been classified and matched with prevailing conditions of the land without rainfed crop production potential, resulting in an assessment of forest suitability in four classes, very suitable, suitable, marginally suitable and not suitable.

4.74 As noted earlier, data limitations prevented the construction of complete land balance sheets for all countries. However, if the sample of 63 countries used above is representative,[62] a perspective on the land realistically available for rainfed crop production can be obtained by examining the shares under non-agricultural uses (Table 4.14). Settlements and protected areas effectively exclude arable cropping while crops are expected to compete further with forest area for suitable land. Of the gross land balance (uncropped land with rainfed land with crop production potential), settlements and protected areas are estimated to cover nearly 15 percent. While there is much overlap between protected area and forest, at least half the remainder is probably forest. There might also be some overlap between protected areas and settlements, but this is probably of minor importance. In Asia, settlements and protected areas already occupy over one-third of the gross land balance. By 2010, this is expected to increase to over 40 percent in East Asia and to over 50 percent in South Asia. In sub-Saharan Africa and Latin America/Caribbean, settlements and protected areas are unlikely to exceed 15 percent of the gross land balance.

Table 4.14 Estimated Shares of Human Settlements, Protected Areas* and Forest Areas in Land Balances

(percent)

Number of countries		SSA (32)	LA&C (18)	EA (7)	SA (6)	TOTAL (63)
1990	Settlement	1.8	1.2	8.1	30.3	2.8
	Protected	10.0	12.6	28.2	9.8	12.0
	Forest	27.7	68.4	29.2	33.8	46.7
2010	Settlement	2.9	1.5	12.0	46.0	4.0
	Protected	10.5	13.0	33.3	11.2	12.6
	Forest	29.2	70.2	34.4	38.9	49.0

* Protected areas for the future are unknown but it is likely that they will expand, so occupying an even larger share in the future.

5. INPUTS FOR CROP PRODUCTION

4.75 Agriculture in the developing countries will become increasingly more dependent on external inputs both in the form of material inputs (fertilizer, machines, etc.) and in the form of knowledge (e.g. knowledge required to implement integrated plant nutrient systems, integrated pest management systems and more efficient irrigation systems). The adoption or not of a particular technology (input package) is greatly influenced by agricultural policies. Some of these issues are discussed in Chapters 7 and 9. Success or failure of any technology however depends under normal circumstances (i.e. excluding man-made or natural adverse conditions) on the ability of the farmer to decide on and to implement any production technique. Development of such capacity forms the subject of Chapter 10 on Human Resources Development. The impact of the use of agricultural imputs on the environment

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62 The 63 countries account for 92 percent of the land with agricultural potential uncropped at present, i.e. for 1 670 mln ha of the total land balance of 1 816 mln ha (Table 4.10).

is discussed in Chapter 11. One of the more promising ways to counter detrimental effects on the environment is to improve the efficiency in the use of inputs. This is discussed in Chapter 12.

5.1 Irrigation

4.76 About 16 percent (123 million ha, Table 4.15) of the arable land in developing countries (excluding China) is irrigated at present.[63] In terms of harvested land this share becomes 23 percent (136 million ha), since the average cropping intensity of irrigated land is estimated at 110 percent due to multiple-cropping. Irrigated arable land is estimated to increase at 0.8 percent p.a. over the projection period to reach 146 million ha by 2010 (or 17 percent of all arable land). In terms of harvested land however it would grow at 1.3 percent p.a. to reach 180 million ha by 2010 (25 percent of all harvested land), due to increases in its average cropping intensity which would be about 124 percent by 2010. Irrigated land is by far the most important land class in terms of contribution to total production which is about 37 percent at present. More than half of the increment in crop production between now and 2010 is expected to come from irrigated land which would bring its share in total production to 42 percent by 2010.

4.77 The foreseen annual growth in irrigated land of 0.8 percent would mean a slowdown compared with past expansion. This trend had already set in during the 1980s when irrigated land grew at 1 percent p.a., considerably slower than the rapid expansion in the 1960s and 1970s. Annual growth was 1.5 percent in the early 1960s, peaked at 2.2 percent in 1972 and then started falling steadily in the 1970s. Most of the developing countries' irrigated land is in Asia: 52 percent in South Asia and 15 percent in East Asia (excluding China which has 45 million ha of irrigated land). About two-thirds of the expansion in irrigated land would be in Asia. While some 30 percent of arable land in Asia is now irrigated, this share is 26 percent in Near East/North Africa, but only 8 percent in Latin America and less than 3 percent in sub-Saharan Africa.

Table 4.15 Irrigated Land, Developing Countries (excl. China)

(million ha)

		SSA	LA&C	NENA	EA	SA	Total
Arable	1988/90	5	15	20	18	64	123
Share of total land (%)		(2)	(8)	(26)	(24)	(32)	(16)
	2010	7	18	23	20	77	146
Share of total land (%)		(3)	(8)	(28)	(23)	(37)	(17)
Harvested	1988/90	4	14	20	22	76	136
Share of total land (%)		(3)	(12)	(31)	(27)	(34)	(23)
	2010	6	18	26	26	105	180
Share of total land (%)		(4)	(12)	(34)	(26)	(42)	(25)

63 This includes irrigated land both on land with rainfed crop production potential (the land classes AT1 to AT7) and on arid and hyperarid (desert) land.

4.78 There are a number of reasons for the recent and expected future slowdown in the expansion of irrigated land. They can be summarized as follows. First, irrigation projects tend to be costly, having often accounted for a large share of expenditure on agriculture in budgets of governments and development agencies. Nearly all the better sites have by now been exploited and new areas can only be brought under irrigation at high costs. At the same time, many irrigated areas have reduced productivity or come in disuse due to lack of maintenance or problems of waterlogging and salinity. In many cases therefore it could be cost-effective to rehabilitate existing areas before expanding into new areas. Second, irrigation water is often used very inefficiently, partly because farmers pay only a fraction of the real economic cost of water due to subsidies. In such cases, it could be less expensive to save water by introducing appropriate price policies and improved water-use technology than expand water supplies (see Chapter 12). Thirdly, measures to avoid degradation problems such as waterlogging and salinity, will increase costs of irrigation projects and thus make increasing total water supply a less obvious option.

4.79 As noted, the slow-down in irrigation also reflects government and donor policies which now question the sustainability of irrigated agriculture (see Chapters 11 and 12). About 10 to 15 percent of irrigated land is to some extent degraded through waterlogging and salinization while in other areas, ground water tables are falling dangerously, as in parts of India, China and Mexico. Inadequate operation and maintenance of equipment and inefficient management of an increasingly scarce resource has been contributing to many socio-economic and environmental problems. New lands being brought under irrigation will be evaluated in the context of trade-offs between environmental impact and gains in yields. An important element in these calculations is the extent to which additional investment in irrigation may relieve pressure on overexploited rainfed lands. The environmental issues related to irrigation and technological and other policy options to respond to them are discussed in Chapters 11-12 and are not repeated here.

5.2 Fertilizer

4.80 Typical fertilizer response ratios (kg of additional crop produced per kg of additional plant nutrient applied) range from 8-12 for cereals, 4-8 for oil crops and 30-50 for roots and tubers. Though demonstrated productivity increases from mineral fertilizer are high, in many cases fertilizer costs remain prohibitive, especially for land-locked states dependent on imports. One-third of fertilizer used in developing countries is imported and shortage of foreign exchange remains often an important constraint on fertilizer consumption at the national level. At the farm level, inefficient distribution systems often prevent fertilizer from being easily available.

4.81 Estimates on fertilizer use by crop suggest that for developing countries as a whole (excluding China), cereals account for some 60 percent of fertilizer consumption, with rice utilizing one-third and wheat one-sixth. The allocation of fertilizer to cereals is marginally larger than their share of total harvested area (55 percent), though some of the coarse grains, especially sorghum and millet, use little fertilizer. Industrial crops and fruit and vegetables secure large shares of fertilizer relative to their area. Sugar cane and cotton are also major consumers (9 percent and 4 percent respectively of total). Oilcrops, roots and tubers and, especially, pulses receive little fertilizer relative to their harvested areas.

4.82 There are marked differences between regions in the allocation of fertilizer to different crops. In sub-Saharan Africa the share used by the major non-food crops is relatively large, about a quarter of total consumption. In Latin America, cereals utilize only a third of fertilizer, almost as much is used on non-food crops and oilseeds, mainly soybeans, use one-fifth. In Near East/North Africa, fruit and vegetables receive a large share (15 percent) but industrial crops only a tenth. East Asia and South Asia use more than two-thirds of fertilizer on cereals, mainly rice and wheat. Little change in the overall pattern of this fertilizer use is foreseen over the projection period.

4.83 Table 4.16 below shows the intensity of fertilizer use in developing regions and its expected growth. At nearly 90 kg/ha, fertilizer dressings in East Asia and Near East/North Africa are currently over two-thirds of the average of developed countries (around 120 kg/ha), while in South Asia and Latin America the average dressing is roughly 70 kg/ha. Fertilizer use in sub-Saharan Africa remains very low at 11 kg/ha though in practice, it is the area fertilized rather than the dressing itself which is small. The expected growth in fertilizer consumption suggests that average dressings will double in South Asia, Near East/North Africa and sub-Saharan Africa, while in East Asia (excluding China) and Latin America they would increase by around two-thirds. For Near East/North Africa and Asia, this would imply average dressings exceeding current levels for developed countries as a whole but their year 2010 level would still be well below current levels in EC countries (250 kg/ha).

Table 4.16 Fertilizer Use per Hectare

	[illegible]ested land		
	1988/90	2010	annual growth %
Sub-Saharan Africa	11	21	3.3
Latin America/Caribbean	71	117	2.4
Near East/North Africa	89	175	3.3
South Asia	67	133	3.3
East Asia (excl. China)	86	141	2.4
Developing Countries (excl. China)	62	110	2.8

* Manufactured Fertilizer in kg N, P2O5, K2O.

4.84 The share of the world's fertilizer consumption in developing countries continues to grow, from 20 percent in 1970 to 32 percent in 1980 and 43 percent in 1990. By 2000, the proportion is expected to exceed 50 percent. Developing countries' fertilizer consumption grew at over 9 percent p.a. in the 1970s but at less than 6 percent p.a. in the 1980s. Growth in consumption is anticipated to slow further with the annual rate of increase in the next two decades expected to be 3.8 percent. Projections suggest quite different patterns of growth in the future from those of the recent past (see Table 4.17). Sub-Saharan Africa's fertilizer consumption, after strong growth in the 1970s (6.2 percent p.a.), increased by an average of 2.8 percent p.a. in the 1980s but stagnated from 1985 onwards. Future growth in this region is expected to be higher again which would reflect its expected higher agricultural production growth as discussed in Chapter 3. Fertilizer consumption in Latin America, which went through severe adjustment problems in the 1980s, showed lower growth in this

period (3.0 percent p.a.), but growth is expected to be slightly higher over the projection period. After high rates of growth in the 1970s and 1980s, consumption of fertilizer in Asia is likely to show more moderate growth rates (less than 4 percent p.a.) in the next two decades. This reflects agricultural production growth lower than in the past and relatively high dressings already reached in favourable areas.

Table 4.17 Total Fertilizer Consumption

	Consumption (million tons)				Annual growth (%)		
	1969/71	1979/81	1988/90	2010	1970-80	1980-90	1988/90-2010
Sub-Saharan Africa	0.4	0.9	1.2	3.3	6.2	2.8	4.8
Latin America/Caribbean	2.8	6.8	8.2	16.9	10.1	3.0	3.5
Near East/North Africa	1.3	3.5	5.6	13.1	10.6	4.8	4.1
South Asia	2.9	7.4	14.8	32.9	10.3	7.8	3.9
East Asia (excl. China)	1.9	4.0	6.9	13.7	7.6	6.4	3.3
Developing countries (excl. China)	9.3	22.6	36.8	798.3	9.6	5.6	3.8

4.85 Declining growth rates in consumption in some developing regions suggest that the diffusion of fertilizer use is becoming more difficult, largely because the remaining environments where fertilizers are not yet used have less-favourable physical, biological and economic conditions. In all regions except sub-Saharan Africa most farmers, even small farmers, are already using fertilizers both for cash crops and staple food crops and the opportunities to increase the fertilized area have become more limited. Though fertilizer use per hectare in developing countries is generally much lower than in developed countries, dressings appear to be reaching their ceilings in some parts of Asia. For example, for wheat, the average dose in developing countries (excluding China) approaches 80 kg nutrient/ha while developed countries apply 106 kg nutrient/ha.[64]

4.86 In contrast to the environmental problems encountered at higher levels of fertilizer use, sub-Saharan Africa generally suffers from too little use, with less than one-fifth of the cereal area fertilized and few countries with average dressings above 20 kg/ha.[65] Some countries of other regions also appear to use little fertilizer such as Laos (under 1 kg/ha), Bolivia (5 kg/ha), Paraguay (5 kg/ha), Myanmar (11 kg/ha), and Yemen (16 kg/ha). Such low levels of fertilizer use may in some cases represent a serious threat to sustainability. Harvested crops "mine" the soil of its nutrients unless they are replaced with plant residues, manures or fertilizers. Soil nutrient deficiencies limit potential yield in many developing countries, especially in sub-Saharan Africa and Latin America/Caribbean. Net average losses

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64 CIMMYT (1989), *1987-88 CIMMYT World Wheat Facts and Trends. The Wheat Revolution Revisited: Recent Trends and Future Challenges*, Mexico.

65 FAO/IFA/IFDC (1992), *Fertilizer use by crop*, ESS/Misc/1992/3.

of more than 50kg/ha are not uncommon. Soil mining, if left unchecked, will lead to significant soil degradation and declining crop yields.

4.87 Some developing countries are now encountering difficulties in increasing yields despite progressively larger doses of manufactured fertilizers. The efficiency of fertilizer use is often quite low, commonly the result of incorrect timing and poor application methods or failure to maintain the balance of the main nutrients (nitrogen, phosphorus and potassium), secondary nutrients and micronutrients. Soil toxicity such as salinity, alkalinity, strong acidity, iron toxicity and excess organic matter, also prevents the full benefits of fertilizer from being expressed. Evidence suggests that fertilizer alone may be insufficient in the long term and that measures to enhance organic matter in the soil are essential. Crop and nutrient management at plot, farm and village level will have to become increasingly sophisticated to ensure that the lack of one element does not prevent the value of all the nutrients from being realized.

4.88 An integrated plant nutrition systems (IPNS) approach to fertilization is being increasingly advocated - optimizing the use of all possible sources of plant nutrients. Thus organic manure, increasing biological fixation and mineral fertilizers are utilized in an integrated manner to improve or maintain soil fertility in cropping systems (see Chapter 12 for more details on IPNS).

5.3 Plant Protection

4.89 Intensification of agricultural production enhances the risks of pest[66] damage. Pressure from animal pests, diseases and weeds is higher in areas where the same crop is grown all year round. Modern varieties are often more susceptible to pest damage and the necessary pest management measures may not initially be in place. Although insect pests are abundant in the humid tropics and sub-tropics, weeds are probably a persistent cause of yield losses in the tropics and more effective weed control could be the most important form of plant protection to raise crop productivity in those countries.

4.90 Traditional plant protection methods remain important in developing countries: tillage (ploughing and hoeing), flooding and burning all contribute to reducing weeds, diseases and animal pests. "Cultural" control measures including crop rotations and disposal of plant material, also help reduce losses due to pests. In addition, chemical control methods have become widely used in developing countries during the last decades. Pesticide consumption varies widely by crop (see Table 4.18). Worldwide pesticide use is high for cotton, deciduous fruits, vegetables, and rice, but is more moderate on citrus fruits, cocoa, coffee, maize, potato, sugar cane, tea, and tropical fruits, while very few pesticides are used on barley, millet and sorghum.

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66 The term "pest" here is used to describe all organisms that cause crop damage, such as animal pests including insects, mites, nematodes, and pathogens such as fungi and bacteria, and weeds.

Table 4.18 World Pesticide Use by Crop

Crops	Herbicides (%)	Insecticides (%)	Fungicides (%)	Total Pesticides (%)
Fruit & vegetables	16	27	43	26
Rice	11	17	16	14
Maize	18	8	1	11
Cotton	5	25	2	11
Wheat	14	2	13	10
Soybean	17	3	2	9
Sugar beet	6	3	2	4
Others	13	15	21	15
Total	100	100	100	100

4.91 Pesticide consumption in developing countries in 1980 was some 620 thousand tons (active ingredient),[67] but then declined, especially in sub-Saharan Africa, Latin America and Near East/North Africa. By 1985, consumption was around 530 thousand tons, but then resumed growth, albeit at a low 1 percent per annum, about the same as growth in developed countries over the same period. By 1991, estimated expenditure in the developing countries on pesticides amounted to US$5.7 billion. In developed countries new policies are gradually being implemented which are expected to reduce pesticide use, but developing countries may continue to show increases in pesticide use, reflecting intensification of production as well as the development of new areas. Pest control strategies that reduce pesticide dependency are, however, already gaining a foothold in developing countries. Most of the growth in pesticide consumption is likely to be in South and East Asia and Latin America.

4.92 Developing countries only accounted for about one-fifth of global consumption of pesticides in the mid-1980s. Their share in world use of insecticides is relatively high at 50 percent, while this share is 20 percent for fungicides and 10 percent for herbicides. East Asia (including China) accounts for 38 percent of developing countries' use of pesticides, Latin America for 30 percent, Near East/North Africa for 15 percent, South Asia for 13 percent, and sub-Saharan Africa for only 4 percent. Currently, around 50 percent of pesticides used in developing countries are insecticides, with fungicides accounting for 35 percent and herbicides 15 percent of total consumption. This contrasts with developed countries, where herbicides account for 48 percent of consumption, fungicides for 35 percent and insecticides only for 17 percent. The differences can be explained by both ecological and economic factors. In humid tropical countries, pest generations may follow each other without being reduced by low temperatures or aridity. Under these conditions damage from insect pests can be particularly severe and also the pressure from fungal infections is strong. In semi-arid areas, animal pests are a severe threat and insecticides are widely used to control migratory pests such as locusts. Fungal diseases are often less important in such areas. Low labour costs prevailing in many of these countries can make manual weed control more economical than herbicide use.

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67 "Active ingredients" means the biologically active part of the pesticide in a formulation, the latter being a combination of various ingredients designed to render the product useful and effective for the purpose claimed.

4.93 The pattern of pesticide consumption is expected to change in developing countries, with an increase in herbicide use where labour is becoming scarce, while insecticide and fungicide use would show less of an increase. As patents on certain products expire, the retail prices for some "older" pesticide types are reduced. Pesticides consumption in developing countries consists mainly of patent-expired, established products and the impact of new products from recent research and development will therefore be much less than in developed countries. Though the cost of pesticides is a small proportion of the total value of agricultural production in developing countries, pesticide use is concentrated on a few crops and for such crops it can account for a high proportion of total production costs, commonly over one-fifth.

4.94 The foreseen increase in demand for plant protection cannot be met through a simple proportional increase in the consumption of pesticides. While pesticides are barely used for some crops, other crops have been subject to excessive applications. Indiscriminant or over-application of pesticides has unacceptable effects on human health (residues in food commodities, hazards to the farmer, etc.) and the environment, and allows pests to develop resistance. These consequences are recognized and pressure has been building up to implement stricter legislation, but control of pesticide distribution and use in most countries is still considered inadequate. The environmental issues related to pesticide use and the technological options to respond to them (in particular Integrated Pest Management) are discussed in Chapters 11 and 12.

5.4 Seeds

4.95 Improved cultivars will continue to offer farmers an effective means to increase yield. Notwithstanding the advent of biotechnology, conventional plant breeding is expected to continue to provide most of the genetic improvement in cultivated plants well into the next century. Potential yields for many staple crops are far above the average yields realized in developing countries. While attempts to raise absolute yield ceilings continue,[68] adapting higher-yielding types to specific conditions and overcoming local constraints will be more important in raising average yields in developing countries. This includes extending the area suitable for crops through breeding varieties with increased tolerance to biotic stresses (diseases, insects, weeds) and abiotic stresses (soil toxicity, temperature, water).

4.96 Seeds produced by the formal seed sector (by public agricultural research and the private sector) are referred to as "modern varieties" (MVs) though are often also described as "high yielding" or "improved" seeds. Such genetic material has been the foundation of the green revolution. "Traditional", "local" or "farmers'" varieties are indigenous types but include those with some exotic material. Between farmers' varieties and modern varieties are a wide range of intermediate ones embodying improvements in various degrees. Though modern varieties are increasing their coverage, traditional varieties remain important both because of their performance and as a source of genetic diversity. Traditional varieties sometimes have superior performance in particular locations, especially in marginal

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68 Concerns that average yields will not increase unless the absolute yield ceilings are broken should be set against the experience of most developed countries: high absolute yields were achieved in cereals more than twenty years ago at research level but national average yields have been raised steadily since, without a commensurate increase in experimental yields.

environments, and on-farm selection of traditional varieties has achieved substantial improvements in yields. The loss of varieties and individual genes has been accelerated by modern plant breeding methods and may be a threat to long-term sustainability of agriculture. However, a large degree of genetic diversity can be maintained with relatively few traditional varieties.

4.97 Experience has shown that modern varieties are not adopted in certain situations. If for MVs the quality of the crop is inferior or input needs are higher, farmer's earnings may be lower or at least not significantly higher. On the other hand, farmers may adopt a modern variety, even when lower-yielding, if it confers other advantages. A typical benefit of modern varieties is early maturation, which may enable more timely planting of the next crop in the rotation, or reduce risk of crop failure during a shortened rainfall season.

4.98 Genetic potentials of many staple crops (other than wheat, rice and maize) have increased little in developing countries. In the last decade, national and international breeders have however been giving more emphasis to genetic improvement of "orphan crops", those that benefited little from the green revolution. This reflects increased awareness of the importance of these staples to food security in many developing countries, particularly in marginal areas. Progress in raising yields of "orphan crops", notably sorghum, millet, pulses, roots and tubers, have been frustrated in part because of the unfavourable environments (socio-economic as well as physical) in which these crops are typically grown. Recent research has offered improved varieties for some environments, usually those with adequate moisture, but under marginal rainfall conditions the degree of risk in using such seeds often discourages farmers from doing so, especially when other inputs are needed to benefit from the improved varieties. Countering fluctuations in yield is therefore often of higher priority than raising potential yield. The formal seed sector generally has not been responsive to the needs of small farmers, and for national seeds systems this is often a too difficult and expensive undertaking. Recognizing this, local level seed supply is receiving increased support from governments and development agencies.

4.99 The proportion of the area planted to modern varieties may not coincide with the share of seed which is purchased off-farm every year. Farmers may either "re-cycle" seed from modern varieties, especially for non-hybrid types [69] or they may buy-in material that is not modern. It is estimated that seed which has not been through marketing channels is being used on some 80 percent of the cropped area in developing countries.

In what follows, varieties will be discussed for major staple crops.

4.100 In many countries, *rice* yields realized by farmers are still relatively low and with some 70 percent of the rice area of developing countries (excluding China) under MVs their adoption is not complete. MVs developed so far have been best-suited to irrigated and favourable lowland areas. Differences in adoption rates of MVs are strongly influenced by

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[69] Hybrid seeds are MVs obtained from a cross of two genetically different parents, and normally higher yields result from increased vigour (heterosis). Hybrids can not be reused successfully and have to be reproduced each season.

the degree of water control or irrigation.[70] Nevertheless, there are also other factors important for the adoption of MVs: in some countries, including the major exporters, yield advantages of modern varieties are more than offset by higher prices paid for traditional varieties (such as Basmati rice) due to the superior palatability of the latter. Recent progress in breeding higher-yielding aromatic types may therefore have a substantial impact in South Asia.[71]

4.101 The gap in yields between irrigated and non-irrigated areas has widened, and is expected to widen further. Average yields in Egypt and the Republic of Korea now exceed 6 tons/ha and are over 5.5 tons/ha in China: in these countries more than 90 percent of rice is irrigated. Yields average 3-4 tons/ha in irrigated areas of Bangladesh, India, Indonesia and the Philippines but have largely remained stagnant at 1.0 to 1.5 tons/ha in unfavourable ecologies where traditional varieties have continued to be used. Some progress in raising yield potentials in more marginal environments is expected to emerge from current breeding efforts but the main impact on production will be from adaptation of high-yielding semi-dwarf and hybrid types to local conditions. Hybrid rice will permit further yield increases to be made in East Asia and it is also being introduced in India, Viet Nam and the Philippines. Hybrids will largely be in substitution for, rather than incremental to, existing high-yielding varieties. The extension of hybrid rice to other areas will have a profound influence on production before 2010 (see Box 4.1 on hybrid rice).

4.102 Significant yield benefits are conferred with semi-dwarf varieties of *wheat*, not least because of their high responsiveness to fertilizer. Such varieties were key elements of the green revolution and are now estimated to account for some 65 percent of the wheat area in developing countries. Semi-dwarfs make up over 70 percent of wheat planted in Asia and Latin America while in Near East/North Africa and sub-Saharan Africa these varieties account for 30 to 40 percent of the wheat area. Virtually all irrigated wheat is now sown with semidwarfs. The spread of these types has been slower in rainfed areas, though diffusion was facilitated by breeding varieties with resistance to major fungal diseases in the 1970s. About half the area sown to semi-dwarfs in developing countries is now rainfed but the use of these varieties is generally correlated with moisture: they cover around 60 percent of the area in good rainfall environments but only 20 percent in drier areas.

4.103 The opportunity to lift the current yield plateau much further appears limited and no hybrid wheat is foreseen. Following the advantage conferred by the first widely successful varieties, more modest but still significant increases in yield have occurred. Since semi-dwarf wheats were released in the 1960s, plant breeders have maintained a long-term average yield gain estimated at 0.7 percent per year. Much current breeding effort is maintenance research, i.e. maintaining crop resistance to changes in insect pests and diseases.

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70 In the Philippines and Indonesia production environments are generally favourable and their adoption rates are amongst the highest in Asia. India's adoption rates are lower than in the Philippines because a greater proportion of its rainfed areas are drought-prone, flood-prone or both.

71 In Bangladesh, Pakistan and Thailand, MV adoption is relatively low; even in irrigated areas MVs are not used because the quality of available MVs has been poor. Semi-dwarf Basmati varieties have only recently been released in Pakistan and India.

Box 4.1

HYBRID RICE

Hybrid rice has shown a quantum leap in yield in China and hybrid rice seed technology is progressing in other major rice producers such as India, Indonesia and Viet Nam. Hybrid rice was introduced to farmers in China in the mid-1970s, with adoption accelerating in the 1980s. In 1992-93 it was grown on 19 million ha in China (65% of the country's total harvested area of rice), 10 000 ha in Korea DPR, and 20 000 ha in Viet Nam. It is expected that India's hybrid rice area will increase from 10 000 ha in 1993 to over 500 000 in 1996.

Hybrids in irrigated conditions generally yield 1 ton/ha (paddy) more than the semi-dwarf modern high-yielding varieties with the same amount or sometimes even less inputs. Many Indian and Vietnamese hybrids have shown a yield advantage of 1.5 to 2.5 tons/ha. Evidence suggests that the yield advantage of heterosis is relatively greater in lower productivity areas. The International Rice Research Institute (IRRI) hybrid variety IR64616H has been recommended for on-farm evaluation in the Philippines after three seasons as the highest-yielding early-maturing variety in national trials. At 10.7 tons/ha it has the highest yield ever recorded at the IRRI farm.

Progress on hybrid rice seed production technology has dramatically lowered the price of seed in China. Yields of hybrid seed were only 1-1.5 tons/ha in 1970s but increased to 2.3 tons/ha in the 1980s and 4.5 tons/ha in 1991-92 (with a peak of 6.35 tons/ha). Because of the high cost of hybrid rice seed, hybrids were only profitable in transplanted rice and in irrigated and favourable lowland rice ecologies during the 1980s. With seed costs having fallen, it is now estimated that hybrids would be profitable on 70 million ha worldwide (nearly half of the 145 million ha total rice harvested area). If the cost of hybrid rice seed, as is expected, falls even further hybrid cultivation could become profitable in direct seeding (which requires ten times more seeds than in transplanting) in irrigated and favourable lowland ecologies.

Hybrid rice programmes are underway in Colombia, Brazil and Guyana. A programme to develop less labour-intensive ways to produce hybrid rice has been formulated in Indonesia and Viet Nam based on the discovery of photo- and thermo-sensitive genic male sterility. Different types of hybrid rice are under development and results have been impressive. The future of hybrid rice seed technology will be based on apomixis-asexual reproduction, requiring the cooperation of upstream research (genetic engineering and protoplast fusion) in China and developed countries. With apomictic hybrids, farmers can retain seeds from their crops for many seasons whereas with conventional hybrids farmers must renew seeds each for each planting.

4.104 Hybrid *maize* has been established for at least three decades in developing countries and no other breakthrough is foreseen in the short-term to shift the yield plateau of this crop. Open pollinated varieties are less expensive to develop and received more attention in the 1970s but improved germplasm for tropical hybrids recently shifted the emphasis in national breeding programmes back towards hybrids. MVs have not yet been adopted everywhere, in particular since breeders still have to find improved varieties which meet the needs of certain groups of farmers. More location-specific adaptive breeding of improved varieties and hybrids is still needed. Some progress in reducing the vulnerability to drought during the crucial silking period is however probable in the near future, which would be of major importance in much of the semi-arid tropics.

4.105 Greater adoption of MVs has occurred in more favourable environments and among more commercially oriented farmers. The pattern of adoption is typically a progression from local varieties to improved open pollinated varieties and then to hybrids. The area coverage by MVs is around 60 percent for East and South Asia and just under 50 percent in Latin America and sub-Saharan Africa. The highest rates of adoption are in southern Latin America and the East Asian countries, using genetic material derived mainly from the United States, which are suitable to temperate climates. The lowest rates of adoption are in western Africa and the Andean countries of South America, where maize is grown under low fertility conditions and primarily by poor farmers for home consumption. Intermediate levels of adoption are reported in Mexico and in most countries of South Asia.

4.106 Although maize benefited from the green revolution, it has shown pronounced geographic variability in yield gains in developing countries which is indicative of the difficulties in raising yields of the so-called "orphan" crops. While wheat and rice which are grown under relatively homogeneous agroclimatic conditions where new technologies can be disseminated more easily, maize is grown under a wide range of agroclimatic conditions and improved varieties cannot always be diffused rapidly. Much of the developing world's maize is grown in marginal environments characterized by unreliable rainfall or low soil fertility. Hybrid maize seed generally needs specialized production and distribution facilities which are lacking in many developing countries.

4.107 *Sorghum* hybrids are widely used in South Asia and Latin America while in Africa, hybrids have shown good yield potential, with yields up to 50 percent higher than yields of control varieties,[72] but seed production is still in the experimental stage. Though improved higher-yielding cultivars are available, these do not seem to express themselves in unfavourable environments. It is widely held that improved soil moisture and fertility status are indispensable for higher-yielding varieties. Nevertheless, breeding in these grains is often aimed at stabilizing rather than maximizing yields. Sorghum varieties with resistance to the parasitic weed striga, which is a severe problem in Africa, have recently been released, and lines are now available with tolerance to acidity and aluminium toxicity, which is especially important on some Latin American and African soils. Identification of the mechanisms of drought tolerance are producing improved *millets* and some new varieties are less vulnerable to downy mildew, which is a severe disease of pearl millet.

4.108 The potential to improve *starchy staple crops* is considered high and so far they are underexploited in genetic terms. In the past two decades, high-yielding cultivars have been bred for resistance to major diseases and insect pests for cassava, sweet potato and potatoes. The production and distribution of planting materials from those varieties with stable resistance is straightforward. However, certain root and tuber crops (yams, aeroides, plantains and cooking bananas) remain vulnerable to insects and disease. Propagation of starchy staples as true seed, as opposed to the vegetative means which are normally employed, does not normally transmit important viruses and other diseases. The problem of disease transmission and multiplication through vegetative propagation is perhaps the most important constraint to production increases of starchy staples. The dissemination of healthy

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72 Hybrid ICSH 89002 NG averaged 3.7 tons/ha over eight locations the highest grain yield in Western Africa. See the 1991 Report of ICRISAT (International Crops Research Institute for the Semi-Arid Tropics).

planting materials requires establishment of nurseries with efficient production and distribution systems, which has proven to be difficult to implement. A more realistic approach would be to develop cultivars with inherent resistance to diseases and insect pests which could be easily multiplied and used by growers with traditional methods. True seed, rather than cuttings, generally does not transmit viruses and diseases and can be used where quality considerations, particularly regularity in size and shape, are of less importance.

6. INPUTS FOR LIVESTOCK PRODUCTION

Below a number of issues related to inputs for raising livestock production are discussed. Chapter 12 discusses further technological options for raising livestock productivity.

6.1 Animal Health

4.109 Meat, milk and egg production are still severely curbed by pests and diseases. Some estimates show that at least 5 percent of cattle, 10 percent of sheep and goats and 15 percent of pigs die annually due to diseases. Apart from the direct loss of animals, indirect losses are incurred as a consequence of poor reproductive efficiency, retarded rates of growth and low levels of production. Growth in meat production between now and 2010 is expected to be derived for about one-third from increases in productivity and two-thirds from greater animal numbers. Together with improved management, veterinary measures to control major epizootics and various disease vectors (such as ticks and tse-tse fly) and preventive medicine will play an important part in increasing yields from both single animals and herds.

4.110 Major infectious animal diseases are those that are of significant economic importance, or have public health implications (such as rabies or brucellosis), or have recently been introduced and threaten to disrupt the sector (such as African Swine Fever (ASF) in Latin America in the 1980s) or can be effectively controlled by vaccination. Disease eradication in developing countries has been fraught with difficulties but the successes are notable. ASF has been eradicated from Cuba, Brazil and the Dominican Republic, and Babesiosis from large areas of Argentina and Mexico. Contagious Bovine Pleuropneumonia has been eliminated from the Central African Republic. Foot and Mouth Disease has been eradicated from all central American countries and also from Chile, though it occurs in all other countries in Latin America.

4.111 There is a large group of chronic diseases that have more insidious effects than the major infectious diseases. Their importance is often overlooked and seriously underestimated. Though less obvious, they often have a serious economic impact through their effects on production or reproductive performance. Examples are helminth infestations, enzootic pneumonia of pigs, mastitis in dairy cattle, and chronic respiratory diseases in poultry. While managerial procedures and prophylactic animal health measures are facilitated when stock is raised under intensive production methods, the higher stocking rates and heightened stress can increase the risk of catching diseases. The development of more intensive production systems causes also a change in the disease spectrum. In cattle, as rinderpest and pleuropneumonia decline, other diseases such as brucellosis, leptospirosis and mastitis usually become more important. For poultry, the conversion from extensive village

poultry practice to intensive commercial systems shifts importance from, for example, Newcastle disease towards chronic respiratory disease, Marek's disease and Gumboro disease.

4.112 In Africa, existing and planned production facilities should make the continent largely self-sufficient in key vaccines which will be a base for substantial improvements in livestock health. The Pan-African Rinderpest Campaign will require around 100 million doses annually, and protecting the cattle population at risk from bovine pleuropneumonia requires some 60 million doses per year. The major disease constraint in Africa however remains trypanosomiasis, which is virtually the only disease which, without preventive measures, entirely precludes the introduction of cattle, though some cattle strains have developed a degree of resistance.[73] Many sub-humid tsetse-infested areas with good agricultural potential could be utilized in a more sustainable manner with mixed farming systems using draft animals. Recent research has provided new control techniques which require low technology inputs and, unlike older methods, do not rely on large applications of insecticides. In many parts of sub-Saharan Africa, however, attempts to improve livestock breeds and dairy production will continue to be hampered unless efforts are made to contain trypanosomiasis. As in other developing regions, the likely expansion of intensive pig and poultry production in Africa will depend on regular measures to control diseases such as avian encephalitis and infectious bronchitis.

4.113 Unlike Africa, Latin America is free from diseases such as bovine pleuropneumonia, rinderpest and peste de petits ruminants. Foot and mouth disease however continues to be a problem. After the successful eradication of the New World Screwworm from the United States and Mexico as well as North Africa, efforts are concentrated on screwworm control in the Caribbean and Central America.

4.114 Asia is also largely free of major infectious animal disease problems in cattle and buffalo. An expanded programme for rinderpest control has been implemented in the Near East and another one is planned for South Asia, both having substantive vaccine requirements. Control of foot and mouth disease and brucellosis in the Near East are of particular concern. Developing preparedness to deal with emergency animal diseases has become an important activity in the region. In many Asian countries, notably the Philippines, Thailand, Indonesia and Bangladesh, the poultry sector is very important and control of Newcastle disease crucial, particularly at the village level. In Bangladesh, the estimated annual loss to poultry diseases is US$ 240 million of which about half is attributable to Newcastle disease alone.

4.115 Where intensive pig industries have been established, classical swine fever is one of the main threats facing production and trade in pigs and pig products. Diagnosis needs sophisticated laboratory testing and trained personnel while facilities are necessary for control

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[73] Some cattle, sheep and goat strains in western Africa have developed tolerance to trypanosomiasis through natural selection. Limited information (from the International Livestock Centre for Africa) on the productivity of trypanotolerant cattle suggests that under light tsetse challenge their loss of performance is negligible and comparable with breeds outside trypanosomiasis risk areas. However, under medium and high tsetse challenge the productivity index falls around a quarter and a half respectively. No evidence suggests that the trypanotolerant of sheep and goats have a lower level of productivity than other sheep and goats in Africa.

and eventual eradication. African swine fever would have devastating effects on the large pig population in Asia and careful monitoring is needed to prevent it from entering the region.

4.116 In the future further development of good quality cost-effective vaccines against most bacterial and viral diseases is expected. The failure of some international eradication campaigns (e.g. rinderpest) was however not due to lack of a suitable vaccine, but to poor veterinary infrastructure. One of the pre-conditions for improved veterinary health will be further investment in expansion of diagnostic facilities and in training of veterinary personnel.

6.2 Roughages and Cereal Feeds

4.117 Feed requirements for ruminant and non-ruminant species have traditionally been provided through grazing, crop by-products and, to a lesser extent, fodder crops. Most of the feed energy supply for ruminants is from rangelands, pastures and crop residues. Reduced communal grazing resources due to increasing population, arable land expansion and degradation of pasture are making livestock increasingly dependent on crop residues.

4.118 Though pasture and forage sources remain the most important animal feedstuffs in developing countries, their supply has increased only slowly and has been inadequate to meet demand for livestock products. Concentrate feeds, mainly feed grains, have been increasingly used to supplement other fodder. Grain output has been growing much faster than pastures and fodder and its use as feed has increased considerably in the past thirty years. Its share in total livestock feed is expected to increase further for the following reasons. Over-grazing is already widespread in much of Africa, Asia and certain parts of Latin America, and the institutional changes required to prevent it will take many years. Pasture improvement and the growing of forage have yet to be widely accepted by pastoralists or settled farmers, except in parts of North Africa, the Near East and China. Expected crop production in some countries will not provide sufficient by-products to meet protein and, in some cases, the metabolizable energy needs. Some nutritional deficits can be met by the use of feed additives, notably urea and molasses, but most of the shortfall in roughages will have to be met by the use of concentrates.

4.119 Cereals, milling by-products, cassava, roots, feed pulses, molasses, oil meals and cakes are the main commodities used for concentrate animal feed. The composition of the livestock population will largely determine the composition of the feed requirements: higher proportions of intensive dairying, poultry and pigs will increase the use of cereals as feed.

4.120 The middle-income countries and China account for over 92 percent of cereal feed use in the developing countries. There is a higher demand for livestock products in the middle-income countries where production systems are generally more intensive, especially for poultry, eggs and dairy. This pattern is likely to persist, with middle-income countries and China using still 92 percent of total cereal feed use by 2010. As discussed in Chapter 3, total feed use of cereals grew by 5.5 percent annually over the last twenty years to reach to 154 million tons in 1988/90, while livestock production grew at around 5.3 percent annually over the same period. The discussion in Chapter 3 also sets out the reasons for an expected slow down in the growth rate of feed demand for cereals to 3.6 percent per year over the

projection period up to 2010, by when total cereals feed demand is expected to reach 327 million tons accounting for over 22 percent of all cereal use in developing countries.

6.3 Animal Genetic Diversity

4.121 While only a few species of livestock are used to meet human needs (in terms of meat, milk, skins, fibre, draft power and fuel), those species have each been developed in a wide array of production environments and to produce specific product types, giving rise to a large number of unique breeds each with their own gene pool. It is the range of genetic diversity formed by this array of breeds which provides the key to future increases in efficiency and sustainability of livestock production.

4.122 Indigenous breeds have been developed to produce within their own specific environment and often possess attributes which are not immediately apparent (for example, the ability to withstand local stress conditions which may not occur each year). In many cases, improved breeds which, under different conditions, have greater output are introduced and crossbreds produced may well be better than the local pure breed. Subsequent backcrosses to the "improving" breed may well result in lower overall productivity due to lower rates of reproduction and lower survival chances, greater disease susceptibility, and the inability to cope with high levels of roughage in the ration. Improved use of available feed resources can be achieved by selection of breeds under the appropriate conditions.

4.123 Crossbreeding can be a most valuable strategy and utilizes the benefits of hybrid vigour. However, sustainable systems of crossing are not easily achieved in all species, particularly those with low rates of reproduction such as horses, cattle, buffalo and some sheep and goats. The practical bottlenecks are the more complicated logistics and reliable provision of sufficient crossbred replacement stock.

4.124 Nevertheless, future technology such as embryo cloning combined with other modern technology such as artificial insemination, *in vitro* fertilization and semen or embryo sexing offers some potential for the better utilization of heterosis. For example, the continued production of first cross (F_1) females for milk production, benefits to the maximum extent possible from both indigenous and exotic genes. Such use of F_1 animals are commonplace in species with higher reproductive rates (pigs, poultry, some sheep).

4.125 The ability to provide animals best suited to the many particular environments, both those of today and of the future, depends on the maintenance of a wide spectrum of diversity within each domestic species. The diverse strains can then be used as required to cover the inevitable change in production environments which occurs with development. The maintenance of genetic diversity is crucial to allow the full exploitation of all genetic means to provide the most efficient production of animal products. Because of the way biology operates in its transmission between generations, the most cost-effective means of sustaining domestic animal diversity is through well-designed breeding operations making continual use of it.

CHAPTER 5

FORESTRY

1. INTRODUCTION

5.1 Forests constitute a major form of land use and have a number of highly important functions. They provide services which contribute to the well-being of people; they have a major role in the environment; and their products are vital in the economy and daily living of people. Forests constitute a renewable resource capable, with sound management, of producing valuable products. They are capable of regrowth and regeneration, and at the same time, they fulfil environmental functions of soil and water conservation and the conservation of biodiversity. The products of the forest and forest industry are generally environmentally beneficent; they have potential for being recycled either in production or in energy generation and the industries themselves have potential for high energy efficiency and low negative impact on air and water quality.

5.2 Through history, forests, as the major natural occupants of land, have been subject to clearance for agriculture, pasture and human settlements. This clearance and cutting wood for fuel, construction and industry have been in the first instance without consideration of the need to ensure sustained delivery of products and services of the forests for the future. With the growth of population and wealth, the demand for land for agriculture as well as the demand for forest products and services increase. At the same time, the side effects of other activities influence the production and service functions of the forest. Thus, the production of more and more of the goods and services of forests are in competition with one another and with other uses of the forest land.

5.3 The future development of the sector has to confront the increased demand for its products, for its services and for the conservation of increasingly scarce ecosystems and biodiversity, as well as for providing sustainable livelihoods to forest-dwelling and forest-dependent communities. At the same time, the forest area, and thereby its supply capacity, will continue to be subject to increasing pressures for the transfer of forest land to agriculture, infrastructure and urban uses. Meeting these intricately interrelated demands and resolving the conflicts among them will be a major challenge for the future. Responding to this challenge will require more efficient and environment-friendly technologies for producing forest products and safeguarding the service functions of the forest; and the recognition of forestry's important role for ensuring sustainable livelihoods in reconciling the very diverse interests in making land use decisions.

5.4 The following sections consider, in turn, the state and trends to change in forests in land use, the present and projected future role of forest products in the economy and the interrelationships between the forest and the environment. The chapter concludes with a review of the future perspectives for sustainable development of the forest.

2. FOREST IN LAND USE

5.5 The world forest area was estimated in the FAO 1990 Forest Resources Assessment to be 3.4 billion ha - an average of some 0.7 ha per head of population. In this estimate, forests are defined as ecological systems with a minimum of 10 percent crown coverage of trees. In addition, there were some 1.6 billion ha of other wooded land with some woody vegetation.

Table 5.1 Forest Area in 1990

	Forest Area	% of Total Land Area	Other Wooded Land
	billion ha		billion ha
World	3.4	26	1.6
Developed	1.4	26	0.5
Developing Tropical	1.7	37	1.0
Other	0.3	13	0.1

2.1 Forests in the Tropical Zone

Natural Forest

5.6 The 1990 area of the natural tropical forest i.e. not including forest plantations, was 1.76 billion ha and accounted for 37 percent of the total land area of the tropical countries covered in the data (Tables 5.2, 5.3). The area of forest per caput in the tropical zone was 0.72 ha. About three-quarters of the tropical forest is in the tropical rainforest zone and the moist deciduous forest zone. Dry lowland formations and upland formations each constitute 12 percent of the total area. Deforestation is a major issue for the tropical forest. For the period 1980-90 it was estimated that the gross loss of tropical forest area[74] amounted to 15.4 million ha, or 0.8 percent of the forest area annually. This indicates a higher rate of deforestation than was estimated in the 1980 assessment.

5.7 In the assessment of the tropical forest resources, a high correlation has been found between the change in the forest area and the change in population density. The exact nature of the relationship varies between ecological zones. According to the model used, the process of population/forest interaction resembles a biological growth process where deforestation is observed to increase relatively slowly at initial stages of increases in the

[74] Gross: before accounting for the area added to forest by reforestation/afforestation.

population density, much faster at intermediate stages and slowly in the final stages.[75] This model has been used to estimate the change in the forest area where survey information on change was not available.

Forest Plantations in the Tropical Zone

5.8 Forest plantations have been established to replace forests that have been harvested and to replace forests that have been cleared both for the production of timber and fuelwood.

Table 5.2 Tropical Forest, Estimates of Forest Cover Area and Deforestation by Geographical Sub-Region

Geographic Sub-Region/Region	Number of Countries	Land Area	Forest Cover		Annual Deforestation 1981-90	
		million ha	1980 million ha	1990 million ha	million ha	% per annum
Africa	40	2 236.1	568.6	527.6	4.1	0.7
West Sahelian Africa	6	528.0	43.7	40.8	0.3	0.7
East Sahelian Africa	9	489.7	71.4	65.5	0.6	0.9
West Africa	8	203.8	61.5	55.6	0.6	1.0
Central Africa	6	398.3	215.5	204.1	1.1	0.5
Trop. Southern Africa	10	558.1	159.3	145.9	1.3	0.9
Insular Africa	1	58.2	17.1	15.8	0.1	0.8
Asia & Pacific	17	892.1	349.6	310.6	3.9	1.2
South Asia	6	412.2	69.4	63.9	0.6	0.8
Continental S.E. Asia	5	190.2	88.4	75.2	1.3	1.6
Insular S.E. Asia	5	244.4	154.7	135.4	1.9	1.3
Pacific	1	45.3	37.1	36.0	0.1	0.3
Latin America & Caribbean	33	1 650.1	992.2	918.1	7.4	0.8
C. America & Mexico	7	239.6	79.2	68.1	1.1	1.5
Caribbean	19	69.0	48.3	47.1	0.1	0.3
Tropical S. America	7	1 341.6	864.6	802.9	6.2	0.7
Total	90	4 778.3	1 910.4	1 756.3	15.4	0.8

Note: The 90 tropical countries of this table do not include the countries of the region Near East/North Africa used in other chapters of this report, nor the temperate countries of Asia (China, among them) and South America (Argentina, Chile, Uruguay). Of the 93 developing countries of this Study, the FOR90 data are available for 69 countries (see country list in the Appendix). These 69 countries account for 1 690 million ha of the 1 756 million ha of forest area for 1990 shown in this table. The difference is the forest area of 21 developing countries not covered individually in this Study.

[75] For further discussion see, FAO, *Summary of the Final Report of the Forest Resources Assessment 1990 for the Tropical World*, Rome, March 1993.

Table 5.3 Tropical Forest, Estimates of Forest Cover Area and Deforestation by Ecological Zone

Ecological Zone	Forest Formations	Land Area	Population Density 1990	Ann. Pop. Growth 1981-90	Forest Cover 1990		Annual Deforestation 1981-90	
		million ha	inh/km²	% per annum	million ha	% land area	million ha	% per annum
	FOREST ZONE	4 186.4	57	2.4	1 748.2	42	15.3	0.8
	Lowland Formations	3 485.6	57	2.3	1 543.9	44	12.8	0.8
1	Rainforest	947.2	41	2.2	718.3	76	4.6	0.6
2	Moist deciduous	1 289.2	55	2.4	587.3	46	6.1	1.0
3	Dry and very dry	1 249.2	70	2.3	238.3	19	2.2	0.9
4	Upland Formations (hill and mountain forest)	700.9	56	2.6	204.3	29	2.5	1.1
5	NON-FOREST ZONE (Alpine areas, deserts)	591.9	15	3.1	8.1	1	0.1	1.0
	TOTAL TROPICS	4 778.3	52	2.4	1 756.3	37	15.4	0.8

- Totals may not tally due to rounding.

The establishment and efficient management of forest plantations will contribute to secure both the productive and protection functions of forests, though biodiversity may be locally reduced. The total plantation area reported in 81 countries of the tropical zone was 43.9 million ha as at the end of 1990. It is estimated, taking account of imperfect stocking, that this is equivalent to an effective net area of 30.7 million ha. About one-third of the area is primarily for industrial production. The annual rate of afforestation and reforestation of 2.6 million ha is small, less than 20 percent of annual gross deforestation. The established forest plantations have a potential for wood production which is already at a level equivalent to or exceeding the developing countries' consumption of industrial wood of some 300 million m^3 per annum.

5.9 The effective extent of tree planting is greater in that considerable numbers of trees are planted outside the forest, around the farm or household or on boundaries, roadsides and embankments. Trees outside the forest make a major contribution to fuelwood, fodder and timber supply.

5.10 In addition to forestry plantations, agricultural plantations of tree crops, such as coconut, palm and rubber, have potential as a source of wood. The total estimated area (for Asia only) is 14 million ha, made up of rubber (7.2 million ha), coconut (4.2 million ha) and oil palm (2.7 million ha). Several million m^3 of rubber wood and coconut stems are being utilized in sawnwood production.

Protected Areas in the Tropical Zone

5.11 Special consideration has been given in assessing the forest resources of both the tropical and temperate regions, to the degree to which measures have been put in place to conserve the wide variety of species and habitats. One such measure is the establishment of protected forest areas. Currently protected forest areas conforming with categories I-V of the International Union for the Conservation of Nature (IUCN) cover 266 million ha or 5.4 percent of the total land area in the tropics, coverage being about 1 percent higher in Latin America than in either Africa or Asia and the Pacific.

2.2 Forests in the Temperate Zone

5.12 Forests in temperate countries cover some 1.64 billion ha, of which some 1.4 billion ha are in the developed countries and the balance in the temperate forests of some developing countries (including China). The main areas are in the former USSR - 0.75 billion ha, North America - 0.46 billion ha and Europe - 0.15 billion ha. Forests in the developed countries cover 26 percent of the land area and the area of forest per inhabitant averages 1.13 ha. In the developing countries situated in the temperate zone the percentage of land area under forest is 13 percent and the average forest area per caput averages 0.15 ha. The land area under forest in the developed countries is largely stable with slight changes due to removal of forest for urban use or addition to forest through afforestation of surplus and unused agricultural land and pasture. Forest which is cut for timber is usually reforested by planting and natural regeneration. Problems for the forests in temperate countries include damage to the forest attributed to air pollution and damage from pests, diseases and fire.

5.13 Some 300 million ha are designated as protected areas in the temperate zone countries, of which some 250 million ha are in the developed countries (4.5 percent of their land area). Two percent of the land area of China and 7 percent of other temperate developing countries is designated as protected areas.

2.3 Issues of Forest in Land Use

5.14 The state of the world's forests and the trends to change are described above. The future development of these trends will determine the ability of forests to meet the demand for their products and services. In this discussion various factors which play a role in forest change are considered with a view to identifying better the areas where policy may play a role in the future development of land use.

5.15 The forests of the developing countries are under pressure from population growth and the extension of agriculture and pasture use of land. The situation in the developed countries indicates stability in land use, increase in the stock and yield of forests in response to management, but there is some evidence of forest decline due to fire and environmental factors.

Institutional Issues in Temperate Zone Forests

5.16 In the developed countries forests may be in public ownership, private one or in various forms of common ownership. In most developed countries the ownership of forests is effectively demarcated and regulated under the law. The management of forest lands is in most countries subject to constraints aimed at conservation of the soil and land stability in upland regions and in a number of countries harvesting is regulated to ensure sustained yield of timber. In recent years, issues relating to the impact of harvesting and tree planting on the environment and biodiversity have emerged and have led to new policies and new constraints under the law, particularly affecting public forest and policy instruments such as subsidization of private forestry. In some countries the rights of original people to forest wealth has been prominent in public debate. The issue of ownership, management and privatization of forests are matters of current discussion in many of the countries in transition in Eastern Europe and of the former USSR.

Tropical Deforestation - Causes and Institutional Factors

5.17 The forest resource assessment shows that deforestation has assumed important dimensions in the tropical zone. This section discusses possible causes and factors affecting these changes. It must be recognized, however, that data inadequacy and the complex interactions between the different factors contributing to deforestation make it difficult to establish quantitatively the extent of deforestation attributable to any particular cause. Therefore, the indications suggested here are necessarily qualitative inferences.

5.18 Land use statistics are unfortunately not so precise that they provide reliable information for monitoring the movement of land from one use to another. The FAO land use data indicate net increases in arable land and pasture of respectively 30 million ha and 13 million ha between 1980 and 1990 in the developing countries (excluding China). In the same period it is estimated that there has been a net reduction in the tropical natural forest area of some 150 million ha (Tables 5.2, 5.3). Only part of this reduction is the recorded transfer from forest to agriculture and pasture. In addition to conversion to recorded agricultural uses and pasture, three main causes of reduction are the following:

(i) Conversion to subsistence agriculture and rough grazing not recognized by official agricultural land use statistics such as conversion to agriculture or pasture.

(ii) Persistent overcutting for fuelwood and charcoal production which reduces the forest to "other wooded land" or completely eliminates woody growth.

(iii) Commercial felling of timber. In the absence of further intervention such areas will naturally revert to forest. However, the construction of logging roads for commercial felling provides access and frequently facilitates conversion of forest land to other uses.

5.19 The pattern of deforestation and degradation indicates that the most intensive extension of forest clearing and forest degradation radiates out from centres of population and established agriculture. A large part is the informal extension of marginal agriculture and

pasture by small farmers and landless people, a process which occurs without support of selection of land or crops according to productive capability, without any extension service to support the establishment of productive and sustainable agriculture and frequently without recovery of wood and woody biomass for productive use as timber or for fuel. Frequently this informal settlement of forest land involves land with poor agricultural potential and is often in upland and hilly areas. The settlers tend to be the least privileged and have the least potential for adopting the required technology and inputs for sustainable agriculture.

- **Population**

5.20 In many developing countries the high population growth rates, in combination with limited employment opportunities, persistent poverty, inequality of access to land and insecurity of food supply, mean that the only option for subsistence is migration, often to forest areas, to find land for agriculture or pasture and shifting cultivation. Thus, population growth occurring in such unfavourable conditions stimulates this kind of out-migration and consequent deforestation. While on average some 60 percent of the net population increase in the developing countries is absorbed by migration to the urban areas, the rest is the net increase of rural and agricultural population - more in sub-Saharan Africa and South Asia, less in Latin America and the Near East/North Africa.

- **Security, Resource Control and People's Participation**

5.21 In the developing countries forest may have been assigned to public ownership but this has not always been followed up with effective demarcation. The assignment may be in conflict with traditional and communal ownership by local people. Common rights of access to and use of the forest by local people may be exercised but may or may not be legally recognized. Whether or not the forest is formally vested in public ownership, it may be regarded as available to open access by the people. National policy may encourage or permit settlement of forest land, or, perhaps more frequently, condone encroachment. The settlers may, however, have no security in the future supply of products or use of the land and therefore no motivation for sustainable utilization practices involving investment in future production or conservative use of the forest or the land.

5.22 A consequence of population increase is to place greater pressure on limited areas available to rural communities. Privatization and encroachment reduce the areas available for communal use. Traditional forms of common property resource management tend to breakdown. In these circumstances, the growth of population tends to lead to ungoverned and unsupported migration to areas which are less able to support an agricultural population, thus worsening the instability of an already unstable community with tenuous rights over the land which it occupies.

5.23 Among the possible responses to this unsatisfactory relationship between the marginalized rural community and the use of the forest is the adoption of measures designed to increase the involvement of those communities in the management of the forest for their benefit. This is an aspect of the recognized need to enhance people's participation for solving the problem of deforestation and low agricultural productivity.

- **Intersectoral Policy Impacts**

5.24 It is clear from the foregoing discussion that the factors that impact on the forest include not only the direct policies and decisions of forestry authorities but also the policies for agriculture in fostering crop and livestock production, the more general government policies supporting settlement and communications, those of the urban ministries seeking water or energy supplies and those of the economic ministries searching for export income and promoting external investment in mining or energy generation or imposing restrictions of structural adjustment on expenditure for social services and extension support. The pressures emanating from many directions impinge not only on the forest but also on the welfare of traditional communities dependent on the forest and on many aspects of environmental conservation.

5.25 In many countries, forest policy and legislation aim at the conservation of forest area and sustained production of timber. However, in the absence of effective regulations, institutions and incentives to secure sustained production, the long production cycle of the forest tends to lead to an exploitative use directed at obtaining immediate returns. Thus, concession agreements, if not appropriately formulated and implemented, may provide incentives for the immediate utilization of existing stocks of mature timber with little regard to the need for sustainability. Few such agreements have adequate enforcement mechanisms or provide incentives to the short-term concessionaire to secure sustained management. Government finance departments, attracted to the immediate royalty income, may encourage the extension of concessions beyond the limits of sustainability. Thus, the practice of harvesting combined with the pressure to use the land for agriculture can contribute to deforestation, conservation policies notwithstanding.

3. FOREST PRODUCTION IN THE ECONOMY

5.26 A major function of the forest is to supply wood and other products of conventional economic value. Forests and the forest industry contribute to the economy through the production of and trade in wood for energy, sawnwood, panels and paper. The value of forest products is estimated to be somewhat over US$ 400 billion, of which about one-quarter is the value of wood as a source of energy and the balance is the value of forest products in industrial use.[76] An important addition is made by products of the forest other than wood, mainly in the subsistence sector, though no comparable estimate of their value is available. The value of exports of forest products was $97 billion in 1990, just over 3 percent of world merchandise trade.

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[76] Fuelwood predominates in the developing countries, with a total value of some US$ 70 billion v. some US$ 65 billion for the products of forest industry. The corresponding estimates in the developed countries are US$ 30 billion and US$ 260 billion, respectively.

3.1 Wood in Energy Supply

5.27 Table 5.4 shows the data and projections for the uses of wood and its products. The quantity of wood used directly as fuelwood and in the generation of energy is about 1.8 billion m^3, just over half of all the wood consumed. In addition, some 300 million m^3 of residues from the manufacture of wood products are recovered for energy production, making a total equivalent to 0.52 billion tons of oil. This is approximately 5 percent of world energy consumption. The bulk of world fuelwood consumption is in the developing countries, where it represents 80 percent of their annual wood production. This volume, equivalent to 0.4 billion tons of oil, constitutes 17 percent of developing country energy consumption. However, in 40 of the world's poorest countries, wood is the source of more than 70 percent of national energy consumption. In these countries consumption of energy from wood ranges from 0.1-0.5 toe[77] per capita, averaging 0.25 toe. It is noteworthy that the average use of wood in energy supply in developed countries is 0.2 toe per capita, where wood in all forms contributes only 5 percent of all energy consumed.

5.28 Wood remains the main fuel for rural communities in many developing countries and for urban communities too, where the people do not have access to, or cannot afford, alternative fuels. In remote rural areas, especially in poorer countries, modern fuels are virtually unobtainable in any substantial quantities. Among communities dependent on traditional fuels, wood is the preferred fuel, but in regions where wood supply is scarce, twigs and leaves may be used as fuel and in some countries other biomass such as crop wastes and cowdung are used as fuel. This is particularly the case in the Indian sub-continent, where 50 percent of biomass energy is from crop wastes and dung, and in certain areas of Africa.

5.29 The predominant use of fuelwood is for household requirements - cooking and space heating. The efficiency of use of fuelwood in traditional fireplaces is low, with useful energy recovery of only 10 percent. Programmes to introduce improved stoves using low-cost local materials, are being carried out in many developing countries with objectives of reducing fuel used for cooking and heating and at the same time reducing smoke in the kitchen and improving kitchen hygiene. This is especially important for women and children on whom responsibilities for the kitchen and fuelwood supply tend to fall. Toxic fumes from traditional burning of wood have been recognized as causing respiratory diseases.

5.30 The consumption of fuelwood by commercial and industrial enterprises is substantial in many developing countries including rural industries such as fish, tea, coffee and tobacco drying and curing, commercial food preparation, baking and brewing, textiles, laundries, metal workshops and industries such as cement, ceramics and brickmaking. Brazil, for example, uses 6 million tons of charcoal per year for iron and steel production.

5.31 The supply of wood for fuel from the forest tends to diminish with the clearance of forest in the areas of settlement. There is substitution of supply from trees planted around the farm, on roadsides, boundaries and on wasteland and from tree crops. The overall effect is a diminution in available supply and increase in cost because of increased competition for the available supply or from the increased distance to the point of collection. In the

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77 TOE = tons of oil equivalent.

neighbourhood of urban areas, in arid zones and areas of dense but poor rural populations without access to alternative energy, remaining forests are destroyed by overuse. Supply of fuel becomes more dependent on availability of agricultural crop wastes and animal dung. Thus, the diminishing fuelwood supply potential of trees and forests in the densely populated low-income regions will tend to become an increasingly important constraint to meeting the energy needs of the population.

Projected Consumption of Wood in Energy

5.32 World consumption of energy from all sources may continue to expand at between 1 and 2 percent per year but the growth rate of energy consumption in the developing countries will be substantially higher.

5.33 Given the above-mentioned supply constraints, the use of wood in energy supply in the developing countries would grow at a rate appreciably lower than the rate of growth of the economy and total consumption of energy, and probably lower than the growth of population. The trend for countries to substitute increasingly fossil and alternative fuels for wood in expanding their energy consumption would continue. Wood and biomass however will remain the main source of fuel for remote and poor rural populations. In developed countries the earlier trend towards decline in the use of wood as a source of energy is likely to be replaced by slight growth. This would reflect continuation of developments since 1975. Growing interest in some developing countries in the rehabilitation of degraded land through energy plantations and in developed countries in using set-aside land for energy trees and crops, could increase further the contribution of wood as a modern energy carrier. It is expected that the recycling of residues in energy production and particularly the use of waste paper not suitable for reuse in paper manufacture will increase. The above considerations indicate that projected world consumption of wood in energy use could grow at 1.4 percent p.a. to some 2.4 billion m^3 in 2010 (Table 5.4).

Table 5.4 Current and Projected Consumption of Forest Products, 1990-2010

	1990			Growth 1990-2010			2010		
	World	Developed	Developing	World	Developed	Developing	World	Developed	Developing
	m^3 or tons (million)			% p.a.			m^3 or tons (million)		
Fuelwood & Charcoal	1 800	240	1 560	1.4	0.8	1.6	2 400	280	2 120
Industrial Roundwood	1 650	1 270	380	2.5	2.0	3.8	2 700	1 900	800
Sawnwood	485	373	112	2.5	1.5	4.1	790	500	250
Panels	125	108	17	4.6	4.3	6.5	310	250	60
Paper	238	196	42	3.1	2.3	5.8	440	310	130

3.2 Forest Products in Industrial Use

5.34 Wood is the raw material in the manufacture of sawnwood, wood-based panels used mainly in construction, housing and furniture and paper used mainly in communications and packaging. It is also used in unprocessed form in the construction of housing, in agricultural fencing, posts and stakes, as the raw material for artisanal products and in transmission poles and for piling. The predominant uses in the rural areas of the developing countries employ unprocessed roundwood.

5.35 The forest industry has grown substantially in the last 30 years: its output doubled in the developed countries, but increased five-fold in the developing ones. Growth in the developed countries was slower than total growth of the economy. In the developing countries the growth of the industry exceeded that of the overall economy and the per caput value of the industry's output doubled to $15, still much below the comparable estimate of $200 for the developed countries.

Industrial Roundwood

5.36 World consumption of industrial roundwood is 1.6 billion m^3, with the bulk of it, some three-quarters, concentrated in the developed countries. Nearly 1 billion m^3 are utilized in the production of sawnwood and plywood. 0.4 billion m^3 are used directly to manufacture pulp for paper and 0.2 billion m^3 are utilized in unprocessed form. In addition, some 0.2 billion m^3 of residues from sawmilling are recycled to pulp manufacture.

Sawnwood, Wood-based Panels and Paper

5.37 World consumption of sawnwood is close to 500 million m^3, of which some three-quarters are in the developed countries. The average consumption in the developed and the developing countries is respectively 300 m^3 and 30 m^3 per 1 000 persons. Wood-based panels' consumption totals 125 million m^3 of which only 17 million m^3 are consumed in the developing countries (Table 5.4).

5.38 The world consumption of paper and paperboard of 270 million tonnes is made up of 100 million tonnes of newsprint and printing and writing papers used mainly in communications, about 12 million tonnes of household and sanitary papers, and the remaining 126 million tonnes are used in packaging, transport and other industrial applications. Per capita consumption of paper averages 45 kg world-wide, but with wide disparities between the developed countries (150 kg) and the developing ones (10 kg). The manufacture of paper utilizes thee main sources of fibre: 61 percent wood pulp, 5 percent pulp of other fibres and 31 percent is recovered paper. In the developing countries, the respective proportions are 29, 27 and 44 percent. In recent years policy measures have been adopted in the developed countries to encourage recycling of used paper with the aim of reducing the volume to be disposed of as waste.

5.39 Consumption of industrial wood products has grown substantially over the past three decades, most rapidly in the 1960s and early 1970s, more slowly in the 1980s. The rates of growth have been generally much higher in the developing countries than in the developed

ones. The world growth rate of sawnwood consumption fell from 2 to 1 percent p.a. over the period while that in the developing countries was maintained at 5 percent p.a.; for panels, the growth rate fell from 10 percent to 2 percent but developing country growth kept to 10 percent and world growth of paper fell from 5 to 3 percent, while developing country growth was respectively 6 and 4 percent.

Projected Consumption of Industrial Forest Products

5.40 The projections of consumption in this section are based on those for the growth of population and the economies and the established relationships between the rates of economic growth and those of consumption of forest products. The growth of consumption of industrial products is projected to continue as indicated in Table 5.4. In the developing countries the projected growth is around 5 percent per annum, approximately equal to projected economic growth. The implication is a near tripling of product consumption over two decades with trend to increasing self-sufficiency in countries with capacity for forest industry. This requires an equivalent expansion in the flow of industrial wood and investment in industry respectively double and three times larger in magnitude than that achieved in the past two decades. In the developed countries, the projections indicate overall growth in consumption of forest products somewhat below the rate of the growth of their economies, with consumption somewhat less than doubling over the next 20 years. The projected expansion and indicated investment are approximately double those achieved in the past two decades.

5.41 The overall implication of these projections is for a growth in world industrial roundwood consumption at about 2.5 percent p.a. (to reach 2.7 billion m^3 by 2010). This growth rate is somewhat below that of the consumption of the industry's products. This would result from a continuing trend towards improved utilization of wood raw material through more complete utilization and use of smaller sizes, recovery of residues as input to panels and paper and the increased recovery and recycling of used paper in paper manufacture. These trends are well established in the developed countries and are an area for considerable potential growth in the developing ones.

5.42 The supply of industrial wood in developing countries is currently mainly dependent on supplies from natural forests. This is also the main source of supply of tropical timber entering the international trade. In certain countries the current rate of harvesting is not sustainable over the long term. In certain regions of high population density, forests have been cleared for agriculture following initial harvesting and thereby the potential for sustainable timber production has declined. This has reduced the supply potential for the type of timber so far established in the international market. The extension of sustained management to secure continuing supply is an essential component of the policy response to this problem.

5.43 Trees planted individually or in plantations may be expected to play an increasing role in meeting developing country requirements for industrial wood. The areas of plantation so far established in the tropics have a yield potential nearly equivalent to current consumption of industrial wood in the developing countries. They are however not all oriented or located for industrial use. An appropriately located area equivalent to an addition of 50 to

100 million ha would meet projected developing country requirements for industrial wood by the year 2010.

5.44 Developed countries' demand for industrial wood is projected to increase by some 30 percent over the period to the year 2010. It is well within the potential of existing forest with sustained management, stock improvement and improved efficiency in harvesting to meet this demand. The area is likely to be further increased by afforestation of land set aside from agriculture. High costs of operations, however, may lead to a continuing trend to reduce intensity of silviculture and the accumulation of stock, particularly in less-accessible areas.

Forest Products other than Wood

5.45 In addition to timber and fuelwood, forests also generate a wide variety of other products which make an important contribution to both the national and local economy and are significant sources of materials and food for local communities. Well-known industrial materials and commercial commodities, which also enter international trade, include cork, gum arabic and rattan, together with a wide range of gums and resins, bamboos, various oils, rosin and turpentine, tanning materials, honey, seeds and spices, edible fungi, wildlife and wildlife products, barks and tree leaves and medicinal plants. The non-wood forest materials are essential inputs to artisanal activity, house construction and furniture. They are often the basis for household economic activity, often carried out by women. The products are traded in local and urban markets providing an additional source of cash income. They also provide an opportunity for productive employment between periods of peak agricultural workload.

5.46 Rural communities benefit directly from these products, as they provide food, fuel, medicinal herbs and extractives, building materials, materials for handicrafts, animal fodder, perfumes and dyes. The wildlife of the forest often provides the main source of animal protein of rural communities. Foods available from the forest enrich diets by providing vitamins and protein rich components. They contribute to food security by their availability when agricultural crops are out of season or deficient due to drought.

5.47 In many countries the collection of non-wood forest products is the subject of established common rights of local people. In other cases, the collection is regulated through a system of licensing. Change of use of the forest results in conflict with these customary activities. Clearing, felling or restriction of access may result in severe hardship to communities which depend on non-wood products for their livelihood. Governments may take special action to protect the interests of local communities, for example, by entering into long-term usufruct agreements with people who agree to live in harmony with the forest, taking from it only what is necessary for their livelihoods, and ensuring the rejuvenation of valuable species.

5.48 The role of traditional products of the forest as materials and food of rural communities will continue to be important with possibility of expansion of their role in linking these communities to markets. There is also possibility of diversification with the discovery of new products and new uses for the myriad plant and animal materials in the forest. These products are of particular socio-economic importance in providing the basis

for small-scale industry, generating employment opportunities for women and for men, particularly in remote rural areas.

3.3 Forest Products in Trade

5.49 World exports of forest products in 1990 were $97 billion, 3.3 percent of world merchandise trade and 23 percent of world exports of agricultural, fisheries and forestry products (Table 5.5). About 85 percent of this trade is accounted for by the imports and exports of the developed countries. Europe accounts for about half. The largest importers are USA, Japan, Germany and UK, all with imports exceeding $10 billion per year. The largest exporters are Canada, USA, Finland and Sweden, all with exports exceeding $9 billion per year. Among developed countries, 13 are appreciable net exporters and 16 significant net importers. Trade in forest products is particularly important to the economies of some developed countries. For three countries forest products exceed 10 percent of their total exports and for a further five countries they exceed 5 percent of total exports.

5.50 Developing countries account for about 15 percent of world trade in forest products. The largest importers among developing countries are China, Republic of Korea and Egypt, each with forest products imports exceeding $2 billion per year. The largest exporters are Indonesia and Malaysia with exports exceeding $3 billion, Brazil with exports of $1.75 billion and Chile with $0.8 billion. Regionally, China and neighbouring countries of East Asia and the countries of the Near East and North Africa are substantial net importers accounting together for half of all developing country imports of forest products. Other developing regions are in balance or are net exporters. In spite of the regional balance, it has to be noted that 50 developing countries are dependent on net imports for their forest products consumption. This number does not include a list of very small countries which are totally dependent on imports for their consumption. Eleven developing countries have forest product exports exceeding 10 percent of their total exports and in a further seven they exceed 5 percent of the total.

5.51 In the period since 1961, the world trade in forest products has increased 3.5-fold in real terms. Developing country exports have increased six times thus moving from 8 percent to 13 percent of the world total. Over this period, the structure of the forest products trade has changed. In 1961, unprocessed roundwood accounted for 60 percent of developing country exports. By 1990, the real value of these exports had more than doubled but constituted only 20 percent of the total. In 1961, developed and developing exports of unprocessed roundwood were about equal. In 1990, with the inclusion of chips and particles, the export of unprocessed industrial roundwood of developed countries is more than double the developing country export. In 1990, the trade in pulp and paper dominated the forest products trade and accounted for more than 60 percent, up from the 30 percent of the early 1960s. Developed country exports of pulp and paper have increased from 4 percent of total exports of forest products in 1961 to 28 percent of the much larger exports in 1990.

5.52 Although subject to considerable fluctuation over the years, the real price of forest products has tended to be broadly constant over the period. The products departing from this broad tendency have been tropical logs and sawnwood which have shown a slight upward tendency - perhaps 0.5 percent per year; and wood-based panels and paper which had a

declining tendency exceeding 1 percent per year in the period 1961-80, but have been constant in real terms in the last decade.

Table 5.5 The Structure of Forest Products Trade 1961 and 1990 (1990 dollars)

	1961			1990		
	Total $ billion	Roundwood percent	Pulp & Paper percent	Total $ billion	Roundwood percent	Pulp & Paper percent
Imports						
World	30	13	31	109	12	60
Developed	27	15	31	90	11	61
Developing	3	5	56	19	15	56
Exports						
World	26	12	35	97	9	62
Developed	24	7	38	84	7	67
Developing	2	60	4	13	20	28

Outlook for Trade in Forest Products

5.53 Total trade in forest products may be expected to expand in proportion to the expansion of aggregate consumption. The expansion of forest product exports of the developing countries may be at a lower rate than the expansion of consumption as priority is given to meeting domestic demand. Likewise, imports of the developing countries may grow less rapidly than consumption as priority is given to self-sufficiency in forest products in which there is comparative advantage in domestic production. Expansion of trade will be greatest in manufactured products, reflecting the strong tendency to concentrate on value added products with diminution in the trade in unprocessed wood raw material.

5.54 Net importing regions of East Asia, particularly China and Japan, and the Near East and Europe may be expected to continue to increase their demand. The main net exporting regions will continue to be North America, Scandinavia, Insular Southeast Asia, the Russian Federation and South America.

The Trade Environment for Forest Products

5.55 Generally speaking, imports of unprocessed roundwood are free from tariffs. Producing countries frequently impose restrictions or exclusions or discriminatory taxes on export of unprocessed wood with the objective of stimulating local processing, securing raw material supply to local industry or discouraging forest depletion. Concerning manufactured wood products, high tariffs are in place in some countries particularly on wood-based panels

and paper. The objectives may be general protection of the industry or protection of an "infant" industry.

5.56 In recent years developed country environmental groups, concerned about tropical forests, have believed that by stopping trade in tropical timber, damage and destruction of tropical forests would be reduced. They have pressed for embargoes and boycotts on imports and some companies and local government authorities have excluded the use of tropical timber in their products and contracts. Others have introduced the idea of labelling timber as coming from sustainably managed forests. The International Tropical Timber Organization has approved best practice guidelines for the sustainable management of tropical forests and set the year 2000 as a target date by which all exports of tropical timber should come from sustainably managed forests. The negotiations of the Uruguay Round under the General Agreement on Tariffs and Trade (GATT) had among its aims the fullest liberalization of trade in tropical products recognizing its importance to a large number of developing countries. Achievement of this objective would enhance the contribution of the sector to those economies.

3.4 People in Forestry and Employment

5.57 The employment associated with forestry and forest industries is considerable. Part of it is the formal employment by enterprises and part is the informal employment of members of the households to meet their own consumption and production needs. The informal sector work related to the delivery of goods and services includes the collection and harvesting of wood for fuel and charcoal making as well as the collection of foods, medicinal and artisanal materials and hunting. People are also involved in the cultivation of forest land for food and cash crops as well as in the collection of fodder and the grazing of livestock in the forest.

5.58 Formal employment by enterprises includes employment in forest management, silviculture and transport of wood. There is also the employment in research, education and training and extension services. In the forest industry sector there is the employment in management, production and marketing of sawnwood, wood-based panels, pulp and paper, together with the considerable employment in further manufactures, joinery, furniture, packaging and paper products.

5.59 A broad and crude estimate of the number of people work-years may be derived from the estimates of the value of the sector's output. This suggests the equivalent of 60 million work-years globally. Of these, some 12 million are in the developed countries, more than 90 percent occupied in industry-related activities, and 48 million are the work-years in the developing countries, half in fuelwood gathering and charcoal production and half in industry-related activities. These estimates indicate very much higher average levels of labour productivity in the developed country industry, dominated by the very high output per unit of employment generated in capital intensive industries. The estimate of some 20-25 million work-years in fuelwood and charcoal production in the developing countries is related to production and does not include the number of people involved with the delivery of fuelwood from tree to hearth. It may be that some 2 billion people in the developing countries depend mainly on wood for fuel. A substantial part of the supply is met by the

work of members of the household. Therefore the work of fuelwood gathering and delivery may be distributed among the members of some 450 million households.

4. FOREST AND THE ENVIRONMENT

5.60 The forest occupying some 26 percent of the land area of the globe, is an important part of the environment, it provides environmental services and it is influenced by the environment. Forests provide the habitat for a large proportion of the world's plant and animal species, are the home of indigenous people and the living environment and constitute a resource from which people derive sustenance. In their service function, forests contribute to conservation of mountain watersheds, soil and water and provide shelter from wind and help prevent desertification and conserve biological diversity. Forests and trees have a role in modulating the microclimates and the local climates of regions. Forests, comprising a major component of the terrestrial biomass, enter significantly into the carbon cycle and play a part in determining the level of carbon dioxide in the atmosphere and thereby have an impact on the global climate change attributed to changes in the levels of CO_2 and other "greenhouse" gases in the atmosphere.

5.61 Changes in the forest influence its performance of environmental services. Thus, the use of the forest for production functions or the change in use is inextricably interrelated with its performance of environmental functions. Forest ecosystems are naturally subject to change whether through natural disaster of volcanic eruption, cyclone or lightning fire or in the course of growth, decay and renewal. Considerable areas of forests in the tropical and temperate regions are more or less undisturbed as natural ecosystems and habitats of their indigenous flora and fauna. However, human intervention is a major determinant of the course of change.

5.62 In many countries, protected areas have been established to secure their conservation. Specific effort has been directed to conserve ecosystems, species and their heritable variation that are endangered and vulnerable, by the establishment of conservation areas. Management of mountain forests in vulnerable watersheds and catchments aims at the conservation of soil and water and the control of erosion and siltation to alleviate flooding downstream and to modulate water flow for sustained supply. Forests have been planted for protection against wind and to control desertification. Programmes of fire control are instituted to reduce damage to the environment. Specific programmes of afforestation have been initiated with the explicit purpose of sequestering CO_2. Forests are managed and trees are planted to improve the atmosphere and landscape for urban populations. Trees are planted in conjunction with agriculture and livestock for shelter, fertilization of soil and soil conservation as well as for their complementary products. In short, the management and conservation of forests is a multipurpose activity.

5.63 In the case of necessary transfer of land to agriculture and the consequent deforestation, the key issue is how to manage the process to ensure sustainability of development. It has to be recognized that after the change of land use, the forest is no longer there to perform either its productive or service functions. Some functions, such as ecosystem conservation, will be totally lost; others, such as soil and water conservation, will require alternative approaches for the sustainable management of the land resources. In the uncontrolled degradation and destruction of forests, both the productive and the service

contributions of the forests may be lost, unless specific action is taken to prevent this from happening.

Forestry, Forest Industries and the Environment: Compatibility and Conflict

5.64 The use of the forest and its products in the economy is often compatible with environmental objectives but also involves areas of competition and conflict. The production of wood is a renewable process, to a high degree compatible with and complementary to the functions of forest in conserving soil, water and biodiversity. Because of renewability, the use of wood and its derivatives is benign in respect of the carbon cycle. In the best case, CO_2 eventually released in burning wood for energy production is sequestered in the growth of wood that replaces it. The use of wood in energy production substitutes for fossil fuel and, given the possibilities for regrowth, it can reduce the net release of CO_2. Mechanical wood products and the most important among them - sawnwood, require low energy inputs in their manufacture and they substitute for high energy structural materials such as steel, aluminium and cement. Paper, though involving relatively high energy consumption in its production, has achieved a high degree of energy economy in manufacture, particularly in the use of spent liquors in energy generation combined with the process of chemical recovery. Recovered used paper is recycled in the manufacture of paper. Waste paper is also used in energy generation. In general, all these results are at their best when energy input in transportation is minimized.

5.65 Forestry and forest industries may involve conflict with environmental objectives. Cutting wood from the forest disturbs the ecological balance and, if extensive, may have significant impact on ecosystems. Disturbance of the forest, road construction and logging activity may have significant impact on soil and water relations. The development of access roads may facilitate colonization and clearance of remaining forest for agriculture and pasture, having in turn more drastic impact on the ecological balance and soil and water relations. Destruction of forest may be associated with burning and release of CO_2. Forest management and reforestation for wood production may locally reduce biodiversity. Forest and plantation management may involve pesticides, herbicides and fertilizers which, if misused, may have adverse effects on the environment. Forest industries involve use of energy, water and inputs in the production process and the generation of residues, effluent and emissions resulting in pollution of land, water and the atmosphere. The products of industry may be damaging to the environment due to leaching of components such as preservative materials or the noxious gaseous emissions from adhesives. The inputs and additions in manufacture may render the wood or paper material less easy to recycle. Some of the products of the industry end up after use in the waste-stream.

5.66 To minimize harmful impact, countries take action to secure sustainable development of the forestry sector through management of forests and public land and regulation of cutting and regeneration of private forests. Some countries have policies and subsidy programmes supporting private forest management and reforestation. The European Community has recently introduced incentives to favour afforestation as a means of "setting aside" land from agricultural use. In the USA cutting has been restricted on public forest lands that provide the habitat for species classified as endangered.

5.67 Forest industries are subject to regulations controlling the permitted levels of noxious waste and chemicals in the water, effluent and noxious gases in smoke stack emissions. Specific regulations have been introduced in a number of countries requiring use of recycled fibre in paper products and requiring the collection of used paper packaging. The removal of waste paper from the waste-stream is subsidized in some areas.

5.68 A particular matter of international concern is the high rate of deforestation in tropical regions and particularly the threat that this poses to the conservation of biodiversity and the natural resource base. The Tropical Forests Action Programme was initiated jointly by FAO, World Bank, UNDP and the World Resources Institute (WRI) as an international initiative to assist countries to confront this issue and particularly to increase commitment, capability and resources to move towards the sustainable management of their forests.

5.69 Several environmental factors influence the state of the forest and its role in sustainable development. Atmospheric pollution has significant impacts on the health and growth of forests in some regions. Significant climatic change, affecting seasonal temperatures and rainfall, as well as increased CO_2 levels in the atmosphere, would have an impact on the growth and eventually on the distribution of species. International agreements on measures to control emissions of noxious chemicals in the atmosphere and eventually to control the level of "greenhouse" gases would contribute to contain these types of adverse effects on the forest.

5.70 The above summary of positive and negative relationships between the use of wood in the economy and the environment and the review of institutional approaches and policies provides a partial picture of the complex of options. For sound decisions, the trade-offs between the relative benefits of wood as an industrial material and its potential for environmental harm, the issues of complementarity and competition between use of wood in the economy vis-a-vis alternative materials and the pros and cons of the exclusive use of forest for environmental benefits have to be assessed.

5. FORESTS IN SUSTAINABLE DEVELOPMENT: FUTURE PERSPECTIVES

5.71 Consideration of the role of the forest in sustainable development to 2010 and beyond, involves three main areas. The forests have a productive role contributing directly to the economy and the material well-being of people; there are competing social demands for land occupied by forests for growing food and for human settlements and infrastructure development; and the forests and the use of their products relate intricately to the environment. Those considerations are dealt with in turn.

Demand for Forest Products in the Economy

5.72 The demand for the products of the forest will continue to increase. Wood and biomass have a significant role in energy supply both for rural communities and as a renewable energy source in total energy supply. Forest and tree biomass have advantages in supplying these energy needs because of their location near rural populations and because they compensate for the CO_2 released in burning through its sequestration in the regrowth process. Growth of consumption of forest products is an essential component in the

expansion of economies and particularly in increasing the material well-being of people in developing countries. Significant expansion of demand is projected to the year 2010. Thus the future supply of wood and forest products other than wood, the development of industry to manufacture forest products and the development of trade in these products are essential components of strategies to promote sustainable development.

Social Demands on Forests

5.73 The necessary extension of agriculture in the developing countries to meet the demand for food and to provide employment and incomes to the rural population will involve a net increase in the area of land in agricultural use (see Chapter 4). Part of this extension will be met by conversion of land from forestry use. Conversion of land to other uses such as reservoirs, may involve an additional million ha of forest land per year.

5.74 The current rate of tropical zone deforestation of 15 million ha per year has been rather haphazard and is much higher than what would have been required under sound management of the agricultural expansion process. For the future, much greater efforts are required to increase the efficiency of converting land to other uses, e.g. the undertaking of adequate assessments of land capability, identification of appropriate technology for agriculture and support to the communities involved to ensure access to the essential inputs for efficient land use. In addition, measures to ensure continued adequate soil and water conservation, including the appropriate use of tree planting in agro-silvi-pastoral activities must play an important role in managing the process of forest land transfer to other uses.

5.75 The efficient use of limited forest and non-forest land resources requires sound understanding of the productive potential of the land and of the technical options for forestry and agriculture. This information must be available and usable by the communities that effectively make the decisions on land use. These communities must be involved in the planning involving changes in land use and must have security that the benefits will be shared equitably.

Environmental Demands on Forests

5.76 At the same time as demands for the products of the forest and for alternative uses of forest land are increasing, so are the demands of society for a more secure environment with respect to soil conservation, the water supply, the protection from flooding, the conservation of the remaining heritage of biological diversity and the need to limit climate change. There is an overall demand for stabilization or increase in living biomass through conservation, renewal and extension of forest.

5.77 Meeting these demands requires effective identification of forests with priority in conserving soil and water and those with priority in conserving species diversity and ecosystems. Expected action includes the extension of protected areas, *in situ* and *ex situ* conservation of genetic resources, extension of sustainable management of existing forest and watersheds, reforestation and afforestation in both developed and developing countries and greening of wasteland, degraded forest and surplus land.

5.78 The impact on forests of atmospheric pollution may be contained by measures to control the level of noxious industrial emissions in the atmosphere. However, the absolute consumption of chemicals and fuels is expected to increase, so the risk of atmospheric pollution in established or new forms has to be reckoned with. Projections of world energy consumption leave no doubt that the emission of greenhouse gases will be difficult to contain at current levels and are most likely to increase. The impact on climate and in turn on forest is a matter for conjecture requiring attention from research.

Summing up

5.79 Summing up, the perspective for forestry development through the year 2010 is one of intensifying competition for the goods and services of the forest and the use of forest land. The demand for the products of the forest will continue to grow with population and economies. In the developing countries, forest land must be transferred to agriculture. The increasing scarcity of undisturbed forest makes more urgent the need to conserve forest in its service functions relating to soil, water, ecosystems and genetic diversity and the composition of the atmosphere.

5.80 It was noted earlier that a major part of the tropical deforestation is due to the pressures for expansion of agriculture, grazing and fuelwood gathering, much of them originating in the growth of rural populations in poverty. Reducing such pressures depends above all on more general economic and social development that would provide alternative income-earning opportunities as well as contribute to reduce the population growth rate. However, if development can reduce the pressures emanating from rural poverty, it also generates increased demands for both the products of the forest and food, in particular livestock products. These demands should be met by adequate technological progress to prevent further unsustainable harvesting and expansion of farming. Thus, efficient forest management and provision of incentives for conservation are an essential part of policies to counter deforestation even when, and perhaps particularly when, poverty-reducing development occurs.

5.81 On the positive side, increasing incomes tend to upgrade the nature conservation concerns in people's priorities and preferences. They also provide the means to pursue this objective. However, this stage is likely to be reached at advanced levels of per caput income rather than at the early phase of income growth and poverty reduction.

5.82 The urgent areas for action to contain the adverse effects on the forest include the adoption of improved technology to secure high productivity from both agricultural and forest use of land combined with most careful assessment of land potential to permit allocation to the best use. Investment in research, training and dissemination of the necessary technology are required to secure its optimum use as are the adjustments of policy and planning to support its implementation. A fundamental requirement is the awareness, commitment and full participation of the *de facto* decision-makers - the populations and communities involved in forests and neighbouring agriculture.

5.83 There is increasing awareness and international commitment to address these issues. It is represented by the Tropical Forests Action Programme, the adoption of Agenda 21 and the Forestry Principles by the United Nations Conference on Environment and Development

and the guidelines for sustainable management of tropical forests of the International Tropical Timber Organization. It has to be recognized that effective implementation requires a supreme effort to reach the localities where the forests are and effective decisions are made.

CHAPTER 6

FISHERIES

1. INTRODUCTION

6.1 The world's fishery resources are an important source of protein as well as employment and economic revenue. The historical developments as well as the future prospects of the sector are conditioned, to a significant extent, by the wild characteristic of the resource and the fact that, for most species, the levels of production are limited by nature. This has three important consequences. First, beyond certain levels, additional investment in fishing effort does not produce additional yields and, in many cases, actually leads to declines in total catch as well as to economic waste. Such an increase in fishing effort is inevitable in those, almost universal, situations where there is ineffective fisheries management. Second, with growing demand and limited supplies, the real prices of fish products inevitably increase. This has important and damaging consequences for low income consumers, particularly those from the developing countries. The third major, and more positive, result is that limited natural supplies and high prices serve to stimulate increased production through the cultivation of those species that allow it.

6.2 The potential for increasing total production much above present levels is rather limited. Attaining and maintaining these somewhat higher levels will depend on greatly improved management of the fishery resources. Without such improvements, there is a risk that even present levels may not be maintained. Under the circumstances, the prospects are that the real price of many species of fish particularly those used for direct human consumption will continue to rise. Better management would, therefore, contribute to, as far as possible, containing such price increases in the longer-term, and to reducing or eliminating economic inefficiencies believed to be widespread in fishing operations at present.[78] Improved management of capture fisheries may, at least in the short term, lead to a lower volume of production, albeit of better quality. Eventually, the overall production constraints may be somewhat relaxed by further growth of aquaculture and stock enhancement programmes such as culture-based fisheries.

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[78] A special FAO study concludes that the industry is overcapitalized, mainly as a result of the still largely prevailing open access regimes to ocean fisheries resources and of heavy subsidies provided by major fishing countries, e.g. up to quite recently the ex-USSR and countries of Eastern Europe, but also the EC and Japan. The study documents the extent to which the value of the global catch falls well short of covering the fleet's operating costs, when these are valued without subsidies (see FAO, *Marine Fisheries and the Law of the Sea: a Decade of Change*, 1993; this is a revised version of a chapter published in the 1992 issue of the *State of Food and Agriculture*). With the reforms under way in the ex-centrally planned economies of Europe, a substantial part of their subsidized operations has become openly uneconomic. The consequent reductions in the fleets of these countries is leading to significant structural change in the world fishing industry.

2. HISTORICAL DEVELOPMENTS AND PRESENT SITUATION

6.3 Since the 1600s, the principle of the freedom of the seas dominated the use of the oceans and their resources. Beyond narrow limits of national jurisdiction (3-12 miles), the resources were open to all comers. With declining catches per vessel in the traditional grounds, the fishermen either moved to new areas or adopted more intensive techniques. In more recent years, the pace of exploration and exploitation was expedited by the development of automotive power, synthetic fibres in nets and refrigeration equipment.

6.4 This pattern had three consequences. One was the generalized depletion of conventional stocks. A second was the global extension of fishing effort to new, less conventional species as well as to far distant waters. And the third was the increase in conflict between the local fishermen of the coastal states and the distant water fishermen from foreign states fishing close to shore. This stimulated increasing claims by coastal states to extended jurisdiction.

6.5 The major maritime powers generally succeeded in maintaining the principle of the Freedom of the Seas, which benefited their military and fishery interests, during the First and Second United Nations Conferences on the Law of the Sea (in 1958 and 1960). But the pressure for extended jurisdiction was inexorable and, while the discussions at the Third UN Conference were still under way in the 1970s, a regime of a 200 mile extended fisheries zone was established, resulting in a redistribution of the seas' wealth.

6.6 The choice of 200 miles, however, has no relevance to the habits of fish. Some species (e.g., oyster, clams) are sedentary while others (e.g. tuna, salmon) swim vast distances and are found both inside and outside a 200 mile limit. Given the wide diversity of the resource, there is also no direct connection between the size of a fisheries zone and wealth of resources. Among the most fertile areas are the continental shelves rich in demersal stocks (groundfish such as cod and haddock) and the upwelling currents inhabited by pelagic species (those feeding on the surface such as herrings and sardines). Temperate zone waters tend to contain relatively large population of few individual species; while outside upwelling areas (e.g., Peru), tropical waters have large numbers of species and small populations of each. In the open ocean, the stocks are diffused. Some high seas species have schooling habits but require high search costs for their location. Others seldom aggregate and can only be taken by gear that filters great quantities of water.

2.1 Production

Volume and Species Composition

6.7 Since the 1950s total world production of fish increased at a rate of about 6 percent per year until the collapse of the Peruvian anchoveta fishery in the early 1970s. After that setback, with some minor fluctuations, production continued to grow reaching the peak of 100 million tons in 1989. However, the overall growth rate declined to 2.5 percent per annum (Figure 6.1). World production fell to 97 million tons in 1990 and has remained at that level for both 1991 and 1992. It has been characteristic of these developments that the contribution of some (notably) traditionally high value species to the total catch and that of other less traditional species has declined, while the catch of predominantly high volume, low

unit value species has been subject to wide fluctuations. For example, a significant part of the growth during the past two decades was due to the increase in the catch of a single species, Alaska pollack, whose catch accounts for some 5 percent of world fish production. Another large part of the increase came from a few species of small shoaling pelagic fish. After the collapse of the Peruvian anchoveta, the total catch of this group fell to 6.3 million tons in 1973, down from 16.7 million tons in 1970. By 1980, the small pelagic global catch was back up to 13.2 million tons and peaked at 21.3 million tons in 1989, making up about 20 percent of total world production. Most notable were the increases in Japanese pilchard, South American pilchard and Chilean jack mackerel. These kinds of species are subject to very wide fluctuations in abundance which are generally cyclical in nature and result from natural environmental changes. Experience has shown that heavy fishing can significantly impede their recovery. The composition of current world production by major species is shown in Figure 6.2.

6.8 During the past two decades, the catch of a large number of demersal stocks (e.g. Atlantic cod, Cape hakes, saithe, haddock, Atlantic redfishes) has declined significantly, due largely to continued, heavy overfishing. Although there are instances of stock rehabilitation through the adoption of conservation measures, these are relatively scarce in most areas of the world. In contrast, production of oceanic pelagics (e.g. tunas), cephalopods and other shellfish has shown a steady increase.

6.9 While marine catch has successively decreased from the peak year in 1989 (86.4 million tons), the production of inland species rose dramatically during the 1980s, to 15 million tons in 1991 (15 percent of total production). Most of this is accounted for by nine major species whose catch was less than 500 000 tons in 1970 but over 5.5 million in 1990. As noted later, these species are produced almost entirely by aquaculture and most of the growth occurred in China.

6.10 A significant aspect of these developments is the change in the value of catch. Except for the tunas, the species whose catch has been growing are relatively low priced. Most of the shoaling pelagics, for example, are caught for reduction into fishmeal. On the contrary, the species whose catch has been falling are mostly high valued. The net result is that the increase in total quantity of catch has not been matched by a commensurate increase in economic value. Overfishing of the high-valued stocks has led to their depletion and, with decreased supplies, to price increases. This pattern will eventually occur for most species which are not readily cultivable. Table 6.1 presents a qualitative overview of the main characteristics of the different market segments and species.

The Dominance of a Few Countries

6.11 It is significant that a very few countries have an extraordinary influence on total world production. The effectiveness (or lack of effectiveness) of management regimes to which the fishery operations of these countries are subjected can have a major impact on global production. Twenty countries accounted for 80 percent of total world output in 1991 and six of them made up more than 50 percent (Figure 6.3). The concentration by countries and that by species are related to each other. For the three major developed countries, most of the increases were due to two species: Alaska pollack and Japanese pilchard. There has been an even greater dominance of individual species in the catch of two of the three major

developing countries. For Peru, 90 percent of the catch in 1990 was from anchoveta and South American pilchard. For Chile, 81 percent was from those two species and Chilean jack mackerel. These are all low-valued species whose abundance tends to fluctuate widely.

The Development of Aquaculture

6.12 During the 1980s, there was a rapid growth in the development of aquaculture. Between 1984 (when FAO began recording aquaculture production) and 1990, total production from aquaculture roughly doubled reaching about 12 million metric tons (excluding seaweeds). This has had two main thrusts: one in China and the other, more globally, for certain high-valued species.

6.13 China's aquaculture output increased about 2.5 times from 1984 to 1990, accounting for roughly 45 percent of total world aquaculture production in the latter year. To a large extent this is made up of various species of carp often raised in conjunction with agriculture since a long time ago. There have also been large increases in the culture of shrimp and mussels; to the point where China produces about 27 percent of global production of shrimp from aquaculture and about 38 percent of global production of mussels.

6.14 A separate development has been the rapid increase in output of salmon, shrimp and various shellfish to meet the demand of the luxury market in developed countries. Currently, farmed salmon makes up about 25 percent of total world salmon production from all sources and farmed shrimp about 24 percent of total shrimp production. In both cases, aquaculture output has been sufficient to significantly affect world prices. Oysters have always been cultivated and there has not been much growth in production in recent years. But there has been a large increase in farming of other shellfish since 1984. Both mussels and clams have increased about 60 percent while scallops have grown by over 300 percent.

2.2 Patterns of Consumption and Trade

6.15 Over the past few decades, fish produced for human use has grown more rapidly than population with a resulting increase in per caput consumption. The relevant data are shown in Table 6.2. While fish is a relatively minor source of dietary energy supplies (it accounts on average for 17 calories out of 2 475 in the developing countries), it is an important source of essential fatty acids, vitamins and minerals. However, although a handful of countries tend to dominate global production of fish, many countries depend heavily upon fish as a major source of protein. For the developing countries as a whole, fish currently make up about 19 percent of total animal protein consumption, or just over 4 percent of protein from both animal and plant origin. However, this latter share is very high in some countries, both developed (e.g. Japan, Norway, Portugal) and developing ones (mostly in East Asia, e.g. Philippines, Thailand, and Africa, e.g. Congo, Angola, Ghana, etc.); and it is very low in others (e.g. Argentina, many land-locked countries in Africa).

Figure 6.1: World Fish Total Catch, 1950-1992
by Marine and Inland Waters

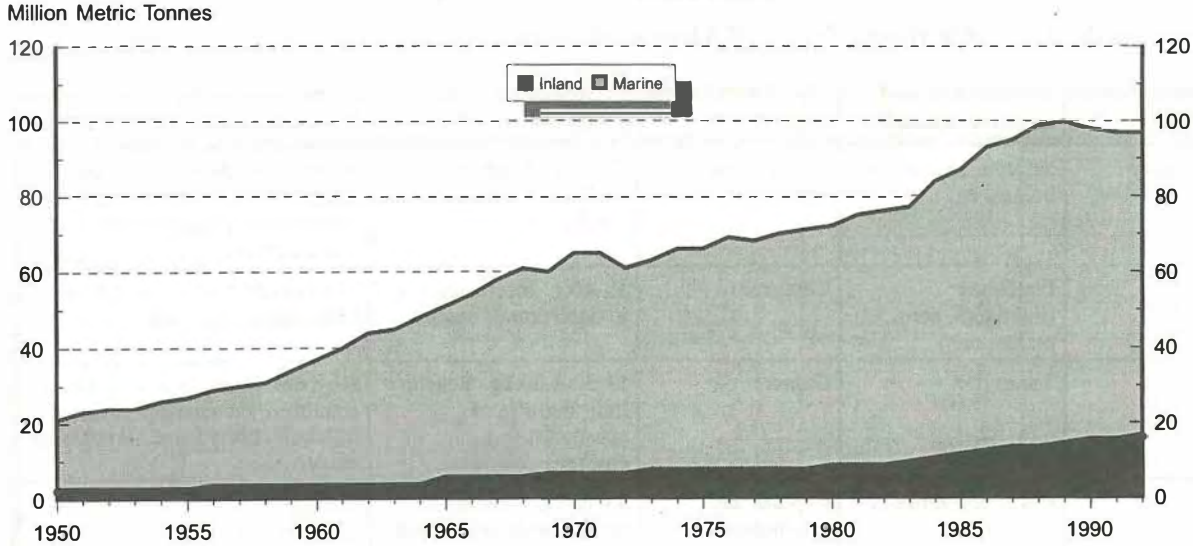

Figure 6.2: Total Catch in 1991
by Major Species

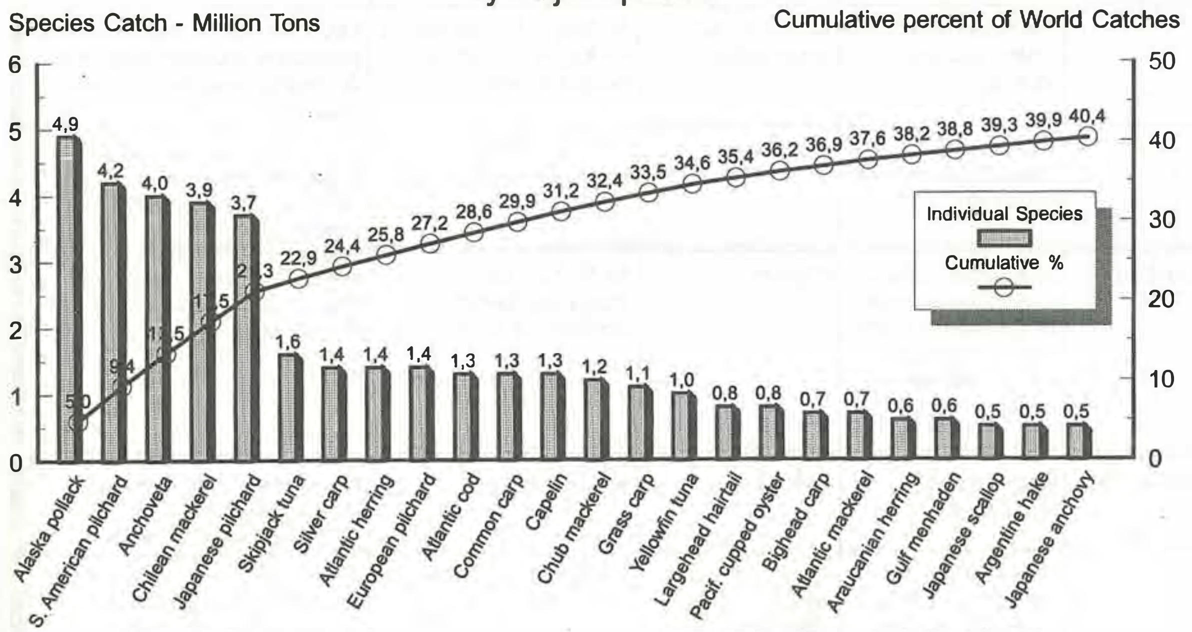

Figure 6.3: Total Catch in 1991
by Major Fishing Countries

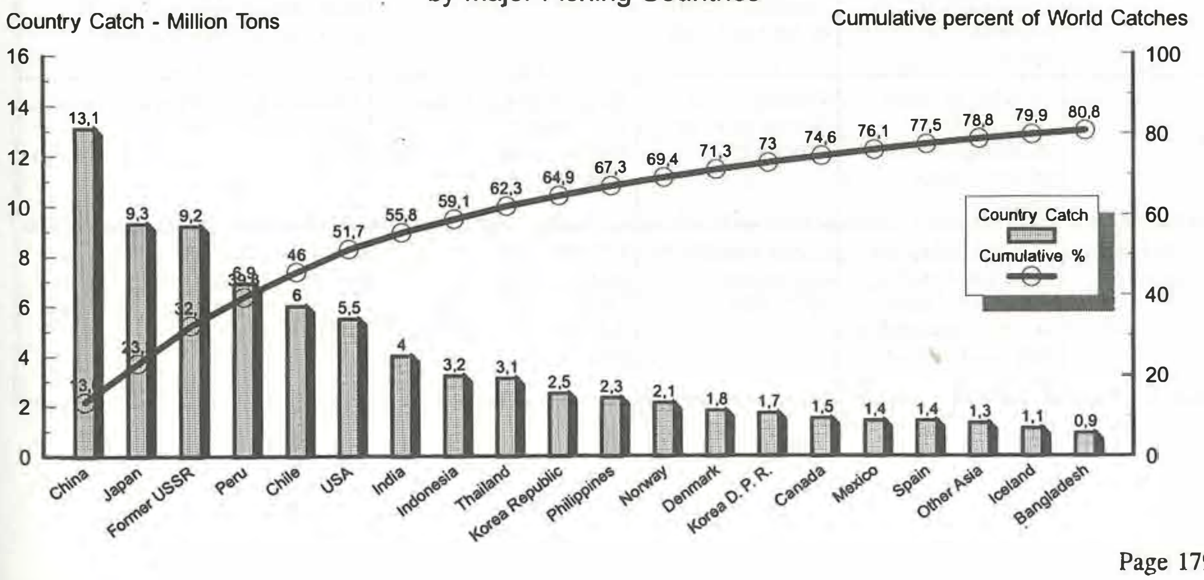

Table 6.1 Characteristics of Major Market Segments for Fishery Products

Market	Types of Species	Sources	Prices (ex-vessel)	Implications
Luxury	Salmon, shrimp, sea bream, etc.	Capture and culture	$3-4/kg. Tending to decline with increased cultivation.	Increased trade from culture countries. Increased demand for fishmeal. Conflicts over space and water use.
	Flatfishes (flounders, soles, plaice, etc.)	Capture	$3-4/kg. Increasing due to depletion of stocks	Most stocks heavily overfished. Incentive for culture.
	Tunas	Capture	$1.50-2.00/kg. Reaching limit because of substitutes (e.g., chicken)	High consumption in developed countries. Increased processing in, and exports from, developing countries.
	Crabs and lobsters	Capture and production of substitutes from low-priced fish through surimi process.	$3-12/kg. Tending to decline with production of substitutes.	
	Molluscs (oysters, clams, cockles, mussels).	Mostly culture, some capture.	$1-5/kg. May decline for cockles & mussels with increased culture.	Opportunities for increased production and consumption in developing countries. Sanitation problems.
	Cephalopods (squids, octopus and cuttlefish).	Capture	$1-4/kg. Likely increases over the long run.	Opportunities for increased capture by some developing states and for increased exports. Healthy food merits.
Standard	Most finfish species making up the bulk of the market (cods, hakes, haddocks, jacks, mackerels, groupers, croakers, etc.)	Capture	$0.50-3.00/kg. Increasing due to depletion of stocks.	Generally heavily overfished with declining total catches and decline in size of animals.
Low-Income	Carps, catfish, milkfish, etc.	Culture	$0.20-1.00/kg.	Heavy production in Asia, mostly China. Very little in Africa and Latin America.
	Artisanal-caught marine and lake fish (sardines, mullets, scads, tilapias, chub mackerels, etc.)	Capture from canoes, rafts and other small craft, generally non-powered.	$0.20-1.00/kg. Rising prices due to depletion.	Generally heavily overfished with declining total catches and decline in size of animals.
	Frozen blocks of low-quality fish of miscellaneous species.	Capture by industrial vessels of former USSR.	Under $1/kg.	Sold to local African coastal states for various reasons. Not likely to continue for long.
	Trawler by-catch (small individuals including juveniles of high-valued species).	Discards from shrimp trawling operations.	$0.05-0.50/kg. Prices increasing as discards sought for feed to use in aquaculture.	Locally an important source of protein for low-income consumers.
Non-Food Markets	Small shoaling pelagics (anchovetas, pilchards, sardinellas, etc.) reduced to fish meal and oil, mostly for feed.	Capture mostly by large-scale operations.	$0.10-0.40/kg. Price increases presently limited by price of substitutes for feed (eg., soybeans)	Conversion to food use possible in future but stocks not found in Asian waters where future need greatest.

Table 6.2 Fish: Historical Data of Food and Non-Food Use

	69/71	79/81	89/91
A. Food (liveweight equiv.)			
Per Caput (kg)			
World	11.0	11.8	13.3
Developing Countries	6.4	7.6	9.3
Africa (sub-Sah.)	7.7	9.1	8.0
N. East/N. Africa	2.7	4.5	5.3
East Asia	8.1	10.0	14.1
South Asia	4.0	3.9	4.1
Lat. America + Caribbean	6.6	9.0	8.5
Developed Countries	22.3	23.2	26.4
W. Europe	18.4	17.3	21.2
E. Europe + FSU	19.3	20.8	21.0
N. America	14.3	16.4	21.7
Japan	67.5	69.9	72.0
Others	11.1	12.2	14.4
Total (mill.tons)			
World	40.4	51.8	68.5
Developing Countries	16.4	24.7	36.1
Africa (sub-Sah.)	2.1	3.2	3.8
N. East/N. Africa	0.5	1.0	1.6
East Asia	9.0	13.5	22.4
South Asia	3.0	3.6	4.7
Lat. America + Caribbean	1.9	3.2	3.7
Others	0.9	0.2	0.4
Developed Countries	24.0	27.1	33.3
W. Europe	6.8	6.7	8.5
E. Europe + FSU	6.4	7.5	8.2
N. America	3.2	4.1	5.9
Japan	7.0	8.2	9.0
Others	0.5	0.6	0.9
B. Fishmeal (liveweight equiv.)			
World totals (mill.tons)	19.7	19.5	27.8
Total Fish Use	60.1	71.3	98.2

6.16 Trends in trade in fishery products closely reflect changes in production and technology development. The expansion of international trade in fish and fishery products has exceeded the growth in world fish production. World fish trade, estimated at 32 percent of world production (24 million tons) in 1980, increased to 38 percent in 1990 (37 million tons). A significant part of this increase was from increased exports of fresh and frozen products (3.3 million tons to 6.0 million tons product weight). Other large increases in exports included those of shrimp, which increased from 0.4 million tons to almost 1.0 million tons, and of fish meal which rose from 2.0 million tons to 3.2 million tons, although with significant fluctuations in volume during the period.

6.17 The increase in trade has been particularly marked in value terms, exports reaching a total of US$ 38 billion in 1991 compared with US$ 15 billion in 1980. The share of the developing countries in total trade has grown slowly but steadily to some 47 percent of total exports in 1989. Exports of shrimp, cephalopods, tuna (both frozen and canned) and fish meal have been on an upward trend and contributing positively to the balance of payments in many developing countries in Asia and Latin America. Particularly marked expansions in export trade have been achieved by Thailand and China. The developed countries, especially those of the European Community, Japan and the USA, remain the principal importers, accounting for some 88 percent of total world fish imports. The USA has also become the world's major exporter of fish and fishery products, reflecting gains through the extension of jurisdiction and its increased catch in the North Pacific.

6.18 Many major fishing countries, both developed and developing, are both large importers and exporters. Most developing countries in Asia, for instance, carry out simultaneously import and export trade in fish, exporting high-value species not consumed domestically and importing fish and fish products of lower prices and quality. Export-oriented fisheries may involve the use of imported inputs (e.g., frozen tuna in Thailand). With the growth of domestic economies and per caput incomes, some exporting countries may find it difficult to maintain exportable supplies in the face of expanding domestic consumption.

6.19 The rise in prices for some fish products is being constrained by market-place competition from alternative foods. On the other hand, the culture of certain species, notably salmon and shrimp, is now producing sufficiently large quantities to put pressure on market prices. The development of new products, particularly those involving the processing of low-valued species, for example, Alaska pollack, into reconstructed high-value products, may also have some impact on prices.

6.20 Demand and taste preference for fish and fishery products and supply patterns are continually undergoing changes. As prices for the more highly preferred species rise, middle-class consumers tend to turn to species traditionally consumed by the poorer sections of the community. At the same time, although the catch of less-favoured, unconventional species is increasing due to the increasing production constraints of commercially preferred species, their availability, particularly for low-income consumers in Asia, is being reduced as a result of competition from aquaculture feed demands and the degradation of coastal areas.

3. PROSPECTS FOR THE FUTURE: PRODUCTION

6.21 As noted, there are severe constraints to increasing aggregate fish production. The little further growth that can be achieved in sustainable ways is unlikely to be sufficient to maintain per caput supplies. Unlike other sectors of agriculture, it is more difficult to relax the production constraints in fisheries by bringing new resources into exploitation, technological change and investment. Often efforts to improve management of fishery resources will be primarily aimed at preventing current production levels from declining.

6.22 Much of the increase in catch during the 1980s came from pelagic species which are subject to wide natural fluctuations and appear to have recently passed their peaks. Some

stocks are now facing significant declines. If the catches of these kinds of fish cannot increase further, the growth of the fishmeal-dependent aquaculture sector will be accordingly constrained unless technological advances are made in providing alternative sources of feed. Moreover, the major demersal species throughout the world have been overfished and they provide little opportunity for increased catch except through improved management, which inevitably will require some reduction of fishing over the medium term to allow stock rebuilding.

6.23 Marine catches can only be increased marginally over current levels. This would still entail a real risk of changing the nature of the marine food chain and affecting other species dependent on it. Total marine catches are not likely to greatly exceed 100 million tons; and could be considerably lower. Aquaculture production may range from some 15 to 20 million tons from the present level of 12 million tons assuming that the growth rate prevailing in the last few years will be maintained. Increases in inland capture fisheries may be insignificant unless improved management of resources is combined with a better environment.

6.24 The above considerations make it clear that estimating future production levels is an operation subject to many uncertainties. With this caveat in mind, indicative estimates are given in the following Table 6.3. These hypothetical estimates could be feasible with better management and other interventions (e.g. sea ranching) which would favour recovery of fish stocks. The rest of this section discusses the factors that are likely to shape the future in the different country groups and species. A schematic presentation of the status and likely future potential by major fishing areas is provided in the Annex at the end of this Chapter.

Table 6.3 Present and Possible Future Production Levels of Fish

(million tons, liveweight)

Type	1989/91	Possible 2010
Capture	86	90-110
Marine	79	
Inland	7	
Culture	12	15-20
Marine	4.5	
Inland	7.5	
TOTAL	98	

Note: Details on production by major fishing areas are given in the Annex.

3.1 The Developed Countries

6.25 The developed countries (aside from Australia, New Zealand and South Africa) derive most of their supplies from capture fisheries in the northern temperate zones in both the Atlantic and the Pacific Oceans and from inland waters; tuna stocks in all oceans; and culture of certain species (e.g. salmon, catfish, shellfish). They also, of course, derive some supplies from imports. In developed countries technological innovation and high demand for fish have lead to heavy exploitation of stocks in adjacent waters.

6.26 The northern Atlantic, the northern Pacific and Mediterranean/Black Sea where developed countries are mainly engaged in fishing, are generally considered to be overfished. At present there are very few instances of successful management, either in the multinational fisheries of the European Community or within the large exclusive zone of the USA, and there is a serious need for catch restraints to allow stock rebuilding. Although, in theory, further increases in supplies could come from the development of underutilized stocks, these are few in number and low in value and are often food fish for higher-value species. The largest opportunity appears to be in the further development of the cephalopod fishery in the north Atlantic and the northern Pacific, if this can be done without affecting ecologically important by-catch species.

6.27 The situation is more serious for a few developed countries who have continued to acquire supplies from coastal countries because of high royalties and increasing costs of operation (e.g., Japan, Spain). The former USSR, an important distant water fishing nation, may play a reduced role as the heavy subsidies are being removed from the industry. Catches from the inland waters of the developed countries are relatively insignificant, except in the case of the former USSR. For many developed countries, aquaculture is becoming of increasing importance in meeting the demand for certain high-value products. The most significant, at present, is from the culture of salmon. Other species include catfish in the US, carp in the former USSR and seabream and amberjack in Japan.

3.2 The Developing Countries

6.28 The situation is relatively more favourable in some developing countries where resources are less overexploited than in the developed countries. For *Africa and the Near East*, the major sources of supply are the capture fisheries in the east-central and southeast Atlantic, the west Indian Ocean, and the inland lakes and rivers. Aquaculture is not, at present, an important source of fish. The west African coastal countries have significant opportunities to increase their share of the existing harvest of their coasts. However, much of the catch is of low-valued species and is now harvested by large-scale foreign industrial vessels. As industrial fisheries are a capital intensive and high-risk sector, some of the coastal countries may still have to depend on extracting rents from foreigners while others expand the development of inshore fleets through joint ventures. There are very large unexploited resources of lantern fish (a mesopelagic species) which are found in relatively deep waters and are suitable for fishmeal. However, it is questionable whether their harvest will become economically feasible before 2010. Inland fishery resources are of importance as sources of food in many countries. However, significant increases are not likely to occur.

6.29 For *Latin America and the Caribbean*, most of the species fished in the Gulf of Mexico and Caribbean are heavily overexploited and the major opportunity for an increase in catch are from squids and octopus. The stocks of cephalopods on the Patagonian shelf appear to be fully exploited though there may be opportunities for increased catch of other cephalopod stocks in the northern coastal areas. The coastal countries may have the opportunity to increase their share of the catch presently taken by the distant water vessels. The northern areas of the west coast of Latin America contain large stocks of small pelagics which are subject to the influence of the current "El Niño" and fluctuate widely in abundance. The catch of Chilean jack mackerel has grown from negligible amounts in the mid-1970s to 3.8 million tons in 1990. The stock is considered to be only moderately

exploited and may allow for some continued increase in catch. Aquaculture is not of great significance in Latin America with the notable exception of Ecuador and Chile which produce shrimp and salmon respectively, mainly for export. The prospect for the latter is dependent upon international market demand which appears to be presently saturated.

6.30 For *Asia*, The demersal stocks of the East and South China Seas, the Yellow Sea and the Gulf of Thailand are heavily fished. It is unlikely that recovery of these stocks, if effective management measures are implemented, would add more than a million tons to total catch. The pelagic stocks are fully utilized and no significant increases would be possible. There may be some possibilities for an increase in catch of cephalopods along the Chinese coast. The great majority of China's aquaculture is of herbivorous carps so that production would not be constrained by shortages of fishmeal. Increases may be feasible in eastern Indonesia where distance from markets has restrained development. Fisheries for large pelagic species and small tunas have doubled their catch in the last two decades and although there may be moderate potential for increase in the future, restrictions on dolphin by-catch may affect use of purse-seines in the future. There may be opportunities to increase the total catch of skipjack. The cephalopods are moderately exploited and may have increased in abundance as a result of the heavy exploitation of the predator demersal fish.

6.31 Brackishwater and marine culture of shrimp for export to the developed countries has increased dramatically, but shrimp culture is beginning to encounter and cause some difficult problems due to disease and organic pollution from shrimp farming and limited space for expansion. Overall improved management could lead to the largest increase in supplies to the region. Additional supplies might come from increased harvest of cephalopods and further development of resources of eastern Indonesia and the eastern Indian Ocean.

6.32 Coastal countries of the Indian sub-continent may be able to increase their catch of tunas, both the large market species and the smaller tunas. Estimates of potential yields are not available, but it is likely that the catch of skipjack in the western Indian Ocean as a whole could be substantially increased. Increase in the other large tunas may be possible but are not likely to be significant.

6.33 Inland fisheries, particularly in India and Bangladesh, provide important sources of protein for local markets. Significant improvements could be made in both countries in culture practices and in the use of water bodies where problems of ownership impede effective production.

3.3 Production Prospects by Species

6.34 In most of the major fishing areas production has reached a plateau and in some areas fish yields are on the decline. In some cases production levels are being maintained by catches of younger fish, and certain localized areas are particularly vulnerable. Below, supply prospects are reviewed by species.

6.35 *Crustaceans* are generally heavily exploited and wild penaeid shrimp production is close to a ceiling. Landings are unlikely to decline as the industry is currently over-capitalized. Penaeid pond shrimp production may also be approaching a saturation. Problems surrounding shrimp culture are the availability of fry, space, feed and

environmental degradation and in particular, the heavy dependence on wild fish catches for feed. The main determinant of increased output will be the cost of inputs in relation to the price of shrimp. A significant potential for expanded catch can be expected from minor crustaceans (e.g. crabs and small shrimps). Molluscan shellfish which does not depend on fishmeal may offer good opportunities both in developed and developing countries, depending on markets, but face deteriorated environmental conditions. In the tropics there are potential resources of bivalve stocks.

6.36 For *cephalopods* the possibilities of increased production, particularly, of oceanic squids, is generally good and future levels of output are likely to depend as much on market considerations as on resource availability, as well as on technological developments in capture and processing. The banning of large driftnets in the northern Pacific could even result in a decline in catches unless new, efficient and environmentally friendly gears are devised. In addition, production levels of oceanic squids and mesopelagic species may be affected by the practice of allocating "food quotas" to predators for their conservation and/or rehabilitation (a practice being initiated for cod).

6.37 The present level of exploitation of *demersal fish* has reached the maximum and there is no potential for increased production. Stocks of cods and other groundfish have declined. Although some potential of increasing supplies exists from use of discards of lower-value species and small flatfish, in both the north Pacific and Atlantic the fishing effort has already shifted to lower-value species (e.g. blue whiting). The tightening of controls in certain countries (e.g. Morocco, Chile, Namibia) could reduce fishing operations and the Total Allowable Catch (TAC) in order to allow rebuilding of groundfish stocks. This is likely to have a negative role on landings in the short to medium term. With good management, long-term potential would be no more than 20 to 30 percent above the present levels.

6.38 The immediate situation for *small pelagics* seems to be pessimistic. The largest global single species (i.e. the Japanese pilchard) has declined again in recent years and its recovery is likely to depend on climatic factors. The principal small pelagic fisheries of the Southeast Pacific are also declining. The retrenchment of the long-range fisheries of the former socialist countries is unlikely to be offset by increased interest by other countries in establishing joint ventures with coastal states to exploit small pelagic species for food. It is unlikely that significant increases in krill production will be realized for a combination of economic and biological reasons due to the need to reserve some of the resource as food for marine mammals. The future for small pelagic fisheries may be tied to improved technology which can convert them to higher-value products using some variation of the surimi process.

6.39 Given the spectacular success of *salmon farming*, and the possibility of its extension, the potential for increased production in the medium and long term is good. By overcoming the problems relating to a market glut through the reduction of input costs, increased production can be expected from improvements in wild stocks and ranching in the medium term. The Russian Federation has promising prospects for increasing salmon production through improved ranching.

6.40 Although some significant potential exists for the *smaller tunas, tuna-like fish and skipjack* in the medium and long term, its materalization will greatly depend on fuel costs and markets. *Conventional tuna* fisheries will also be affected by the marine mammal factor which may restrict further expansion of the use of purse seines and large-scale gillnets.

6.41 Although some growth can be expected from *inland fisheries*, the most interesting developments in this sector in the medium- and long-term basis are likely to depend on stocking programmes to enhance the stock in floodplains, rivers, reservoirs and irrigation ponds and in intensive management of small water bodies. Inland aquaculture may also have some potential for development in Latin America and Africa.

3.4 Overall Assessment of Production Prospects

6.42 Past estimates of the annual potential supply of fish from all sources have ranged from 100-120 million tons. It is now evident that the marine capture fisheries are adversely affected at extraction levels beyond about 80 million tons. Inland capture fisheries yield is about 6.0 million tons, of which Asia produces half and the overwhelming constraints to further increases in production rest with the appropriate allocation of water rights and water quality.

6.43 Aquaculture, although recording a remarkable growth over the period 1984 to 1990, has experienced significant problems in saturation of markets and consequent price reductions as well as environmental and disease setbacks. These, however, are expected to be only temporary and characteristic of a growing industry. The major constraint would appear to be the restricted knowledge of the requirements for growing only a relatively few species. Most notable is that finfish farming has mostly occurred for freshwater herbivore species (7.4 million tons) with only a modest contribution from marine species (1.0 million tons). The further expansion of finfish supplies from freshwater aquaculture is likely to be constrained by the freshwater environment. By contrast, the marine environment offers far better prospects for production growth, provided technology can overcome difficulties in locating pens and cages further offshore. With the exception of molluscs, carps and tilapia, the growing of fish in captivity is still in its infancy and can be compared with early attempts at animal husbandry and the domestication of wild animals.

6.44 The greatest prospects for increasing fish supplies for food are to be found in the use of small shoaling pelagics for direct human consumption. Presently these species are used for producing fishmeal, for pig and poultry production as well as aquaculture. The feed specifications for aquaculture now demand a level of quality of meal that requires an upgrading in the method of harvest, which, in itself, would result in an increase in the price of the species used, and a consequent increase in feed costs for aquaculture. The implication, however, of increases in the price of low-valued species is the adverse effect on both the poorer segments of populations as well as on marginally viable fish farmers. However, the quality requirement for the aquaculture feed would also be sufficiently high for direct human consumption and, in time, might be sufficient to generate developments in alternative feed sources.

6.45 The remaining option for increases in fish supplies would be that the present condition of overfishing prevails and that the majority of the marine catch increases would come from fishing further and further down the "food chain". The end limit, as has occurred in one or two areas, is a fishery that is almost entirely a "trash" fishery of mixed juveniles and other small-sized species for direct feed to grow several preferred species. That is to say, the wild production from the marine areas could end up being nearly all utilized to grow two or three species in captivity. The impact would be the loss of the present wide spectrum of food

items that the existing 1 000 commercial species now provide, to be replaced by very few species providing only differences in flesh, colour and texture.

6.46 Estimates of potential from mariculture are precarious to make at this juncture with only a short time series of production showing a spectacular increase. However, there are projections of 500 000 tons of farmed salmon production by 2000 and these may be projected to 2010 by a further doubling. Shrimp farming produced 700 000 tons in 1991 and has been projected to expand at a reduced rate, estimated at 1 million tons by 2000 as a result of constraints in expertise, pollution, disease, infrastructure and market fluctuations. Any projections for farmed fish will be determined by demand pull and the price relationship between capture fish and other food products.

4. IMPLICATIONS FOR CONSUMPTION

6.47 The constraints limiting increases in production of fish will put severe strains on the nutritional situation of the countries and population groups with high dependence on fish for their protein supplies and on small-scale fisheries for employment and income. Such impacts would be the greatest in East and South Asia where an additional 8.5 million tons will be required by the year 2010 to maintain the present levels of consumption. This region contains a number of countries where fish plays a vital role in the diet (e.g. Bangladesh, China, Indonesia, Myanmar, Philippines, Sri Lanka, Thailand), in all of which fish accounts for a half or more of the animal protein supplies.

6.48 The consequence of a shortfall in supply will be increases in the price of fish. Such increases by themselves will further stimulate aquaculture production and provide the incentive for further technological advances. Increased prices will also mean that consumer demand will switch to lower priced substitutes. Many of the presently preferred species will move to "the luxury food" class but it is expected that the broad range in fish products that has been the characteristic of fisheries will remain, thereby providing fish at an array of prices. This has been the experience of the past whereby lobsters, shrimps, crabs, salmons, flatfish and cephalopods have had a relatively inelastic demand. By contrast, demand for cods, hakes, haddocks, tunas, mackerels, redfishes, jacks, mullets and Alaska pollack is generally much more responsive to price changes.

6.49 Projections would indicate that a number of the species with elastic demand would shift to those groups having an inelastic demand. The substitution effect would draw on these less-preferred species. In the same way, species formerly used for fishmeal would gradually be expected to enter the elastic part of the food fish demand. The overall consequence would be that the existing supplies of low-value fish that are important to the poorer sections of the population would be removed from within their purchasing power. This is already occurring in some regions as the result of increased demand for fishmeal and consequent increases in price.

6.50 Currently, almost 30 percent of total world catch of fish is used for *non-food purposes*. Most of this is reduced to fishmeal which is used in combination with other ingredients such as soybean meal and skimmed milk powder, in the preparation of protein feeds for animals, in particular poultry, pigs, and, increasingly, high-value cultivated fish such as salmon and shrimp. While in the past the most important consumers of fishmeal

have been the developed countries, their apparent consumption has increased only moderately or declined. Several developing countries have become increasingly important in the 1980s. In all cases, the rapid growth in fishmeal use has been associated with rapid expansion of aquaculture.

6.51 Although fishmeal is also derived from sources other than the small shoaling pelagic species (trash fish as by-catch of trawling, refuse from processed food fish, and even, in the case of China, mussel culture), the bulk comes from fish caught specifically for the purpose of reduction to meal. The demand for fishmeal is dependent in part on demand for protein feeds, although the share of fishmeal in these feeds can vary considerably with its price relative to the prices of fishmeal substitutes (e.g. soybean, coarse grains). In recent years fishmeal has tended to establish itself as an essential element in feed compounds, due to growth factors such as its immunological effects, and the price competition of substitutes has become less critical. A continuation is foreseen of the high demand for special quality fishmeal for aquaculture purposes. Anticipated demand for shrimps and salmons will have to be met by the aquaculture output because their wild stocks are currently fished at maximum levels. New opportunities may be generated for special quality fishmeals. The industry forecasts indicate that in the next decade the share of prime fishmeal would increase from the present 8 percent to 25 percent of the total fishmeal production. However, there are serious limitations to the expansion of the world reduction industry because most stocks of fish used as raw material are highly variable and the resource situation seems likely to prevent substantial increases in production.

5. MAJOR POLICY ISSUES FOR THE FUTURE

6.52 Beyond the issues related to the food and nutrition problems likely to emerge from the supply constraints of the fisheries sector, those related to management of the resources and the environmental dimensions also require urgent and adequate policy responses.

5.1 The Essential Need for Management

6.53 As described earlier, the most important impact of the likely supply-demand gap and the consequent projected increases in the real price of fish is the stimulation such price effects will have in maintaining the excessive levels of fishing intensity and the continuation of overfishing. It is clear that, without directed government intervention to protect and manage fisheries, the resource base will continue to degenerate at a rate corresponding to the increases in real prices of fish. This will continue to occur until governments can establish effective controls over the rate and type of exploitation of the fishery resources. It will become increasingly difficult to manage fisheries with successive price increases stimulating further pressure for greater exploitation levels, particularly since rebuilding depleted stocks will require periods (up to a decade for long-lived species) of reduced catches.

6.54 The major contribution that fishing countries could make to solving the problems relating to overfishing is by controlling better and, in some cases, reducing their fishing effort. Another important contribution would be the design and introduction of more selective and efficient fishing gear and practices, thus helping to reduce the wasteful

incidental catch of non-targeted species, not only those of commercial value but also endangered species such as marine mammals, turtles and sea birds.

6.55 The concept of "responsible fishing" embraces not only the impacts of fishing gear and methods upon the overall sustainability of the fisheries but also many other aspects of policies and practices to maintain the quality, quantity, biological diversity and economic availability of fishery resources and to protect their environment.

5.2 Small-Scale Fisheries and Environmental Degradation

6.56 Small-scale fisheries are critically important in many countries as sources of both employment and protein. They are, however, being seriously affected by two developments: conflict with large scale operations in the inshore waters and degradation of the coastal environment. Often the small-scale fishermen have been displaced from agricultural or other natural resources employment and have turned to fisheries because the access to resources is free. There is high mobility into small-scale fisheries but very few opportunities to move out of them. Small-scale fishermen have limited range for their activities. Medium- and large-scale vessels, particularly shrimp trawlers and more recently, those using large purse seines, often find it advantageous to fish in the inshore waters. This creates conflict over the resources as well as space and is damaging to the vulnerable small-scale operators.

6.57 The problems of excessive pressures on the inshore stocks and damaging competition among different gears is compounded by environmental degradation. The coastal zone receives large amounts of pollutants including: organic wastes from municipalities, chemical wastes from industries, pesticides and herbicides from agriculture and siltation from forest land clearing and road building. In addition, activities within the coastal zone also affect the environment. These include mining of coral reefs and destruction of mangrove swamps. Fishermen themselves contribute to these kinds of damages by converting mangrove swamps to mariculture ponds for shrimp; by excessive use of feed and antibiotics in cage culture; and by using dynamite, poison and other kinds of techniques that destroy coral reefs.

6.58 The effects of these alterations of the coastal environment on fish production are not easily measurable. Some changes may actually be positive: the production of pelagic stocks in parts of the Mediterranean is increasing, possibly as a result of nutrient discharges in these semiclosed seas. But more often, the effects are negative. Pollution can lead to eutrophication (reduction of dissolved oxygen) which causes mass mortalities of stocks. Changes in the marine environment have also apparently led to an increase in red tides, with toxic effects on both fish and man. The destruction of mangrove swamps is quite likely to have diminished nursery areas for many species of fish. Inland fisheries suffer from dams and diversions which affect fish migrations as well as aquatic productivity.

6.59 Although these damages can affect all fishing operations, they are particularly acute for the small-scale fishermen in developing countries, in particular those of Asia where demand is high and the resources are of such vital importance as a source of food as well as employment. Adoption of effective coastal area management is critically important and could facilitate the rehabilitation of stocks and increased yields, as well as alleviate the hardships of the small-scale fishermen.

6.60 Environmentally sound management for sustainable development should therefore be based on the integration of all components of sectoral development. Multisectoral integration should occur at the conceptualization stage of policies, plans and programmes; components of an integrated plan should then be implemented by different ministries under the technical leadership and coordination of a single agency. Integrated Coastal Area Management (ICAM) which has been experimented in a number of developing countries is an important step taken for achieving the sustainable development of coastal resources.

6. CONCLUSIONS

6.61 There will be a significant global shortage of supply of fish in the future. Although the severity of the shortage will differ among countries, the overall effect will be a major rise in the real price of fish, which will have critically important consequences in several regards.

6.62 A basic problem is that with the absence of efficient systems to control access to the resources under open access conditions, the rise in prices will stimulate even greater investment in fishing effort than already exists. A vicious circle is established whereby stock depletion reduces supplies, leading to additional price increases.

6.63 This vicious circle can partly be broken by the establishment of systems of exclusive use rights which provide the fishermen with a stake in the resource and an interest in future returns. However, as many governments have found, this is difficult to achieve. The creation of exclusive use rights, by definition, awards benefits to some at costs to others and, thereby redistributes wealth. At national levels, fishery administrators generally do not have the mandate to make such decisions. In international areas or areas where stocks are shared by countries (e.g. the northeast Atlantic), negotiators cannot readily agree to controls which limit the rights of their own fishermen.

6.64 But as the problems become increasingly severe, the issues are raised to higher political levels and, eventually, will force the necessary decisions. Several countries have already taken the basic steps to create exclusive use rights and have achieved significant benefits. Although the systems still contain many imperfections, the improvements that have been produced provide valuable lessons for other countries.

6.65 There is some hope, therefore, that the management of fisheries will eventually improve. However, although the benefits will be significant in reducing biological and economic waste, they will still not be sufficient to overcome the limits to supply. There will be continued increases in real prices with severe effects on low-income consumers, particularly those of the developing countries of Asia and Africa for whom fish is a critically important source of animal protein. Alleviation of these hardships will require major efforts by governments to adopt policies that ensure the most effective use of the scarce resources.

Supply Prospects by Major Fishing Areas

MARINE	Production (million tons)	
	Historical Maximum (year)	Present 1989/91
CAPTURE FISHERIES Northern Atlantic: Generally overfished; catches of most important high-value species (Atlantic cod, capelin, Atl. herring) in decline; consequent pressures on low-value stock (pollack, silver hake), already fully exploited; few instances of successful management; even successful management could add only 2-3 m.tons to total catch; possibility of increasing cephalopod catch by 1 m.tons. Over the last decade notable is the increase in landings of invertebrates, making up 32% of the catch in 1990, and high proportion of the total value. The coastal states curtailed or eliminated distant water efforts in their EEZs. Management of shelf areas seaward of 200 miles has been conducted by the Northwest Atlantic Fisheries Organization (NAFO) to maintain stocks levels. In the Northeast Atlantic TAC (Total Allowable Catch) systems has been used as the standard tool in managing stocks. Agreed TACs have exceeded the TACs recommended by the International Commission for Exploitation of the Seas, and actual catches have exceeded the agreed TACs.	West 4.2 (1970) East 12.3 (1975) of which culture	3.1 9.6 12.7 (0.8)
Central Atlantic: Current catch some 5.8 m.tons; Generally fully exploited: in Western Atlantic marine fisheries include small and large pelagics, reef fish, coastal demersal fish, crustaceans and molluscs. Some underutilized resources like cephalopods. Many of the resources are shared by several countries: in Eastern Atlantic catches are recorded by 21 coastal countries and more than 18 non-coastal countries giving a markedly international character. The share of landings by non-African long-range fleets remains high, being at 58 percent in 1989/90.	West 2.2 (1975) East 4.1 (1990) of which culture	1.8 3.9 5.7 (0.1)
Southern Atlantic: Important fisheries include hake, blue whiting fishing. The latter is considered moderately exploited. Several management measures (e.g. licensing, mesh size regulation, etc.) have been in force for some years. Rapid development of offshore fishing in the Southern Patagonian shelf and slope by long-range fleet is source of concern in the Southeast Atlantic, Southern Angola and Namibia have an exceptionally high biological productivity due to the Benguela current, but currently Namibian policy is low catches and stock rebuilding. However, the total fishing potential of the Benguela region is not well known.	West 2.4 (1987) East 2.8 (1975)	2.2 1.6 3.8
Mediterranean and Black Seas: Stocks are fully exploited with possible exception for mackerel, horse mackerel and sardines. The recent decline has been caused by the environmentally-induced collapse of fish catches from the Black Sea. Overfishing of most of the highly valued demersal species such as hake, red mullet and clams. Few stock assessment recommendations have been made. The complex of problems faced in many Mediterranean countries with fisheries management, are focused on the coastal zone, where critical habitats for fisheries often encountered, and uncontrolled expansion in the use of the same areas for other human activities.	2.1 (1988) of which culture	1.5 0.16

Supply Prospects by Major Fishing Areas (continued)

	Production (m. tons)	
	Historical Maximum (year)	Present 1989/91
Indian Ocean: Catches of most important high-value species (shrimp) are fully or overexploited. Main opportunities increase of catches 4.3 m.t for small pelagic stocks off Mozambique and Somalia, for demersal fish off Mozambique, Madagascar and Tanzania and increased utilization of increased by-catch from shrimp trawlers. Potential development for small pelagics (anchovies, scads, Indian and Jap. mackerel, round herring) in the Southwestern Indian Ocean, needs to be assessed. Some form of management is required for trawl fishing in Somalia, shrimp fishing in Mozambique and Madagascar. Stock assessment work is needed in the Southwestern Indian. Under-exploited deep-sea resources may exist in the shelves of the Amadaman and Nicobar Archipelago, and Myanmar, but generally fisheries of the northern Indian Ocean are heavily exploited to overfished. Fishing by foreign vessels in Eastern Indian Ocean has grown less intense. Scientific management of fishery resources is not yet well established although development of fisheries has passed the point where this is becoming urgently needed.	West 3.4 (1989, 1990) East 2.8 (1990)	3.4 2.8 ——— 6.2
Northern Pacific: The total landings remain among the highest in the world: 31% of the total world marine catch. The recent decrease was primarily from the decline in landings of Alaska pollack and the Jap. pilchard. In Northwest Pacific the stock of pollack is fully exploited and there has been a significant increase in the proportion of undifferentiated fish in the catch. Most cod stocks are fully exploited. The demersal stocks in East China Sea and Yellow Sea seriously depleted and estimated 1/5 to 1/10 of their highest levels. Little sign of recovery. The Jap. pilchard exceeded 5.4 m.t in 1988, making it one of the largest singles species catches: subject to wide fluctuation: probable future declines possibly counterbalanced by other shoaling pelagic species. The total catch of pelagic fish ranged from 6 to 8 m.t. Due to major changes in relative abundance of different species, it is difficult to establish long-term sustainable yields for individual species. Cephalopod stocks around Japan fully exploited but oceanic squids in the Northern region and neritic cephalopods in the Southern region may provide certain opportunities if bans on certain current fishing gears are not extended (i.e. large driftnets). Salmon stocks appear to have stabilized due to improved artificial breeding and releasing techniques. Shrimp stocks fully exploited. There is no functional multilateral organization to assess and manage shared fish stocks. In Northeast Pacific the marine environment linked to "El Niño". The total catch ranged from 3.2 to 3.5 m.t in recent years. Alaska pollack consistently accounts for slightly less than half of the total catch. The pollack stocks tend toward a gradual decline. Major decline in salmon stocks attributed to degradation of the freshwater habitats resulting from urbanization and long standing drought conditions. Canada initiated individual vessel quotas (IVQs) for habitat on a two-year trial basis. Stocks of cods, hake and sablefish seem to be declining. Pressures are now growing for the institution of individual transferable quotas (ITQs) or alternatively, community development quotas (ACDs).	West 26.7 (1988) East 3.4 (1987, 1990) of which culture	25.5 3.2 ——— 28.7 (2.7)
Central Pacific: Western Central Pacific generally over-exploited; small-scale fisheries contribute the most of the total catch. Demersal and small pelagic fish comprise most of the total catch. Shrimp and tuna are the major export fisheries. Total catch has continuously increased over the last 20 years primarily due to the extension of fishing onto new grounds, but the rate of increase has slowed. Most stocks of coastal shrimp in Asian waters and in Northern Australia are fully exploited. Few countries have formulated fisheries management plans. Some of the excess fleet have had to compensate fishing in the waters of neighbouring countries through various bilateral agreements. In Eastern Central Pacific fisheries are strongly influenced by the California current system, and dominated by pelagic species and shrimps. Sardine stocks are subjected to wide natural fluctuations. Shrimp stocks are fully exploited except the stocks off Nicaragua. Catches of tuna are relatively stable.	West 7.9 (1991) East 1.8 (1989) of which culture	7.5 1.6 ——— 9.1 (0.3)

Supply Prospects by Major Fishing Areas (continued)

	Production (million tons)	
	Historical Maximum (year)	Present catch 1989/91
Southern Pacific: The Southwest Pacific generally overexploited both in pelagic and demersal species. Cephalopods show large fluctuations. The ITQ systems adapted by New Zealand and Australia have managed to stabilize a number of fisheries at more appropriate economic levels: in the Southeast Pacific the fisheries, particularly anchoveta and squids, are greatly affected by "El Niño". The current level of production (14 m.t in 1990) exceed the record catches of 13.8 m.t in 1970. Small pelagics are dominant, representing 90 percent of total landings. Potential annual yield is estimated to be 2 to 5 m.t and the stock is fully exploited. The potential yield of squid is believed to be much higher than the current level of production. Chilean jack mackerel is considered to be moderately exploited although catches are relatively high.	West 1.1 (1989, 1991) East 15.3 (1989)	1.1 14.5 ——— 15.6
Southern Oceans: Most of the catch is krill, accounting for about 90 percent of the total. Finfish are also taken but their resources are very limited. Most of the catch taken by the former USSR fleet and Japan. Because the annual net production of krill is low compared to the available biomass, the resource could be vulnerable to overfishing, and supplies the food requirements of Antarctic mammals and birds. There is a need for precautionary management measures.	0.5 (1989)	0.4
Marine total:	of which culture	83.6 (4.06)
Inland Fisheries: It represents 15% of the total supply from all sources. The production of fish, crustacean and molluscs has increased steadily during the last decade; inland capture fisheries have shown sluggishness, whereas inland culture made a remarkable growth reaching about 55% of total inland production. Inland fisheries are becoming increasingly conditioned by degradation of environment. Management tends to centre around mitigation of adverse environmental impacts. Formulation of adequate legislation for the protection of stocks in lakes, reservoirs and rivers is needed.	15.2 (1991) capture culture	14.5 6.8 7.7
Aquaculture: (All figures quoted are already included in above table as appropriate). Current production some 12 m.tons; Aquaculture development has been rapid, registering a mean growth of 10.9% per year; coastal aquaculture growth has been less than that of inland aquaculture. Important increases in yield have been achieved through culture of shrimp in the tropics and salmon in the temperate zones. Aquaculture has expanded over most of the world and is responsible for the increasing contribution of inland waters to the world fisheries production. The intensification of production of export oriented communities such as salmon and shrimp is largely industry driven. Severe strains are on the environment and allocation of sites, disease control and feeds. The general failure of rural aquaculture can be largely traced to managerial problems.	12.0 (1990) Mariculture Inland waters	12.0 ——— 4.5 7.5
World Production:	100.3 (1989)	98.2

9.6 From a policy perspective it is necessary to know the characteristics of the population groups making-up the rural poor. A recent study on rural poverty[144] identifies the small farmers, the landless, the women, the nomadic pastoralists, the artisanal fishermen, the indigenous ethnic groups and the displaced persons as the functionally vulnerable groups in the rural sector and indicates that alleviating poverty in each may require different policy instruments and approaches. Although few indicators are disaggregated by gender, the available data on literacy indicate wide gender disparities. Thus the female adult illiteracy rate in 1990 was 46 percent compared with a total rate of 36 percent. In 1987 there were only 81 females per 100 males in primary education and 75 females per 100 males in secondary education. Women's inferior educational endowments, combined with reduced access to assets, cultural constraints on engaging in certain types of employment and their continuing daily responsibilities for children, make it even harder for them to escape the poverty trap.

9.7 The regional patterns of poverty presented here are fairly similar to those presented earlier for the incidence of undernutrition (Chapter 2). Data on related indicators such as the prevalence of underweight children or the incidence of micronutrient malnutrition further confirm the close association of deprivation in the nutrition/health nexus with that of poverty.[145] It can be expected that progress in poverty alleviation would be largely reflected in amelioration of these poverty-related indicators of deprivation in the nutrition, health and other areas. However, public policy which targets directly the areas of nutrition, health, education and housing will also be essential. The fact that countries with similar per caput incomes have widely differing rates of undernutrition, morbidity and illiteracy, proves that there is considerable scope for such public policy. Moreover, the increasing recognition of the role of human resources in overall development (discussed in Chapters 7 and 10) strengthens the case for such public policies.

3. RURAL POVERTY AND AGRICULTURAL GROWTH

9.8 A general case can be made from several studies that when the economy grows the incidence of poverty (percent of population below the poverty line) tends to decline. Whether such a relationship holds in all cases, depends essentially on what happens to income distribution when the economy grows. It is possible that income distribution could become less equitable, thus offsetting partially or completely the potential benefits of such growth to the poor. Whether this happens is an empirical question. It is difficult to establish whether systematic relationships exist between overall economic growth and changes in the distribution of income. Comparative studies seem to indicate that economic growth is as

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144 Jazairy, I., M. Alamgir and T. Panuccio *The State of the World Rural Poverty - An Inquiry into Its Causes and Consequences*, New York: New York University Press, 1992, pp. 45-52 (a study by IFAD).

145 FAO/WHO, *Nutrition and Development, a Global Assessment*, and WHO, *Nutritional Strategies for Overcoming Micronutrient Malnutrition*, Document for the International Conference on Nutrition, Rome, 1992.

likely to be associated with increases as with decreases in inequality.[146] A recent study illustrates such diverging effects by comparing the experiences of rural India and Brazil (Table 9.4). According to this study, in India the positive growth effects on poverty were reinforced by improvements in the distribution of income. In Brazil, on the other hand, a worsening of the income distribution led to one-half of the potential poverty reduction effects of growth being cancelled.

Table 9.4 Effects of Growth and Distribution on the Incidence of Poverty, India and Brazil

Rural India		Brazil	
% of population poor in 1986/87	36.8	% of population poor in 1987	24.2
% of population poor in 1977/78	52.7	% of population poor in 1981	26.5
Reduction in Poverty	-15.9	Reduction in Poverty	-2.3
Due to:		Due to:	
- Growth	-13.8	- Growth	-4.5
- More equal distribution	-1.9	- Worsening distribution	2.1
- Other	-0.2	- Other	0.1

Source: Datt, G. and M. Ravallion, "Growth and Redistribution Components of Change in Poverty Measures: A Decomposition with Applications to Brazil and India in the 1980s", (mimeo), Washington D.C.: The World Bank, 1990.

9.9 With regard to the relationship between agricultural growth and rural poverty, the empirical evidence seems to lend support to the common-sense proposition that the distribution of benefits from increased agricultural production will approximately reflect the initial distribution of productive assets and of access to inputs and services, as well as changes in the distribution of such assets brought about by the process of agricultural growth itself. It is, therefore, possible for agricultural growth to be associated with worsening of the distribution of income. If, moreover, the deterioration is sufficiently severe, it can even cause parts of the rural population to become poorer in absolute terms. This seems to have been the case in Latin America in the 1980s when the incomes of the rural poor declined despite considerable increases in aggregate agricultural production.[147]

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146 Fields, G. "Changes in Poverty and Inequality in Developing Countries," *World Bank Research Observer*, July 1989. A more recent study on Latin America shows that periods of recession in the 1980s tended to be associated not only with increasing poverty but also with worsening income distributions, meaning that recessions hit the poor the hardest; Psacharopoulos *et.al*, *Poverty and Income Distribution in Latin America: the Story of the 1980s*, World Bank, Washington D.C., 1992.

147 The most severely affected category - landless labourers - suffered a 23 percent fall in real wages between 1980 and 1987 (Programa Regional de Empleo para América Latina y el Caribe (PREALC), "Evolution of the labour force market during 1980-1987", Santiago, 1988, cited in *Report of the Secretary-General, Policies and activities relating to assistance in the eradication of poverty and support to vulnerable groups, including assistance during the implementation of structural adjustment programmes*, ECOSOC, E/1992/47, New York, May 1992).

9.10 The specific impacts of agricultural growth on different socio-economic categories of rural producers and labourers, as well as the mechanisms through which these impacts are mediated, depend on the nature of the growth processes and the structural factors underlying the social organization in rural areas. Much of our empirical knowledge on these matters comes from studies (mostly from India) of situations in which rapid agricultural growth occurred as a result of the spread of the green revolution.

9.11 The evidence in these studies indicates that the advent of the new technology, in the form of biochemical innovations, was associated with reductions in rural poverty, e.g. the proportion of the poor among the cultivating households declined and so did the severity of the poverty of those households which remained poor. At the same time, however, some of the poor became poorer and some of the non-poor were pushed below the poverty line. Much of the adverse impact on selected groups of the rural population was the consequence of the initial inequality in access to land. Since smallholders were impeded by restricted credit markets, input supply problems, limited access to extension services, risk aversion and tenure insecurity, the benefits of the new technology tended to accrue mainly to large landholders. The latter expanded acreage through resumption of land for personal cultivation (by evicting tenants) and/or through leasing or purchase of land from small landowners. As a result, the distribution of gross cropped area became more unequal and the percentage of landless households increased from 25 to 35 percent.[148]

9.12 On the other hand, the longer period (1974-84) evidence from North Arcot (a small region in South India)[149] indicates that where small-scale, owner-occupied farms dominated, the effects were more favourable to the poor, largely because there was a conducive institutional setting, in which state and local governments made credit and modern inputs available to small farmers, and invested heavily in infrastructure.[150] Even then, the early adopters of the high-yielding varieties (HYVs) were typically large farmers. But eventually, over 90 percent of the paddy area was planted with the HYVs, with no systematic differences by farm size, and similar yields were obtained on large- and small-scale farms alike. There was no evidence of a general increase in land concentration or of loss of land by smallholders and there were sizable absolute gains in income of all household categories and a decline in the incidence of absolute poverty.

9.13 In addition to the fact that agricultural growth may be associated with at least some parts of the rural population becoming worse-off economically, concern with rural poverty must also encompass those sections which are chronically poor and too marginal to be affected by agricultural growth, one way or the other. These sections comprise people living in remote, resource-poor regions, without any infrastructure; backward sections of society, debarred from owning assets, denied access to education and condemned to menial

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148 Data and analysis for rural India for 1968-70 from Gaiha, R., "Impoverishment, Technology and Growth in Rural India," *Cambridge Journal of Economics*, 1987, Vol. 11.

149 Hazell, P.B.R. and C. Ramasamy, *The Green Revolution Reconsidered. The Impact of High-Yielding Rice Varieties in South India*, Baltimore: The Johns Hopkins University Press, 1991.

150 Evidence from other regions also indicates that small farmers' adoption of new technologies depends on access to credit markets, input supplies, extension, tenure security and problems of risk aversion. Rural women are particularly disadvantaged in these areas.

occupations; and the disabled and the aged, incapable of augmenting their incomes above a bare subsistence level.

9.14 Over a longer-term perspective, the sustainability issues related to agricultural growth assume increasing importance for the rural poverty problem. Continued population growth in the context of rural poverty, and in particular when it occurs in conditions of inequality of access to land, tends to push the rural poor to expand agriculture into ecologically fragile areas. This causes deforestation (see chapter on Forestry) and exploitation of the land in ways which damage its productive potential. This process sets the stage for continued poverty on the part of the population concerned. Examples of this process abound, from the Himalayan and Andean ecosystems, large parts of Africa and the colonization experiences (spontaneous or officially sponsored) of the tropical rainforest (e.g. Brazil, Indonesia). To the extent that this process takes place in parallel with production increases in the higher potential areas, it provides another example of agricultural growth bypassing, and often making worse-off, part of the rural poor, e.g. by lowering the prices they receive for their own production. The sustainability issue and its relation to rural poverty is also relevant for the better off agricultural lands, in so far as more intensive agriculture, if not carefully managed, can reduce the productive potential of the land and water resources and threaten the sustainability of the poverty-reduction effects obtained initially.

9.15 We can conclude that while, on balance, agricultural growth can be expected to bring about reductions in rural poverty, some parts of the rural population may become worse-off economically. The structural characteristics of the rural economy at the inception of agricultural growth play a predominant role in the distribution of benefits from higher production. Scale-neutral technical change can benefit large and small farmers alike, if institutional rigidities do not stand in the way. With regard to the latter, an activist public policy in the area of institutions, research, credit, etc., can be instrumental in ensuring the wider spread of benefits.

4. POLICIES FOR ENHANCING EQUITY AND POVERTY ALLEVIATION IN RURAL AREAS

4.1 Interventions to Improve Access to Land

9.16 It was noted above that the structural characteristics of the rural economy - particularly land ownership and land tenure systems - play a decisive role in determining the distribution of benefits and the rural poverty effects of agricultural growth. The pros and cons of interventions and the lessons of experience from efforts to enhance the access of the poor to land are discussed below with regard to (a) redistribution of ownership rights; (b) regulation of tenancy contracts; and (c) the role of land titling.

4.1.1 Land Redistribution

9.17 The most recent attempt to take stock of progress in redistributive land reform was undertaken in 1991 for the quadrennial FAO report on progress under the WCARRD Programme of Action.[151] The report concludes that progress has been limited, mainly because the implementation of land distribution programmes was strongly affected by political realities.

9.18 The *equity case* for land redistribution from large landowners to the landless and/or small owners of land rests on at least three considerations: (i) the landless/small owners are usually poorer than large landowners; (ii) in general, but with important exceptions, total employment and production per hectare increases as farm size decreases; and (iii) inequality in the distribution of land conditions the poverty effects of agricultural growth not only because of the resulting unequal distribution of the income attributed to land but also because it breeds social stratification patterns inimical to the poor in many other areas, e.g. the distribution of political power or access to credit.

9.19 The *efficiency case* requires that land redistribution increases, or at least does not reduce, farm output and the potential for growth. Since often an *inverse relationship* between farm size and output per hectare is observed, land redistribution has the potential of increasing output.[152] In most cases, the inverse relationship is due to a higher cropping intensity, and a more labour-intensive and higher-value crop mix, on smaller farms. Land quality differentials may account for part of this inverse relationship, e.g. when large farms contain a higher proportion of inferior quality land compared with the small farms. Controlling for these differences in land quality can attenuate the inverse relationship, but it does not cancel it.

9.20 The inverse relationship, however, can be modified with the onset of green revolution where land augmenting technology tends to equalize the yields attained by small and large farms. But differences in labour use per hectare tend to remain, and this is an argument in support of the continued relevance of the efficiency case for land reform even under the new technology. This is because in the context of rural market imperfections, particularly of labour markets, large farms tend to use factor proportions skewed in favour of capital (mechanization) and against labour beyond the proportions dictated by social allocative efficiency considerations, even in the absence of policies distorting prices in favour of capital, i.e. even when governments have implemented policies to "get prices right". This is a rather important consideration in the debate on what is the appropriate mix of policies

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151 FAO, "Third Progress Report on the WCARRD Programme of Action", Rome, document C91/19, 1991.

152 The inverse relationship refers to land productivity (physical yields or gross value of output per ha) as opposed to total productivity and is, in fact, generally associated with a higher level of inputs per hectare on small farms, in particular labour per hectare. However, in countries where labour is abundant and land is the scarce factor of production, maximizing output per unit of land is of primary importance.

for getting prices right and those for bringing about changes in basic structural characteristics of the rural economies.[153]

9.21 The case for a more equal land distribution is further strengthened when linkages with non-agricultural activities in the rural sector are considered. Some South Asian evidence, for example, suggests that in villages with relatively equal land (and farm income) distributions, the share of locally produced labour-intensive non-farm goods in total consumption is higher compared with that in villages characterized by higher inequality. Thus, it can be expected that a more equal land distribution contributes to rural poverty alleviation indirectly via its effects on rural non-farm employment.

9.22 The extent to which the changes brought about by policy interventions prove durable and the persistence of the unavoidable upheavals in the production structures are important elements in the land reform process. Chile's experience with land reform is instructive. Initiated during 1964 to 1970, land redistribution was extended during 1970 to 1973 and reversed during 1973 to 1976. Expropriation of land was stopped. Land worked by the campesinos in the transition period *(asentamientos)* was partly confirmed to them, partly restored to the previous owners and the balance was sold at public auction. New farm enterprises with strong financial resources entered the sector. The modern sector became strongly export oriented. In parallel, the lack of technical and credit support induced many small farmers to retreat into more traditional patterns of subsistence production. Producer cooperatives were dismantled. But more than half of the land expropriated was ultimately given to beneficiaries.[154] The crisis of 1982-83 resulted in a notable reversal of policy. From 1987 the Government started financing a considerable part of the costs of technical assistance to smallholder beneficiaries of agrarian reform.[155]

9.23 Policy interventions also led to structural changes in production in the Philippines where land reform was limited to rice and maize lands which were managed predominantly through tenancy arrangements. This limitation induced landlords to divert their land to other crops, often at the expense of both efficiency and equity. For instance, rice lands with higher income-earning and labour absorptive capacity were converted to less labour-intensive crops such as coconuts.

9.24 Success is more likely to be achieved when distributing state-owned land, where resistance is less than when trying to redistribute land away from large landholders. In the Philippines, between 1987 and 1990, two-thirds of the total land distribution targets of state-owned land were fulfilled. However, only 2 percent of the target for private land redistribution was achieved, due to disputes with owners over appropriate compensation.[156]

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[153] For a thorough treatment of the subject see Platteau, J.Ph., *Land Reform and Structural Adjustment in Sub-Saharan Africa, Controversies and Guidelines*, FAO Economic and Social Development Paper No. 107, Rome, 1992.

[154] Jarvis, L.S., "The Unravelling of Chile's Agrarian Reform, 1973-1986", in W.C. Thiesenhusen (ed.) *In Search of Land Reforms*, London: Unwin, 1989. Also, Gomez, S. and J. Echenique, *La Agricultura Chilena, las Dos Caras de la Modernización*, Flacso-Agraria, Santiago, 1991.

[155] Meller, P., *Crisis and Adjustment in the Chilean Economy*, 1988, Santiago, Chile.

[156] World Conference on Agrarian Reform and Rural Development (WCARRD), 1990, "Country Report on the Philippines", (mimeo), Manila.

9.25 Another important issue is the extent to which the state of modernization of agriculture is related to the process and chances of success of redistributive reforms. It was noted above that under the new technology, the inverse relationship between yields and farm size tends to weaken. This can weaken the efficiency case for reform. The experience also shows that the threat of reform can be instrumental in prompting larger farmers to promote modernization as a defensive action. For example, in some Latin American countries, the threat of expropriation and incentive policies (input subsidies, tax breaks) were successful in inducing large farms to modernize and hence in increasing agricultural output. One outcome of this modernization, however, was to render expropriation with compensation very costly. Further, as was recently found in Colombia, larger farmers often successfully used their influence to extract promises from the government that their land would not be expropriated if they modernized. As a consequence, redistribution of land to the poor was negligible. Interestingly, modernization of agriculture had the opposite effect on land redistribution in the Philippines. There, compensation had been fixed at pre-green revolution land values and the economic gains associated with modern seed-fertilizer rice technology allowed the beneficiaries to capture significant economic surpluses.

9.26 Government support to the beneficiaries of land reform is an essential component of the whole operation. The case of Mexico illustrates the pitfalls of unsupported land reform. There, the reform was not accompanied by significant productivity gains as most of the small farmers of the agrarian reform sector were left with non-irrigated land, and government support policies were not always effective. Even in the case of small farmers who had some irrigated lands, the government-supported cooperatives did not provide the needed services. By contrast, most of the irrigated land was left in the medium and large holdings and government support policies were heavily skewed in their favour.

9.27 The preceding discussion is more relevant to cases where the reform aims at creating more equal distribution of landholdings to be owned and operated as individual units. But there have been experiences with alternative ownership and exploitation structures in the post-reform periods. The creation of producer cooperatives is a case in point. Here the general conclusion is that the experiments with producer cooperatives led to disappointing results - particularly in some Latin American countries. In Peru, for example, earlier reforms had led to some two-thirds of agricultural land being controlled by producer cooperatives in 1979. However, these cooperatives suffered from serious diseconomies of scale and work incentive problems and many were broken up in the early 1980s and the land was distributed as individual holdings.

9.28 In Nicaragua, producer cooperatives were initially thought to be better suited for the large-scale production of export products such as coffee, cotton and beef. Subsequently, the emphasis on land distribution moved away from the establishment of producer cooperatives towards direct distribution to individuals. This followed the realization that dividing large farms into smaller holdings would not necessarily cause a reduction in output if adequate credit and other support were provided.

9.29 Land reform will continue to be a relevant issue in the future in the quest for poverty alleviation and more equity in the rural areas. However, it may cease to be the burning issue it once used to be, especially in those countries where the non-agricultural sector will be increasingly the main source of additional employment and income earning opportunities and land will lose its primacy as the main form of wealth. As indicated in Chapter 3, a number of developing countries are expected to have over the next 20 years economic growth rates

high enough to imply that the bulk of additional wealth will be generated in the non-agricultural sector. It can be expected that trends for increasing farm size will emerge in such situations, just as they did in the developed countries. This is because pressures build-up for the incomes of people in farming to follow (though not necessarily become equal to) those that can be potentially earned in the non-agricultural sector. A combination of more land per person and higher income earned per unit of land are normally the results of these pressures, brought about by technological change and the flow of labour from agriculture to other activities, though not necessarily always urban-based ones.

9.30 Many developing countries may not, however, enter this phase of transition in the foreseeable future. In many low-income countries with unfavourable overall growth prospects, high incidence of rural poverty and continued high population growth rates, the number of people seeking to make a living in agriculture will continue to grow. In these circumstances, the distribution of land ownership and the potential role of interventions to change it towards patterns more conducive to poverty alleviation and enhanced equity will continue to be live issues.

9.31 It is to be noted, however, that a more equitable distribution of a growing agricultural income can only contribute in limited ways to make significant dents in rural poverty directly, so long as the population dependent on agriculture continues to grow. This is because even an optimistic agricultural growth assumption (e.g. around 3.5 percent p.a. in gross value terms) will probably mean a growth in average per caput incomes of the growing agricultural population of under 2.0 percent p.a. Welcome as such an outcome is for its potential for reducing rural poverty, it cannot be compared with the long-term benefits obtainable from a combination of vigorous non-agricultural growth and declining agricultural population.

4.1.2 Tenancy Reforms

9.32 Tenancy is the term commonly used to refer to those land tenure arrangements (legal and customary) which regulate access to land in forms other than acquisition of ownership rights. It refers to all those situations where a person's access to land is through some arrangement with another person or entity who enjoys superior land rights. Policies to reform tenancy arrangements are often predicated on grounds of both efficiency and equity or poverty alleviation. One of the major issues concerns the relative merits of alternative arrangements for renting land, e.g. fixed payment for a definite period of time (fixed rent), share-cropping, labour service or mixtures thereof.

9.33 A major thrust of tenancy reform policies has been to restrict or prohibit share-cropping contracts. The concern with share-cropping was also associated with the feudal conditions existing in agrarian societies. In retrospect, however, it has been found that such policies can have unintended negative effects on the poor. There is now increasing realization that under special circumstances, share-cropping contracts can be an efficient

vehicle for *risk-sharing*[157] with positive impacts on both efficiency and equity. For example, evidence shows that there is a higher implicit rent on share-cropped rented land (which may reflect a risk premium) and a higher frequency of share tenancy in areas with variable weather. Cost-sharing arrangements in share-cropping can allow poor farmers to have access to certain inputs which they would not otherwise obtain because of their limited access to financial resources. For example, because fixed rents on leased lands generally must be paid in advance, poor farmers without access to credit may be prevented from leasing land. This constraint is overcome under share-tenancy as payments are made only at harvest.

9.34 The experiences of tenancy reform in China, Laos and Viet Nam indicate that changing from forms of socialized farming systems to ones based on the household economy, where allocative decisions, ownership of other productive means, and longer land-use rights are given to the individual households, can bring substantial efficiency and equity gains. In China, for example, the increases in agricultural production, and the development of the non-farm rural economy were spectacular and led to significant reductions in the incidence of rural poverty.[158] Viet Nam, after the implementation of land tenure reforms, became self sufficient in food grains for the first time and subsequently a net exporter of rice.

9.35 It must, however, be noted that regulation of tenancy contracts could result in a contraction of the supply of land for tenancy and may thus lead to an increase in the number of the landless in rural areas as tenants are evicted (as happened in the Philippines, India and Sri Lanka in South Asia, and numerous Latin American countries).[159]

9.36 Concerning Africa, recent evidence suggests that most indigenous land tenure systems are adapting efficiently to changes in resource availability. As a policy option, it may therefore be better to concentrate on providing an appropriate legal and institutional environment for more efficient transactions than to restrict land sales and rental markets with tenancy legislation.

4.1.3 Land Titling

9.37 Three arguments are usually put forward in support of land titling: (a) titling is assumed to increase tenure security with a view to promoting investment in land and water conservation and capital inputs, and adoption, where appropriate, of permanent crops;

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157 A landlord has the option of either cultivating the land himself with the help of hired workers or leasing it out to a tenant for a fixed rent or for a fixed share of the output. Suppose first that the only kind of risk is in production. Output depends, not only on the inputs, but on the weather. In the owner-operated system, the entire risk is borne by the landowner because the labourers earn a fixed wage and the owner earns the residual. In a fixed-rent system, the tenant bears the entire risk. Thus, given risk-aversion, share tenancy may be preferred because it reduces the effects of the risk element in the decision-making process with respect to investment, input use, etc.

158 Along with the significant acceleration in the growth rate of agricultural production, the rural industry, employing 100 million people, gradually became the backbone of the rural economy. The incidence of rural poverty declined from 33 percent to 11.5 during 1978 to 1990.

159 Osmani, S. R., "Social Security in South Asia," mimeo, STICERD, London School of Economics, London, 1988.

(b) by providing collateral, titles may increase access to institutional credit; and (c) land titles are considered necessary for the development of land markets which are essential for promoting commercial development of agriculture.

9.38 Recent evidence from Africa suggests that the expected positive relationship between tenure security or the extent of land rights, particularly inheritance, and long-term investment in the form land improvements hold in some areas, but not in others. Further, formal ownership titles are not necessary for tenure security, since under most communal tenure systems, a farmer has usage rights to specific plots which are often hereditary. In other places where such hereditary rights are not available, however, lack of title does bias production decisions in favour of short-cycle crops.[160] Although some evidence from Africa shows that titling may not have a significant effect on credit access, evidence from some countries in Asia and Latin America is rather more favourable, with significant increases in access to institutional credit after land titling.

9.39 Land titling often aggravates inequality since wealthier and more influential individuals can obtain greater rights than they formerly enjoyed. In these conditions the poor are exposed to increased risk of landlessness and loss of common property resources after implementation. Women require a special focus. Land titling programmes, for example, tend to concentrate on the land parcel as the relevant target unit, paying little attention to distribution of land rights within the household. Granting land titles to male household heads tends to diminish women's control over land usage and transfers. Land titling may also cause the loss of secondary rights in land, such as the right to gather fuelwood, which are of particular importance to women. There is thus a strong case for designing land legislation and reforms to target women as direct beneficiaries.

9.40 Advances in electronic data processing have opened up new horizons for traditional land titling and cadastre systems. There is no inherent reason why land registration and cadastre cannot be made sensitive to special cultural conditions on the one hand, and to equity and efficiency criteria of sustainable rural development, on the other. With the evolution currently taking place in thinking about land tenure and the shift from social to private property models, the compilation of land records (land registration and cadastre), and local community involvement in land regulation (taxation, zoning, etc.) can be expected to be major activity areas in the coming decades.

4.2 Rural Finance

4.2.1 General

9.41 The environment for rural financial intermediation has changed significantly in recent years. The concept of privatization has been embraced by an ever increasing number of countries, and the role of markets in the determination of prices for traded agricultural products has been enhanced. Food and agricultural input subsidies, including those for

160 For instance, squatters on government land in Jamaica devoted half as much land to permanent and semi-permanent crops than did titled farmers. A third of recipients under a government titling programme moved away from short-cycle crops after the change in their status (Feder, G. and R. Noronha, 1987, "Land Rights Systems and Agricultural Development in Rural Sub-Saharan Africa", *World Bank Research Observer*, Vol. 2).

agricultural credit, have been reduced or eliminated. A larger share of rural credit comes from private sources, and a declining share from the state. As subsidies on credit are reduced the cost of credit increases, and as subsidies on other inputs are reduced the amount of credit needed rises.

9.42 Until the early 1980s most attention was focused on formal finance, i.e. that sector of the financial system regulated by a central monetary authority; only occasionally was mention made of financial activities that were not regulated, i.e. informal finance. During the 1980s, however, research increasingly showed that informal finance plays an important role in rural development, especially for poor people: small farmers, landless people, micro entrepreneurs, and particularly women within these groups. It also became apparent in a number of countries that the informal system operated more efficiently and equitably than did the formal financial structure.

9.43 Far too often talk about financial services is limited to credit alone. Surprisingly large amounts of savings deposits can be mobilized even in low-income countries and among people who would fall in the category of the poor, when a reliable and effective system for doing so exists. There are a number of studies which confirm that a great percentage or, in some cases, the entire seasonal lending for agricultural production could be financed with locally mobilized funds (local in this context meaning rural). Again, this requires improvements and further developments in the financial system, which at village and district levels makes possible the mobilization of savings. At the national level the financial system must also be capable of transferring such savings from surplus to deficit areas, at the same time maintaining the confidence of savers in the safety of their deposits. As an agrarian economy develops, the flow of savings generally has been from rural areas to urban centres, a flow often stimulated by the adverse terms of trade for agriculture stemming from government policies that explicitly or implicitly tax the sector (see Chapter 7).

4.2.2 Specialized Credit Institutions and Commercial Banks

9.44 When governments and donors alike started focusing attention on credit as a means of fostering rural development, a variety of specialized, mostly government-owned, credit institutions were created. The overall experience with these types of institutions has been quite unsatisfactory. They were directed to extend below-cost loans to target groups or activities identified either by the government or by external funding entities. Because the selection of those groups or activities was often made on criteria other than commercial ones linked to their financial performance, the loan repayment rate was poor. In most cases the lending agencies were supervised and controlled by ministries which were not equipped to deal with financial institutions. All these negative features, together with excessively high transaction costs, have led many of these institutions into great difficulties, and made them increasingly dependent on state subsidies for survival.

9.45 Simultaneously with government efforts described above, commercial banks were urged to increase their activities in rural areas, particularly by lending to the agricultural sector. Again, results were generally below expectations and the intended target group, small-scale farmers, benefited little from these measures. Small-scale farmers were ignored because lending to them was expensive and they were considered to constitute a higher risk than large farmers, though there is no adequate empirical evidence to support the latter argument.

9.46 Partly on their own initiative and partly as a means of complying with the government directives, commercial banks in some countries have experimented with group lending schemes for small-scale farmers. For example, in Ghana, such schemes were initially fairly successful, but when the numbers of groups increased the staff involved could not manage them properly. This shortcoming was reflected in loan default and consequently considerable sums were lost in these schemes. However, during the last three to four years some Nigerian commercial banks have made special efforts to build up lender-customer relationships with selected cooperatives, so that the latter can satisfy the demand for credit by their members. Initial results have been encouraging.

9.47 Except for a few recent successes, both specialized credit institutions and commercial banks lacked adequate institutional and operational arrangements at the grassroots level. In particular, most of these institutional models are too far removed from their clientele to make optimum lending decisions and to exercise sound loan collecting procedures.

4.2.3 Cooperatives and Other Rural Organizations

9.48 To overcome these crucial problems, increasing efforts are being made to involve in the provision of financial services various rural organizations, such as cooperatives, informal groups of small farmers and other rural people, and traders dealing with agricultural inputs and produce.

9.49 Cooperatives permit economies of scale for their members in access to financial services; they provide an institutional means for integrating the smallholder sector into the national economy; they permit the increased exchange of goods and services between the traditional and other sectors of the economy; and allow members to benefit from technology transfer. Moreover, cooperatives in their ideal form are adaptable to many economic activities and are particularly well suited to providing financial services to rural people as they operate at grassroots level among people who know each other well, a basic condition for trust. Often a cooperative is the only financial institution (or formal organization) in a rural area, and is therefore an obvious structure for the operation of new financial services to supplement the traditional, informal sources of credit.

9.50 Cooperatives and other less formal group arrangements offer the potential of reducing both the transaction costs of lending to small-scale farmers and other segments of disadvantaged population, and of improving the management of risk. Successful lending programmes have shown the importance of factors such as homogeneous borrowing groups, which are jointly liable and themselves assume some managerial and supervisory responsibilities, and are bound in loyalty by a common bond other than credit. Important factors for the success of cooperatives include bottom-up institutional development, extensive training at all levels, reliance on savings mobilization and equity contribution rather than external funds, gradual expansion of activities, and strict monitoring and auditing. The limited success observed with such arrangements to date is mostly due to shortcomings in their implementation and general deficiencies such as low nominal rates of interest that have squeezed operational margins and an unfavourable operational environment, rather than to factors inherent in their design.

4.2.4 Informal Finance

9.51 For the rural people, and particularly for the rural poor, the main source of credit has been and continues to be various types of informal arrangements. The popularity of informal finance is not dependent on the state of development of formal financial markets. Although more common among poor people, informal loans and savings activities are known among and between all economic classes. Traditionally, informal finance has been viewed by outsiders as a plague on poor people, whereas in fact large numbers of the poor benefit from it. Furthermore, contrary to widely-held opinion, there is surprisingly little evidence in recent studies of exploitation or monopoly profits. Women, in particular, often have to resort to informal finance because of institutional and legal barriers to formal credit such as lack of collateral or requiring husband's signatures on loan agreements.

9.52 A great number of financial intermediaries operate in the informal financial markets. Probably friends and relatives are the most common source of credit, particularly in rural areas, in some countries accounting for more than half of all informal loans. In most cases, no interest or collateral are involved and repayment conditions are very flexible. These attributes have great merit for those without collateral, such as the landless or those without land titles, and in such situations where production risks may be high. Furthermore, loans are often paid in kind, such as seeds and fertilizers, and may be repaid also in kind.

9.53 Rural communities of some countries may save jointly for a variety of purposes, generally not for lending but for the bulk purchase of farming inputs (e.g. in Zimbabwe) and for various social functions. Informal rotating savings groups among women also have become popular as a means of maintaining their financial independence. More sophisticated groups are the ROSCAs (Rotating Savings and Credit Associations),[161] which are found in many low-income countries and which have been extensively studied in recent years. In many areas, more individuals participate in ROSCAs than deal with formal financial institutions; recent research in the Cameroon[162] suggests that the volume of deposits moving through ROSCAs may sometimes be larger than amounts held in banks.

9.54 The predominance of informal credit arrangements in rural credit markets necessitates the analysis of the complex transactions that occur in such markets. Recent developments in the analysis of informal credit institutions emphasize the role of informational deficiencies in shaping such transactions. In developing countries, incomes of rural borrowers are uncertain, collateral is often lacking and repayment, if not willingly made, is extremely difficult and costly to enforce. Thus, when a loan transaction takes place, it is very costly for the lender to determine the default risk of a borrower and monitor that her/his behaviour makes repayment likely.

9.55 Borrowers and lenders in their effort to reduce transactions costs of screening and monitoring loan performance may link the terms of the loan contract to transactions taking place between them in other markets. Such transactions may be between traders and

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161 A typical ROSCA is a group of 15-30 members who contribute a fixed sum weekly or monthly to a pool which is distributed among members in various, predetermined ways.

162 Schrieder, G., *Informal Financial Groups in Cameroon: Motivation, Organization and Linkages*, Unpublished MA Thesis, Department of Agricultural Economics and Rural Sociology, Ohio State University, Columbus, Ohio, 1989.

farmers (traders making loans to farmers for purchases of inputs), landlords and labourers (landlords making advance payments to workers to secure their labour when needed in the future), etc. Such interlinkages[163] lower the transaction costs of screening the borrower's creditworthiness, provide a source of control by the lender on the borrower's earnings and income, and give the opportunity to the lender to affect the probability of loan repayment by manipulating the terms of trade in other markets.[164] High information and transactions costs often restrict loans to members within geographical or social boundaries (a village or kinship group) where transactions are sanctioned by the community. This type of behaviour may explain the high segmentation of rural credit markets.

9.56 The analysis of informal markets shows that the scope of financial market liberalization will be limited if the basic reasons for the distortions in rural credit markets (i.e. informational asymmetries) are not sufficiently dealt with. Given the significant role of interlinked transactions in rural credit markets, actions by governments in other markets as well as risk reduction policies may have beneficial secondary effects on rural credit markets. For instance, land titling, increasing market integration of agricultural production, improvements on rural infrastructure and other risk-reducing policies, will increase the credit receiving capacity of rural borrowers and reduce the importance of information constraints. High segmentation in rural credit markets may introduce monopolistic elements. Existing evidence points to the existence of such elements in the behaviour of lenders. In cases where highly priced rural credit is the result of monopolistic or collusive behaviour by local lenders, entry should be encouraged.

9.57 The conclusion of the preceding discussion is that highly specialized credit institutions are no longer considered the most suitable type of financing arrangement for rural areas and particularly not for the rural poor. Intermediaries which accept savings deposits, such as local unit banks, cooperatives and other rural organizations, have gained popularity among the rural people themselves and have demonstrated promising results. It is commonly accepted that there should be a choice of institutions offering financial services and that they should compete with each other and thus improve services to their customers. Suitability of an institution to prevailing conditions and its acceptability by prospective customers should be the main criteria in promoting different types of financial intermediaries in rural areas. For the poor people in rural areas it is extremely important to have informal financial intermediaries included and to have appropriate operational linkages between them and formal financial institutions established.

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163 "An interlinked transaction is one in which two parties trade in at least two markets on the condition that the terms of all such trades are jointly determined" (Bell, C., "Credit Markets and Interlinked Transactions" in *Handbook of Development Economics*, Vol. 1, Ch. 16, Amsterdam: North Holland, 1989).

164 For instance, a trader who is also a lender may provide better prices for modern inputs to his borrower, since the use of such inputs reduce the probability of default on the loan (Hoff, K., and J.E. Stiglitz, "Imperfect Information and Rural Credit Markets - Puzzles and Policy Perspectives". *The World Bank Economic Review*, 4(3) pp. 235-250 (Symposium on Imperfect Information and Rural Credit Markets), 1990.

4.3 Marketing

9.58 The structure of rural markets influences the incidence and persistence of rural poverty, because it is instrumental in determining the way in which trade takes place and the processes governing the terms of exchange by which the poor's endowments can be translated into entitlements to goods and services. Although the structure of the marketing system in developing countries is diverse and often complex, covering arrangements for credit, storage, transport, and involving a hierarchy of intermediaries (e.g., large and small private operators, cooperatives and state agencies engaged as traders, processors, distributors, wholesalers and retailers), one common characteristic shared by many developing countries is that the exchanges enacted, especially by the poor, tend to be relatively small. The rural poor participate in those exchanges as producers with small quantities of cash crops or food surpluses to sell, as net purchasers of food and other basic necessities for own consumption, as petty traders in staple food producing areas, and as labourers in agricultural production, food processing and local distribution.

9.59 The limited scope of the market increases both transaction and production costs; the former because of informational deficiencies, and the latter because of the limited nature of specialization and division of labour. Moreover, where the formal market structure is absent or incomplete, the small trader, consumer or producer is impeded by barriers to entry, insecure property rights, and poorly enforced laws. In response, there are frequently alternative "organizational forms" and "rules and conventions" that attempt to provide a structure for exchange.

9.60 Thus the development of an efficient marketing system, apart from its implications on general welfare, can be seen to have additional benefits for the poor because it makes possible; (1) the progressive commercialization of agriculture, which in turn can act as a major stimulus to agricultural growth and employment creation, (2) the diversification of agricultural production and exports, through reducing price and income instability, (3) the improvement of nutritional status, through increasing access to a cheaper and wider range of foods, throughout the year and by ensuring that traded food products conform to established standards of quality and safety.

9.61 In the past some state marketing interventions have been linked to these considerations as well as to other sectoral or macro-economic objectives, with inevitable repercussions in terms of the structure, conduct and performance of the marketing sector. The policy instruments used in these interventions have ranged from steps taken to improve market infrastructure, and price interventions, to creating and fostering marketing parastatals and cooperatives. The pros and cons of direct government involvement in agricultural marketing is part of the wider issue of the role of the state in economic life which has come under increasing scrutiny in the context of structural adjustment policies. This wider issue is discussed in Chapter 7. Here, the focus is mainly on the significance for the rural poor of a government role in agricultural marketing.

9.62 **Improving Market Infrastucture:** A well-recognized role for policies in this area includes the provision of marketing services (e.g., urban and rural wholesale and retail markets, rural assembly markets, auction rooms etc.); collecting, analysing, and disseminating marketing information on prices, quantities, qualities and crop conditions to enhance market integration and market transparency; establishing a uniform system of grades, weights and measures; and, provisioning of marketing extension services to advise on what

to grow, how to handle it and where to market it, can bring significant long-term benefits to the poor as consumer and small farmer, particularly through reduced transaction costs and lower real prices of food. Whether government intervention should range beyond this raises more contentious issues relating to price policy and state provision of marketing services.

9.63 **Price Interventions:** Price interventions can take many forms and have multiple objectives. Stabilization of prices and/or incomes (not the same thing and often incompatible with each other) can confer important benefits to the poor because of a more secure investment climate, easier access to credit and reduced short-term stress on household consumption. Even when such stabilization schemes are appropriate and cost-effective, however, care must be taken not to introduce sustained price biases. If prices do not conform to the long-run opportunity costs represented by world market prices, the resulting misallocation of resources can seriously hinder economic efficiency, growth and poverty alleviation.[165]

9.64 **Marketing Agencies:** In the past, rural traders were often mistakenly associated with exercising monopoly power and exploitation of small farmers and this presumption in fact was one argument for the creation of marketing boards. In practice, however, rural traders often operate with low overheads and margins, and there is little systematic evidence that small farmers have been disadvantaged. Indeed, in many cases, agricultural parastatals have not performed any better, and sometimes far worse, than private agents. Often they tax farmers indirectly by absorbing a large part of prices of commodities they handle. This has discouraged production or at times encouraged farmers to employ resources in bypassing the formal sector in favour of the informal sector, with the additional costs which that entails.

9.65 Despite these deficiencies, however, some marketing boards have performed well, successfully extending to small farmers the benefits of large-scale marketing organizations - especially in remote areas (e.g., the Grain Marketing Board in Zimbabwe). In other cases, marketing boards have been operationally efficient and relatively cost effective, but due to inappropriate pricing policies and multiple objectives imposed by governments they were allowed to accumulate large losses, with subsequent burdens on government budgets.

9.66 **Cooperatives:** Similar advantages of economies of scale are often cited for cooperative ventures. The smallholders can benefit from the economies of scale in processing, storage or transport of the particular crop, where there are few private agents competing to provide these services. Vertical integration would be attractive to the small farmer producing traditional cash crops, or milk and livestock products, but is less appealing for those producing food crops, which require little processing and which are sold locally. However, timeliness and appropriateness of pricing decisions, and the coordination of processing, storage and transportation call for considerable managerial competence. Finding appropriate leaders, with the broad range of management skills required, is often difficult.

9.67 Given these difficulties, there may be some scope for limited government intervention as a stopgap measure while some of the market imperfections are tackled. One

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165 Price interventions have also been used as means of transferring resources between different sectors or interest groups (i.e., in the form of pan-territorial pricing schemes, as in several African countries, of income supports to the producers of selected products, or of implicit taxation of the agricultural sector, etc.). From an efficiency point of view, alternative forms of interventions, such as lump sum transfers or asset redistributions may be more effective.

general point should, however, be noted. In the short term, it is generally a matter of balancing the relatively low administrative costs of regulating a privatized system with the high costs involved when the State performs the marketing function itself. In the longer term, mechanisms to improve the functioning of the market itself will have to be found. The critical question is how to move smoothly from one organizational form to the other. Where major disruptions in services take place, it is likely that the poor will suffer first and probably most. Finding ways to avoid the adverse impact of reform on vulnerable groups, while attaining the benefits of a more efficient market structure, will be the main challenge in marketing in developing countries for some time to come.

4.4 Agricultural Technology and the Poor

9.68 Some aspects of the effects on poverty of agricultural growth which had its origins in the technologies known as "green revolution" were discussed earlier in this chapter.[166] The next chapter on human resources development also addresses the issue of how to reach the poor with policies for agricultural extension. Finally, Chapter 11 discusses wider issues of technology generation and diffusion in a future perspective.

9.69 Here, it is noted that technological change in agriculture will be in the future more than in the past the major determinant of the rate of agricultural growth and, hence, will continue to influence profoundly the incidence of rural poverty. Technological change is not simply a matter of increasing productivity; it is an adjustment to the whole system of technical, economic, institutional, social and political arrangements. When the full effects - both direct and indirect[167] - are taken into account, the results may turn out to be different from those expected.

9.70 Of the foreseeable technological developments (discussed in Chapter 11), biotechnology promises to have the greatest impact on society. Its overall effects are likely to be similar to those of other technological developments: increased agricultural productivity, possibly leading to lower prices at the farm level and hence not necessarily to higher farm incomes, apart from the early adopters. But the lower prices, particularly of food, will contribute to improved standards of living, more especially for the poor who are net buyers of food. Furthermore, it will have repercussions on some sectors of agriculture by shifting the balance of economic power increasingly to high-technology large-scale farms, more closely linked to industry, and away from smaller farms in disadvantaged regions and countries. In so doing, it may fuel the controversy surrounding technological change and the poor.

9.71 The divisible and scale neutral nature of the technology and its ability to provide greater control over the production environment, are characteristics that should make the new technology attractive for the poor. But, here, as in the case of green revolution, any bias in

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166 For a more complete discussion, see Lipton, M. and R. Longhurst, 1989, *New Seeds and Poor People*, Baltimore: The Johns Hopkins University Press, 1989.

167 The direct effects refer to changes in input use, output, production costs and income. The indirect effects concern pressures on the physical and institutional infrastructure, linkages with the non-agricultural sector, changes in the distribution of income, wealth and power, as well as in values, attitudes, expectations and customs.

adoption will not be due to the nature of the technology *per se* but to the initial structural characteristics of the rural economy which condition, among other things, access to information and credit, possession of management skills, ability to take risks and contact with distributors, etc. In this respect, some of the new production processes will require more knowledge and managerial competence than traditional operations. Moreover, since much of the biological research effort is conducted or supported by private companies in developed countries, the efforts are likely to be concentrated in high value crops and livestock products, which are being produced by the largest farming units and receiving the most support, rather than in commercially less attractive agricultural products and food crops unique to the farming systems prevalent in the poor countries, difficult habitats and small farmers. This, of course, enhances the need for public sector research, but at the same time relegates it to an area in which it is unlikely to be successful in terms of the yardstick of commercial rates of return which is being increasingly emphasized by public research policy. Policies are, therefore, required to ensure that broader social criteria and poverty alleviation impacts are fully accounted for in evaluating the role of the public sector in this area. Furthermore, the issue of intellectual property rights with respect to public sector biotechnological research needs to be addressed.

9.72 Finally, to the extent that biotechnology does away with certain labour operations (i.e., chemical spraying, where genetically engineered pest resistant crops are grown) or changes the structure of agricultural production towards economically more attractive but less labour intensive products, employment per unit of land used might fall, adversely affecting the poor as farm labourers. On the other hand, biotechnology offers opportunities for employment off the farm in fairly labour-intensive operations such as tissue culture, particularly in countries with relatively skilled, but low-cost labour, such as India and Brazil.

9.73 Another technological trend in agriculture which offers scope for creating employment, but not necessarily higher incomes, is the increasing emphasis being placed on so-called environmentally friendly production techniques. The range of such techniques is wide, at one extreme from organic farming which eschews all use of chemicals, including mineral fertilizers, to less strictly defined, low external input systems, which partially substitute on-farm materials such as manures, mulches, etc., for purchased chemically-based inputs. These systems often involve the greater integration of livestock and crop production, more complex cropping systems, composting, etc. They share the need for more inputs of labour, and so may favour the smaller-scale, family or cooperatively run farms, where labour costs or income expectations are lower than those of commercially motivated operations.

4.5 Rural Development in the Non-farm Sector

9.74 There is growing recognition that major increases in rural non-farm employment will be required in most developing countries to absorb the rapid growth in the rural labour force and to stem the tide of rural-urban migration which is leading to urban poverty and squalor. In fact, available, but rather sketchy, evidence suggests that rural non-farm activities constitute an important source of employment for the rural labour force in sub-Saharan Africa and Asia, the ranges falling between 10 and 20 percent in the former and between 20 and 30

percent in the latter.[168] Furthermore, the dependence on non-farm employment tends to be much higher for the landless and the land-poor households than for those with the larger size holdings.

9.75 Much of the employment in non-farm activities is wage employment. Amid wide variation in Africa, commercial establishments tend to constitute the largest source, employing about 35 percent of the rural non-farm workforce. Manufacturing and services follow with 30 and 25 percent, respectively, while construction and mining account for the remainder. Within manufacturing, food processing, tailoring, carpentry and metal working tend to dominate. Although similar estimates are not readily available for Asian countries, some results in India suggest that commerce and services account for the bulk of the non-farm employment, followed by manufacturing.

9.76 Despite the importance of rural non-farm activities in terms of their contribution to employment and income generation, the developments there are closely related to the developments in the farming sector. There are linkages between the two sectors on both the production and the demand sides. Farms, for example, provide inputs for non-farm activities (e.g. flour for making bread), while they use inputs produced in the non-farm sector in their own production activities (e.g. agricultural implements). Moreover, higher agricultural incomes stimulate the demand for consumer goods and services produced in the rural non-farm sector. Agricultural growth may thus stimulate all-round rural development.

9.77 Available evidence for Africa and Asia points to a *positive* relationship between rural non-farm employment and agricultural income. In most cases, for any given level of agricultural income, Asian countries generate higher levels of non-farm employment than do their African counterparts, thus suggesting that agricultural multipliers may be higher in Asia. African growth multipliers are about 60 percent of those in Asia: a $1 increase in value added from agricultural tradables produces an additional $0.50 of rural income in Africa, compared to about $0.83 in Asia.[169] The multipliers were similar for both smallholders and estate farms. Although the latter are more dependent on purchased inputs, these are mainly produced in urban areas or are imported. In sub-Saharan Africa, most of the impact of agricultural growth on non-farm activities originates in the increased consumption demand for locally produced goods and services, while in Asia the production linkages of agriculture are relatively stronger and provide additional stimulus to local non-farm activities.

9.78 The experiences of Japan and Taiwan (province of China) in the 1950s and 1960s, and more recently of China, characterized by rapid expansion of non-farm rural enterprises provide additional evidence of the importance of these linkages. Effective implementation of reforms at the farm level favouring small farmers (e.g. land reforms in Japan and Taiwan and the introduction of household responsibility system and relaxation of price controls in China) were the most important factors in raising agricultural incomes, which in turn

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168 These estimates are taken from Islam, N. "Non Farm employment in Rural Asia: Issues and Evidence, in R. D. Shand (ed.) *Off-Farm Employment in the Development of Rural Asia*, Canberra: Australian National University, 1986, and Hazell, P., and S. Haggblade, "Rural-Urban Growth Linkages in India", (mimeo), Washington D.C.: The World Bank, 1990.

169 Hazell, "Rural Growth Linkages and Rural Development Strategy", mimeo, Washington D.C.: IFPRI, 1984.

stimulated the demand for producer and consumer goods and services and contributed to growth in the rural-based activities of manufacturing, distribution and servicing. The expansion of non-farm activities was further aided by the provision of institutional and infrastructural support. In Japan and Taiwan, the infrastructural support was provided in the form of an integrated system of rail and road facilities together with rural electrification. In China, local policies (e.g., financial aid, credits and tax breaks) in favour of rural enterprises were important in stimulating rural non-farm development.

4.6 Selected Direct Antipoverty Interventions

4.6.1 Rural Public Works

9.79 Public employment schemes have long been used in many developing countries in emergency situations, such as during periods of drought and famine (and, more recently, during periods of macro-economic stabilization and adjustment), and when there is large-scale, transitory unemployment and underemployment in the rural sector. However, in recent times, many developing countries have incorporated such schemes as regular elements of an antipoverty strategy.

9.80 The experiences of Asia and sub-Saharan Africa provide useful examples of the worth of public employment schemes used for poverty alleviation during periods of drought and associated threats of famine in the 1980s (e.g. Botswana in 1983-85, India in 1987). In South Asia, Rural Public Works (RPW) form the core of government antipoverty strategies, creating useful employment for many of the rural unemployed and underemployed, as well as significantly reducing income variability. In Latin America many countries, such as Bolivia, Chile and Peru, have used public employment schemes to counter the temporary drops in labour demand that occurred during periods of structural adjustment or macro-economic shocks.

9.81 Apart from providing substantial welfare benefits for the poor, RPW programmes often contribute to economic growth through the creation of assets such as roads, schools and canals. Social and economic returns to assets created through such programmes can be enhanced by ensuring that the projects are well integrated into existing rural development plans. Community participation in project design and execution can help to select highest priority projects, avoid wastage, and promote labour-intensive methods. It can also help in the maintenance of the assets after they are created, even though regular financial provisions for maintenance are also necessary.[170]

9.82 While there are few estimates of the cost-effectiveness of RPW, simulations based on Indian data for the period 1980-2000 suggest that RPW programmes can have a greater impact on the poor than investment in irrigation or schemes of public distribution of food at

170 For an analysis of the experience in the maintenance of common property resources by villagers themselves in rural South India see Wade, R. *Village Republics*, Cambridge: Cambridge University Press, 1987.

subsidized prices.[171] However, care must be exercised in targeting the poorer households if the aim is poverty alleviation. This has been achieved, for example, in the Maharashtra Employment Guarantee Scheme and the Bangladesh Food for Work Programme, where the programmes pay lower-than-market wages. In contrast, Bolivia's Emergency Social Fund (ESF), which largely financed local infrastructure projects executed by private contractors and permitted the hiring of construction workers at market wages, was not well targeted. Fewer than one-half of the workers employed on ESF schemes were drawn from the poorest 40 percent of Bolivian households.[172]

4.6.2 Food and Nutrition Interventions

9.83 Since some sections of the poor (e.g., the old and the handicapped, as well as some of the groups referred to earlier - para 9.13) are not likely to be in a position to benefit from the direct antipoverty interventions discussed so far, special interventions to raise their income levels are necessary. Unanticipated fluctuations in food prices may also have serious consequences for the 'entitlements' of the poor, particularly for casual agricultural labourers. In this context, there is a strong justification for direct interventions to enhance their access to food, usually in the form of food subsidies.[173] The design and implementation of food subsidy schemes raise many contentious issues. Such subsidies take a variety of forms (e.g., general food subsidies, food rations, food stamps, etc.) and the choice of an appropriate form is often very difficult. Also, the direct welfare effects of food subsidies may be quite different from the indirect effects operating through other markets.[174] The experiences with food subsidization policies are summarized below.

9.84 **General Price Subsidy Schemes:** Their general characteristic is that they supply unlimited amounts of specific subsidized food to anyone who wishes to buy it. The subsidy may cover a portion of the total production, storage and marketing costs. The price wedge may be administered at a point of import, or a point of processing, storage or sale. Such schemes have been extensively used in developing countries because they are administratively convenient, especially where private market channels exist. However, they also tend to be costly, because of leakage of benefits also to the non-poor.[175] For this reason some

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171 Parikh, K. and T.N. Srinivasan, 1989, "Poverty Alleviation Policies in India: Food Consumption Subsidy, Food Production Subsidy and Employment Generation", (mimeo), New Haven: Economic Growth Centre, Yale University, and Narayana, N.S.S., K.S. Parikh, and T.N. Srinivasan, 1988, "Rural Works Programs in India: Costs and Benefits", *Journal of Development Economics*, Vol. 29, 1988.

172 World Bank, *World Development Report 1990*, Washington D.C.

173 However, other efforts to improve the ability of poor households to make better use of the resources available can also have significant nutritional benefits. These efforts include, for example, nutrition education, introduction of appropriate technologies, expansion of water and sanitation facilities, and increasing/subsidizing cooking fuels.

174 For some illustrations, see Timmer, P., *Getting Prices Right: The Scope and Limits of Agricultural Price Policy*, Ithaca: Cornell University Press, 1986.

175 Costs ranged from less than 1 percent of total public expenditure in Colombia during 1978-80 to 10-17 percent in Egypt between the mid 1970s and 1984. In Egypt, only about 20 cents out of each dollar spent reached those in the poorest quartile of the population (World Bank, 1990, op.cit.).

countries have limited general food subsidies applied to commodities that are consumed mainly by the poor, as in Egypt where the benefits of coarse flour subsidies accrue mainly to low-income groups, or to specific geographic regions, as in Philippines, where rice and cooking oil were made available to selected poor villages through local retailers at discounted prices. It is estimated that 84 percent of the total cost of subsidies accrued as benefits to the target groups.

9.85 **Ration Schemes:** An alternative to a general subsidy is to provide a quota, or ration, of subsidized food to each eligible household and let the market supply any further requirements. Ration schemes are designed to ensure access to a regular supply of basic staples at "reasonable" prices. The absolute transfer under a general ration is similar for *all* income groups. Thus, rations tend to be more progressive than general food subsidies.[176] However, as is true of general subsidies, ration schemes are often limited in coverage - especially in rural areas - because the infrastructure and distribution networks needed to implement them are lacking.[177]

9.86 **Food Stamp Schemes:** A subsidy scheme that is similar to ration is food stamps, where the rations are measured in terms of nominal currency units rather than in commodity weights or volumes. There are, however, some important administrative differences in their functioning. Food stamps do not require the government to handle directly any commodities. They do, however, require that retailers accept a parallel currency and are able to redeem this currency conveniently.

9.87 The experiences with food stamps in Sri Lanka and Jamaica suggest that such schemes have to be well targeted. In Jamaica targeting was achieved by selecting well-defined needy groups such as pregnant and lactating women and children under five registered at health centres. However, even if the programme is broader in scope, as was the case in Sri Lanka, where stamps for food and kerosene were provided to families with self-reported incomes below a certain minimum, the financial burden of such programmes can be much smaller compared to the implementations of general ration schemes and other food subsidies. If the inflationary pressures cannot be kept under control through appropriate macro policies, the value of the food stamps can quickly erode, partially nullifying the beneficial effects on the poor.

9.88 Despite these two relatively successful experiments, the schemes in Colombia, Egypt, Peru and Venezuela ran into difficulties because of the problems in establishing the

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176 Experience in Sri Lanka after 1978 indicates that a targeted rice ration scheme covering the poorest half of the population benefited the poorest groups (bottom 20% of the population) much more than the general wheat and bread subsidy schemes implemented during the same time. A similar pattern of transfers is seen in the distribution of food grains through fair price shops in certain states in India. In Kerala in 1977, for example, the poorest 60 percent of the population received 87 percent of the foodgrains distributed.

177 In some parts of India as well as in other countries, including Bangladesh and Pakistan, the benefits of ration systems accrue disproportionately to urban consumers, despite the fact that, as noted earlier, poverty is largely a rural phenomenon in South Asia.

stamps as an alternative currency.[178] Taken together these experiences indicate that in the absence of sound macro-economic management and the lack of a well-developed market network in rural areas, the implementation is likely to be difficult with the gains to the poor eventually eroding.

9.89 **Supplementary Feeding Programmes:** These are a form of highly targeted ration or in-kind transfer schemes. Their main objective is to reduce undernutrition. Subsidized or free food is distributed through schools, nutrition and health centres or community organizations for direct or home consumption to those deemed specifically vulnerable to nutritional and health risks. The beneficiaries usually comprise children under five, school children and pregnant and lactating women. Additional targeting on the basis of growth monitoring, location or income helps in identifying the neediest members within these groups. Older children and adults are also fed in many emergency situations.

9.90 The Indian experience with two supplementary feeding programmes provides some useful lessons. Initiated in 1975, the Integrated Child Development Services (ICDS) programme aims to improve the nutrition and health of children 0-6 years of age by simultaneously providing supplementary feeding, immunization and curative medical care to children and pregnant and lactating women, and health and nutrition education to mothers. However, the primary emphasis in the ICDS programme is on providing meals. The results have been mixed, mainly because of difficulties faced in targeting the beneficiaries, strong urban bias and other reasons. By contrast, the Tamil Nadu Integrated Nutrition Project (TINP), initiated in 1980, is *area-targeted* (to the rural areas of six districts having the lowest calorie consumption in the state), *age-targeted* (concentrating exclusively on children 6-36 months of age), and *need-targeted* (depending on weight gain over a certain period). Since the children are on the supplementation programme only for the duration of time their weight gain is below standard, it is essentially a short-term intervention that endeavours not to foster long-term dependence of beneficiaries on public assistance.

9.91 **Home and Community Gardens:** The production of secondary food crops in home and community gardens and small livestock and poultry rearing or fish farming can make an important contribution to improving household food security by improving food consumption, particularly during times of seasonal scarcity of food. In addition, this would also provide additional income to families from sale of surplus utilizing available family labour.

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178 Alderman, H., "Food Subsidies and the Poor", in G. Psacharopoulos (ed.) *Essays on Poverty, Equity and Growth*, Oxford: Pergamon Press, 1991.

CHAPTER 10

HUMAN RESOURCES DEVELOPMENT IN AGRICULTURE: DEVELOPING COUNTRY ISSUES

1. INTRODUCTION

10.1 There is increasing evidence and recognition that what matters for development, more than natural resources and man-made physical capital, is the capability of people to be effective and productive economic agents, in short, human capital. In the particular case of agriculture, most studies on the subject establish that the education and skills of agricultural people are significant factors in explaining the inter-farm and inter-country differences in agricultural performance, along with the more conventional factors such as availabilities of land and water resources, inputs, credit, etc.

10.2 With the shrinking of per caput agricultural resources following demographic growth, with the agricultural labour force in the developing countries projected to continue at positive (though declining) growth rates and with the share of young people in the total also continuing to grow, the task of upgrading the literacy, the skills and other capabilities of the agricultural people is enormous, for coping with both the increases in numbers and the backlog inherited from the past. Moreover, the increasingly binding character of natural resource scarcities imposes severe limits on the extent to which production increases can be had through expansion of extensive agriculture. The generation and diffusion of technology and management capabilities for more intensive and modernized agriculture and supporting services become imperative. This can only be achieved through the upgrading of the quality of human resources employed in agriculture.

10.3 It is noted that many dimensions of the human resources development (HRD) issue are final end-objectives of development, e.g. literacy, better health and nutrition, etc. Although this chapter is concerned with policies to upgrade the quality of people to become more productive and more energetic economic agents, the need to make progress in literacy, health, nutrition, etc. as objectives in their own right, should not be lost sight of. This is important, since it implies that evaluation of returns to investment in these areas must take into account the value of improvements in literacy, etc. as increasing the welfare of individuals directly and not only indirectly through making them more productive economically. These considerations cannot but influence the criteria for making decisions concerning the allocation of scarce resources, e.g. between promoting basic education versus creation of more directly productive agricultural skills.

10.4 For practical purposes, this chapter does not cover the entire set of variables whose evolution determines HRD outcomes. In particular, it does not cover aspects of health, sanitation and nutrition.[179] It rather focuses on those actions aimed directly at upgrading

[179] See Chapter 9 for policy interventions to improve nutrition.

the productive potential of people making a living in agriculture. *Section 2* presents the magnitude of the target population, now and in the future (the population economically active in agriculture). *Section 3* focuses on basic education and agriculture. *Section 4* focuses on policies and actions to diffuse technical and management knowledge to the persons working in agriculture through the extension services. In both sections the historical developments and present situation are presented and discussed before discussing the needs and possible developments in the future. *Section 5* highlights the important place of technical and professional education in agriculture in HRD itself and in development in general.

2. MAGNITUDE OF THE TASK

10.5 A first impression can be had by observing that the present population economically active in agriculture (PEAA) in the developing countries of just over 1 billion is likely to continue to increase by some 13% in the next 20 years (Table 10.1). The growth rate is slowing down from 1.2% p.a. in the last 20 years to 0.6% in the next two decades, and indeed the PEAA is about to peak-off in the regions of Latin America/Caribbean and East Asia. But this is not likely to happen in the two regions with the highest shares of their population in agriculture and with high incidence of rural poverty (sub-Saharan Africa and South Asia). This means that 20 years from now, these two subregions are still likely to have 60% of their labour force depending mainly on agriculture for employment and income. This contrasts with likely developments in the Latin America/Caribbean and N. East/N. Africa regions which seem to be transiting towards patterns of labour force dependence on agriculture more typical of Southern Europe.

10.6 Naturally, the human resource development effort has to provide for the entire agricultural, and indeed the rural, population, not only those classified as economically active. In particular, interventions in the areas of basic literacy, health and nutrition have to reach people well before they grow to become members of the PEAA. The magnitude of the task can be appreciated from a few related parameters. In the first place, the numbers in Table 10.1 have to be multiplied by a factor of 2.2 for the developing countries as a whole to obtain the estimates of the total agricultural population (a lower factor applies to East Asia, a much higher one to Near East/North Africa). Secondly, the age structure of the rural population implies that some 13% of the total, or some 350 million, are in the age group 15-24 years, a group commonly referred to as youth in the HRD programmes. Their numbers will be edging-up towards 400 million in the future. Indeed, from the point of view of providing basic education services, these estimates will have to be more than doubled to account for children in the age group 6-15. Finally, the share of economically active women in PEAA is about 30% for the developing countries as a whole, but with wide regional variations, e.g. 56% in sub-Saharan Africa, 37% in Near East/N. Africa, 31% in Asia, but only 12% in Latin America. It is obvious that the data referring to women are of great importance for focusing the HRD effort in the rural areas given the increasing recognition of the role of women in development (WID) in policy-making in combination with the fact that past HRD policies have tended to favour men rather than women.

Table 10.1 Population Economically Active in Agriculture

(million)

	1970	1980	1990	2000	2010
All Developing Countries (% of total econ. active popul.)	790 (71)	923 (66)	1051 (60)	1130 (53)	1190 (47)
93 Study Countries (% of total)	780 (71)	912 (66)	1039 (60)	1120 (53)	1180 (47)
Africa (sub-Saharan) (% of total)	98 (81)	118 (76)	140 (71)	170 (66)	205 (60)
N. East/N. Africa (% of total)	31 (57)	32 (46)	35 (37)	38 (30)	39 (24)
East Asia (% of total)	411 (76)	488 (71)	549 (63)	550 (55)	530 (47)
South Asia (% of total)	203 (71)	235 (68)	275 (65)	320 (61)	365 (57)
Latin America/Caribbean (% of total)	37 (41)	39 (32)	41 (26)	41 (21)	40 (17)

Note: The data, and in particular the projections, should be understood as indicative of broad orders of magnitude. They are, as far as possible, standardized for comparability among countries and regions. They may differ from those obtained from the routine labour force survey statistics. For discussion see FAO, *World-wide Estimates and Projections of the Agricultural and the non-Agricultural Population Segments, 1950-2025*, ESS/MISC/86-2, 1986. Data by country are given in the Statistical Appendix. The basis of these estimates are the historical data up to the early 1980s from ILO's work providing internationally comparable statistics. ILO is in the process of updating these data.

3. BASIC EDUCATION AND AGRICULTURE

10.7 Basic education, often referred to as literacy and numeracy education, is the most fundamental of HRD efforts, not only as a universal right of the individual but also as the foundation for any further initiative in human resource development in agriculture designed to improve agricultural production, and, hence, incomes and welfare. Basic education can significantly improve the efficacy of training and agricultural extension work which in turn affect agricultural production through: (a) enhancing the productivity of inputs, including that of labour, (b) reducing the costs of acquiring and using information about production technology that can increase productive efficiency and (c) facilitating entrepreneurship and responses to changing market conditions and technological developments.[180]

180 T. P. Schultz "Education Investments and Returns," in H. Chenery and T.N. Sirinivasan (eds), *Handbook of Development Economics, Volume 1*, Amsterdam: North-Holland, 1988, pp. 543-630.

10.8 An analysis of 37 sets of farm data from developing countries showed that farmers completing four years of elementary education had higher productivity by, on average, 8.7 percent.[181] The same authors estimated social returns to investment in rural education of 7-11 percent in Korea (Rep.), 25-40 percent in Malaysia, and 14-25 percent in Thailand, under various assumptions. But the most extensive studies related to rates of return to education at different levels have been conducted using data at the national level. A summary of the findings of these studies is presented in Table 10.2. The rates of return are highest for investment in primary schooling in all regions for which there was information. Since rates of return on public investment in most other sectors are commonly well below those presented in Table 10.2, there is a strong *prima facie* case for strengthening public provision of education, including the reallocation of funds within the total education budget in favour of primary education.

Table 10.2 Average Social and Private Rates of Return to Education, by Region*

Region	Social			Private		
	Primary	Secondary	Higher	Primary	Secondary	Higher
Africa	27	19	14	45	28	33
Asia	18	14	12	34	15	18
L. America	35	19	16	61	28	26

Source: Schultz, 1988, *op. cit.*, p. 575.

* These rates of return are based on statistical associations between the market earnings and schooling of individuals, therefore they do not include other possible benefits such as the effects of education on the productivity of non-market time such as the time spent by farmers in own cultivation and the time spent by women in home production, on infant mortality and female fertility, etc. Private returns are typically the internal rate of return to investments made by individuals in their own education. The investments include both explicit (tuition fee, costs of uniform and books etc.) and implicit (opportunity, cost of time) costs of education. In calculating social returns, all costs of education, including public sector subsidies, are included on the cost side of the calculation. The social rate of return is lower because the same benefits (incremental income of the person receiving the education) are compared with total costs of providing the education, not only with those financed by the person concerned. In this case, the term "social" may be misleading because it does not include the benefits of education of a given person accruing to other persons and society at large (externalities) beyond those reflected in the incremental earnings of the person educated.

10.9 The share of public expenditure on education in GNP in developing countries has climbed from 2.9 percent in 1970 to 4.1 in 1988.[182] However, the improvements have not been uniform across different regions, e.g. sub-Saharan Africa and Latin America and the Caribbean experienced reversals in the 1980s. Nor have they been that impressive for the least-developed countries when the real expenditures on education are adjusted for population

181 D. T. Jamison and L. J. Lau, *Farmer Education and Training Efficiency*, Baltimore: Johns Hopkins University Press, 1982.

182 The comparable estimate for the developed countries was 6 percent in 1988 (Unesco, *World Education Report 1991*, p. 36).

growth. Notwithstanding the reported declines in expenditure in some regions, the enrollment rates in all regions seem to have consistently improved, as evidenced by the increases in expected years of school enrolments.[183]

10.10 Nevertheless a large proportion of adult population, both female and male, in rural areas in many developing regions continues to be classified as illiterate (Figure 10.1). Apart from the factors already noted, possible misallocations of public resources within the education sector, relatively long gestation periods required for training teachers, and relatively higher unit costs of providing educational services in the rural areas may have also contributed to the persistence of high rural adult illiteracy rates. The relevance of the first factor can be illustrated by considering the fact that despite the relatively lower social rates of return to higher education, the "developing countries as a group spend over 25 times as much per student for the 7 percent of the school-age population enrolled in higher education as for the 75 percent in primary education."[184] Moreover, since the education system produces its own main input, the rate at which the system expands is limited by the capacity of the system in producing teachers. Thus in the initial phases of developing the education system, the rate at which educational services expands can be slow and costly. The fact that rural populations tend to be spatially more dispersed exacerbates these problems and increases the unit costs of providing educational services in rural areas.

10.11 The situation of access to education of rural women deserves a special mention. The importance of women's labour in planting, cultivation, weeding, harvesting and processing of food, in feeding their families and in rearing children, brings into sharp focus the urgency of improving women's access to educational services. Despite the increases in enrollment rates for women, in line with overall increases mentioned above, "in the low- and middle-income countries as a group, there were still only 81 females per 100 males in primary school and 75 females per 100 males in secondary school in 1987. In sub-Saharan Africa, there were only 77 and 59 females per 100 males in primary and secondary school, respectively, with the lower number of females relative to males in school reflecting both fewer female entrants and a higher dropout rate among women."[185] Indeed, these disparities are even larger in the rural areas.

10.12 The reasons for the gender disparity in enrollments (and educational attainments) are both cultural and economic. Tradition often demands special concern for their privacy and social reputations. In cultures where female seclusion is practiced, the impact of that tradition on girls' enrolment after puberty is substantial. These concerns prevent parents from sending girls to school, unless schools are located close to home, well supervised, and served by

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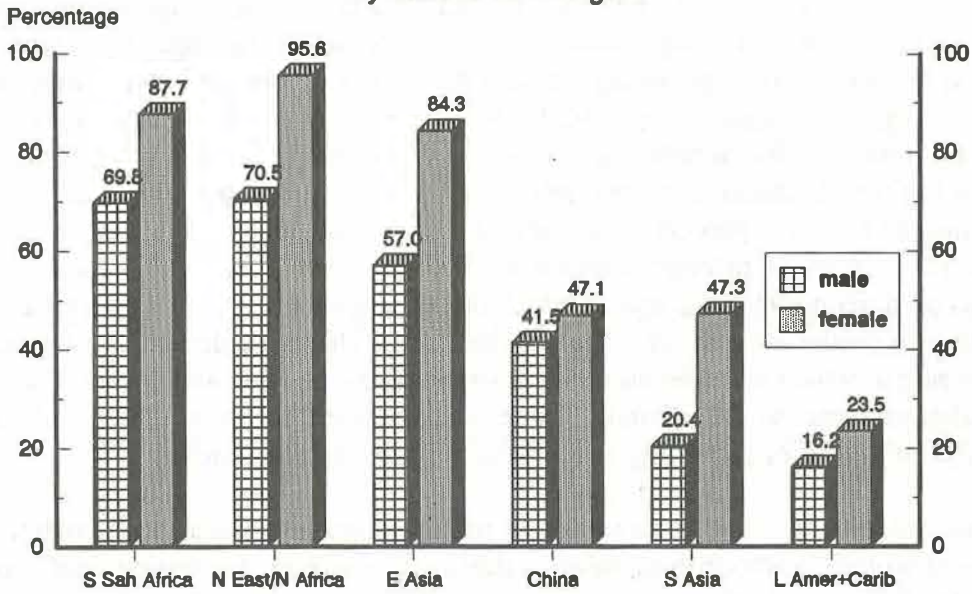
183 Based on data provided in the *World Development Report - 1984*, Schultz estimated that over the period 1960-1981 the expected years of school enrollments in low income countries had increased from 6 to 8 years, with greater improvements for middle income countries. The apparent "paradox " of increased enrollments with lower public expenditures in low income countries is explained in terms of: (1) declining quality of schooling per student; (2) declining unit costs of production of educational services of a constant quality relative to the general price level; or (3) errors in the underlying data (Schultz, *op. cit.*, pp. 552-557). It must, however, be stated that data referring to the 1980s indicate temporary reversals also in enrolments in most regions.

184 FAO, *International Agricultural Adjustment - Seventh Progress Report*, C-91/18, Rome, 1991.

185 FAO, *International Agricultural Adjustment*, 1991, pp. 33-34.

female teachers. When parents themselves lack education, they are more reluctant to challenge tradition to educate their daughters. Traditional constraints tend to be far more severe in rural areas.

Figure 10.1: Rural Illiteracy Rates
by Gender and Region



Source: Aggregated from Unesco, *Statistical Yearbook 1992*, Paris, for those countries for which data are available. The data do not necessarily correspond to the same year for each country.

10.13 Among economic reasons, the high opportunity costs of sending girls to school weigh heavily in household decisions. These costs include chore time, children's foregone earnings, and - especially for girls - mothers' foregone earnings. Also the opportunity costs of sending girls to school are likely to be higher for poor families in rural areas, since they tend to make a greater contribution to family welfare.

10.14 Given the nature of the problems in providing basic education in developing countries, it is not too surprising to find that extending past trends into the future continues to yield nearly 20 percent illiteracy rate for males and 37 percent for females by the year 2000. Overall, the absolute number of illiterate adults in developing countries is projected to remain high, around 920 million compared to 840 million in 1970. Given the importance of education in increasing the productivity of agricultural activities, raising rural incomes and improving welfare, a careful restructuring of the basic education system towards diversification and curriculum development may also be necessary to meet the future challenges related to environmental sustainability, poverty alleviation, improved nutrition, better health, reduced infant mortality etc.[186]

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186 The experience with diversification and curriculum development in some developing countries (i.e., Colombia, Tanzania, Indonesia and India) with respect to future employment prospects, unit costs of providing such specialized education and student performance, was mixed.

4. AGRICULTURAL EXTENSION AND TRAINING

10.15 Agricultural extension "assists farm people, through educational procedures, in improving farming methods and techniques, increasing production efficiency and income, bettering their levels of living and lifting the social and educational standards of rural life."[187] Organized publicly supported agricultural extension services for farm people are an innovation of the twentieth century. For example, the United States of America established its Cooperative Extension Service in 1914.

10.16 This HRD innovation in agriculture has been spreading in recent years. Out of 198 extension organizations in 115 countries which provided reports to FAO in 1989, only 10 percent had been established before 1920, while 50 percent had been established after 1970.[188] The increasing adoption of organized extension in the developing countries reflects the realization of its importance for agricultural development and the high rates of economic returns that have been demonstrated by the experience of countries where extension has been properly delivered. For example, a study reports that in the USA a US$ 1 000 increment in extension spending was associated with a US$ 2 173 increase in farm output within a two-year period.[189] Comparative studies from several countries reinforced the earlier claims of relatively high economic returns to investment in agricultural extension.[190] More recently, studies on productivity increasing effects of agricultural extension services have been reported. A report on World Bank support to agricultural extension services in 22 sub-Saharan African countries is illustrative. An average of 40 percent increase in yields in the first year have been recorded in a 1989-90 study.[191]

10.17 The findings of the recent Global Consultation on Agricultural Extension of FAO indicate that the rate of return to investment in extension is likely to be influenced by a variety of factors. These range from the economic value of the farm product, with cash and export crop farmers enjoying higher returns than food crop farmers; the general economic climate, with returns being lower in relatively poorer agricultural nations; to the nature of the extension services provided, with larger returns to those systems that embrace large

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187 FAO, *Agricultural Extension: A Reference Manual*, Rome, 1984, p. 1.

188 Swanson *et. al*, "Current Status of Agricultural Extension Worldwide" in FAO, *Report of the Global Consultation on Agricultural Extension*, Rome, 1990, p. 45.

189 Evenson, R.E., "Agriculture" in R.R. Nelson (ed.) *Government and Technical Progress*, New York: Pergamon Press, 1982.

190 Evenson reporting on nine studies, four in the USA and the remaining in India, Brazil, Kenya and the Philippines, found generally respectable cost-benefit ratios (R.E. Evenson, "The Economics of Extension" in L. Jones (ed.) *Investing in Rural Extension: Strategies and Goals,* London: Elsevier, 1982). Evenson and Kislev's pioneering evaluation of agricultural extension in 15 Indian states, covering 1953-54 and 1970-71 (R.E. Evenson and Y. Kislev, *Agricultural Research and Productivity*, New Haven: Yale University Press, 1975) and Feder *et. al's* more recent estimates (G.T. Feder, L.J. Lau and R.H. Slade, *The Impact of Agricultural Extension: A Case Study of the Training and Visit System in Haryana and India,* mimeo, Washington D.C.: The World Bank, 1985) suggest rates of return greater than 15 percent.

191 "T and V has a High Payoff" in *Findings: Africa Regional Studies Programme Newsletter*, Vol.1, Number 1, June 1992, p.1.

numbers of farmers and have lower per-farmer costs.[192] More generally, it is recognized that an effective extension system cannot be considered on its own and that it "needs a supportive environment that includes a long-term commitment to agricultural growth expressed through the provision of adequate agricultural support services - of which extension is but one - and macro-economic policies that, at a minimum, do not disfavour agriculture".[193]

4.1 Scope of Extension Effort Worldwide

10.18 Agricultural extension services in the world have been expanding during the past three decades. Around 1959, there were approximately 68 organized extension services, with as many as 180 000 agricultural extension personnel. By the year 1980, the number of organized extension services had increased to around 150, with a total personnel of about 350 000.[194] The estimated extension workers in 1989 stood at approximately 600 000, of whom nearly two-thirds were located in developing countries. A least-developed country like Mozambique, for example, had, in 1989, about 350 professional/technical staff in extension following the establishment of a national extension service in 1986 with UNDP/FAO assistance. The data collected for FAO's Global Consultation indicate that agricultural extension expenditures were approximately US$ 4.6 billion (equivalent) in the 98 countries for which data were available. Of this total nearly 87 percent was undertaken in developing countries. If it had been possible to include all countries of the world, the estimated total expenditure on extension would probably have exceeded US$ 6 billion per year.[195]

10.19 In spite of the tremendous increase in the numbers of agricultural extension workers in the last three decades, the actual coverage of agricultural extension services in the developing countries has been limited. In the USA, Canada and Europe, one public extension agent covers about 400 economically active persons in agriculture, even before counting the services of private sector extension agents. However, in the four developing regions of Africa, Asia, Latin America and the Near East, an extension worker covers on average about 2 500 such persons. This suggests that in actual practice, only one out of every five economically active persons in agriculture receives extension service each year in developing countries. This rate is likely to be lower when one considers that about one-fourth of the extension worker's time is devoted to non-educational duties, which is equivalent to approximately 140 000 full-time years of extension workers' time in 1989.[196]

10.20 Another issue is the kind of farmers served by the extension agents. Data from the Report of the FAO Global Consultation on Agricultural Extension show that in the reporting

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192 T.E. Contado, "Agricultural Extension Approaches: What FAO's Case Studies Reveal" in FAO, *Report of the Global Consultation on Agricultural Extension*, *op.cit.*, pp.77-107.

193 Hayward, J.A., "Agricultural Extension: The World Bank's Experience and Approaches" in FAO, *Report of the Global Consultation on Agricultural Extension*, *op.cit.*, p.122.

194 Evenson, R.E., *The Economics of Extension*, *op.cit*, p. 73.

195 FAO, *International Directory of Agricultural Extension Organizations*, Rome, 1991, pp. 100, 289.

196 FAO, *Report of the Global Consultation on Extension*, *op.cit*, p. 60.

developing countries 6 percent of extension agents' time and resources are devoted to large commercial farmers, 26 percent to smaller commercial farmers, while 24 percent is devoted to subsistence farmers and 6 percent to farm women. In a well-documented case study of the extension programme in two provinces of Turkey,[197] however, the record indicates that 100 percent of the 5 100 large farmers were served by the extension service, while only 55 percent of the 62 300 small-scale farmers were receiving extension services. Of the 17 900 medium-scale farmers, 90 percent were receiving services from extension. It may be noted however that the 5 100 large farmers constituted only 9 percent of the 55 500 farmers served by the extension services in the two provinces.

10.21 The preceding paragraph illustrates the problems associated with extension coverage and resource availabilities. What scope is there for NGO and the private sector participation in extension in developing countries? It is widely recognized that in most countries, the private sector has varying degrees of involvement in agricultural extension work. In developed countries, the trends towards privatization relate to budgetary problems.[198] In the developing countries, increasing coverage and public extension cost reduction are the main reasons for NGO and private sector involvement in extension.[199] For example, in Colombia, 35 percent of the 2 315 extension agents are provided by an NGO - the National Federation of Coffee Growers. In Uganda, 7 percent of the 2 040 agricultural extension agents are provided by a private company.[200] However, at the end of the 1980s, worldwide, such non-governmental organizations and private firms providing agricultural extension services constituted only 7 percent and 5 percent, respectively, of the total number of extension agencies.[201] Furthermore, their coverage in the developing countries tends to be small and concentrated among cash crop farmers. But with the move towards structural adjustment policies and privatization of production enterprises and services more recently, there has been an increasing involvement of the private sector in providing extension services. Even if this involvement is concentrated on large commercial farmers and commodity producers, it could result in freeing public funds which could then be channelled to small-scale men, women and young farmers.

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197 Contado, T.E. and Maalouf, W.D., "Agricultural Extension in Corum-Cankiri: A Case Study under the Rural Development Project in Turkey", paper presented at the National Workshop on Agricultural Extension, Tunisia, February 1990.

198 Michel Legouis, "Alternative Financing of Agricultural Extension: Recent Trends and Implications for the Future" in W.M. Rivera and D.J. Gustafson (eds), *Agricultural Extension: Worldwide Institutional Evolution and Forces for Change*, Amsterdam: Elsevier, 1991, p.31.

199 W.D. Maalouf, T.E. Contado, R. Adhikarya, "Extension Coverage and Resource Problems: The Need for Public-Private Cooperation" in Rivera and Gustafson, *op. cit.*, p.68.

200 FAO, *International Directory of Agricultural Extension Organizations*, Rome, 1991.

201 FAO, *Report of the Global Consultation on Extension*, *op.cit.*, p.46. Note that the data are from 113 countries that provided FAO with information on 186 agricultural extension organizations.

4.2 Issues and Trends Toward 2010 in Developing Countries

10.22 As noted, the population economically active in agriculture will continue to grow in the developing countries, to about 1.2 billion by year 2010. There would be a need for over 2.4 million extension workers in order to provide effective extension coverage to the projected PEAA.[202] Is this attainable? If the rate of increase from 1980 to 1989 continues, there could be 2.11 million extension workers by 2010, which would be very close to the requirements. There are, however, two factors that may hinder the attainment of a similar growth performance. First, the considerable contribution of China to the increase of extension workers during 1980-89 might not be repeated in the next two decades. Second, is the observed declining resources devoted to extension by the Ministries of Agriculture (25.6 percent of total budget of the Ministries of Agriculture in 1980, 22.3 percent in 1985 and 18.8 percent in 1988) in Africa.[203] But there are also countervailing factors. One is the increasing allocation for extension by Ministries of Agriculture in Asia and the Pacific, Near East and Latin America and the Caribbean. Another is the trend towards expanding the role and share of the private sector (NGOs and private commercial firms) in agricultural extension services. A third factor is the expansion of agricultural development schemes where farmers pay for agricultural extension services through commodity levies such as the Rubber Industries Smallholders Development Authority (RISDA) and the Federal Land Development Authority (FELDA) in Malaysia[204] and the Federacion Nacional de Cafeteros de Colombia, etc. A fourth factor is the increasing number of countries adopting a partnership in funding extension services between the Central Government and the Local Government as in the case of China, Poland, etc. Finally, there will be increased availability of people trained in agriculture for extension work in most developing countries as the intermediate and higher level schools of agriculture established in the 1960s and 1970s mature and turn out more graduates in the years toward 2010.

10.23 Another critical problem in HRD in agriculture is the gender issue. In developing countries, an important proportion of farm work continues to be done by women but only 17 percent of agricultural extension workers are women. If the proportion of women extension workers remains constant over the projection period, there will be approximately 330 000 female extension workers by the year 2010. But by giving stronger recognition to the role of women in agriculture, increasing the number of female students in agricultural schools and colleges and increasing resource allocation for extension with women farmers, it may be possible to raise the proportion of women extension workers to the 20 percent level in the developing countries.[205]

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202 The estimate is based on a ratio of 500 economically active persons in agriculture to one extension worker which is deemed to be the upper limit for providing effective extension service.

203 FAO, *Report of the Global Consultation on Agricultural Extension, op.cit.*

204 In the mid-1980s, RISDA had around 1 500 extension workers serving 500 000 rubber smallholders, while FELDA had around 4 000 extension workers.

205 FAO, *Agricultural Extension and Farm Women in the 1980s*; Appendix III shows that in 1988-89, there were 17 countries which had 20 percent or more women extension workers. The FAO Report on *Training of Manpower for Agricultural and Rural Development in Africa*, Rome, 1984, p.14, shows that in 1983-84, the enrolment of women in all agricultural education institutions in Africa was 15 percent.

10.24 The low level of training of a large proportion of extension workers is another issue for developing countries that must be addressed in the future. Given the increasing number of middle-level and college agriculture graduates in many developing countries, it is probable that the older high school trained extension workers would be replaced gradually by certificate or college graduates. This is already happening in many countries of Asia, Latin America and the Near East, where the proportion of low-level extension workers could decline from 40 percent in 1988-89 to perhaps 20 percent by the year 2010.

5. TECHNICAL AND PROFESSIONAL EDUCATION IN AGRICULTURE

10.25 The number and quality of trained technical and professional manpower in agriculture are critical factors, both in agricultural development and more general HRD. This "human capital" is relatively scarce because training takes years and is costly. However, investing in technical and professional education has a high multiplier effect when trained personnel are properly employed as extension agents, trainers, researchers, programme managers, policy-makers and as agents of increasing productivity in the private sector.

10.26 Although many developing countries still have serious shortages of trained manpower in fields related to agriculture, considerable progress has been made during the last three decades. By 1983, for example, three were over 400 000 trained agricultural personnel in 46 countries in Africa. In 25 of these countries, moreover, the existing institutional capacity was sufficient to allow the training of the required number of agricultural personnel for the year 2000.[206] Worldwide, increases in institutional capacity for training are reflected in the increased number of extension personnel mentioned earlier, as well as of agricultural research personnel. ISNAR reports that agricultural research personnel in developing countries increased at the rate of 7.1 percent annually from 19 753 to 77 737 during 1961-65 to 1981-85.[207]

10.27 However, when these numbers are compared with requirements, especially in the least-developed countries, there are still considerable shortages. For example, Ethiopia would have to graduate 231 people at the professional level and 1 254 at the technical level annually to reach the minimum estimated requirements for trained manpower in agriculture by the year 2000.[208] As mentioned earlier, the problem in agricultural extension is shortage of well-trained extension agents in many developing countries. In the case of research, Unesco data show that there were approximately 500 scientists and engineers per million population in a sample of developing countries as compared to more than 3 000 scientists and engineers per million population in developed countries.[209]

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206 FAO, *Training of Manpower for Agricultural and Rural Development in Africa*, Rome, 1984, p.1.

207 ISNAR, *Summary of Agricultural Research Policy: International Quantitative Perspectives*, the Hague, 1992, p.6.

208 FAO, 1984, *op.cit.*

209 Unesco, *World Education Report*, 1991. It should be noted that these numbers are for all sectors.

10.28 For most developing countries, the supply of technical and professional manpower in agriculture for the next decades will remain problematic. Many countries in Africa are cases in point. In this region, 18 of 46 countries surveyed in 1983, had reported that their technical agricultural personnel was less than 50% of the year 2000 minimum requirement. Even in developing countries where, in general, numbers of technical and professional manpower met the minimum requirement, the problem is excess of numbers in certain fields and shortages in others. For example, in Africa only 7 percent of technical and professional trained manpower in agriculture are in forestry, 5 percent in fisheries and 11 percent in livestock.[210]

10.29 The major problems of developing countries as they face a new century include inadequate institutional capacity, relatively low level of public and private support to agricultural education and limited resources and experience to cope with new areas of training in agriculture, i.e. environment and natural resource management, biotechnology, farming systems management and agri-business, etc.

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210 FAO, *Trained Agricultural Manpower Assessment in Africa*, Rome, 1984.

CHAPTER 11

PRESSURES ON THE ENVIRONMENT FROM AGRICULTURE

1. INTRODUCTION

11.1 Chapter 4 sketched out the growth prospects and the main underlying parameters for the crop and livestock sectors. These prospects imply further intensification of land and water use. More mineral fertilizers and, to a lesser extent, pesticides will be used in the future. The progressive introduction of environment friendly technologies can only moderately attenuate growth in pesticide use in the next 20 years; it will not stop it, let alone reverse past trends for growing use (see below). The projected growth path may be challenged therefore on a number of grounds concerning its environmental impacts and sustainability. Two related issues stand out in this regard.

11.2 First, what are the technological options for putting agriculture on to a more ecologically sound pathway that not only achieve the projected output, but also lay the foundation for sustainable agricultural development in the longer term? Second, given the inevitability of some trade-offs between the environment and development in the medium-term future, what other actions are required to minimize them and ensure progress towards the objective of sustainable agriculture and rural development? These issues were at the heart of the debate at UNCED and at the more technical meetings leading up to it, notably the FAO/Netherlands Conference on Agriculture and the Environment.

11.3 The first issue on technology is dealt with in Chapter 12, whilst Chapter 13 examines the wider, and in the main, complementary policy and institutional actions that are needed at the national and international level to avoid or minimize the environment and development trade-offs. Examples of such actions are those for resource use planning, infrastructural development, farmer support services, and the wider ones affecting overall development and international economic relations. Several of these issues have been discussed in previous chapters. It remains for this chapter, which deals primarily with the developing countries, to describe and where possible quantify, the agricultural pressures on the environment that are implicit or explicit in the definition of the probable growth paths of the crop and livestock sectors.

2. PRESSURES ON LAND AND WATER RESOURCES

2.1 Competition for Land and Water

11.4 Competition for *land* is projected to intensify between sectors and production systems. It is expressed most accurately in the expansion of the use of land for arable and tree crops, shifting cultivation and grazing of livestock and its conservation under forest. Then there is the competition between crop and livestock production and, on a much smaller

scale, between crop production or mangrove swamp preservation and aquaculture; and, as noted in Chapter 5, there will be further pressures on the forest for timber and fuelwood extraction. Finally, increasing population and economic growth will contribute to further diversion of land to human settlements and infrastructure.

11.5 Forest land loss to agriculture is primarily a tropical rather than a temperate zone problem (see Chapter 5). In the former, deforestation rates are currently about 15.4 million hectares a year, of which a large part is thought to result from extension of grazing and cultivation, particularly shifting cultivation, a considerable proportion of which will eventually revert to bush and then tree fallow. In the temperate zone, shifting cultivation is no longer a significant feature of agricultural production systems and in many countries net afforestation, either naturally or through plantations, is taking place. China has a considerable programme of afforestation.[211]

11.6 It is possible that the rate of deforestation would slow down for a variety of reasons, notably the following. First, the lagged effect of recent policy improvements: for example, those to remove incentive and tax distortions favouring deforestation or to strengthen the controls on logging practices. Second, the increasing scarcity of forest land suitable for arable cultivation. Third, the projected slower growth of the population dependent on agriculture in the developing countries. Fourth, technological improvements which meet agricultural demands through land intensification rather than land expansion. Fifth, the adoption and implementation of sustainable agriculture and rural development policies and programmes. And sixth, policy changes in some financing institutions which are adopting more rigorous environmental impact assessments of investment projects as a consequence.

11.7 These reasons are not, however, going to be sufficient to reduce the pressure altogether. Even if current rates of deforestation are considerably reduced, significant areas of tropical forest are likely to be converted to some form of agricultural use during the next 20 years or so. As noted in Chapter 4, some 90 million ha of additional land may come under crop production by year 2010 in the developing countries, excluding China. This is a small part of the 1.8 billion ha of land with crop production potential not used now for agriculture. However, it is estimated that at least 47 percent of the latter land overlaps with forest and the real overlap is probably much larger.

11.8 This continued pressure highlights two priority actions which are considered in Chapters 12 and 13: (a) greater emphasis for agricultural research on sustainable alternatives to shifting cultivation; (b) a more holistic strategy for tropical forest conservation such as that sought by FAO's Tropical Forests Action Programme, since current forestry policies have tended to treat the deforestation problem as a forestry problem in isolation from a better understanding of the reasons for agricultural intensification and as a consequence have commonly failed. In addition, emphasis on wider rural development and agrarian reform could contribute to the slowing down of migration into marginal, environmentally fragile areas.

11.9 Crop production in dryland areas (land class dry semi-arid in Table 4.8) is projected to expand by 6-7 million hectares, a relatively small figure. However, much of this land is

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211 People's Republic of China, *National Report of the People's Republic of China on Environment and Development*, submission to UNCED, China Environmental Science Press, Beijing, 1992.

currently rangeland and its conversion carries the risk of either increasing grazing pressure on the remaining pastures or displacing livestock onto even more marginal land, which must be managed carefully if degradation is to be avoided.

11.10 The competition of aquaculture for land may not be very significant quantitatively, because the areas involved are generally quite small. It can, however, be highly important qualitatively, because in some countries the land being developed is relatively unique mangrove swamp, with potentially valuable biogenetic resources and an on-going role as a breeding ground for coastal fisheries. No projections have been made of the total area at risk, but specific studies for key localities suggest that major losses could continue during the next two decades unless greater protective measures are taken.

11.11 Finally, moving onto the competition between agriculture and human settlements, including urban/industrial and infra-structural development, there are a number of unknowns that make it difficult to be emphatic on the magnitude of the pressure, yet there are clear grounds for adopting the precautionary principle, which is embodied in the Rio Declaration.

11.12 Over the next 20 years the population of the developing countries is projected to increase by about 1.9 billion, but there is great uncertainty about how much land these people will occupy. Economic growth, industrialization and continuing urbanization will further increase pressures for expansion of land under human settlements. The tentative and very speculative projections presented in Chapter 4 place the additional land to be occupied by human settlements in the period to 2010 in developing countries (excluding China) at about 35 million ha, of which 20 million ha would be land with agricultural potential. This is only a small fraction of the 1.8 billion ha of land with agricultural potential (see Chapter 4).

11.13 Thus, for the developing countries as a whole land loss to human settlement appears not to be a substantial threat - a modest improvement in the productivity of the existing land, or a small addition from the land not yet used for agriculture, could compensate for the loss. But the aggregate picture is misleading.[212] First, because some countries have little or no additional land. Second, much of the urbanization tends to be in areas with high quality soils, whilst the land not in agricultural use tends to have poorer quality soils. Third, the population of the developing countries will continue to grow well into the second half of the 21st century, causing the possible loss of further substantial areas, which once built on would be lost for ever. The situation in coastal areas of many small island countries is particularly critical because of the pressure on land from tourism. And of course the problem does not end here, because expansion of human settlements is not the only factor causing land loss. Degradation, for example, is causing both land loss and reduced productivity over a far wider area (see below). Long-term global warming and climate change also could threaten as much as one-half of the high-quality land resources of some countries through sea level rise or deterioration in agro-ecological conditions, e.g. in Bangladesh or the Gambia. These facts are put forward as justification for the above conclusion that the precautionary principle should be applied so as to minimize the loss of land to human settlement; and this notwithstanding the contrary possibility that some developing countries will be able to follow the pattern now exhibited by many developed countries, namely the reduction in arable area

212 Norse, D., C. James, B.J. Skinner and Q. Zhao, Agricultural Land and Degradation, in J.C.I. Dooge *et al.*(eds.), *An Agenda of Science for Environment and Development into the 21st Century*, Cambridge University Press, Cambridge, 1992.

as a consequence of successful intensification. The zoning and other land use planning policies required are discussed in Chapter 13.

11.14 The combined effect of population and economic growth will exert even greater pressures on *freshwater* supplies than they will on land. Chapter 4 indicated that technological growth would generally continue to make it possible to increase agricultural production with relatively modest expansion of the land in agricultural use. This, however, has not been the experience to date with water consumption, and major improvements in water use efficiency are unlikely in the medium term. Though technological progress has raised water use efficiency in a few areas, it has been insufficient to compensate for income growth and wasteful consumption patterns which collectively can cause a manyfold increase in per capita water demand for non-agricultural uses (Table 11.1). The future need not be like the past, but technological improvements and changes in consumption patterns seldom take less than 15 years to have an appreciable effect, and generally the time-lag is much longer.

11.15 These facts have serious implications for the next two decades and beyond. Africa and Asia already show a worsening shortage in per capita freshwater availability, although much of South America is well endowed (Table 11.2). Many countries are already closer to their water supply limits than to their land limits, and the need to increase the agricultural production will accentuate pressures on the water resources. Three aspects are of particular importance.

11.16 First, food supplies in the developing countries are already heavily dependent on irrigated cereals production, which accounts for about one-half of the total production of cereals. This dependence is projected to grow somewhat, in spite of the high cost of irrigation in some countries and the pressures to remove the subsidies (hidden or open) on existing irrigation, which will become increasingly difficult to justify on economic or social grounds.

11.17 Second, the growing water demand for irrigation and the rising industrial and domestic demand will increase competition for water and could push up its price beyond a level that is profitable for staple food production in some areas. Agriculture is the dominant water user, accounting for nearly 70 percent of total consumption of managed water resources, compared with about 21 percent and 6 percent for industrial and domestic use, respectively. The latter are commonly in the situation where they can only expand their consumption of water by 'taking' it away from agriculture, and can generally afford to pay more for it than agriculture. Third, overextraction of ground water is a growing problem in many areas. It is most acute in the Near East, where it is leading to salt-water intrusions that ultimately make the water unsuitable for crop production. But it is also a problem in large areas of South Asia, where food security is heavily dependent on irrigation. Overpumping in these areas is causing water levels to fall beyond the reach of shallow tubewells with the risk that irrigation may eventually become too expensive or physically impractical. Finally, the supply problem will be intensified by degradation of existing irrigation systems to the point that they have to go out of use, and deterioration of water quality (see below).

Table 11.1 Sectoral Water Withdrawals by Country Income Groups

Income Groups	Annual Withdrawals Per Caput	Withdrawals by Sector		
		Agriculture	Industry	Domestic
	m^3	.... percent		
Low-income	386	91	5	4
Middle-income	453	69	18	13
High-income	1 167	39	47	14

Source: World Bank. *World Development Report 1992*, Washington DC, p. 100, based on data from the World Resources Institute.

Table 11.2 Per Caput Water Availability by Region, 1950-2000

Region	1950	1960	1970	1980	2000
	..................'000 m^3				
Africa	20.6	16.5	12.7	9.4	5.1
Asia	9.6	7.9	6.1	5.1	3.3
Latin America	105.0	80.2	61.7	48.8	28.3
Europe	5.9	5.4	4.9	4.4	4.1
North America	37.2	30.2	25.2	21.3	17.5

Source: Ayibotele, N.B., *The World's Water: Assessing the Resource.* Keynote paper at the International Conference on Water and the Environment, Dublin, Ireland, 1992.

2.2 Degradation of Land and Water Resources

11.18 The effects of existing degradation, notably erosion, nutrient mining, salinization of soils, and contamination of water, are included implicitly in the production analyses of this Study because the base year yields and fertilizer response ratios reflect the productivity effects of such damage. Less tangible problems, like desertification and forest degradation, are not included although a more qualitative analysis will be attempted.

11.19 The magnitude of the current extent and intensity of degradation has recently been estimated from a standardized methodology - the Global Assessment of Soil Degradation (GLASOD) - and is more defensible than earlier calculations that pooled the results of

Box 11.1

GROUND WATER MINING

Much of the successful expansion of irrigation in recent decades has come from the exploitation of groundwater using tubewells. They have the advantage of small-scale, low-cost, and rapid construction without the loss of fertile land and the destruction of human settlements commonly associated with large-scale, gravity-fed schemes based on reservoirs. The expansion has been very rapid. In India alone, the number of tubewells jumped from nearly 90 thousand in 1950 to over 12 million in 1990. Behind this success, however, is the neglect of the fact that agricultural development based on groundwater is unsustainable, when it uses 'fossil' water or extraction rates exceed rates of recharge.

The rapid expansion of tubewell irrigation has put extreme pressures on what is commonly a static resource because natural rates of recharge are low. Moreover the problem has been intensified by pressures that are generally some distance from the site of extraction, largely through deforestation in upland watersheds, or overgrazing and other forms of land degradation that accelerate run-off and reduce rainfall infiltration. Consequently, water tables are dropping and causing a wide range of environmental, economic and social problems. Saline intrusions are becoming a problem in many coastal regions. Over-pumping has led to increased investment or operating costs as falling water tables have necessitated deeper wells and greater energy consumption for pumping. In some instances poor farmers without the capital to deepen their wells have had to revert to rainfed production. In others the necessary adjustments have been too late and the land has been desertified, as in some places in India.

diverse national and regional assessments without common definitions and methodologies.[213] Soil erosion is by far the most widespread cause of degradation, with water erosion being the principle agent (Table 11.3). Of greater consequence still are the estimates of the intensity of degradation. Nearly 1 billion ha of vegetated land in developing countries are estimated to be so degraded that productivity is being moderately or severely affected. Some 9 million ha worldwide, of which 5 million ha in Africa, have had their original biotic functions fully destroyed and reached the point that rehabilitation is probably uneconomic. This latter aspect is difficult to assess, in that farmers and rural communities in some areas of Africa and Asia have demonstrated that land which GLASOD classifies as unrestorable can in fact be rehabilitated. Thus, for example, farmers in Kenya (see Chapter 12) and China have rehabilitated formerly abandoned or heavily degraded land at modest cost given appropriate incentives and technologies, though the conventional approaches assumed by GLASOD would probably have been uneconomic.

11.20 The output projections assume some changes in national policies and farm practices to correct part of the soil/water degradation, though the full benefits of such changes will not be felt in the short term; i.e. they do not assume miracles. Thus some degradation is assumed to continue. However, the projection of future degradation and its consequences, particularly its impact on productivity, is very difficult to determine as discussed below.

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213 ISRIC/UNEP, *World Map of the Status of Human-Induced Soil Degradation*, Global Assessment of Soil Degradation, Nairobi, 1991.

Table 11.3 Soil Degradation by Type and Cause (classified as moderately to excessively affected)

(million ha)

	Water Erosion	Wind Erosion	Chemical Degradation	Physical Degradation	Total
Regions					
Africa	170	98	36	17	321
Asia	315	90	41	6	452
South America	77	16	44	1	138
North & Central America	90	37	7	5	139
Europe	93	39	18	8	158
Australasia	3	-	1	2	6
TOTAL	748	280	147	39	1 214
	.... percent				
Major Causes					
Deforestation	43	8	26	2	384
Overgrazing	29	60	6	16	398
Mismanagement of arable land	24	16	58	80	339
Other	4	16	12	2	93
TOTAL	100	100	100	100	1 214

Source: Adapted from ISRIC/UNEP, *op. cit.*

2.2.1 Soil erosion

11.21 There is widespread evidence of erosion resulting in losses greatly in excess of 50 tons of soil per hectare per year, losses that may be five or more times the natural rate of soil formation. The impact, however, of such losses on crop yields or production has not been well established in physical or economic terms though there have been many attempts to do so. The relationship between erosion and productivity loss is more complex than previously thought, as is that between man-made and natural erosion. Similarly, the experimental techniques once used to quantify these losses are less effective than previously thought.

11.22 The relationship between soil erosion and yield loss is not linear; i.e. it is not directly proportional to the thickness of the layer lost, nor to the type of particles lost. Moreover, the impact on soil structure, particularly the impact on the size of the air spaces, can be more important than that on its chemical composition. It is also possible that yield loss in one area may be compensated by gains further down the slope, valley or plain, where the soil is eventually deposited. Though here again the issues are not straightforward. First, because deposition may also have negative external consequences, e.g. where it silts up reservoirs and irrigation canals and reduces their effective life (Table 11.4). Second, because man has commonly been blamed for much of the silt load of rivers, whereas it is now considered that a substantial proportion results from recent upward and ongoing movements in the earth's crust. In China, for example, whereas the severe erosion of the Loess Plateau was once attributed largely to man's activities, and is still presented in these terms by some observers, it is now thought that over 60 percent of the erosion is due to such movements.

Table 11.4 Siltation of Selected Indian Reservoirs

Reservoir	Assumed Rate	Observed Rate	Expected Life as % of Designed Life
	acre-feet per annum		
Bhakara	23 000	33 475	68
Maithon	684	5 980	11
Mayurakshi	538	2 080	27
Nizam Sagar	530	8 725	6
Panchet	1 982	9 533	21
Ramganga	1 089	4 366	25
Tungabhadra	9 796	41 058	24

Source: Data from Central Water Commissioner, Ministry of Water Resources, Government of India.

2.2.2 Soil Nutrient Mining

11.23 This is an issue brought into prominence by the ongoing debate on environmental accounting. The shortening of fallows and prolonged crop harvesting without adequate technological responses to replace the soil nutrients taken out by crops with organic or mineral fertilizer inputs, leguminous crops, nitrogen-fixing algae and so on (see Chapter 12), is lowering the nutrient status of soils and the actual or potential crop yields. It consequently threatens the sustainability of agricultural production. Part of the problem is often masked by the gains from unbalanced fertilizer use, which although it raises yields, also introduces an additional economic cost because the lack of balance lowers the technical efficiency of the mix of fertilizer nutrients.[214]

11.24 The situation is most acute in sub-Saharan Africa, but serious in many other areas, both for major nutrients like nitrogen and phosphate, and for micro-nutrients like boron and manganese. In the mid-1980s all countries in the region were estimated to be suffering from nutrient mining to a greater or lesser degree, with the most serious problems occurring in semi-arid areas where livestock manure is in short supply and the use of mineral fertilizers is seldom economic. The projected situation shows some improvement but the time horizon to 2010 is too close to remove the main gaps in technology and infrastructure. These constraints are examined in Chapters 12 and 13 respectively. In particular there is the need for better and less-costly integrated plant nutrient systems and improved transport and marketing systems to lower mineral fertilizer prices, raise farm gate prices and provide incentives for more sustainable agricultural practices.

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214 Twyford, I.T., *Development of Smallholder Fertilizer Use in Malawi,* Paper to the FAO/FIAC meeting on fertilizer economics, 26-29 April 1998, FAO, Rome, 1988.

2.2.3 Salinization of Soils

11.25 This is primarily a problem of irrigated areas, but also occurs in hot dry zones where strong evaporation brings salts to the surface. In irrigated areas it is usually the consequence of bad design causing poor drainage, and/or inadequate maintenance and inefficient management leading to excessive application rates, and seepage from water courses. The end result is waterlogging, salinization, depressed crop yields and eventually, if corrective action is not taken, loss of land for agriculture. Thus there are two pressures involved: (a) physical pressures on the finite resource base if land is permanently lost, which according to some estimates may vary in the range of 0.2-1.5 million hectares a year worldwide, while some 10 to 15 percent of irrigated land is to some extent degraded through water-logging and salinization; and (b) economic pressures because of the accelerated loss of major investments in irrigation, and from the reduced yields which raise the unit costs of production.

11.26 The production projections of this Study assume a net increase in irrigation of 23 million hectares in the developing countries, excluding China. They also assume that appropriate measures, described in the next two chapters, are taken more or less immediately, so as to prevent further losses of existing irrigated land through salinization. There is some validity for such an assumption in that there is now greater emphasis on improved water management and drainage, but the required investments and institutional changes will take a number of years to mobilize.

2.2.4 Desertification

11.27 This can be broadly - if oversimplistically - defined as land degradation in dryland areas.[215] Much of the attention has been on Sudano-Sahelian Africa where the deserts were once reported to be steadily advancing, though such reports are now challenged (see below). It is not, however, just an African problem. All the major continents face it and the area of crop- and rangeland prone to desertification is estimated to cover 30 percent of the world's land surface.

11.28 A major shift in scientific thinking on this topic has occurred since the 1987 edition of this Study, with a growing consensus for the view that the area affected by desertification has been greatly overestimated.[216] FAO has placed particular emphasis on the weakness

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215 FAO's suggested definition is "The sum of geological, climatic, biological and human factors which lead to the degradation of the physical, chemical and biological potential of lands in arid and semi-arid areas, and endanger biodiversity and the survival of human communities." (FAO, *Sustainable Development of Drylands and Combating Desertification,* Rome, 1993).

216 Nelson, R., *Dryland Management - The Desertification Problem*, World Bank Environment Department Working Paper 8, The World Bank, Washington DC, 1988. Warren A. and C.T. Agnew, *An Assessment of Desertification and Land Degradation in Arid and Semi-arid Areas,* IIED Paper 2, London, 1988. Bie, S.W., *Dryland Degradation Measurement Techniques,* World Bank Environment Department Working Paper 26, The World Bank, Washington DC, 1990.

of the methodology used to produce some of the more extreme estimates. It is now recognized that drylands are much more resilient to drought and to man's abuse than previously thought.

11.29 Although man's role in desertification is still not well understood, there is little doubt that soil nutrient mining and the overcultivation of fragile soils does lead to dryland degradation and desertification. The land and fertilizer use projections of Chapter 4 point to increasing pressures of this type. Amelioration of these pressures will be dependent on improvements in farm practices, such as soil moisture conservation, and the development through research of leguminous live-mulches and other techniques (see Chapter 12).

2.5.5 Water Contamination

11.30 The future water supply is threatened both by the quantitative constraints examined above, and qualitative problems arising within agriculture which are a threat to crop yields and to human, livestock and wildlife health. The principal threats of agricultural origin are the following: rising salt concentrations in irrigated areas; fertilizer and pesticide contamination of surface and ground water; and discharges of organic effluents from intensive livestock units and fish-farms. All of them are projected to increase, because of the long length of time required to achieve appropriate corrective actions.

11.31 The intensification of irrigation will raise the degree of water reuse, and hence the build up of salt concentrations, with risks to crop yields and to the sustainability of irrigation if corrective actions are not taken. Fortunately the main irrigated cereals, rice and wheat, are relatively tolerant to low or moderate salinity, but are subject to yield losses of about 10 percent at high salinity levels.

11.32 Greater applications of organic and mineral fertilizers are essential to prevent soil nutrient mining and raise crop yields, but in many developing countries application will remain below those likely to cause major pollution problems. However, in some areas with either very high application rates (e.g. the Punjab) or thin sandy rock strata above aquifers (as in parts of Sri Lanka), the risks could be significant if corrective measures are not taken. Per hectare application rates of mineral fertilizer in some countries of Near East/North Africa and South Asia are projected to exceed 100 kg of nitrogen by 2010, and so heavy rates will have been applied for 20-30 years or more. This is the time span over which the developed countries started to face severe ground water nitrate problems, underlining the importance of adjusting application rates to the rate of uptake by plants. Restrictions on the use of agricultural chemicals and on the disposal of wastes from agroprocessing to protect water quality for increased human consumption, will necessarily impose costs on consumers.

11.33 Intensive dairying, pig and poultry units are projected to account for an increasing proportion of total livestock output, and so their effluents will also grow. Many developed countries have introduced measures regulating the storage and disposal of such effluents. Livestock concentrations are strictly regulated in the areas of permeable sandy soils in the Netherlands, for example. The situation in the developing countries is likely to worsen before similar measures begin to be taken there.

2.3 Pesticide Use

11.34 The production projections of this Study imply three changes that, in the light of the past approaches to pest control, could pose serious threats to the environment. First, the further reduction in the length of fallow periods may not only endanger soil fertility as noted above, but in the absence of suitable corrective actions, could lead to more serious and more frequent weed, insect and disease attacks because the causal agents are able to survive in greater numbers from one cropping season to the next. Second, the increase in the area of land carrying two or even three crops a year, could have similar effects to fallow reduction. Finally, the rise in the demand for vegetables, and to a lesser extent fruit, could lead to greater pollution and health risks from excessive use of insecticides. These crops tend to receive excessive applications of insecticides and often too close to harvest, either as insurance against the risk of loosing a high-value crop or in order to improve their cosmetic appearance and hence their price. Such excessive application rates can pose numerous risks - to the people applying them, to consumers, to natural predators of vegetable pests, and to drinking water supplies.

11.35 Well-known data problems make it difficult to project the future rates of pesticide use in any detail. It is assumed, however, that a combination of greater emphasis on IPM and concerns about public health risks and ecosystem protection, will continue the present trend for a slowing down in the overall growth rate of pesticide use, and a reduction in both the rates of application and the mammalian toxicity of insecticides and pesticides in general. These positive trends are evident, for example, in Egypt which has banned the use of a number of toxic pesticides, and Indonesia, where the successful introduction of Integrated Pest Management (IPM) on rice has brought widespread benefits (see Chapter 12).

11.36 Consequently, it is a reasonable assumption that the growth rate of pesticide use will be lower compared with that of the past two decades, and that there will be a reduction in the environmental risks per unit of pesticide use. Thus, while the concerns expressed by certain groups are important, and there are no reasons for complacency, there are no grounds for arguments based on linear extrapolations of past mistakes.

3. GLOBAL CHANGE ISSUES

3.1 Loss of Biodiversity

11.37 The projections indicate two particular pressures that warrant attention, namely deforestation and the loss of wetlands. Forests, biodiversity and climate change considered below, are closely interlinked because forests have a dual role as habitats and as major carbon sinks. The many levels of forest canopy, especially those in the tropics, with their varying light intensities and moisture levels, allow a multitude of habitats to co-exist in a small area rich in biodiversity. The closed tropical forests, for example, cover only 7 percent of the earth's surface, yet contain at least 50 percent and possibly 90 percent of the world's species. Many of these species have not been described or assessed for their utility as foods, medicines or other purposes. It is impossible to say which of them may be redundant for long-term sustainable development, though it is also difficult to argue that life as we know it could not go on without some of these unassessed resources.

11.38 Although the area of tropical forest that may be taken up by agriculture during the period 1990-2010 would be only a relatively small percentage of the remaining global stock, there are grounds for attempting to minimize such losses. A small proportion of the developing countries wetlands are also projected to be drained and used for crop production, since they represent one of their few remaining resources suitable for permanent agriculture. The wetlands are both a source of biodiversity and an ecosystem providing environmental services such as the purification of water, flood mitigation, fisheries and wildlife habitat and amenity. Their role needs to be protected, but the areas likely to be converted to agriculture will probably be a very small share of the total, and will provide a vital contribution to staple food security.

3.2 Climate Change: Potential Global and Regional Impacts

11.39 Agricultural activities are a major contributor to anthropogenic sources of greenhouse gases, that in turn contribute to radiative forcing and hence climate change. In turn, climate change will impact on agriculture.[217] Apart from the release of carbon dioxide caused by biomass burning, mainly through deforestation and savanna fires, which together account for about 30 percent of the total amount of the CO_2 emitted, agriculture's main contribution to radiative forcing is through the emission of methane (CH_4, about 70 percent of the total emitted) and nitrous oxide (N_2O, about 90 percent of the total).

11.40 Rice cultivation appears to be the largest anthropogenic source of global methane emissions, influenced by a complex set of factors that primarily affect methane-generating and methane-absorbing bacteria. These interactions are very sensitive to the physical, chemical and biological conditions of the rice paddy environment and hence can be manipulated by management practices. For example, methane emissions to the atmosphere are higher in deep water than in shallow water rice cultivation.

11.41 The harvested area for rice is expected to increase by about 11 million ha by 2010, an increase of about 10 percent. Hence the projected increase of methane emissions from this source is relatively modest also because some of the increase in rice area will arise from the conversion of wetlands which produce some methane in their natural state. The modest incremental contribution from this source will be further depressed by the expected move away from deep water rice cultivation, mainly because of increasing competition from aquaculture.

11.42 A greater increase in methane emissions to the atmosphere than from rice cultivation may arise from ruminant livestock, the numbers of which (excluding camelidae) are projected to increase by nearly 30 percent by 2010. Methane is released as a result of incomplete decomposition of plant material by aerobic fermentation, a process favoured by the fibrous and varying quality forage feeds widely used for ruminants in developing countries. Thus, more methane is lost from poorly fed than from better fed ruminants. The overall effect of the projections on radiative forcing is difficult to assess, being the combined effect of the numbers of ruminant livestock and the nutritional composition of their feeds, which is

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217 The role of forests and forestry in relation to the carbon cycle is discussed in Chapter 5.

expected to improve moderately under the pressure of the rising demand for livestock products.

11.43 The annual rise in atmospheric nitrous oxide is relatively small and precise measurements of sources are scarce. Emissions are estimated to be mainly from biotic sources, related to nitrification and denitrification processes. These take place in the sorts of natural ecosystems such as tropical rain forests, tropical/subtropical savannas and intensively fertilizer agro-ecosystems. Applications of nitrogenous fertilizers are estimated to account for about 20 percent of the current annual increase in atmospheric N_2O. Such applications are expected to rise little in industrialized countries, but significantly in the developing countries, particularly on the better quality arable land. However, typically these lands do not have the seasonally hydromorphic soil conditions that specially favour N_2O emissions.

11.44 There is still a great deal of uncertainty regarding the nature, timing and regional distribution of the potential impacts of climate change. In spite of the extensive research stimulated by the Intergovernmental Panel on Climate Change (IPCC) and by national concerns, it will be 5-10 years before these uncertainties are resolved. Nonetheless, there is a scientific consensus that global warming is a real phenomenon that could have a range of both negative and positive impacts on agriculture. Some of the most severe negative impacts could be in those regions already vulnerable to present day climate variation, notably sub-Saharan Africa, and with the least ability to research or buy their way out of trouble. In broad terms the developing countries may be more affected by the possible changes than the developed countries, even though the temperature rise from global warming is projected to be greatest at the higher latitudes where most of the developed countries are located. The potentially greater impact on developing countries is, on the physical side, because most of them are in low rainfall areas or have significant areas of arid land, which are already subject to major agricultural production problems because of rainfall variability and associated constraints, and on the economic side because of their greater dependence on agriculture (see Chapter 2).

11.45 All of these potential climate impacts probably lie outside the time-frame of this report, since they are not currently envisaged to play a notable role before about 2030. There is, however, one positive, non-climate impact which may already be influencing agricultural production, namely the boost to crop growth arising from the enhanced carbon dioxide levels in the atmosphere that are one of the forcing factors for global warming and climate change. The higher CO_2 levels lead to faster growth of plant biomass and better water utilization in many crops, contributing to stronger root growth and denser ground cover. Some scientists believe that this affect accounts for a proportion of crop yield gains in recent decades, possibly as much as 10-25 percent of the aggregate increase. Moreover, even if the developed countries succeed in stabilizing CO_2 emissions in the early part of the next century, it is unrealistic to expect the developing countries to do so before its end. Hence this CO_2 fertilization will have an important impact over the 20 years of the current projections and beyond.

11.46 Finally, although the main negative impacts of climate change are likely to be post 2010, there are agricultural measures which can be justified against current socio-economic needs and yet would help to minimize the potential impacts of climate change. These are considered in Chapters 12 and 13.

4. CONCLUDING COMMENTS

11.47 Two aspects of the foregoing discussion are worthy of emphasis. First, as initially raised in Chapter 4, and developed further in this chapter, the rate of growth of land expansion for agriculture will be reduced during the next two decades. The pressures on water, however, will grow considerably as will those on the environment arising from the intensification of land use. Secondly, the analysis has focused primarily on pressures on natural resources in the aggregate, which does not identify clearly the distribution of such pressures among countries arising through trade. Trade contributes to transfer pressures on resources in importing countries onto exporting ones, as happened with the production of cassava in Thailand for export to Europe. Such effects may be significant and require deeper consideration in the whole discussion of gains and losses from trade (see Chapter 8).

CHAPTER 12

LAYING THE TECHNOLOGICAL FOUNDATION FOR SUSTAINED AGRICULTURAL DEVELOPMENT

1. INTRODUCTION

12.1 Views have become excessively polarized in recent years regarding the environmental soundness or appropriateness of low or high external input technological development paths in responding to many of the pressures outlined in Chapter 11, with both camps claiming too much for their respective options. One issue is clear. Increasing agricultural production depends on replacing most of the soil nutrients removed in the harvesting of crops, otherwise nutrient mining will take place and production will not be sustainable. The low external input systems will require large inputs of labour (which are not always available) and the high external input systems will need considerable inputs of fossil fuel (i.e. non-renewable) energy. Although the use of mineral fertilizers will continue to grow, it cannot, in many situations, provide all of the inputs necessary to maintain soil fertility and must be used with organic manures and other biological inputs as part of an integrated plant nutrition system. It is also noted that low external input systems are not necessarily less polluting than high input ones. Badly timed applications of manure, for example, can be a more serious source of ground and surface water contamination than appropriate amounts of mineral fertilizers, so the requirements are not just technological, but also include manpower training and regulatory instruments.

12.2 Fortunately, this polarization is diminishing with growing acceptance from both camps that neither has the whole answer, and that what is required is a balanced integration of the two systems. A number of the underlying forces are particularly significant in that they stem from changing perceptions as to priorities and pathways for technological development in the developing countries, and changing opportunities in developed countries. These aspects will be considered in the next three sections. The penultimate section will discuss the technological responses required to achieve the growth in agricultural production projected in this Study with the minimum risk to the environment. The final section will briefly assess the needs and opportunities for laying the technological foundation for sustainable agricultural development beyond the year 2010.

12.3 This emphasis on technology is not intended to suggest that a new technological pathway is sufficient in itself. There is a wide range of policy and institutional measures required to provide the incentives needed for farmers, forest users, and fishermen to adopt sustainable technological and resource management practices. These other measures are the subject of Chapter 13.

2. CHANGING PERCEPTIONS OF TECHNOLOGICAL DEVELOPMENT REQUIREMENTS IN DEVELOPING COUNTRIES

12.4 Early efforts to support agricultural development in the developing countries were heavily based on transferring technologies and management practices of the developed countries for a narrow range of crops in areas with favourable soil and agro-climatic conditions. This had a number of positive benefits but also some undesirable consequences. On the benefit side, and as noted in Chapter 2, agricultural growth in the developing countries exceeded that of population, with the exception of sub-Saharan Africa. Moreover, a number of countries have been able to raise agricultural export earnings and local incomes derived from them without sacrificing domestic food production. This has been achieved through major technological improvements in the high potential areas, though in some instances with the environmental penalties described earlier. Notable achievements include the uptake of high yielding wheat and rice varieties in Asia and Latin America and the increase of sugar yields in some countries (e.g. Colombia) as well as the rapid growth of the palm oil sector. There is no reason to believe that these benefits cannot be maintained in the medium term whilst production is shifted onto a more sustainable development path.

12.5 The main undesirable consequences were the following.

(a) Traditional mixed cropping and interplanting practices with high resilience to climate variation and pest attack were commonly discouraged and replaced by less stable mono-cropping and row planting. It is now accepted that this shift was undesirable in some situations and positively deleterious in others for both short-term household food security and long-term sustainability in the more marginal environments.

(b) The technological needs of the arid and semi-arid areas were neglected, except where the lack of water could be overcome through formal irrigation.

(c) Plant breeding focused on cash crops or on a few major staples, and thus generally neglected grains like millet, roots and tubers, and most legumes. Moreover, breeding objectives were focused on maximizing yield rather than stabilizing them, which is a primary concern of many farmers. And in some cases, e.g. sorghum and millet, by aiming for higher yields breeders were implicitly selecting for long-season varieties, which exposed the farmer to greater risks of crop failure in areas where the length of growing period permitted by rainfall or climate is critical.

(d) Tillage systems were centred on conventional ploughing, which is not well suited to some of the fragile soils of the developing countries, where the emphasis should have been on minimal tillage systems.

(e) Soil nutrient replacement was dominated by mineral fertilizer use rather than the development of integrated plant nutrition systems.

(f) Soil conservation techniques were drawn up around engineering and not biological approaches to soil stabilization, and with erosion control rather than soil moisture management as the primary objective.

12.6 These undesirable consequences are now broadly accepted, and are increasingly addressed by research and extension systems.[218] As yet, however, this acceptance has not resulted in a major shift in national and international research priorities, and where it has, the main technological and institutional findings are unlikely to be applied widely in the short to medium term. Consequently the production projections of this Study are based on the assumption that the prevailing technological path will be dominant for the next 15-20 years, particularly in the high potential areas, but that there will be a gradual shift in researching a pathway for the more marginal areas.

12.7 Low acceptance rates for some of the research stemming from the "Western" style approach to agricultural development was commonly ascribed to the lack of integration of peasant farmers into the market economy, and their lack of profit motivation. Blame was seldom attributed to the deficiencies outlined above or to the inappropriateness of the technologies to farmers' needs. A number of changes, however, have taken place or are in process, in the way technological needs are identified and research is conducted, which should make the production levels assessed for 2010 more achievable and sustainable.

12.8 There are three notable changes concerning the identification of farmers' needs. First, widespread acceptance now of the earlier contention that peasant farmers are profit maximizers provided the technologies are not too risky, and are profitable very early in the adoption process (see Chapter 7). Both aspects have been neglected in the design and evaluation of many technologies. Second, some progress has been made in understanding the links between population pressure on resources and the development and adoption of technologies, for example, the extent to which the adoption by farmers of land-augmenting, yield-enhancing technologies depends on their access to land reserves and market incentives.[219] A later section considers this aspect in more detail. Third, growing recognition that the decision process of farmers is weighted more by the profitability of technologies than by their environmental friendliness.[220]

12.9 Similarly there are three notable changes regarding the conduct of research. First, there is the emphasis on farming systems research (FRS) with the greater involvement of

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218 CGIAR, *A CGIAR Response to UNCED Agenda 21 Recommendations*, Paper presented to the International Centres' Week, 26-30 October, Washington, DC, 1992.

219 Pingali, P. and H.P. Binswanger, *Population Density and Farming Systems: the Changing Locus of Innovations and Technical Change,* Working Paper No. ARV 24, World Bank, Washington, DC, October 1984; Lele, U. and S.W. Stone, *Population Pressure, the Environment and Agricultural Intensification: Variations on the Boserup Hypothesis,* MADIA Discussion Paper 4, World Bank, Washington, DC, 1989; Tiffen, P. and M. Mortimore, *Environment, Population Growth and Productivity in Kenya: A Case Study of Machakos District*, Development Policy Review, Vol. 10, pp. 359-387, December 1992.

220 Bebbington, A.J., H. Carrasco, L. Peralbo, J. Trujillo, and V. Torres, *Fragile Lands, Fragile Organizations: Indian Organizations and the Politics of Sustainability in Ecuador*, Transactions of the Institute of British Geographers, Volume 18, No. 2, 1993.

farmers in the decision process, which helps to place commodity research in a more meaningful production context. Second, the introduction of on-farm client oriented research or on-farm research, which is an approach designed to meet the need of resource poor farmers, and complements as well as depends on, experiment station research. Finally, the "rediscovery" of indigenous technical knowledge, with growing acceptance of the need to build on existing technologies which have been selected and refined by farmers in harmony with their own sociological and ecological conditions,[221] but with the understanding that they are not sufficient in themselves.[222] The use of the velvet bean as soil cover and green manure in communities in Honduras is an example of such participatory research and development.[223]

3. CHANGING OPPORTUNITIES IN THE DEVELOPED COUNTRIES

12.10 **The rise in public willingness to pay for a better environment.** Although a better environment which is achieved through cleaner technologies and sustainable agricultural practices may be cost-saving in the long term, there are commonly short-term economic penalties through higher production costs, restrictions on resource use, and public expenditure financed through taxes. Thus, organically grown foods cost 10-20 percent more than the "conventional" product; calls for restrictions on resource use in the United States to promote sustainable timber extraction and protect the habitat of the spotted owl contributed to the increase in US timber prices in early 1993.[224] Consequently, public policy changes towards sustainable technologies and practices are heavily dependent on the willingness of private consumers and the public sector to pay these additional costs. This willingness has been growing since the early 1970s, and can be expected to continue, albeit with some short-term declines during periods of economic uncertainty.

12.11 **Environmentally oriented shifts in technology.** These shifts are driven by three forces. First, the public pressures discussed above. Second, and largely in the European Community (EC), the need to address the surplus production problem. Third, scientific and technological progress itself.

12.12 The first and second forces, for example, are combining in the EC to restrict the use of mineral and organic fertilizers in sensitive watersheds, and to ensure more sustainable land

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221 Altieri, M., *Agroecology, The Scientific Basis of Alternative Agriculture*, Westview, Boulder, 1987; Chambers, R., A. Pacey, and Thrupp (eds), *Farmer First, Farmer Innovation and Agricultural Research*, Intermediate Technology Publications, London, 1989.

222 Richards, P., *Indigenous Approaches to Rural Development: The Agrarian Populist Tradition in West Africa*, in Altieri, M. and S. Hecht, *Agroecology and Small Farm Development*, CRC Press, New York, 1990; Bebbington *et al., op. cit.*

223 Bunch, R., *Low Input Soil Restoration in Honduras: The Cantarranas Farmer-to-Farmer Extension Programme,* Gatekeeper Series No. 23, IIED, London, 1990.

224 In fact the peak in US timber prices lasted barely a month, March 1993, and by May they had returned to their level of late 1992. The 'spotted owl' controversy added further uncertainty to an already uncertain market. There were costs nevertheless.

management practices. They may ultimately result in significant amounts of agricultural land being withdrawn from cultivation and placed under pastures, forests or leisure uses.

12.13 The third force, the growth in scientific knowledge and technological progress, expresses itself in two particular ways. Firstly, in the greater understanding of the risks to human and ecosystem health of certain practices. As an example, the discovery of the link between the use of chlorofluoro-carbons (CFCs) and ozone damage and the discovery of the ozone hole over the actarctic led rapidly to the Vienna Convention and the Montreal Protocol. Secondly, in the development of cleaner and more energy efficient technologies that are more cost effective and hence will be taken up through market forces even in the absence of regulatory pressures.

12.14 Though these forces may have their initial impact in the developed countries, they will also benefit the developing ones. They will provide new or better tools for technology development in developing countries themselves (see section on biotechnology), and some of the technologies for developed country markets will be directly usable, such as certain biopesticides, or adaptable to developing country conditions, such as surge irrigation.

4. POPULATION PRESSURE AND TECHNOLOGICAL CHANGE

12.15 Analyses of the complex relationships between growth in total population and the part of it dependent on agriculture, land use (and hence environmental change) and technological change, help to put the 1990-2010 projections into a wider perspective. They also provide useful insights for policy so that it may guide rather than work against the natural processes determining the intensification of land use and the adoption of technologies. Two viewpoints tend to prevail. The first assumes that there is a negative relationship between rural population growth and environmental quality. The second looks at the relationship in a more dynamic way and with greater regard for the economic dimension.

12.16 The first viewpoint lays great emphasis on the fact that the pressure of population bearing on a limited land base and the slow introduction of farmer-based or formal research-based innovations in response to these pressures, has had widespread negative impacts on the environment. Reduced fallow periods and tree cover on erodible soils, together with the slowness of the natural processes that restore soil fertility, have lowered land productivity through loss of nutrients or nutrient mining.

12.17 The second viewpoint is centred on the work of Ester Boserup[225] who applied the concepts of factor substitution (labour for land) and technological change to hypothesize that as population density increases, technological changes "autonomously" occur through shortening fallow periods, increasing inputs of labour and the adoption of improved tools (planting sticks to hoes to animal-drawn ploughs). According to this hypothesis the problem of population growth, giving rise to an increased demand for food, can lead to its own solution by altering factor prices: first increasing scarcity of land compared to labour, giving rise to increased land intensification or shortening fallow and increased use of labour; and

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225 Boserup, E., *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure,* Aldine Press, New York, 1965; and Boserup, E., *Population and Technological Change: A Study of Long-term Trends*, University of Chicago Press, Chicago, 1981.

then increasing scarcity of labour at some stage through the land intensification sequence - gathering, forest fallow, bush fallow, grass fallow and annual cropping - leading to the adoption of improved tools. Such a process of "farmer-based innovation"[226] describes the evolutionary process of adapting production technology to changes in factor scarcity. The responsiveness of "science-based innovation" to economy wide factors, such as its endowment of land and labour, the non-agricultural demand for labour and conditions of demand for food and other agricultural products, gave rise to the closely associated concept of "induced innovation".[227] Thus the land scarce agricultural economy of Japan by the late 1800s gave rise to biological innovations that increased yields per unit of land, while the US, which at that time had 100 times more land per head of agricultural labour, adopted a mechanized agricultural technology. In the US, biological innovations were not adopted widely until several decades later, until the 1940s, in response to rising land values.

12.18 The "autonomous" process, however, leading to appropriate institutional and technological responses to the pressures on the environment, such as the building of terraces to control erosion, and the utilization of organic manure to restore fertility, may not occur fast enough if population growth is rapid or, conversely, is constrained by labour shortages if an easier, less labour-demanding option is open in the form of migration.[228] The adoption of research-based innovations may also be constrained by deficiencies in infrastructure, extension and marketing and credit systems. Thus the end result can be a treadmill of low rates of adoption of either farmer-based or research-based innovations, low productivity agriculture, environmental degradation and poverty. As noted in Chapter 2, failure of institutional governing land tenure to adapt to changing conditions contributes to create a vicious circle between poverty and environmental degradation.

12.19 There remains the issue of poverty, which is commonly associated with these treadmill situations. It can be argued that in some situations poverty becomes part of the solution as the poor respond by migrating; by making personal sacrifices so that their children can be educated and find better employment opportunities outside agriculture; and by diversifying their agricultural and non-agricultural incomes in response to changing market opportunities. This benign process is clearly exemplified by the recent longitudinal study of the Machakos district of Kenya (see Box 12.1). In other cases, the necessary conditions are not in place and poverty and environmental degradation coexist and become mutually re-enforcing.

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226 Pingali and Binswanger, *op. cit.*

227 Hayami Y. and V.W. Ruttan, *Agricultural Development: An International Perspective*, Johns Hopkins University Press, Baltimore, 1985; Binswanger, H.P. and V.W. Ruttan, *Induced Innovation: Technology, Institutions and Development*, Johns Hopkins University Press, Baltimore, 1978.

228 The HIV/AIDS pandemic sweeping many rural communities in affected African countries is having a similar effect on labour supplies leading to less labour intensive but less productive farming systems.

Box 12.1

ENVIRONMENTAL RECOVERY IN THE MACHAKOS DISTRICT OF KENYA[1]

Large parts of this agro-ecologically diverse district of some 1.4 million hectares are inherently marginal for the production of the preferred staple, maize. Much of it is highly sloping land with a mean annual rainfall of less than 800 mm per year which is spread over two rainy seasons, with marked inter- and intra-annual variation. Consequently, with such constraints and low population pressure in the more favoured areas, it was largely uninhabited at the beginning of this century. This changed rapidly. The best lands were settled first, followed by the more marginal ones. By the 1930s substantial areas were so badly degraded by crop production and grazing that observers of the time thought that the district was on the edge of ecological collapse. There was severe soil erosion over about 75 percent of the inhabited area, and tree cover was down to around 5 percent. By the 1940s the population carrying capacity of the district was exceeded at the prevailing low technological input levels.

Yet by 1990 the pictured had changed completely. The population of over 1.4 million was nearly six times that of the early 1930s, with population densities in the most marginal agro-ecological zones increasing nearly 30 fold between 1932-89. Agricultural output was up, dependence on food imports from other districts was down, and there was less soil erosion and more tree cover.

Thus, and contrary to the prevailing view, population growth meant less degradation and a more sustainable agriculture. The factors involved, and their sequencing, have been thoroughly analysed. There was internal and external migration from the 1920s onwards in response to land shortages, with the former being to more marginal lands within the district. External migration to urban areas was followed by return flows of remittances which provided part of the subsequent fixed and variable capital needs for agricultural development. Then, there was intensification of land use, starting in the late 1930s on the better and more populated lands close to the urban markets, but not until the 1960s on the less populated "marginal" lands. This intensification was largely through reduction of the fallow periods, the introduction of multiple cropping, the closer integration of crop and livestock production, and heavier applications of manure, compost, or, in the case of export crops, mineral fertilizer. It was parallelled or followed by the widespread adoption of soil conservation measures to rehabilitate degraded land, notably conservation tillage, contour farming, and terracing (the proportion of the treated area rose from about 52 percent in 1948 to 96 percent in 1978), with substantial gains from soil erosion reduction and from enhanced rainfall infiltration and soil moisture retention. This widespread adoption was encouraged by the introduction of a range of cash crops, particularly coffee, fruit, and other horticultural crops that gave higher incomes than basic staples, and thus made soil conservation more profitable. Finally, and perhaps most critically, there was investment in improved roads and other infrastructure aspects governing ready access to urban and overseas markets and to local processing locations. Much of the incentive and the capital for this retreat from supposed ecological disaster came from the people of Machakos themselves with significant community and local NGO inputs and relatively small central government and donor inputs.

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1 Tiffen, M., M. Mortimore and F. Gichuki, *More People, Less Erosion: Environmental Recovery in Kenya*, Wiley, Chichester, 1993 (in press).

5. THE TECHNOLOGICAL CHALLENGES OF AGRICULTURAL GROWTH

5.1 Limiting Land and Water Degradation

12.20 Chapter 11 highlighted the extent of degradation and our lack of understanding as to its full implications for crop productivity and sustainability. Two aspects of soil conservation are becoming increasingly clear. The success of conservation measures is highly dependent on farmers receiving crop yield and economic benefits in the first or second season after implementation.[229] In dryland areas such gains will commonly arise more from improvements in physical structure leading to enhanced soil moisture levels and retention[230] than from the reduction of soil nutrient losses, although the latter are important.[231]

12.21 Failure to meet these requirements, together with institutional weaknesses, accounts for the failure of many past conservation techniques and projects, which were either very labour intensive or required costly mechanical operations. Hence they were often not profitable in the short or even the medium term, and, moreover they were costly to maintain. Farmers therefore seldom adopted the conservation techniques, or did not maintain the conservation structures after the end of the project. The success stories of today, which in a sense are success stories of the past since they commonly use or build on indigenous technologies,[232] are consistent with these conclusions.

12.22 The above conclusions and observations carry several important messages for technology development to achieve long-term sustainability. First, soil conservation strategies, research and extension should concentrate on measures with no or low external capital requirements, so that they are more appropriate for resource poor farmers in marginal areas that are projected to be under increasing pressure. Second, provided the appropriate institutional support is given (see Chapter 13), known techniques could help to boost or stabilize yields in the first half of the projection period, and in the longer term. Third, these techniques are not widely used and could benefit a much larger area. Possibly as much as 50 million hectares of drylands in sub-Saharan Africa and an even greater area in Asia, could gain from them through both increased and more stable yields and by more frequent cropping. Again, nearly 25 million hectares of slopelands in the high rainfall tropics could gain from techniques better adapted to their particular constraints (land class "humid" with scope of 8-16 percent, see Chapter 4).

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229 FAO, *Soil Conservation for Small Farmers in the Humid Tropics*, FAO Soils Bulletin 60, Rome, 1989.

230 Shaxson, T.F., *Soil Moisture: Capture, Retention and Use*, Unpublished working paper for the FAO Investment Centre, 1992.

231 Stocking, M., *The Cost of Soil Erosion in Zimbabwe in Terms of the Loss of the Three Major Nutrients*, Consultant's Working Paper No. 3, Land and Water Division, FAO, Rome, 1986.

232 Reid, W.V.C., *Sustainable Development: Lessons from Success*, Environment, May 1989; Kerr, J. and N.K. Sanghi, *Indigenous Soil and Water Conservation in India's Semi-arid Tropics*, Gatekeeper series No. 24, IIED, London, 1992; FAO, *A Study on the Reasons or Failure of Soil Conservation Projects*, FAO Soils Bulletin 64, Rome, 1991.

12.23 There are additional implications for technological research. The focus should be on biological rather than mechanical approaches to soil conservation which, as with vegetative barrier techniques or with systematic crop and residue management, either retain soil particles and eventually build up natural terraces or protect the soil surface from rain impact and erosion. Attention should also concentrate on techniques that combine soil erosion limitation with wider land degradation control functions, such as the use of leguminous live mulches.[233] The International Agricultural Research Centres of the CGIAR, notably CIAT, ILCA and IITA have been supporting national research efforts by collecting and testing suitable legumes for forage or mulch purposes, but the current national and international efforts are inadequate relative to the task and their potential contribution to sustainability.

12.24 Finally, at a more specific level, there is the problem of salinization. As noted in Chapter 11, irrigated land is being lost and substantial amounts suffer reduced yields through salinization. Corrective actions are therefore a prerequisite for achieving the irrigated areas and levels of productivity projected.

12.25 The most common causes are inadequate drainage, rising water tables because of water seepage from distribution canals, and excessive application rates. Consequently, the standard corrective actions have been additional drainage and canal lining, both of which can be costly though economic. In the future, however, part of the solution seems likely to lie in conjunctive use of surface and ground water and the parallel use of canal and tubewell systems, with the latter providing vertical drainage as well as secondary irrigation. Experience in China, for example, has shown how a more holistic approach to water management - what is called there the "four waters concept" - can prevent and reclaim salinized land (Box 12.2).

5.2 Promoting Integrated Plant Nutrition Systems (IPNS)

12.26 IPNS aims at maximizing the efficiency of plant nutrient supply to crops through better association of on- and off-farm sources of plant nutrients and ensuring sustainable agricultural production through improved productive capacity of the soil. Such systems may significantly reduce needs for mineral fertilizers, because they provide timely and sufficient supplies of plant nutrients, according to targeted crop yields, and reduce as far as possible plant nutrient losses in cropping systems. Adoption of IPNS has the potential of increasing farmer profitability in fertilizer use.[234]

12.27 Progress towards achieving these broad objectives must be viewed in the various ecological and economic contexts of agriculture in developing countries. Firstly, there are situations where plant nutrients are mined from the soil because extractions by crops and losses of plant nutrients through erosion, leaching and volatilization exceed the low level of plant nutrient supply. Here IPNS will assist in reaching a better balance of nutrients and

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[233] Low growing crops that fully cover the ground and protect the soil surface against rainfall impact and wind erosion, and also provide nitrogen to the associated crops, food for earthworms, and raise soil organic matter levels so as to increase soil porosity, rainfall infiltration and retention.

[234] FAO, *Integrated Plant Nutrient Systems and Sustainable Agriculture,* 17th Consultation of the FAO Fertilizer Programme, Islamabad, May 1993.

Box 12.2

MANAGING THE "FOUR WATERS"

From 1949 to 1980, the irrigated area in China increased by 32.7 million ha and currently covers 46.7 million ha. Due to problems of scarce water resources and the limited possibility of expansion, the rate of growth has fallen significantly in recent years. In response, Chinese engineers and agronomists have developed an innovative method of water management, known as the concept of the "four waters", which refers to a comprehensive control and supervision of groundwater, surface water, soil moisture and rainfall for agricultural production. The objective of this approach is to produce two crops per year over the most extensive area possible with limited use of surface water. The basic innovation of the "four waters concept" is the dynamic control of the aquifer. Whereas traditional horizontal drainage keeps the ground water table below a certain level to avoid waterlogging and secondary salinization, dynamic ground water management, in addition to controlling the water table, uses the aquifer as storage. Dynamic ground water management keeps the level of the aquifer within a specified range, which is defined by hydrological and agricultural requirements, and takes into account the constraints posed by salinity hazards and the need for efficient energy use. The "four waters concept" has been tested extensively in the Nanpi experimental station in Hebei Province and in a pilot project of 23 600 ha. The results have been positive. The implementation of this water management approach showed that large areas of saline-alkaline land could be reclaimed, and land which was previously unsuitable for irrigation due to ground water salinity, has been cultivated. Moreover, rice yields increased by 77 percent: from 3.7 tons/ha, to 7.8 tons/ha. Multi-annual hydrological simulation demonstrates that, with only 550 mm average annual rainfall, as much as 43 percent of the dry season irrigation requirements can be met without ground water mining or external water imports.[1]

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[1] Shen F. and W.H. Wolter, *Managing the "Four Waters", an Innovative Concept of Modernization*, unpublished mimeograph, IPTRID/World Bank, Washington, DC, 1992.

begin the intensification of cropping systems with limited use of external inputs, better recycling of local sources of nutrients and, above all, a drastic reduction of nutrient losses.

12.28 Secondly, there are situations where plant nutrient efficiency is low, even with significant supplies of nutrients from various sources. In these cases, IPNS will improve the combination of plant nutrient sources and cropping techniques and improve efficiency. In most cases, this low efficiency is due to an unbalanced supply of plant nutrients (too much nitrogen relative to other nutrients) or to another limiting factor such as secondary or micronutrient deficiency, physical or physico-chemical constraints of the soil and climatic risks. IPNS seeks to relieve economically such constraints depending on the availability of resources (plant nutrients, equipment, energy, adapted varieties and irrigation).

12.29 Thirdly, there are situations where losses of plant nutrients are polluting the environment because of excessive or improper management of plant nutrient supplies: examples are nitrates in surface and ground water, phosphates in surface water and nitrous oxides and ammonia in the atmosphere. Here IPNS will better balance or even reduce the supply of nutrients, maintain yields but focus efforts on both increasing plant nutrition efficiency and reducing plant nutrient losses.

12.30 Fourthly, there are arid and semi-arid areas where the maintenance of soil organic matter is crucial for efficient plant nutrient management, maintaining soil permeability and waterholding capacity, and promoting development of deep rooting systems capable of exploiting water stored in the soil. One challenge of IPNS is to produce sufficient biomass in order to restore to the soil at least the quantity of organic material equivalent to that mineralized during the crop rotation. In mining the reserves of soil plant nutrients, farmers reduce the capacity of their soils to produce biomass and cause the soils to lose organic matter. However, the mineralization rate of the soil organic matter is rapid when the soil temperature is high, and the biomass production, when plant nutrition is not a limiting factor, is directly related to the availability of water. Therefore, in the semi-arid tropics it may be difficult to restore the organic matter content of a degraded soil.

12.31 In the humid tropics, leaching of plant nutrients, erosion and acidification, and immobilization of plant nutrients in the soil may hamper the efficient supply of nutrients to plants. Additionally, competition of weeds and pressure of pests are important factors decreasing this efficiency. However, crop production, biomass production, and crop diversity are higher and the effect of temperature on the mineralization of soil organic matter is generally lower, than in the semi-arid tropics. The climatic risk is also low as compared to semi-arid areas and the natural conditions are generally more favourable for agricultural intensification. IPNS will then address rather diversified levels of intensification in accordance with the conditions of the market for agricultural products and with farmers' production objectives. The upgrading of the soil fertility parameters is easier than in the semi-arid or arid tropics because the production of biomass is higher. However, because of high rainfall, compaction can rapidly occur in soil profiles under mechanization. Limiting plant nutrient losses is more complex than in semi-arid tropics because the overall quantity of plant nutrients involved is higher and the pressure of the factors causing these losses is also higher.

12.32 In the irrigated areas, the removal of drought risk for crops greatly increases the potential for plant nutrient efficiency. However, the economy of plant nutrients is often quite poor because of poor control of nitrogen losses in the cropping system or unbalanced fertilization. IPNS in irrigated areas is rather special as the use of crop residues has to be carefully regulated to avoid the development of diseases and the leaching of plant nutrients. However, fixation of nitrogen is possible either directly through traditional flooding irrigation (blue algae, azolla) or when irrigation is provided through sprinklers in mixed cropping or in relay cropping systems. IPNS will then mostly involve improving plant nutrient efficiency, as maintaining soil organic matter content is simpler than in rainfed areas because production of biomass is generally high.

12.33 The economics of nitrogen is a major problem in IPNS. Fixation of atmospheric nitrogen may provide significant quantities of nitrogen to the cropping system if water is available and if phosphorus and sulphur are available. However, nitrogen biofixation cannot cover all nitrogen requirements above moderate levels of intensification. There is a wide range of free-living soil bacteria that extract nitrogen from the atmosphere and make it available for plant growth. There are other bacteria, notably Rhizobia, which live symbiotically with plants in small nodules (swellings) on their roots, receiving sugar from them and providing in return nitrogen that they have taken from the atmosphere. The latter have been exploited by man for many years and sustained cropping systems in Europe and other parts of the world before the discovery of mineral fertilizers in the latter part of the last

century. In China, Thailand, Viet Nam and other Asian countries, the alga *Anabaena azollae*, which lives symbiotically with the water fern Azolla, has sustained rice cropping for centuries by providing much of the nitrogen required.

12.34 The challenge now is to use conventional techniques combined with methods of genetic engineering to improve on nature to raise the available yield of nitrogen and widen the range of plants and environments that can benefit. Current natural or managed plant/microbe systems in good rainfall areas can provide 20 to 60 kilograms of nitrogen per hectare, sufficient to sustain cereal yields of around one ton. Technology could conceivably raise this by 25 percent by the year 2010. Conventional plant breeding techniques may assist to obtain better efficiency through varieties using plant nutrients better to raise yields, or with stronger rooting systems to avoid losses by leaching. Varieties tolerant to soil constraints (salinity, lack of oxygen, free aluminum) will also have more benefits from plant nutrient supply than traditional varieties.

12.35 IPNS is likely to make a significant contribution to crop production growth during the period to 2010 and to the achievement of sustainable agricultural systems. It would be unwise, however, to underestimate the difficulties facing IPNS in the short to medium term, and to overestimate the gains in the long term. Lack of livestock and labour will be a major constraint in some areas: e.g. many smallholders cannot keep sufficient livestock to generate the required amounts of manure (up to 10 tonnes or more per hectare) or cannot provide the large labour input for collecting, carting and spreading it. Where land constraints are severe and the objective is a high rate of national food self-sufficiency, it may be impossible with current or foreseeable technologies to achieve or sustain the required high yields with the recycling or biofixing techniques for plant nutrient supply that some ecologists argue for.[235]

12.36 China has been in this situation for several decades. It has efficient systems for organic residue recycling and biological nitrogen utilization. Yet, since about 1950 staple food production has become increasingly dependent on mineral fertilizers, and China is now the largest user of mineral fertilizers in the world. In spite of the present efforts in China to develop further the science of ecological agriculture, this trend seems likely to continue, and even intensified by the increasing shortage of labour for the collection and application of organic manures. The production projections of this Study suggest that several other countries or areas face the same dilemma as China, e.g. Senegal, Burundi, Rwanda, Malawi, India and Thailand.

5.3 Expanding the Opportunities for Integrated Pest Management (IPM)

12.37 The past agricultural performance carries with it the burden of mistakes arising from our previous lack of knowledge of pesticide toxicity, their persistence in soils and water, their accumulation through food chains and their impact on both non-target and target species. Some of the costs of these mistakes are to be seen in human mortality and morbidity, in damaged ecosystems and in the increase of pesticide resistance. There are now over 450 injurious species of arthropods that have developed resistance to one or more

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[235] Norse, D., *Policies for Sustainable Agriculture: Getting the Balance Right*, Paper prepared for the IFAD International Consultation on Environment, Sustainable Development and the Role of Small Farmers, Rome, 11-13 October 1988.

pesticides because of repeated applications.[236] Resistance is also increasing in plant pathogens and weeds. Fortunately, man learns by his mistakes though not always quickly enough.

12.38 Following research showing the growing damage to human health and ecosystem function from pesticide use, FAO spearheaded efforts in the mid-1960s to develop and implement the concept of Integrated Pest Management (IPM). Progress was slow in the early years whilst understanding was advanced of predator-prey systems and other key aspects of ecosystem function. But in the past 10-15 years the success stories have grown and the concept has become more comprehensive. It now brings together five mutually enhancing control approaches.

- pest control using crop rotations, intercropping and other management methods;

- host plant resistance;

- biological control using natural methods or introducing new enemies of the pests;

- selective use of pesticides - preferably bio-pesticides - in conjunction with pest population monitoring and the establishment, where possible, of economic thresholds for pesticide use;

- plant health programmes, including plant quarantine.

12.39 FAO's extensive experience in Asia with the Intercountry Rice IPM Programme, adds an additional dimension: namely that of farmers becoming managers and experts in their own fields. Through "Farmer Field Schools", they learn how to grow a healthier crop, to conserve natural enemies of crop pests, and to use the appropriate pesticide on a need basis only.

12.40 Chapter 11 outlined the increasing pest pressures envisaged for future agricultural growth, notably because of the intensification of production. It noted that although total pesticide use may continue to grow, this will occur at a lower rate compared with the past and that application rates, environmental persistence and mammalian toxicity levels of pesticides will be lower in the future. These prospective developments are likely to come about because of the growing political, technical and farmer support in developing countries for IPM, and against the excess pesticide use of the past. These improvements presuppose continued or even greater donor support for FAO's efforts in this field and those of other national and international bodies.

12.41 In pursuing the further development and implementation of IPM, priority should be given to the crops accounting for the bulk of pesticide use: cotton, maize, rice, soybeans, fruit and vegetables. All have potentialities for wider IPM implementation though they are not effective for the full range of major pests. The FAO rice IPM programme has reached

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[236] Georghiou G.P. and A. Lagunes-Tejeda, *The Occurrence of Resistance to Pesticides in Arthropods: An Index of Cases Reported through 1989*, FAO, Rome, 1991.

some 600 000 farmers in Asia, cutting their pesticide applications by up to two-thirds, increasing yields and lowering costs of production. It is expected to surpass the figure of 1 million trained rice farmers in Asia before the end of the century, but even greater support will be required if it is to reach the approximately 90 million rice farmers who could benefit from this programme's approach.

12.42 Although prospects for the other major crops are also good, experience thus far has been less favourable. The experience with cotton is mixed, with some countries achieving substantial reductions in pesticide use but others still increasing such use. Nonetheless, a more effective sharing of international experience could achieve widespread reductions by 2010 and lower cotton's dependence on pesticides.

12.43 Perhaps the most threatening situation is that for vegetables. As indicated in Chapter 11, the relatively high value of vegetables and the agronomic conditions under which they are grown,[237] commonly lead to the heavy use of toxic pesticides. FAO is trying to stimulate action in this area through a regional vegetable IPM programme for Asia which is based on the lessons from the rice IPM programme mentioned above. However, the benefits of this programme and of various national initiatives are unlikely to have a major impact on the projected situation unless the problem receives much higher priority.

12.44 Progress has been made with the use of biocontrol agents, i.e. living or dead organisms (bacteria, fungi, insects, viruses, nematodes and protozoa), but mainly in the developed countries and commonly for glasshouse conditions. The most widespread biopesticide is *Bacillus thuringiensis* which, for example, is very effective against some cabbage pests, but it is only used on a minor proportion of developing country production. However, in Brazil, a baculovirus is being used on about 1 million ha of soybeans to control the velvet bean caterpillar, a major pest of soybeans.

5.4 Water Development and Water Saving

12.45 Chapter 11 presented a perspective view of growing competition for water, a competition that agriculture has lost in some developed countries, such as the Texas high plains in the United States, and seems destined to loose in some developing countries. Achievement of the projected irrigation pathway is therefore dependent on a number of technological developments[238] that increase the efficiency of water capture or water use, particularly:

- steps to safeguard the existing irrigation infrastructure through the soil conservation measures discussed earlier that will slow down the siltation of

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237 These are: irrigated or well watered conditions; relay cropping with two or more harvests a year; crops at different stages of maturity in close proximity; no or limited fallows. All favour the substantial carry over of pests from one crop to the next, and the early infection of young plants or competition with them, in the case of weeds.

238 The requirements for sustainable water use are not just technological. The institutional and policy dimensions are equally important and are dealt with in Chapter 13.

canals and reservoirs, and the actions to stop salinization and to rehabilitate saline land that are described later.

- the introduction of techniques, pricing policies and institutional changes that raise water use efficiency.

- improvements in irrigation design and technologies to raise the efficiency and lower the costs of operation and maintenance.

- expansion of the use of marginal quality water including brackish water and municipal wastewater.

- removal of technical constraints to conjunctive use of surface water and ground water resources.

12.46 Irrigation is the largest water user, yet irrigation water use efficiency can be as low as 40 percent.[239] Consequently, even a 10 percent improvement in water use efficiency can release a substantial volume of water for other uses and delay the onset of competition. The substitution of marginal for high-quality water can have similar benefits. Several semi-arid countries in the Near East region already use treated sewage effluents for irrigation, releasing high quality water for other purposes.

12.47 Many of the technical solutions have been produced and implemented in the developed countries, but adoption has been slow in most developing countries, mainly because of their high cost and complexity. Most of them are overhead irrigation systems involving sprinklers, and a range of micro-irrigation systems that are twice as efficient as surface irrigation. The more recent techniques such as Low-Energy Precision Applications (LEPA) can be 90 percent more efficient than surface irrigation, as well as permitting the use of saline water (Box 12.3). They are being adopted in some developing countries, such as Morocco, but are unsuitable replacements for the bulk of present irrigation because the latter consists mainly of surface systems involving complete flooding for paddy rice, or furrow irrigation. The principal opportunity for the latter seems to be surge flow irrigation (Box 12.3), but this generally needs to be adapted to the farming conditions in developing countries.

12.48 Such solutions could have an appreciable impact on non-flood irrigation schemes well before 2010, and make the projected pathway even more feasible. For the rest, the immediate task is applied research to improve flood irrigation, and to adapt sprinkler and micro-irrigation systems more closely to developing country conditions. Given the long gestation period for the completion and implementation of such research, its main benefits are likely to be post 2010.

12.49 In the past attention has been focused on the health risks that can be posed by irrigation systems, through malaria and the spread of bilharzia, for example. Conjunctive use of water, however, presents an opportunity not only to reduce the competition for it but also

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239 Kandiah, A. and C. Sandford, *Research and Development Needs for Integrated Rural Water Management,* Paper presented to the Technical Consultation on Integrated Rural Water Manageme nt, FAO, Rome, 15-19 March 1993.

to help reduce the most widespread threat to health in many rural communities, namely the lack of potable water. Gastro-intestinal diseases from polluted water lower labour productivity and in effect cause severe food losses through poor digestion and retention. Irrigation canals and tubewells are increasingly recognised as a relatively safe source of drinking water, yet technologies and irrigation system design seldom take this into account. Research and technology development are urgently needed to determine the design requirements for dual-purpose systems, to identify treatments to safeguard health, and to adapt existing techniques and equipment to satisfy these requirements.

Box 12.3

EMERGING IRRIGATION TECHNOLOGIES: LEPA AND SURGE IRRIGATION

The Low Energy-Precision Application (LEPA) method of irrigation basically consists of a low pressure moving irrigation system, such as modified centre pivot system or linear-move system, where sprinkler heads are replaced by drop tubes which deliver water to the soil surface. The crop response to this system of irrigation is similar to stationary drip installation with closely spaced emitters. Saline water can be used without damage to foliage under this system. It maximizes irrigation efficiency with low pressure nozzles near the ground, and the application efficiency could be as high as 90 percent.[1] It was reported that the average amount of water applied per hectare by Texan farmers dropped 28 percent by between 1974 and 1978 because they adopted LEPA.[2]

Surge flow irrigation is defined as the intermittent application of water to furrows or borders creating a series of on and off periods of constant or variable time spans. Usually water is alternated (switched) between two irrigation sets until irrigation is completed. The switch is accomplished with a surge valve and an automatic controller. Surge flow greatly reduces the intake at the top of the field because the opportunity time is much less than under continuous flow method. It is reported that efficiency of irrigation could be improved to an average of 70 percent or more. In the USA, the effectiveness of surge irrigation as a water conservation measure is demonstrated by its rapid growth and acceptance by farmers.

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1 Fangmeier W., F. Vlotman and S. Eftekhazadeh, *Uniformity of LEPA Irrigation Systems with Furrow Drops,* American Society of Agricultural Engineers, Vol. 33, No. 6, St. Joseph, Michigan, 1990.

2 Postel S., *Water for Agriculture: Facing the Limits,* World Watch Paper 93, World Watch Institute, Washington, DC, 1989.

12.50 Finally, there is the question of low-cost irrigation. The rate of development of irrigation slowed in the 1980s, and this has been an issue of great concern given population growth and the critical role that irrigation plays in achieving food security. The causative factors are complex and wide ranging. They include the exhaustion of the easier sites for irrigation development and hence rising costs; donor disappointment in the performance of externally funded irrigation projects; decline in commodity prices; and public sector constraints to irrigation equipment supply. Some of these constraints can be removed rapidly enough to affect the year 2010 situation; others like the lack of sufficiently cheap solar pumps for low-cost tubewells seem to lie beyond the projection period. Yet in Bangladesh, for example, the mere removal of import constraints on small, cheap and technologically

simple irrigation pumps and diesel engines dramatically boosted small-scale irrigation in less than five years.

5.5 Raising Livestock Productivity

12.51 The projections pose a number of technological challenges for the livestock sector itself and for those supporting it with feedgrains, high-protein feeds, processing services and other inputs. The challenges differ between the land dependent commodities like beef, and those which are becoming increasingly separated from land like eggs, pig and poultry meat that are increasingly produced by intensive systems dependent on imported feeds and located in peri-urban areas or with good access to urban markets. The former tend to be resource constrained and supply driven, and are exerting growing pressures on the environment through overgrazing by extensive livestock management systems. The latter are increasingly able to side-step resource constraints because they are driven by rapidly growing domestic demand, and by price or market conditions that enable producers to purchase the feed concentrates and best available production and processing technologies. They may also place unsustainable burdens on the environment, but their main problems tend to be point source pollution stemming from poor waste disposal by intensive production and processing systems.

12.52 The main challenges are to compensate for the lack or poor quality of land through measures to raise pasture and rangeland output and improve management systems; to bring about a closer integration of crop and livestock production; to raise the supply and quality of supplementary feeds; to achieve genetic improvements from conventional breeding and modern biotechnical tools; and to complement these gains by cheaper and more effective animal health measures. There is much in the technological pipeline to meet these challenges, which could have their impact well before 2010.

12.53 CIAT, for example, has selected forage legumes, grasses and browse species, which fit well into pasture management and ley systems for poor acid soils. Farmers are achieving major increases in stocking rates, and animal weight gains of 100 percent or more. Only a relatively small proportion of the total area which could benefit in Latin America has been reached, but a much wider uptake could be achieved by 2010, and the technology could be adapted for the large land areas in Africa and Asia suffering from similar constraints.

12.54 Closer integration of crop and livestock systems is partly culture dependent, partly resource constraint driven, and partly market driven, all of which link in one way or another to incomes and household security issues. Land pressures are forcing nomadic pastoralists to settle and become cultivators. Land and labour pressures are forcing cultivators to adopt animal traction, and to keep livestock as a vital source of manure for maintaining or increasing crop production and cash incomes.[240] Market opportunities and the desire to obtain more regular income streams are favouring dairy-based cropping systems. All of these are on-going shifts that can be expected to strengthen during the 1990-2010 period and increase sustainability.

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[240] Mortimore, M., *Profile of Technological Change*, ODI Working Paper 57, ODI, London, 1992.

12.55 In recent decades conventional animal breeding has allowed the developed countries to raise productivity per animal by 1-2 percent per year. Similar attempts in the developing countries have been far less successful, in part because of unsuitable breeding stock, poor feed, and environmentally stressful conditions, particularly temperature stress. Modern biotechnical tools now provide the possibility of modifying the genome of indigenous animals and mixed breeds to cope better with such stresses or diseases, and raise milk and meat output. Moreover this potential can now be brought to the farmer more quickly through new reproduction techniques, like embryo transfer and *in vitro* fertilization which can speed up the breeding and stock multiplication process. The techniques, however, are unlikely to be widely used in most developing countries by 2010, because of institutional and structural constraints.

12.56 Biotechnical tools and processes are also starting to have a practical impact in the animal health sphere, notably in the prevention, diagnosis and control of animal diseases, particularly vector-borne diseases. They will have an increasing impact over the projection period, with growing relevance to the needs of small-scale farmers. New vaccines are already on the market for the control of bacteria causing diarrhoeas in lambs, calves and pigs.

12.57 In the medium term, vaccines should become available to control trypanosomiasis and theileriosis although commercialization of the former is unlikely to happen soon. Once achieved, however, it would help to free large areas of Africa of trypanosomiasis and replace trypanocidal drugs, new types of which have not been developed for some 30 years with the consequent increasing threat of resistant trypanosomes. In the shorter term, new control techniques such as low-level or selective insecticide spraying, pherenome traps and sterile male release, will continue to reduce populations of the trypanosomiasis vector - the tsetse fly - and replace the older but environmentally negative techniques of massive spraying of residual insecticides, bush clearance and wildlife control. The eradication of rinderpest also is an attainable target within a 2010 time frame if sufficient resources were to be devoted to the task.

12.58 In recent years new perceptions have arisen regarding the desirable principles of animal nutrition appropriate to the conditions of the majority of developing countries, which will shape the direction of future research. Greater advantage should be taken of the particular digestive characteristics and complementarity of the different species of livestock. Ruminants can use fibrous feed and non-protein nitrogen sources which cannot be used by man and monogastric animals, the latter converting high energy feeds more efficiently.[241] Ruminants can be regarded as two sub-systems: the rumen and its microbial contents, and the animal itself which can convert nutrients produced by the microbes and those derived directly from feeds (undegraded nutrients) that usually cost more. Therefore, greater attention is now paid to improving the rumen function through manipulation of its microbial environment. A further point is that strategic supplementation with small quantities of essential nutrients to balance the nutrients absorbed from the basal diet (generally pasture and crop residues), may greatly benefit productivity.

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241 Recent studies have shown that, among the ruminants, buffaloes and cumelids have a greater efficiency in digesting fibrous feeds and recycling urea.

12.59 Arising from the above improved understanding of the feed process, two areas of work are regarded as priority to enhance livestock performance: optimize protein/energy ratio in nutrients absorbed by ruminants from diets based on poor quality forage; and optimize the digestibility of the basal feed resource.

12.60 Pursuing these approaches involves research in the area of rumen manipulation, development of local sources of undegradable protein supplements, feed processing to improve the digestibility of low quality forage, and genetic manipulation of plants so that their proteins resist rumen microbial attack.

12.61 Examples of innovations embodying these new approaches in animal nutrition and which are likely to have increasing application in the future are the following. Firstly, the use of locally manufactured multinutrient blocks (molasses-urea) which now have been successfully tested in about 60 developing countries, including India, particularly in milk production, and the Sahel in Africa. These blocks encourage an efficient rumen ecosystem by providing a source of minerals, vitamins and fermentable nitrogen in order to correct an unbalanced nutrient supply. Secondly, leguminous forages as strategic feed supplements for ruminants. Promising species of such legumes are *Leucaena leucocephala* and *Gliricida* sepium which contribute fermentable nitrogen in the rumen as well as undegradable proteins, to diets based on fibrous crop residues. The third example is the fractionalization of sugar cane for pig and ruminant feeding in Latin America. With this method, which could be a breakthrough for feeding monogastrics in the humid tropics, sugarcane juice is the basis of the diet for pigs and can totally substitute for maize. In a fully integrated system, the sugar cane tops and leaves as well as the bagasse is fed to ruminants, with the leftovers being used for fuel. Sugarcane also can be grown in association with soybeans and selected species of fodder trees to provide protein-rich livestock feed.

5.6 Developing the Potential of Biotechnology

12.62 Biotechnology[242] is not new and many products are the result of a simple but effective use of traditional biotechnologies: e.g., fermentation processes for the production of cassava-based foods, which combined with boiling lowers the cyanide content. Biotechnology here refers to both traditional (e.g. fermentation) and modern biotechnology which is based on the use of new tissue culture methods and recombinant-DNA (r-DNA) technology, often referred to as "genetic engineering". Tissue culture includes *in vitro* fertilization and embryo culture, protoplasts and the culture of isolated cells and microspores. Such methods are used to produce pathogen-free plants and for germplasm storage. The current largest use of plant biotechnology is in the clonal propagation of plants, particularly ornamentals because of their relatively high market value. The modern technique of r-DNA offers the potential of moving any cloned gene from any organism into any other organism - the transgenic host - and is much more precise and faster in achieving results as compared to conventional plant or animal breeding techniques. However, biotechnology is not a

[242] Defined as any technique that uses living organisms to make or modify a product, to improve plants or animals, or to develop micro-organisms for specific uses.

substitute for the latter and should be seen as complementary. Indeed, the strengthening of traditional biological research is an essential prerequisite for establishing a biotechnological research capability in most developing countries.

12.63 Biotechnology offers a range of applications mainly for plant and animal production. Some are likely to have an increasing impact well before 2010; others are of a longer-term nature. The former include tissue culture of virus-free stocks of cassava and other root crops, and the introduction of microbial plant growth promoters, e.g. mycorrhiza. The latter include cereals with the ability to fix some of their own nitrogen needs, and transgenic tree crops, but the greatest expectations are in introducing disease and drought resistant genes.

12.64 Many of these applications will contribute to more sustainable resource use, particularly by: (a) raising crop yields and reducing land requirements for a given level of production, thereby lowering the pressures on natural forests; (b) complementing industrial with biological sources of nitrogen for plant growth; and (c) raising production performance of animals through growth manipulations and by producing improved vaccines and enhancing disease resistance.

6. A RESEARCH AGENDA FOR A SUSTAINABLE FUTURE

12.65 UNCED's Agenda 21, as well as setting a formidable agenda into the next century, also provided a philosophy for sustainable development which may be interpreted to guide the direction of agricultural research. The first emphasis is on the improved management of biological systems, based on a better understanding of their feedback and balancing processes. Examples are integrated plant nutrition systems (IPNS) and integrated pest management (IPM) to substitute for heavy reliance on chemical-based interventions. The second emphasis is on better information management, implying the need for sound data on natural resources, land use and farming systems, agrometeorology etc, to improve environmental monitoring capability and make better use of natural resource potential. The third emphasis is on improved farm-household system management, in order to obtain a better understanding of the differing systems and hence considering in an integrated way household, farm and off-farm activities. The emphasis also must be to obtain a fully participatory approach to development.

12.66 Moving to a more operational level, two central thrusts can be identified, each having a set of priorities. One thrust is aimed at promoting sustainable increases in productivity in the higher potential areas. The second should target on marginal and fragile environments where current degradation must be reversed and production stabilized or raised. These must be supplemented by two cross-cutting and highly complementary approaches, that of rehabilitation and restoration of ecology, and that of exploiting the synergism of indigenous technical knowledge and modern science. All four actions must be supported by international efforts to strengthen the national agricultural research systems, both institutionally and financially, since they will have to undertake much of the adaptive and applied research.

12.67 The priorities for making progress towards sustainable growth in productivity include: expanding on-farm/biological production and recycling of inputs and lowering off-farm mineral fertilizer and pesticide needs; raising crop yield ceilings; improving irrigation

water management; limiting soil acidification; using energy more efficiently and promoting renewable energy sources; and reducing labour inputs of some multiple cropping systems.

12.68 On-farm production or recycling of inputs can serve three main purposes. First, they can provide small-scale farmers with a profitable alternative to high cost external input systems, which though effective in technical terms, incur financial risks. Second, they can help to prevent soil nutrient mining and the excessive build-up of mineral fertilizer and pesticides residues in soil and ground and surface waters. Third, through the greater use of live leguminous mulches, green manures and other organic residues, they can improve soil structure, maintain soil fertility and enhance the soil's role as a sink for carbon dioxide. This requires a much deeper knowledge of agro-ecosystem function, intercropping, and so on, but may also face severe labour constraints. It is difficult to imagine, for example, how some of the complex intercropping and relay planting systems currently used in China to achieve three crops a year, which involve a lot of hand work, can survive in a higher labour cost environment. Research priorities include nutrient recycling processes and techniques, natural resources management at village level, and integrated crop/livestock management systems.

12.69 Raising yield ceilings in difficult environments has been an issue for a number of years. There is now a better understanding of the issues involved, and progress is being made with some crops like millet and legumes. In parallel, there is renewed emphasis on raising yield ceilings of staple food crops in the high potential areas, which have been the centre of the successes of the "green revolution" (the irrigated rice and wheat areas of Asia) and where experimental yields seem to have reached a plateau and have been virtually static for the past ten years or more.[243] Although average farm yields in these areas are still well below experimental yields, and so yield growth trends could continue to 2010, thereafter there would be rapid decline in yield growth unless research manages to break through the plateau and bring about another shift in the production frontier.[244] This challenge has become a major priority for IRRI and other research institutions, but their efforts must be backed up by national action. Recent widespread introduction of hybrid rice in China and other countries in Asia, first for temperate rice but subsequently for tropical varieties, offers great promise of significantly raising the yield ceiling on rice (see Chapter 4). Priority research tasks include: (a) production of crop varieties with enhanced tolerance or resistance to moisture stress and soil nutrient constraints; (b) studies to overcome micro-nutrient deficiencies; and (c) investigating soil conditions under continuous intensive crop production as well as under low input conditions.

12.70 The research agenda for irrigation has three components. One is the use of cheap sources of low-quality water in place of scarce high-quality water. The second is raising water use efficiency so as to reduce unit costs. The third is to improve the management of irrigation systems. Existing technologies can go a long way to sustaining growth in the medium term, but accelerated research is needed to find more economic ways of preventing

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243 Pingali P., P.F. Moga and L.E. Velasco, *The Post-Green Revolution Blues in Asian Rice Production: The Diminishing Gap Between Experiment Station and Farmer Yields*, IRRI Social Sciences Division, Los Baños, 1990.

244 Hayami, Y. and K. Otsuka, *Beyond the Green Revolution: Agricultural Development in the New Century,* Paper presented to the World Bank Conference on Agricultural Technology: Issues for the International Community and the World Bank, Virginia, October 1991.

the further deterioration of existing water resources and to widen the technological options for the future. Key priorities are: (a) raising the efficiency of flood irrigation by practical methods of flood depth and seepage control, better land preparation, and the use of alternate wet and dry regimes; (b) adaptation of surge irrigation to developing country conditions; (c) development of simple, efficient and economical wastewater treatment methods so as to prevent or minimize adverse human health and environmental impacts; and (d) identifying the main institutional characteristics of successful irrigation management systems and the effects of transferring management to farmers.

12.71 A common outcome of more intensive land use, whether it be through high or low external input systems, is increasing competition between crops and weeds for the available soil nutrients and water, and for light. The conventional responses are either more hand weeding or more herbicides. Labour for the former is becoming increasingly scarce and expensive, and the increasing quantities of pesticides are a growing threat to the environment and human health. Key priorities are: (a) greater emphasis on weed management; (b) increased research on biological control methods and biodegradable herbicides; and (c) researching innovative ways to reduce herbicide applications.[245]

12.72 Fulfilling the energy needs of agriculture and of rural services is at the core of improving productivity, income-generation and overall well-being of farmers. Land preparation harvesting, irrigation and processing require different types and levels of energy inputs, both in a direct (mechanical, thermal and electrical energy) and indirect forms (fertilizer). Without these energy inputs, agricultural productivity will remain low and probably well below its full potential. At the same time, unsustainable practices based on unnecessarily high energy inputs lead to resource depletion. There is the need, therefore, to better understand the energy-agricultural links, and to promote sustainable energy systems based on renewable energy sources, mainly biomass, solar and wind energies. The potential of agriculture itself as an energy producer requires further studies and research into the use of biomass residues, energy plantations and combined energy and food production schemes. Key priorities are: (a) evaluation of the energy-agriculture interrelationships for different ecosystems, and in relation to high and low potential areas; (b) better understanding of the integrated management of energy and other inputs (water, fertilizer, pesticides, mechanization); and (c) assessment of the potential of biofuels for different environmental and land-use policy situations.

12.73 Concerning the need to safeguard the marginal areas, there are two facets to this problem. The first concerns those areas that need not be permanently marginal, since with suitable investments, institutional changes, and technologies, they could become moderate to high potential areas (see Box 12.1). The second relates to areas that are inherently marginal because of severe aridity constraints that cannot be overcome by irrigation, or adverse soil types that cannot be overcome economically. Here priority must be given to limiting degradation whilst non-agricultural employment opportunities are created, so that people can afford to buy food from the better endowed areas, instead of being forced to over-exploit the land to meet basic needs.

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245 For example, in the "Cerrado" area of Brazil, soybean farmers practising minimum tillage methods, spray herbicides at night (calm, cool and damp conditions) and successfully reduce applications rates to a quarter of those recommended.

12.74 It is increasingly acknowledged that there are many indigenous techniques for on-farm or local water conservation that can be used now or quickly adapted to complement the above actions. Maintaining progress after 2010 will, however, require more basic and applied research in the next two decades. As with plant breeding lead times can be 10-15 years or more. Some of the minimal tillage techniques, for example, that have transformed dryland crop production in parts of the USA, took some 20 years to develop and implement. And whilst they are lower rather than low-input systems, they are much more sustainable in terms of fossil energy inputs and soil fertility maintenance than the farming practices they have replaced. Priorities include: (a) development of minimal tillage systems for low-income farmers in the drylands of developing countries; and (b) methods to improve pastures in the extensive range areas, both under tropical and temperate conditions.

12.75 While there are substantial opportunities for developing sustainable lower input systems, complete independence from external inputs is a myth except in a few special circumstances such as volcanic and aeolic dust deposition or sediment loaded flooding. More research is therefore required on lowering the unit costs of external inputs, or achieving the same objective by raising input use efficiency, or reducing needs through innovative ways of overcoming the factors that currently impose marginality. Some of the opportunities are well illustrated by the widespread problem of phosphate deficient soils. Phosphate is an essential chemical for plant growth but many soils are highly deficient in it, or the phosphate present is not available to plants because of other soil factors: e.g. aluminium or iron toxicity. Organic manures are seldom the long-term solution if high yields are to be achieved while manure made from biomass grown or phosphorous-deficient soils will itself be deficient in phosphorous.

12.76 The conventional production of phosphate fertilizers is expensive, and when long distance transport costs are added, they tend to become even more uneconomic for farmers in marginal areas. Many countries, however, have low-grade phosphate rock or other phosphate bearing materials that could be used if cheap methods could be found for treating them so that the phosphate becomes readily available to plants. Alternatively, and in the longer term, there seem to be possibilities for genetically transferring to other crops the properties of pigeon peas to release bound phosphates in the soil and make them available for plant growth. Without such technological breakthroughs however, sustainable development in many marginal areas will be impossible. Research priorities therefore include: (a) development of cheap techniques for improving the effectiveness of low-grade phosphate bearing rocks, such as incorporating organic matter and promoting mycorrhiza activity in the soil; and (b) determination of the pigeon peas mechanism for releasing bound soil phosphate, and possible transfer of the mechanism to other crops.

12.77 Increasing competition between crop and livestock production for land in both high potential and marginal areas, and the threat to crop yields from declining soil fertility, will be a positive force for integrating the two systems. This will, however, intensify the demands on research to come up with more satisfactory solutions to a number of problems and opportunities, notably: (a) reduction in the labour needs and other constraints to the adoption of livestock oriented alley cropping and other sylvo-pastoral systems, taking into account competition for water, light and plant nutrients; (b) development of legume based relay, intercropping, soil conservation, and other practices to raise the supply of high protein feeds and forages; and (c) introduction and refinement of ley farming systems for acid and other low fertility soils based on legume - grass pastures.

7. CONCLUDING COMMENTS

12.78 The foregoing gives an indication of the needs and opportunities for achieving the output projected for 2010 and for laying the foundation for sustainable agriculture in the 21st century. The needs, however, are not only those of research and technology development. Unless technological progress is accompanied by institutional change and other improvements in the incentive environment for agricultural development, many of the research findings will not leave the laboratory or the experimental station, or be evolved on farms themselves. These aspects, some of which have been already discussed in earlier chapters, will be further explored in the next, concluding chapter.

CHAPTER 13

MINIMIZING THE TRADE-OFFS BETWEEN THE ENVIRONMENT AND AGRICULTURAL DEVELOPMENT

1. INTRODUCTION

13.1 The preceding chapters have demonstrated that there are commonly a number of trade-offs between the environment, food security and other aspects of development. Some of the trade-offs are avoidable, but others are not at this point in time. The underlying issues were clarified and brought into prominence by the Brundtland Commission. Its Report[246] emphasized the difficult task of reconciling the short-term imperative of increasing food and agricultural production as well as incomes for the current generation with the longer-term but almost unspecifiable, need of conserving natural resources for meeting the requirements of future generations. Thus, whilst the long-term objectives may be sustainable development of agriculture and of the whole economy, the pathways or processes involved may have to breach the environmental requirements of this goal in the short to medium terms. Hence the importance of minimizing the trade-offs.

13.2 Chapter 11 spelled out as far as possible the pressures on the environment associated with the possible future evolution of agriculture. Many of the pressures on the environment associated with the quest for development have, however, become a subject of contention between the developed and the developing countries and account for some of the differing priorities pursued by these two groups at the United Nations Conference on Environment and Development (UNCED) and other international fora.

2. THE NORTH-SOUTH DIVIDE

13.3 The developed countries tend to give priority to the environmental dimension and to measures to limit natural resource degradation, in spite of the economic and social costs that may be associated with such measures. In doing so they seldom acknowledge that a sound environment is, in some respects at least, a luxury good which they can now afford, but which in their earlier history they had largely ignored. The developing countries, of necessity, tend to argue for different priorities. They recognize the importance of shifting onto a more sustainable growth path and at UNCED gave overwhelming support to AGENDA 21 (Box 13.1), and the conventions on biodiversity and climate change. But they emphasize the need to ensure that environmental measures do not have adverse effects on their development, arguing, for example, that unless rural poverty is eliminated, many of their people will have no alternative to overexploit natural resources for day to day survival.

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246 World Commission on Environment and Development, *Our Common Future*, Oxford University Press, New York, 1987.

Box 13.1

THE OUTCOME OF UNCED[1]

The UN Conference on Environment and Development (Rio de Janeiro, 3-14 June 1992), at which 172 Member Governments were represented, concluded with the Earth Summit, during which 102 Heads of State and Government made statements, expressing their commitment to environmentally sound and sustainable development. The main agreements reached and subsequently endorsed by the 47th Session of the UN General Assembly were:

(i) the Rio Declaration on Environment and Development (to be further elaborated as an Earth Charter for adoption by the UN General Assembly in 1995 on the 50th anniversary of the UN);

(ii) Agenda 21, which describes in some 280 pages a comprehensive plan of action consisting of 115 programme areas, grouped in 40 chapters. Of particular interest to food and agriculture are Chapter 10, integrated approach to the planning and management of land resources; Chapter 11, combating deforestation; Chapter 12, managing fragile ecosystems: combating desertification and drought; Chapter 13, managing fragile ecosystems: sustainable mountain development; Chapter 14, promoting sustainable agriculture and rural development; and Chapter 17, oceans and marine resources.

(iii) the Framework Convention on Climate Change, signed by 162 governments (out of 50 ratifications needed 22 have now been received);

(iv) the Convention on Biological Diversity, signed by 159 governments (21 ratifications received so far out of 30 needed);

(v) the "non-legally binding authoritative statement of principles for a global consensus on the management, conservation and development of all types of forests", which may lead to "internationally agreed arrangements to promote international cooperation";

(vi) agreement on sources and mechanisms to mobilize financing for Agenda 21, including new and additional resources in grants and concessional terms from the international community: (a) the multilateral development banks and funds, including the IDA, regional and sub-regional development banks and the GEF; (b) the relevant specialized agencies, other UN bodies and international organizations; (c) multilateral institutions for capacity building and technical cooperation; (d) bilateral assistance programmes; (e) debt relief; (f) private funding (NGOs); (g) investment; and (h) innovative financing.

(vii) international institutional arrangements for follow-up, particularly the establishment of the Commission for Sustainable Development of ECOSOC, and an Inter-Agency Committee on Sustainable Development, established by the ACC.

(viii) the launching of a negotiating process for an International Convention to combat Desertification in those countries experiencing serious drought and/or desertification, particularly in Africa, to be finalized by June 1994.

(ix) convening of a number of UN Conferences, among them the Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks (New York, July 1993), and the Global Conference on Sustainable Development of Small Island Developing States (Barbados, April 1994).

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1 See also FAO "FAO Activities on Sustainable Development and Environment", C93/10, 1993.

13.4 Most developed countries have already taken measures to overcome or continue to alleviate the more serious agricultural threats to the environment. They have, for example, taken marginal land out of production; reduced or banned the use of mineral fertilizers and residual pesticides on sensitive watersheds vulnerable to groundwater contamination; tightened the controls on waste disposal from intensive livestock units, and so on. Further measures to protect the environment from agricultural pressures are largely a question of social choice since they have the economic and technical capabilities to introduce additional control measures or technologies that are environmentally more benign and sustainable. They can also bear with less economic hardship than the developing countries the eventual economic consequences of such action, e.g. higher food costs and/or higher food imports or lower exports. With the wider acceptance of, and further progress in, environment-friendly technologies, it can be expected that trade-offs between the environment and development, as the latter is conventionally defined and measured (e.g. per caput incomes, etc.), will tend to become smaller.

13.5 The situation in most developing countries is quite different. For them, improving agricultural resources management is a social imperative rather than a social choice, because degradation of these resources is both a cause and a result of poverty (see Chapter 2). But their environmental options are often severely constrained in the short to medium term at least. They will have to use more of their less-productive land, as well as some of their wetlands with high agricultural potential. They cannot reduce their often low use of mineral fertilizers without endangering food security and intensifying soil degradation, and cannot exploit more fully technological options for integrated plant nutrition quickly. For some production or environmental problems appropriate technical solutions do not yet exist and are not readily available or affordable. Any appreciable rise in food production costs and consumer prices would have adverse effects on already low consumption levels, and many countries could not afford to increase commercial food imports. Finally, they are already finding it very difficult to maintain existing levels of public services, so environmental measures are commonly in direct competition with projects for scarce resources for investment in material and human capital.

13.6 Fortunately, there is much that can be done to minimize these trade-offs, and there are also a number of actions which are sounder in environmental terms as well as profitable. Chapter 12 has dealt with the technological problems and opportunities. It remains for this chapter to consider the wider institutional and policy changes that are needed to provide the right incentives and support mechanisms for the technology uptake required to achieve the agricultural production projected in this Study, and to contribute to sustainable agriculture and rural development (SARD). Section 3 suggests what the main thrusts might be of a strategy to minimize any environmental and development trade-offs. Section 4 moves from strategy to tactics and deals with policies and resource management measures to address the main environmental pressures emanating from the continuation of agricultural growth.

3. A STRATEGY FOR MINIMIZING ENVIRONMENT AND DEVELOPMENT TRADE-OFFS

13.7 The technological opportunities considered in chapter 12 are not sufficient in themselves to stimulate ecologically sound and sustainable development to 2010 and beyond.

The economic and institutional environment must also be favourable. Farmers must have better access to proven technologies, production inputs and services, and to markets for their products. They must be secure in their rights to access to land and other resources so that they have the stability and confidence to take up the technological opportunities and make the necessary investments. And, finally, since few technologies are totally risk free in the absence of safeguards to protect public goods, there must be an appropriate regulatory environment. Inconsistencies or gaps in these supporting measures can seriously undermine the effectiveness of individual technologies and of the total package. It is therefore essential that the minimization of trade-offs and actions to shift agriculture on to a sustainable growth path take place within a consistent strategic framework.

13.8 FAO took the lead in developing such a framework as one of its contributions to the UN Conference on Environment and Development.[247] In particular, FAO took responsibility for a number of the chapters of AGENDA 21, the main operational recommendations of the Conference (see Box 13.1). AGENDA 21 contains proposals for a wide range of technical and institutional changes that support the policy and other assumptions underlying the 2010 projections, and which are essential for longer-term development. These numerous changes have been distilled into an overall strategy for sustainable agricultural and rural development in the long-term. But within this overall strategy it is possible to think of component strategies which focus on specific issues, in this case the minimization of environment and development trade-offs, e.g. by lowering the pressure to clear primary forests or drain wetlands for agricultural use.

13.9 The preceding chapters, in particular Chapters 7 to 10, have discussed the main thrust of policies that should underpin efforts to improve the performance of agriculture, reduce rural poverty and improve access to food. It remains for this chapter to discuss the issues that are more specific to the objective of having a strategy which seeks to minimize the environment-development trade-offs. First, as shown in Chapter 12, emphasis must be put on shifting technology from "hardware" solutions requiring large inputs of fixed and variable capital, e.g. machine-made land terraces or pesticides, to solutions based on more sophisticated, knowledge and information-based resource management practices. The latter solutions carry fewer environmental, economic and health risks for the producer, agricultural worker and consumer. Examples are vegetative barriers to soil erosion instead of machine or man-made terraces, and integrated pest management based on knowledge of predator-prey relationships, as opposed to control strategies based mainly on the use of pesticides. Thus they aim to lower both off-farm costs and environmental pressures. Machine-made terraces, for example, require large capital investments. These commonly come from scarce public resources and hence compete with other needs, including expenditure on health and education. The machinery and the fossil fuel to run it generally have to be imported using scarce foreign exchange. Such terraces often fail through early neglect because they were introduced through a top-down process that excluded farmers and communities from the design or implementation stages.

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247 FAO,1991, *The Den Bosch Declaration and Agenda 21 for Action on Sustainable Agriculture and Rural Development: Report of the Conference.* FAO/Netherlands Conference on Agriculture and the Environment, 's-Hertogenbosch, The Netherlands, 15-19 April 1991, and UN, *Earth Summit, Agenda 21: The United Nations Programme of Action from Rio*, New York, 1993.

13.10 Second, greater importance must be given to establishing well-defined property or user rights for public and private resources. Examples are land tenure arrangements or the creation of user groups commonly building on traditional systems. In Africa especially, the latter tend to work better than western style individual titling of land holdings. Without such changes, users of common property resources will have little or no incentive to exploit them in a sustainable way; uncontrolled development will commonly lower the economic benefits of given resources. Clear rights of access to land, on the other hand, provide economic and social incentives to protect and improve resources, although it is seldom a sufficient condition alone to achieve these objectives (see Chapter 9).

13.11 Third, success depends greatly on peoples' participation and decentralized resource management. In the main it is small farmers, herders and forest dwellers who make the key decisions about resource use. They decide whether to adopt sustainable practices, to clear forests or plough up pastures, and they do so in response to household security needs and incentives rather than government dictates. And collectively, as villages or larger communities, they decide about watershed management. The public sector of developing countries cannot afford the cost of enforcing such requirements, and furthermore lacks the vested interest of owners and users in safeguarding the resources being exploited.

13.12 Fourth, as far as possible market signals must embody proper valuation of environmental goods. As far as possible, commodity prices should include all direct and indirect environmental costs. Public bodies cannot "police" all aspects of resource use without their becoming a politically and economically unsustainable burden. The alternative is to use price signals to achieve the same broad objective, but with the support of a national and international regulatory environment that sets appropriate standards, e.g. certification schemes for timber harvested in a sustainable way, and labelling requirements for "organically" produced commodities.

13.13 The above basic thrusts of a broad global nature are a prerequisite for some countries to achieve the agricultural improvements projected for 2010 while minimizing trade-offs with the environment. To a greater or lesser degree, however, they are essential to all countries, developed and developing, if the output projected for 2010 is to be sustainable in the long term. But these thrusts are not sufficient in themselves. If they are to lead to effective policy changes and operational measures, they must be amplified and adapted to national circumstances and to the specific problems of different agro-ecosystems. Four broad agro-ecosystems account for more than 95 percent of food and agricultural production in the developing countries, and their individual contributions to present and future production are recognized in the projections. They are dryland/uncertain rainfall, lowland humid/per-humid, irrigated and hill/mountain agro-ecosystems. These may coexist within a single country, although any one of them may dominate. The specific characteristics, problems and opportunities of such agro-ecosystems can provide a rational basis for strategic planning at the national or supra-national level. However, the final trade-off decisions will have to be made by the farmer or local community who may have to make decisions with regard to resources with different production characteristics.

13.14 Most important of all is the need to adopt the strategic approach to the national institutional setting or framework since this is a unique blend of cultural, political, economic, social and physical factors, that govern the validity of the different trade-offs. The strategy must be national yet operationally decentralized. Certain responsibilities will have to be

carried at the national level but with much of the consequent action being devolved to the user. It is the sovereign responsibility of governments to reconcile the resource demands of present users and the needs of future generations. Only governments have authority over the required range of legal, fiscal and social instruments as well as the supporting institutions and services. Only governments have the authority to make binding agreements on trans-border issues, such as the management of international water basins, that are vital for sustainable development and environmental protection. Yet the potential for government failure is indisputable and there are distinct limits to the role governments and national bodies can play in natural resource management. Therefore, much of the responsibility for specific trade-off decisions must be left to local communities and farmers, encouraged by appropriate national policies and regulations.

13.15 The strategy must recognize that the first priority of many farmers is household food security and family welfare. Farmers will trade-off immediate food production, even though it may involve some degradation, against a less tangible but sustainable future. Thus efforts to minimize trade-offs must be centred on actions that improve household food supply or food purchasing power, reduce seasonal fluctuations and improve overall access to food. Moreover, meeting food needs is not enough. The strategy must be profitable to farmers and other private investors on time scales which meet their differing circumstances or risk perceptions. At a minimum they must have the time or earnings to invest in sustainability.

13.16 Any strategy must have a legal basis and well-defined rules for resource utilization. Strategies must clearly define responsibilities and allocate rights of access to or use of environmental resources (see next section). They must be socio-politically acceptable and equitable as well as within the implementation capacity of both governments and individuals. Governments must be both willing and able to exert their sovereign responsibilities for action. First, the political will must exist to accept possible negative public reactions to trade-offs that are perceived to restrict private behaviour. Then governments must ensure that sound public or private institutional mechanisms exist to provide all farmers and communities with the support services needed to act on the options for minimizing trade-offs. They must also respond to any major social stresses arising from the need for people to move out of agriculture into other sectors.

4. MINIMIZING SPECIFIC TRADE-OFFS

13.17 As stated in the introduction, some trade-offs between the environment and agricultural development are unavoidable in the short to medium term at least.

13.18 First, some developing countries may have to clear more of their natural forests and drain part of their wetlands in order to feed their people, promote economic growth and improve net social wellbeing. Secondly, appropriate environmentally sound technologies do not exist for many problems or situations, so less sustainable ones will have to be used in the short to medium term whilst research develops suitable replacements. Thirdly, they have insufficient suitably trained manpower. Finally, many developing countries lack the local and central institutional mechanisms required to collect and analyse data relating to resource management, to assess the various options open to them, to improve the functioning of markets, and to obtain farmer and rural community support. Some of these obstacles will take at least a decade to overcome and in some instances, much longer.

13.19 Minimizing the trade-offs requires a holistic approach with three main dimensions - technical, institutional and international - which have their own policy requirements but must also be formulated and implemented together in order to give overall policy consistency.

4.1 The Technical Dimension

13.20 Population and economic growth has raised food and agriculture demand above levels that can be produced by extensive, environmentally sound, farming practices (see Chapter 12). Consequently farming practices have to be intensified and output raised by technical inputs that may have unavoidable environmental penalties in the short term. Yet these penalties can be ameliorated and must be placed in their proper perspective. The nitrate problem in ground and surface water, and the issue of mineral versus organic sources of nitrogen, provide illustrations. There are those who argue for a complete ban on the use of mineral fertilizer. This is totally unrealistic. It would not solve the groundwater nitrate problem, and would inevitably lead to serious food shortages, declining incomes and malnutrition, as well as creating greater soil degradation through nutrient mining for the following reasons:

13.21 Firstly, both mineral and organic sources of nitrogen contribute to the problem. Examples are when mineral fertilizers are broadcast on the soil surface, or organic manures are applied to fallow land when there are no crops to take up the nutrients released by breakdown of the manure, and they are leached down into the groundwater. Again sometimes livestock units or fish farms dispose of their organic wastes directly into streams and rivers, or store them badly so that they are dissolved by rain and carried off into the surface water system.

13.22 Secondly, in large areas of Africa, for example, there is insufficient organic nitrogen available from livestock manures or legume-based production systems. Hence organic sources of nitrogen alone cannot achieve the high yields required to compensate for the very small size of farms, or to meet basic food needs at the national level. Hence developments to give small farmers higher incomes inevitably result in the use of some mineral and organic fertilizers and the release of their residues into the environment. Nonetheless much can be done to minimize the problem. Some of the technical measures for limiting the problems through the adoption of IPNS and other measures to raise fertilizer use efficiency were shown in Chapter 12. But as with other technical measures for soil conservation, pest control, irrigation and water management, mere existence is not enough, nor are unconstrained market forces. There are also a range of institutional requirements to shape and support development and uptake of these measures.

4.2 The Institutional Dimension

13.23 It is difficult to establish the nature and magnitude of some of the causal relationships between institutional change and environment impacts, and hence the precise role of such changes in minimizing the trade-offs. It is clear, however, that changes are required at a number of levels to achieve greater consistency between the technical and the institutional dimensions. Actions are required at the national and local planning levels to

restrict or direct resource use; at the research and extension level to develop and transfer to farmers, forest users and fishermen the knowledge of sustainable technologies and agricultural practices: at the technological input level to ensure that the delivery systems operate efficiently and in the interests of the users; at the input and commodity price policy level to avoid or ameliorate market distortions so that farmers have the economic incentive to shift onto a more sustainable technological pathway. Finally, actions to create a regulatory environment that ensures that public goods such as air and water are protected, and consumers are not placed at risk through the overuse of pesticides, fertilizers, livestock growth promoters, etc.

13.24 Concerning the scope for resource development planning, it is noted that national water and land use plans tend to be rigid in their perception and unrealistic in their objectives and mechanisms for implementation. It is not possible to legislate for sustainable land use. The basic motivation must come from the awareness, self-interest in terms of household food security or welfare objectives, and functional capacity of the user.

13.25 This is not to say that national resource use planning is not vitally important, but to present the case for a more balanced institutional mechanism which brings together the top-down and the bottom-up approaches. National planning for resource use and management is important in a number of key areas:

(a) Determining the land and water resources most suited for development or more intensive use as the first step in the planning process leading to land or water use changes, and the formulation of price and other incentives for resource users that are as consistent as possible with the sustainable management of those resources.

(b) Helping to resolve problems of competition between different sectors or sub-sectors for diminishing land and water resources, and catalyzing or imposing their conjunctive use, e.g. through agroforestry or the use of urban waste waters for irrigation.

(c) Identifying and protecting fragile ecosystems, critically important habitats, sources of biodiversity and watersheds, through the creation of national parks, collection of germplasm and so on;

(d) Ensuring spatially balanced rather than uni-polar urban development so that it is not centred on one or two mega-cities, and as far as possible secondary towns and cities are allowed to expand or are developed in areas with marginal soils yet adjacent to regions with good soils that can sustain them without overstretching the lines of communication between producers and consumers.

(e) Establishing road, rail and water links that do not expose protected areas to informal development; improve access between the areas which can develop sustainable production systems and their urban or overseas markets so that resource users have both the incentive and the financial means to adopt better conservation measures, etc., and minimize the transaction costs

for supporting farmers with production inputs and the urban areas with food and agro-industrial raw materials.

(f) Determining the allocation of public support between agriculturally marginal areas and those with high production potential. This requires a careful and analytically rigorous assessment of land suitability, in that current marginality is not necessarily a true reflection of land potential given appropriate soil conservation measures and other technological changes as has been demonstrated clearly by the people of Machakos District of Kenya (see Box 12.1). Thus it is important to have a clear understanding of how research may change land use suitability, and widen the resource use options. It also needs an appreciation of what is happening in the rest of the economy, in that although the long-term objective may be to encourage people to move out of the marginal lands into areas which can provide more sustainable livelihoods, this may not be possible in the short to medium term. Hence, public resources may need to be allocated to the marginal areas, more or less as a holding operation whilst the possibilities for alternative livelihoods are put in place.

(g) Monitoring land and water use to anticipate problems of resource competition and degradation, and to identify and implement corrective actions, e.g. through conjunctive use of water as noted above.

(h) Where feasible, charging for resources such as water, often regarded as an open access resource, at least to maintain infrastructure and protect water catchments.

13.26 **Research, extension and technology.** Chapter 4 drew attention to the large gap between current best farmer yields and national average yields. However, it also stressed that there are gaps between the available technologies and those needed for achieving the production levels projected for 2010 in an environmentally sound way, and for setting the foundation for long-term sustainable growth. The institutional problems are manifold. They start with the lack of political awareness of the role agriculture plays in economic development (see Chapter 7). There is also a lack of appreciation of (a) the large returns that can come from sound agricultural research which may far exceed those stemming from alternative development investments, and (b) the contribution such research makes to resource conservation by reducing the pressure to bring undeveloped land into cultivation. In India, for example, the introduction of high-yielding wheat varieties may have saved about 30 million hectares of marginal lands and forests from being brought into wheat cultivation.

13.27 Then there is the skill gap for technology development, and the scaling up of research for commercialization, which needs to be addressed by appropriate manpower and institutional support (see Chapter 10). Providing this support leads to the problems of the research and extension institutions and mechanisms themselves, because in the main they have not focused their efforts on the issue of sustainability. They have seldom focused on the land areas with pressing environmental problems or on sustainable technologies appropriate to poor farmers in these areas or in high potential regions. There needs to be better mechanisms for research priority setting at the national level because the International Agricultural Research Centres (IARCs) cannot be expected to do the adaptive research or the

more fundamental research for geographically confined problems. Large- and small-scale farmers need to be more closely involved in the identification of research problems and to be drawn more frequently into partnerships with scientists for the solution of these problems, building on the best of indigenous and laboratory knowledge.

13.28 Economic policies affecting agriculture, as well as policies relating to public sector involvement in input and commodity marketing, have been dealt with in some depth in Chapters 7 and 9. Hence it is sufficient just to underline the importance for reversal of policies which discriminate against agriculture and lead to unsustainable practices by making unprofitable the use of inputs and the diffusion of sustainable technologies. In particular, policies, including those relating to the functioning of marketing parastatals, must be corrected to remove (a) upward distortions in the price of production inputs through import restrictions and tariffs; and (b) uncertainties regarding the timely supply of seeds and mineral fertilizers, in cases of parastatals with monopoly powers for their sale and distribution, in that late delivery exposes the farmer to poor returns from what to them are high cost and risky expenditures. One should not forget that subsidies provided to pesticides and mineral fertilizers can also lead to their excessive use, causing the degradation problems discussed in Chapter 11. These and other problems of public sector origin have been a common disincentive for the adoption of soil conservation techniques, the balanced use of mineral fertilizers and other requirements for meeting food security and wider development needs in a sustainable way.

13.29 **The regulatory environment.** Developed country experience has shown that the foregoing actions are not sufficient in themselves to direct growth towards a pathway that brings social and environmental objectives together. Land use planning, for example, may identify which areas to protect and which are the most favourable for development, but the introduction of new technologies and unconstrained market forces are likely to over-ride such planning considerations and therefore need to be backed by legally enforceable restrictions. Similarly, diminishing marginal returns to mineral fertilizer use may not limit their application rates soon enough to prevent serious groundwater pollution. It follows, therefore, that public institutions must be established to set appropriate regulatory standards, to monitor compliance with them, and to take suitable legal or financial steps when practices are not meeting the objective of minimizing environment and development trade-offs.

13.30 The required regulatory measures are quite diverse, and include: (a) statutory restrictions on the use of protected areas or on the development of high-quality arable land for urban/industrial use; (b) restrictions on the use of mineral fertilizers on sensitive watersheds; (c) constraints on the quantity and timing of organic fertilizer applications to land; (d) design requirements for manure storage on livestock farms; (e) effluent quality standards for discharges to water courses from livestock units, fish farms, and agro-processing activities; (f) sanitation standards for slaughterhouses and cold storage units; (g) restrictions on the type of pesticides that can be imported and used, and the timing of their application in conformity with the International Code of Conduct on the Distribution and Use of Pesticides and Codex Alimentarius, respectively; (h) controls on the labelling of pesticide containers and their disposal; and (i) biosafety standards for the release of genetically modified organisms into the environment.

13.31 **Property rights.** Unsustainable agricultural practices commonly take place where those involved have limited or no property or user rights to the resources they are

overexploiting. The awarding of secure rights, whether individual or communal, would greatly increase their vested interest in improving resource management and investing in soil conservation and other land improvements. Property rights have a wider institutional dimension relating to the efficiency of markets and the management of public goods. Environmental trade-offs are also not minimized in situations when the institutions controlling public goods have collapsed, or because markets are not able to value public goods such as fresh air, or to cost public "bads" such as pollution. Markets must be made to work better by defining property rights more precisely and establishing or strengthening the institutions to manage them; introducing realistic prices for environmental public goods such as water; and attempting to cost public "bads" and adopting "the polluter pays principle" where this is appropriate.

4.3 The International Dimension

13.32 This dimension is particularly important given that much of the mismanagement of natural resources in developing countries relates to poverty and to the lack of economic growth to provide better and sustainable livelihoods outside subsistence agriculture. Minimizing the trade-offs needs a global economic environment that is more conducive to growth so that the developing countries can significantly increase gainful employment outside agriculture. This is critically important for those arid, highland and land locked countries with predominantly marginal land which tend to suffer from high transport costs for off-farm inputs like mineral fertilizers and/or poor inherent biological productivity. Therefore, any policies which affect the development prospects of the developing countries via the link of the international economic environment are of direct importance to the objective of minimizing the environment-development trade-offs. Here belong the issues of trade, debt and resource flows. Some of these issues are discussed in other chapters and the discussion is not repeated here.

13.33 Of particular interest is the extent to which environmental pressures are transmitted among countries by means of the agricultural trade flows. The terms "environmental subsidies" or "ecological footprints" are sometimes used to denote the transmission of such pressures.[248] For example, there might be environmental subsidies from the USA to those countries which import large quantities of maize from the USA, whose production contributes to soil erosion, involves heavy applications of mineral fertilizers and pesticides which are a source of ground and surface pollution and a negative pressure on natural ecosystems. Similarly, the Netherlands exports dairy products which indirectly are a major cause of pollution in the Netherlands. On the other hand, the Netherlands, together with other European countries, imports large quantities of cassava chips from Southeast Asia, which are commonly grown in high rainfall areas on steep slopes with fragile soils, and result in very large soil losses through erosion. Thus, these are issues for developed and developing

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248 Environmental subsidies are the costs of land degradation, loss of biodiversity and so on arising from agricultural production, that an exporting country gives to an importing country when goods are priced by the present international market system. Ecological footprints are the total inputs of natural resources and environmental services from the land, sea and air that are required to sustain a given population at its current consumption rate. A country which is totally self-sufficient in food, fuel, minerals and other natural resources, and did not trade in them, would have a footprint that falls entirely within its own national boundaries if it could also confine its pollution to those boundaries.

countries alike, but with the former better able to adopt the "polluter pays principle" or to introduce environmental regulations to make market prices reflect the environmental costs (for more discussions see Chapter 8).

5. THE ENDPOINT AND THE BEGINNING

13.34 The possible environmental dimensions of the agricultural projections have been edged with uncertainty but they are objective as far as the data and understanding of them allow. They will be wrong to some degree or other. The feed-back loops between the economy, agricultural development and the environment are too complex and too dynamic to mimic with any certainty. And consequently, the strengths of the trade-offs and their associated risks are equally uncertain, hence the present stress on minimizing them, and adopting the precautionary principle. Nonetheless, two aspects seem clear.

13.35 First, it is important not to take an excessively static view of what is possible. The people of the Machakos district of Kenya have shown that it is possible to turn back from the edge of environmental disaster, rehabilitate seriously degraded land and introduce more sustainable production systems (Box 12.3) as have others in China, Indonesia and many agro-ecologically different parts of the world.

13.36 Second, the required actions go well beyond the so-called technological fix, although new technologies based on the latest scientific understanding will be vitally important, as will the revival or upgrading of indigenous technologies. They include international action to create a more open and equitable trading system with wider and stronger environmental safeguards, and to channel development assistance towards sustainable agriculture in a more consistent way. But the key actions are at the national and local levels. They include those which promote development, create a regulatory and incentive environment that encourage the uptake of sustainable technologies, promote decentralized, participatory, bottom-up approaches to natural resource planning and management, and contribute to slowing down the population growth rate.

13.37 Perhaps most important of all, what is required is a more anthropocentric approach to development, and greater humility amongst those who argue for an ecocentric approach that does not match the expectations and resources of the farmers in the poor countries.

APPENDIX

Countries and Commodities Classification

Statistical Tables

COUNTRIES AND COMMODITIES CLASSIFICATION

List of the Developing Countries of the Study

Africa, sub-Saharan

*	Angola
*	Benin
*	Botswana
*	Burkina Faso
*	Burundi
*	Cameroon
*	Central Afr. Rep.
*	Chad
*	Congo
*	Côte d'Ivoire
*	Ethiopia
*	Gabon
*	Gambia
*	Ghana
*	Guinea
*	Kenya
	Lesotho
*	Liberia
*	Madagascar
*	Malawi
F	Mali
F	Mauritania
	Mauritius
*	Mozambique
F	Namibia
*	Niger
*	Nigeria
*	Rwanda
*	Senegal
*	Sierra Leone
F	Somalia
*	Sudan
	Swaziland
*	Tanzania
*	Togo
*	Uganda
*	Zaire
*	Zambia
*	Zimbabwe

Latin America and Caribbean

	Argentina
*	Bolivia
*	Brazil
	Chile
*	Colombia
*	Costa Rica
*	Cuba
*	Dominican Rep.
*	Ecuador
*	El Salvador
*	Guatemala
F	Guyana
F	Haiti
*	Honduras
*	Jamaica
*	Mexico
*	Nicaragua
*	Panama
F	Paraguay
*	Peru
*	Suriname
*	Trinidad and Tobago
	Uruguay
*	Venezuela

Near East/North Africa

	Afghanistan
	Algeria
	Egypt
	Iran
	Iraq
	Jordan
	Lebanon
	Libya
	Morocco
	Saudi Arabia
	Syria
	Tunisia
	Turkey
	Yemen

South Asia

*	Bangladesh
*	India
*	Myanmar
*	Nepal
*	Pakistan
*	Sri Lanka

East Asia

*	Cambodia
	China
*	Indonesia
	Korea, DPR
	Korea, Rep.
*	Laos
*	Malaysia
*	Philippines
*	Thailand
*	Viet Nam

Note Data on land with rainfed crop production potential as well as data on cropping patterns of land-in-use by agro-ecological class are available for all countries except China and Namibia. In addition, for tropical countries marked with an asterisk, data on both forest areas and protected areas are available. For countries marked with F data are available on forest areas but not on protected areas (see Chapter 4). The Forest Resources Assessment 1990 for the Tropical World (FOR90) generated data on forest areas for some more tropical countries, not included in the 93 developing countries of this Study.

List of the Developed Countries of the Study

EC	*Other Western Europe*	*Eastern Europe and the former USSR*
Belgium	Austria	Albania
Denmark	Finland	Bulgaria
France	Iceland	Czech Republic
Germany	Malta	Hungary
Greece	Norway	Poland
Ireland	Sweden	Romania
Italy	Switzerland	Slovak Republic
Luxembourg	Yugoslav SFR	Former USSR
Netherlands		
Portugal		
Spain		
United Kingdom		
North America	*Oceania*	*Other Developed Countries*
Canada	Australia	Israel
United States	New Zealand	Japan
		South Africa

List of Commodities of the Study

Crops	*Livestock*
Wheat	Beef, veal and buffalo meat
Rice, paddy	Mutton, lamb and goat meat
Maize	Pig meat
Barley	Poultry meat
Millet	Milk and dairy products (whole milk equivalent)
Sorghum	Eggs
Other cereals	
Potatoes	
Sweet potatoes and yams	
Cassava	
Other roots	
Plantains	
Sugar, raw [1]	
Pulses	
Vegetables	
Bananas	
Citrus fruit	
Other fruit	
Vegetable oil and oilseeds (vegetable oil equivalent) [2]	
Cocoa beans	
Coffee	
Tea	
Tobacco	
Cotton lint	
Jute and hard fibres	
Rubber	

1 Sugar production in the developing countries (excl. China) analysed separately for sugar cane and sugar beet.
2 Vegetable oil production in the developing countries (excl. China) analysed separately for soybeans, groundnuts, sesame seed, coconuts, sunflower seed, palm oil/palm-kernel oil, all other oilseeds.

Note on Commodities

All commodity data and projections in this report are expressed in terms of primary product equivalent unless stated otherwise. Historical commodity balances (Supply Utilization Accounts - SUAs) are available for about 160 primary and 170 processed crop and livestock commodities. To reduce this amount of information to manageable proportions, all the SUA data were converted to the commodity specification given above in the list of commodities, applying appropriate conversion factors (and ignoring joint products to avoid double counting: e.g. wheat flour is converted back into wheat while wheat bran is ignored). In this way, one Supply Utilization Account in homogeneous units is derived for each of the commodities of the study. Meat production refers to indigenous meat production, i.e. production from slaughtered animals plus the meat equivalent of live animal exports minus the meat equivalent of all live animal imports. Cereals demand and trade data include the grain equivalent of beer consumption and trade.

The commodities for which SUAs were constructed are the 26 crops and six the livestock products given in the list above. The production analysis for the developing countries (excl. China, see paragraph 3.27, Chapter 3) was, however, carried out for 33 crops because sugar and vegetable oils are analysed separately (for production analysis only) for the nine crops shown in the footnote to the list.

STATISTICAL TABLES*

* Notes to the tables are given at the end of the Appendix.

Table A.1 Total Population and Population Economically Active in Agriculture

	Total Population						Population Economically Active in Agriculture								
	Million			Growth rates (% p.a.)			Thousand			% of Total Population Economically Active			Growth rates (% p.a.)		
	1990	2000	2010	80-90	90-2000	2000-10	1990	2000	2010	1990	2000	2010	80-90	90-2000	2000-10
World	**5 296.8**	**6 265.0**	**7 208.6**	**1.8**	**1.7**	**1.4**	**1 101 503**	**1 165 520**	**1 214 966**	**46.6**	**42.1**	**37.8**	**1.0**	**0.6**	**0.4**
All Developing Countries	**4 045.9**	**4 946.9**	**5 835.2**	**2.1**	**2.0**	**1.7**	**1 051 424**	**1 130 744**	**1 191 157**	**59.6**	**53.0**	**46.7**	**1.3**	**0.7**	**0.5**
93 Developing Countries	**3 987.5**	**4 879.1**	**5 757.9**	**2.1**	**2.0**	**1.7**	**1 039 049**	**1 118 171**	**1 178 767**	**59.8**	**53.3**	**46.9**	**1.3**	**0.7**	**0.5**
Sub-Saharan Africa	**487.7**	**673.2**	**914.6**	**3.2**	**3.3**	**3.1**	**140 019**	**168 818**	**205 810**	**71.2**	**65.6**	**59.7**	**1.7**	**1.9**	**2.0**
Angola	10.0	13.3	17.6	2.6	2.9	2.8	2 851	3 323	4 004	69.8	65.6	61.4	1.3	1.5	1.9
Benin	4.6	6.4	8.7	3.0	3.2	3.2	1 338	1 439	1 546	61.4	51.7	42.0	0.7	0.7	0.7
Botswana	1.3	1.8	2.5	3.8	3.4	3.0	271	329	398	62.9	54.6	45.9	1.7	2.0	1.9
Burkina Faso	9.0	12.1	16.3	2.6	3.0	3.1	4 004	4 872	6 055	84.4	81.8	78.9	1.8	2.0	2.2
Burundi	5.5	7.4	9.7	2.9	3.0	2.8	2 594	3 258	4 141	91.3	89.4	87.2	2.1	2.3	2.4
Cameroon	11.8	16.7	23.7	3.2	3.5	3.5	2 656	2 912	3 263	61.0	51.6	42.4	0.8	0.9	1.1
Central African Rep.	3.0	4.1	5.5	2.7	3.0	3.0	884	901	921	62.7	51.7	41.1	0.1	0.2	0.2
Chad	5.7	7.3	9.5	2.4	2.6	2.6	1 472	1 546	1 560	74.6	63.4	50.6	0.8	0.5	0.1
Congo	2.3	3.2	4.4	3.1	3.4	3.4	506	635	827	59.6	56.6	53.3	1.7	2.3	2.7
Côte d'Ivoire	12.0	17.6	25.5	3.9	3.9	3.8	2 545	2 820	3 174	55.6	45.9	37.2	1.2	1.0	1.2
Ethiopia	49.2	66.4	88.9	2.4	3.0	3.0	15 461	17 825	20 773	74.5	68.5	61.8	0.9	1.4	1.5
Gabon	1.2	1.6	2.1	3.8	3.2	2.4	351	359	353	67.8	58.7	49.2	1.9	0.2	-0.2
Gambia	0.9	1.1	1.4	3.0	2.7	2.5	316	371	436	81.0	77.6	73.8	1.8	1.6	1.6
Ghana	15.0	20.6	26.9	3.5	3.2	2.7	2 751	3 205	3 808	50.0	44.0	38.2	1.7	1.5	1.7
Guinea	5.8	7.8	10.7	2.6	3.1	3.1	1 835	2 072	2 324	74.1	66.2	57.1	1.0	1.2	1.2
Kenya	24.0	35.1	50.9	3.7	3.8	3.8	7 645	10 062	13 041	77.0	72.4	67.3	2.7	2.8	2.6
Lesotho	1.8	2.4	3.1	2.9	2.9	2.8	653	735	806	79.6	71.0	60.5	1.3	1.2	0.9
Liberia	2.3	3.6	4.9	2.6	4.6	3.2	666	800	977	69.8	65.1	59.8	1.8	1.8	2.0
Madagascar	12.0	16.6	22.8	3.2	3.3	3.2	3 953	4 755	5 763	76.6	71.3	65.3	1.8	1.9	1.9
Malawi	8.8	12.5	17.1	3.5	3.6	3.2	2 690	3 099	3 488	75.4	65.2	53.7	1.6	1.4	1.2
Mali	9.2	12.7	17.3	3.0	3.2	3.2	2 371	2 903	3 666	80.8	74.9	67.6	2.1	2.0	2.4
Mauritania	2.0	2.7	3.6	2.7	2.9	2.9	417	509	641	64.4	59.3	54.4	1.8	2.0	2.3
Mauritius	1.1	1.2	1.3	1.1	1.0	0.9	96	93	82	22.8	18.1	14.3	0.7	-0.3	-1.3
Mozambique	15.7	20.5	26.5	2.6	2.7	2.6	6 666	7 824	9 354	81.6	78.5	75.1	1.4	1.6	1.8

Table A.1 Total Population and Population Economically Active in Agriculture (cont.)

	Total Population						Population Economically Active in Agriculture								
	Million			Growth rates (% p.a.)			Thousand			% of Total Population Economically Active			Growth rates (% p.a.)		
	1990	2000	2010	80-90	90-2000	2000-10	1990	2000	2010	1990	2000	2010	80-90	90-2000	2000-10
Namibia	1.8	2.4	3.3	3.2	3.2	3.1	184	201	229	35.0	28.2	22.8	0.3	0.9	1.3
Niger	7.7	10.8	14.9	3.3	3.4	3.3	3 421	4 217	5 169	87.3	82.2	75.6	2.3	2.1	2.1
Nigeria	108.5	149.6	201.3	3.3	3.3	3.0	26 577	33 004	41 608	64.8	61.2	57.6	2.0	2.2	2.3
Rwanda	7.2	10.2	13.8	3.4	3.5	3.1	3 216	4 265	5 653	91.3	89.5	87.3	2.8	2.9	2.9
Senegal	7.3	9.7	12.7	2.8	2.9	2.7	2 466	3 008	3 688	78.4	76.1	73.7	1.9	2.0	2.1
Sierra Leone	4.2	5.4	7.2	2.4	2.7	2.8	891	962	1 064	62.3	54.6	47.0	0.5	0.8	1.0
Somalia	7.5	9.7	13.1	3.4	2.6	3.0	2 108	2 366	2 773	70.9	64.4	57.5	1.4	1.2	1.6
Sudan	25.2	33.6	44.0	3.0	2.9	2.7	4 923	5 388	5 722	60.2	48.5	37.3	1.3	0.9	0.6
Swaziland	0.8	1.1	1.6	3.4	3.6	3.3	207	240	279	66.1	57.8	48.9	1.4	1.5	1.5
Tanzania	27.3	39.6	56.3	3.8	3.8	3.6	10 315	12 905	16 103	80.8	74.9	67.9	2.4	2.3	2.2
Togo	3.5	4.9	6.7	3.1	3.2	3.2	995	1 211	1 493	69.6	65.9	61.7	1.8	2.0	2.1
Uganda	18.8	27.0	37.0	3.7	3.7	3.2	6 569	8 282	10 333	80.9	74.6	67.1	2.2	2.3	2.2
Zaire	35.6	49.2	67.5	3.1	3.3	3.2	8 683	10 396	12 854	65.8	60.1	55.0	1.6	1.8	2.1
Zambia	8.5	12.3	17.3	4.0	3.8	3.5	1 872	2 557	3 611	68.9	64.5	60.1	3.3	3.2	3.5
Zimbabwe	9.7	13.1	17.0	3.1	3.1	2.6	2 600	3 169	3 830	68.2	63.1	58.0	2.2	2.0	1.9
Near East/North Africa	**305.5**	**396.6**	**492.9**	**2.8**	**2.6**	**2.2**	**34 593**	**37 562**	**39 449**	**37.2**	**29.9**	**23.5**	**0.7**	**0.8**	**0.5**
Afghanistan	16.6	26.5	32.4	0.1	4.8	2.0	2 687	3 730	4 043	54.8	48.2	41.6	-0.9	3.3	0.8
Algeria	25.0	32.9	41.5	2.9	2.8	2.4	1 391	1 573	1 654	24.4	18.7	14.1	0.9	1.2	0.5
Egypt	52.4	64.2	75.7	2.5	2.0	1.7	5 880	6 752	7 616	40.5	35.5	30.7	1.4	1.4	1.2
Iran	54.6	68.8	87.8	3.5	2.3	2.5	4 267	4 412	4 525	27.6	20.8	15.3	0.6	0.3	0.3
Iraq	18.9	26.3	35.3	3.6	3.4	3.0	1 049	1 074	970	20.5	14.1	8.9	-0.3	0.2	-1.0
Jordan	3.3	4.6	6.0	3.9	3.3	2.7	47	39	30	5.8	3.2	1.8	-0.4	-1.9	-2.4
Lebanon	2.7	3.3	3.9	0.0	2.1	1.6	72	53	39	8.7	5.0	2.9	-3.8	-3.0	-3.2
Libya	4.5	6.5	9.0	4.1	3.6	3.3	155	170	187	13.7	10.7	8.3	1.0	0.9	1.0
Morocco	25.1	31.6	37.6	2.6	2.3	1.8	2 824	2 960	2 954	36.6	28.1	20.9	0.9	0.5	0.0
Saudi Arabia	14.1	20.7	29.6	4.2	3.9	3.6	1 596	1 720	1 756	39.0	30.2	22.4	1.8	0.7	0.2
Syria	12.5	17.8	24.3	3.6	3.6	3.2	746	844	956	24.1	18.2	13.5	0.5	1.2	1.3
Tunisia	8.2	9.9	11.5	2.5	2.0	1.5	655	573	470	24.3	16.2	10.5	-0.4	-1.3	-2.0
Turkey	55.9	66.8	75.3	2.4	1.8	1.2	11 670	11 593	11 515	48.2	39.4	32.1	0.6	-0.1	-0.1
Yemen	11.7	16.6	23.1	3.6	3.6	3.3	1 554	2 069	2 734	55.6	49.5	43.3	3.0	2.9	2.8

Table A.1 Total Population and Population Economically Active in Agriculture (cont.)

	Total Population						Population Economically Active in Agriculture								
	Million			Growth rates (% p.a.)			Thousand			% of Total Population Economically Active			Growth rates (% p.a.)		
	1990	2000	2010	80-90	90-2000	2000-10	1990	2000	2010	1990	2000	2010	80-90	90-2000	2000-10
East Asia	**1 582.8**	**1 828.3**	**2 000.6**	**1.5**	**1.5**	**0.9**	**548 874**	**552 228**	**527 659**	**63.3**	**55.4**	**47.2**	**1.2**	**0.1**	**-0.5**
Cambodia	8.2	10.0	11.5	2.7	2.0	1.4	2 630	2 754	3 087	70.0	65.5	60.6	0.7	0.5	1.1
China (Mainland)	1 118.8	1 276.1	1 370.6	1.3	1.3	0.7	450 285	448 407	423 941	67.5	59.8	51.7	1.2	0.0	-0.6
Indonesia	184.3	218.7	246.7	2.0	1.7	1.2	35 077	35 970	34 221	48.5	39.8	31.7	0.9	0.3	-0.5
Korea DPR	21.8	26.1	29.3	1.8	1.8	1.2	3 777	3 501	3 022	33.5	25.4	18.6	1.1	-0.8	-1.5
Korea Republic	42.8	46.4	49.5	1.2	0.8	0.6	4 633	3 541	2 438	24.6	16.0	10.1	-1.4	-2.7	-3.7
Laos	4.1	5.5	6.8	2.6	2.8	2.3	1 380	1 605	1 930	71.5	67.0	62.1	1.1	1.5	1.9
Malaysia	17.9	22.0	25.2	2.7	2.1	1.4	2 255	2 181	2 045	32.1	23.8	17.1	0.2	-0.3	-0.6
Philippines	62.4	77.5	92.1	2.6	2.2	1.7	10 503	12 030	13 418	46.8	41.8	36.9	1.5	1.4	1.1
Thailand	55.7	63.7	71.6	1.8	1.3	1.2	18 990	19 852	19 003	64.3	57.1	49.7	1.3	0.4	-0.4
Viet Nam	66.7	82.4	97.4	2.2	2.1	1.7	19 344	22 387	24 554	60.6	53.2	45.7	1.6	1.5	0.9
South Asia	**1 169.3**	**1 449.2**	**1 728.2**	**2.4**	**2.2**	**1.8**	**274 502**	**318 100**	**365 489**	**64.7**	**60.7**	**56.5**	**1.6**	**1.5**	**1.4**
Bangladesh	115.6	150.6	188.2	2.7	2.7	2.3	23 193	28 323	33 001	68.5	61.5	54.0	2.1	2.0	1.5
India	853.1	1 041.5	1 223.5	2.2	2.0	1.6	214 664	246 358	280 509	66.5	63.2	59.8	1.5	1.4	1.3
Myanmar	41.7	51.1	60.6	2.1	2.1	1.7	8 500	9 044	9 507	46.9	41.2	35.8	0.6	0.6	0.5
Nepal	19.1	24.1	28.9	2.6	2.3	1.8	7 276	9 089	11 116	91.7	90.2	88.5	2.0	2.3	2.0
Pakistan	122.6	162.4	205.5	3.8	2.8	2.4	17 580	21 540	27 178	49.7	44.6	39.4	2.4	2.1	2.4
Sri Lanka	17.2	19.4	21.5	1.5	1.2	1.0	3 289	3 746	4 178	51.7	50.0	48.4	1.2	1.3	1.1
Latin America and Caribb.	**442.1**	**531.9**	**621.6**	**2.2**	**1.9**	**1.6**	**41 061**	**41 463**	**40 360**	**26.3**	**21.2**	**16.9**	**0.5**	**0.1**	**-0.3**
Argentina	32.3	36.2	40.2	1.4	1.2	1.0	1 197	1 101	987	10.4	8.2	6.5	-1.2	-0.8	-1.1
Bolivia	7.3	9.7	12.8	2.8	2.9	2.8	949	1 061	1 221	41.6	35.9	30.8	1.6	1.1	1.4
Brazil	150.4	179.5	207.5	2.2	1.8	1.5	13 366	12 458	11 108	24.3	18.4	13.6	-0.3	-0.7	-1.1
Chile	13.2	15.3	17.2	1.7	1.5	1.2	585	524	457	12.5	9.5	7.2	-0.3	-1.1	-1.4
Colombia	33.0	39.4	45.6	2.1	1.8	1.5	2 885	2 832	2597	27.3	21.2	16.0	0.6	-0.2	-0.9
Costa Rica	3.0	3.7	4.4	2.8	2.1	1.6	251	240	217	23.9	17.8	13.0	0.5	-0.4	-1.0
Cuba	10.6	11.5	12.2	0.9	0.8	0.6	860	777	653	19.2	15.5	12.4	0.4	-1.0	-1.7
Dominican Republic	7.2	8.6	9.9	2.3	1.9	1.4	819	795	718	35.8	26.8	19.3	0.7	-0.3	-1.0
Ecuador	10.6	13.3	16.1	2.7	2.3	1.9	996	993	928	30.3	22.9	16.8	0.6	0.0	-0.7

Table A.1 Total Population and Population Economically Active in Agriculture (cont.)

	Total Population						Population Economically Active in Agriculture								
	Million			Growth rates (% p.a.)			Thousand			% of Total Population Economically Active			Growth rates (% p.a.)		
	1990	2000	2010	80-90	90-2000	2000-10	1990	2000	2010	1990	2000	2010	80-90	90-2000	2000-10
El Salvador	5.3	6.7	8.5	1.5	2.5	2.3	603	673	737	36.5	30.9	26.1	-0.3	1.1	0.9
Guatemala	9.2	12.2	15.8	2.9	2.9	2.6	1 346	1 663	2 038	51.2	45.4	39.6	1.9	2.1	2.1
Guyana	0.8	0.9	1.0	0.5	1.1	1.2	66	66	66	22.3	18.5	15.4	0.0	0.0	0.0
Haiti	6.5	8.0	9.8	2.0	2.1	2.1	1 823	1 936	2 075	63.8	57.6	51.7	0.5	0.6	0.7
Honduras	5.1	6.8	8.7	3.4	2.9	2.4	879	1 136	1 412	55.0	49.3	43.4	3.0	2.6	2.2
Jamaica	2.5	2.7	3.0	1.4	1.1	1.0	324	338	333	27.1	23.0	19.4	0.9	0.4	-0.2
Mexico	88.6	107.2	125.2	2.3	1.9	1.6	9 340	9 705	9 399	30.0	24.0	18.9	1.1	0.4	-0.3
Nicaragua	3.9	5.3	6.8	3.4	3.1	2.6	463	545	611	38.5	30.7	25.0	1.9	1.7	1.2
Panama	2.4	2.9	3.3	2.1	1.8	1.4	218	211	191	25.0	19.0	14.2	0.4	-0.3	-1.0
Paraguay	4.3	5.5	6.9	3.1	2.6	2.3	674	831	1 000	46.3	43.6	41.0	2.7	2.1	1.9
Peru	21.6	26.3	31.0	2.2	2.0	1.7	2 443	2 694	2 842	34.7	29.6	24.9	1.3	1.0	0.5
Suriname	0.4	0.5	0.6	1.9	1.7	1.3	24	24	24	16.6	13.0	10.4	1.3	0.3	0.0
Trinidad and Tobago	1.3	1.5	1.7	1.7	1.5	1.3	36	33	29	7.4	5.6	4.0	-1.0	-1.1	-1.0
Uruguay	3.1	3.3	3.5	0.6	0.6	0.5	162	154	145	13.5	11.7	10.2	-0.9	-0.5	-0.6
Venezuela	19.7	24.7	30.0	2.8	2.3	2.0	752	673	572	11.0	7.4	4.9	-0.5	-1.1	-1.6
Developed Countries	**1 248.9**	**1 314.7**	**1 369.7**	**0.7**	**0.5**	**0.4**	**50 070**	**34 769**	**23 806**	**8.3**	**5.5**	**3.6**	**-3.3**	**-3.6**	**-3.7**
Western Europe	**400.4**	**407.9**	**409.7**	**0.3**	**0.2**	**0.0**	**12 511**	**8 379**	**5 402**	**6.8**	**4.5**	**2.9**	**-3.4**	**-3.9**	**-4.3**
EC-12	**344.0**	**349.8**	**350.8**	**0.3**	**0.2**	**0.0**	**9 322**	**6 213**	**4 026**	**6.0**	**3.9**	**2.6**	**-3.4**	**-4.0**	**-4.2**
Belgium-Luxembourg	10.3	10.2	10.1	0.0	0.0	-0.1	78	47	28	1.8	1.1	0.7	-4.2	-4.8	-5.1
Denmark	5.1	5.2	5.1	0.0	0.0	-0.1	134	87	52	4.7	3.0	1.9	-3.8	-4.3	-5.0
France	56.4	58.4	59.7	0.4	0.4	0.2	1 341	848	517	5.2	3.2	1.9	-4.0	-4.5	-4.8
Germany	79.1	78.5	76.6	0.0	-0.1	-0.2	1 855	1 225	822	4.6	3.2	2.2	-3.3	-4.1	-3.9
Greece	10.0	10.2	10.2	0.4	0.1	0.1	945	747	567	24.2	18.7	14.2	-1.8	-2.3	-2.7
Ireland	3.5	3.8	4.2	0.3	0.9	0.9	184	155	123	13.5	9.7	7.0	-2.4	-1.7	-2.3
Italy	57.6	57.8	56.7	0.0	0.0	-0.2	1 663	957	513	7.1	4.1	2.3	-4.4	-5.4	-6.0
Netherlands	15.0	15.8	16.4	0.5	0.6	0.3	228	161	107	3.7	2.5	1.6	-2.7	-3.5	-3.9
Portugal	10.3	10.6	10.8	0.6	0.3	0.2	764	524	332	16.3	10.6	6.6	-3.7	-3.7	-4.5
Spain	39.2	40.7	41.7	0.4	0.4	0.2	1 561	1 016	617	10.7	6.6	4.0	-3.4	-4.2	-4.9
United Kingdom	57.4	58.6	59.2	0.2	0.2	0.1	569	446	348	2.0	1.5	1.2	-2.1	-2.4	-2.4

Table A.1 Total Population and Population Economically Active in Agriculture (cont.)

	Total Population						Population Economically Active in Agriculture								
	Million			Growth rates (% p.a.)			Thousand			% of Total Population Economically Active			Growth rates (% p.a.)		
	1990	2000	2010	80-90	90-2000	2000-10	1990	2000	2010	1990	2000	2010	80-90	90-2000	2000-10
Other Western Europe	**56.4**	**58.1**	**58.9**	**0.5**	**0.3**	**0.1**	**3 189**	**2 166**	**1 376**	**11.7**	**7.6**	**4.8**	**-3.2**	**-3.8**	**-4.4**
Austria	7.6	7.6	7.5	0.0	0.0	-0.1	211	134	82	5.7	3.6	2.2	-3.6	-4.4	-4.9
Finland	5.0	5.1	5.1	0.4	0.2	0.1	205	139	89	8.0	5.3	3.5	-3.3	-3.8	-4.4
Iceland	0.3	0.3	0.3	1.1	0.8	0.6	9	7	5	6.6	4.5	3.0	-2.6	-3.0	-3.4
Malta	0.4	0.4	0.4	-0.4	0.4	0.4	5	4	3	3.8	2.7	2.0	-3.0	-1.8	-2.9
Norway	4.2	4.4	4.4	0.4	0.3	0.2	112	73	45	5.2	3.2	1.9	-3.7	-4.2	-4.7
Sweden	8.6	8.7	8.7	0.3	0.1	0.0	169	120	83	3.8	2.7	1.9	-3.3	-3.4	-3.5
Switzerland	6.7	6.8	6.8	0.5	0.2	0.1	137	88	56	4.0	2.6	1.7	-3.1	-4.3	-4.4
Yugoslav SFR	23.8	24.9	25.6	0.7	0.4	0.3	2 341	1 601	1 013	21.7	13.8	8.5	-3.1	-3.7	-4.5
Eastern Europe	**99.6**	**103.7**	**107.5**	**0.4**	**0.4**	**0.4**	**9 070**	**6 828**	**4 972**	**17.9**	**12.6**	**8.8**	**-2.9**	**-2.8**	**-3.1**
Albania	3.2	3.8	4.3	2.0	1.6	1.3	753	791	775	48.4	41.2	34.5	1.1	0.5	-0.2
Bulgaria	9.0	9.1	9.1	0.1	0.1	0.0	542	362	230	12.2	8.0	5.2	-3.9	-4.0	-4.4
Czechoslovakia	15.7	16.2	16.7	0.2	0.3	0.3	774	587	418	9.3	6.5	4.6	-3.1	-2.7	-3.3
Hungary	10.6	10.5	10.5	-0.2	0.0	-0.1	596	384	227	11.5	7.2	4.4	-4.6	-4.3	-5.1
Poland	37.9	39.8	41.9	0.7	0.5	0.5	4 037	3 108	2 321	20.8	14.8	10.4	-2.7	-2.6	-2.9
Romania	23.3	24.3	25.0	0.4	0.5	0.3	2 368	1 596	1 001	20.2	12.7	7.7	-3.5	-3.9	-4.6
Former USSR	288.6	308.4	327.1	0.9	0.7	0.6	18 779	12 644	8 551	13.0	8.3	5.2	-3.6	-3.9	-3.8
North America	**276.5**	**294.6**	**311.1**	**0.9**	**0.6**	**0.5**	**3 319**	**2 394**	**1 684**	**2.4**	**1.6**	**1.1**	**-2.8**	**-3.2**	**-3.5**
Canada	26.5	28.5	30.1	0.9	0.7	0.6	439	288	180	3.3	2.0	1.2	-3.4	-4.1	-4.6
United States	250.0	266.1	280.9	0.9	0.6	0.5	2 880	2 106	1 504	2.3	1.6	1.1	-2.7	-3.1	-3.3
Others	**183.8**	**200.2**	**214.4**	**1.0**	**0.9**	**0.7**	**6 391**	**4 524**	**3 197**	**7.4**	**4.8**	**3.3**	**-3.0**	**-3.4**	**-3.4**
Australia	17.1	19.1	20.9	1.5	1.1	0.9	408	337	264	5.0	3.6	2.6	-1.3	-1.9	-2.4
Israel	4.6	5.3	6.0	1.7	1.5	1.2	76	69	56	4.3	2.9	2.0	-1.7	-0.9	-2.1
Japan	123.5	128.5	131.0	0.6	0.4	0.2	4 013	2 334	1 245	6.4	3.6	2.0	-4.5	-5.3	-6.1
New Zealand	3.4	3.7	3.9	0.8	0.8	0.6	139	125	109	9.1	7.5	6.1	-0.5	-1.1	-1.4
South Africa	35.3	43.7	52.7	2.2	2.2	1.9	1 755	1 659	1 523	13.6	10.1	7.3	0.8	-0.6	-0.9

Table A.1a Revised Population Data and Projections to 2025 from the 1992 UN Revision*

	Total Population				Growth rates				
	1990	2000	2010	2025	1980-90	90-2000	2000-10	2010-20	2020-25
	.... millions				.... % per year				
World	**5 295**	**6 228**	**7 150**	**8 473**	**1.8**	**1.6**	**1.4**	**1.2**	**1.0**
All Developing Countries	**4 042**	**4 896**	**5 744**	**6 989**	**2.1**	**1.9**	**1.6**	**1.4**	**1.2**
93 Developing Countries	3 983	4 828	5 666	6 896	2.1	1.9	1.6	1.4	1.2
Sub-Saharan Africa	486	658	874	1 282	3.1	3.1	2.9	2.7	2.4
Near East/North Africa	309	406	512	672	2.9	2.8	2.4	1.9	1.6
East Asia	1 597	1 835	2 008	2 231	1.6	1.4	0.9	0.8	0.6
South Asia	1 157	1 414	1 679	2 017	2.3	2.0	1.7	1.1	1.1
Latin America and Caribb.	435	516	593	694	2.1	1.7	1.4	1.1	0.9
Developed Countries	**1 253**	**1 332**	**1 406**	**1 484**	**0.7**	**0.6**	**0.5**	**0.4**	**0.3**
Western Europe	401	413	420	421	0.3	0.3	0.2	0.0	-0.1
EC-12	344	354	360	359	0.3	0.3	0.2	0.0	-0.1
Other Western Europe	57	59	61	62	0.5	0.4	0.3	0.2	0.1
Eastern Europe	100	103	107	111	0.4	0.3	0.4	0.3	0.2
Former USSR	289	305	326	353	0.9	0.5	0.7	0.6	0.5
North America	277	306	330	360	0.9	1.0	0.8	0.6	0.5
Others	187	206	222	238	1.1	1.0	0.8	0.5	0.4

* Not used in this Study.

Table A.2 Per Caput Food Supplies for Direct Human Consumption

	Calories / day				All Cereals, including milled rice (kg/year)			
	1961/63	1969/71	1979/81	1988/90	1961/63	1969/71	1979/81	1988/90
World	**2 288**	**2 434**	**2 579**	**2 697**	**139**	**146**	**157**	**164**
All Developing Countries	**1 945**	**2 122**	**2 327**	**2 474**	**131**	**145**	**161**	**170**
93 Developing Countries	**1 939**	**2 116**	**2 322**	**2 470**	**131**	**145**	**161**	**171**
Sub-Saharan Africa	**2 120**	**2 138**	**2 120**	**2 098**	**120**	**115**	**113**	**114**
Angola	1 910	2 127	2 117	1 881	75	76	75	74
Benin	2 038	2 116	2 144	2 383	95	80	91	103
Botswana	2 032	2 165	2 154	2 260	149	162	145	183
Burkina Faso	1 856	1 775	1 816	2 218	161	161	160	205
Burundi	2 047	2 099	2 060	1 947	40	44	54	54
Cameroon	2 140	2 314	2 339	2 207	114	116	110	115
Central African Rep.	2 167	2 296	2 135	1 847	44	51	43	60
Chad	2 298	2 145	1 710	1 733	171	158	110	109
Congo	2 182	2 090	2 235	2 295	21	29	51	60
Côte d'Ivoire	2 192	2 419	2 845	2 566	74	96	129	111
Ethiopia	1 804	1 723	1 795	1 699	141	129	137	136
Gabon	1 950	2 194	2 381	2 442	36	42	71	90
Gambia	2 235	2 203	2 102	2 290	188	168	159	181
Ghana	2 028	2 228	1 972	2 141	62	74	74	78
Guinea	2 211	2 172	2 268	2 243	105	95	107	122
Kenya	2 158	2 230	2 147	2 063	149	156	147	130
Lesotho	1 997	2 006	2 353	2 121	199	202	221	199
Liberia	2 110	2 219	2 399	2 263	90	108	131	117
Madagascar	2 366	2 460	2 472	2 157	143	146	143	122
Malawi	2 067	2 370	2 274	2 049	165	197	176	165
Mali	2 167	1 999	1 899	2 259	188	163	157	198
Mauritania	1 967	1 943	2 081	2 447	112	108	121	155
Mauritius	2 407	2 351	2 701	2 897	149	151	160	174
Mozambique	1 953	1 917	1 951	1 805	78	72	74	68
Namibia	1 851	1 974	1 952	1 968	93	102	106	121
Niger	2 049	1 989	2 223	2 240	221	219	231	239
Nigeria	2 473	2 340	2 131	2 200	143	115	95	98
Rwanda	1 820	2 048	2 064	1 915	52	50	50	46
Senegal	2 397	2 470	2 416	2 323	179	181	193	183
Sierra Leone	1 829	2 096	2 095	1 900	97	122	131	114
Somalia	1 721	1 735	1 946	1 873	94	75	98	109
Sudan	1 841	2 168	2 215	2 042	116	142	127	138
Swaziland	2 159	2 268	2 462	2 634	153	158	154	168
Tanzania	1 800	1 804	2 239	2 195	91	86	130	132
Togo	2 376	2 378	2 265	2 269	104	124	112	137
Uganda	2 292	2 275	2 114	2 179	101	105	81	72
Zaire	2 220	2 210	2 133	2 129	36	42	44	46
Zambia	2 093	2 194	2 185	2 016	204	196	204	195
Zimbabwe	2 054	2 141	2 180	2 256	195	195	188	177
Near East/North Africa	**2 208**	**2 384**	**2 833**	**3 010**	**171**	**183**	**204**	**213**
Afghanistan	2 171	2 310	2 179	1 764	229	240	217	170
Algeria	1 723	1 824	2 613	2 945	143	151	195	213
Egypt	2 287	2 443	3 090	3 310	177	186	226	242
Iran	1 999	2 280	2 916	3 022	138	164	201	216
Iraq	1 958	2 259	2 757	3 092	132	157	193	222
Jordan	2 229	2 474	2 551	2 710	150	165	162	163
Lebanon	2 436	2 336	2 668	3 142	147	135	132	145
Libya	1 643	2 437	3 473	3 295	127	148	197	194

Table A.2. Per Caput Food Supplies for Direct Human Consumption (cont.)

	Calories / day				All Cereals, including milled rice (kg/year)			
	1961/63	1969/71	1979/81	1988/90	1961/63	1969/71	1979/81	1988/90
Morocco	2 185	2 407	2 696	3 031	190	216	229	248
Saudi Arabia	1 796	1 873	2 760	2 932	143	127	145	172
Syria	2 354	2 369	2 961	3 121	167	164	172	209
Tunisia	2 074	2 288	2 800	3 123	165	172	200	213
Turkey	2 690	2 863	3 053	3 197	194	205	211	203
Yemen	1 942	1 908	2 056	2 232	169	158	158	180
East Asia	**1 729**	**2 020**	**2 342**	**2 600**	**126**	**151**	**181**	**201**
Cambodia	2 150	2 301	1 657	2 122	182	201	146	183
China (Mainland)	1 659	1 989	2 325	2 642	124	153	190	215
Indonesia	1 816	2 020	2 464	2 605	102	125	159	183
Korea DPR	2 031	2 109	2 652	2 843	154	148	188	188
Korea Republic	1 957	2 470	2 747	2 826	158	185	171	159
Laos	1 982	2 251	2 365	2 465	185	207	206	209
Malaysia	2 375	2 482	2 685	2 671	154	154	149	122
Philippines	1 722	1 738	2 201	2 343	111	109	133	150
Thailand	2 029	2 196	2 292	2 280	146	157	149	137
Viet Nam	2 053	2 148	2 097	2 216	167	175	157	162
South Asia	**1 967**	**2 041**	**2 098**	**2 224**	**139**	**149**	**154**	**158**
Bangladesh	1 976	1 962	1 973	2 038	163	157	169	173
India	1 992	2 031	2 099	2 229	138	146	152	155
Myanmar	1 782	2 060	2 314	2 454	132	162	191	202
Nepal	1 914	1 907	1 846	2 206	176	175	166	194
Pakistan	1 803	2 180	2 154	2 283	119	152	141	144
Sri Lanka	2 111	2 292	2 243	2 247	119	138	135	141
Latin America and Caribb.	**2 364**	**2 503**	**2 694**	**2 689**	**115**	**119**	**128**	**129**
Argentina	3 073	3 267	3 195	3 068	137	134	128	131
Bolivia	1 799	1 974	2 120	2 013	99	93	108	99
Brazil	2 321	2 504	2 707	2 730	97	99	117	114
Chile	2 532	2 633	2 645	2 484	147	159	155	146
Colombia	2 164	2 060	2 410	2 453	83	80	88	91
Costa Rica	2 198	2 409	2 581	2 711	102	107	107	115
Cuba	2 298	2 653	2 954	3 129	104	122	133	132
Dominican Republic	1 852	2 025	2 269	2 310	51	59	85	90
Ecuador	2 035	2 147	2 293	2 399	72	77	82	97
El Salvador	1 768	1 849	2 317	2 331	108	117	143	139
Guatemala	1 928	2 081	2 146	2 255	135	141	141	149
Guyana	2 266	2 273	2 499	2 495	133	123	146	145
Haiti	1 967	1 943	2 067	2 005	98	91	92	86
Honduras	1 926	2 160	2 133	2 211	118	133	124	127
Jamaica	2 043	2 522	2 632	2 558	96	115	112	105
Mexico	2 490	2 626	3 001	3 061	159	166	175	181
Nicaragua	2 247	2 378	2 281	2 234	112	123	115	129
Panama	2 169	2 372	2 322	2 269	122	125	102	113
Paraguay	2 404	2 667	2 660	2 684	86	96	84	98
Peru	2 222	2 271	2 102	2 035	113	111	106	107
Suriname	1 967	2 240	2 440	2 436	114	141	142	159
Trinidad and Tobago	2 399	2 500	2 931	2 769	139	136	141	149
Uruguay	2 793	2 965	2 810	2 691	117	137	136	143
Venezuela	2 186	2 385	2 719	2 441	108	131	144	136

Table A.2. Per Caput Food Supplies for Direct Human Consumption (cont.)

	Calories / day				All Cereals, including milled rice (kg/year)			
	1961/63	1969/71	1979/81	1988/90	1961/63	1969/71	1979/81	1988/90
Developed Countries	**3 032**	**3 195**	**3 287**	**3 404**	**157**	**149**	**145**	**146**
Western Europe	**3 077**	**3 227**	**3 355**	**3 468**	**143**	**136**	**135**	**135**
EC-12	**3 065**	**3 226**	**3 349**	**3 483**	**139**	**132**	**132**	**131**
Belgium-Luxembourg	3 216	3 352	3 474	3 925	127	119	120	117
Denmark	3 381	3 391	3 464	3 639	113	108	110	117
France	3 288	3 327	3 435	3 593	137	113	114	123
Germany	2 978	3 206	3 361	3 522	122	128	131	138
Greece	2 844	3 185	3 443	3 775	165	160	154	157
Ireland	3 558	3 687	3 886	3 951	162	144	142	151
Italy	2 986	3 378	3 561	3 498	179	189	186	163
Netherlands	3 092	3 047	3 070	3 078	105	89	102	88
Portugal	2 656	3 013	2 913	3 342	138	138	130	140
Spain	2 740	2 809	3 248	3 473	150	118	116	117
United Kingdom	3 268	3 290	3 171	3 270	125	118	114	117
Other Western Europe	**3 154**	**3 234**	**3 391**	**3 378**	**172**	**162**	**158**	**153**
Austria	3 268	3 276	3 400	3 486	151	139	112	113
Finland	3 216	3 150	3 054	3 067	133	112	106	108
Iceland	3 335	3 082	3 230	3 448	94	91	83	183
Malta	2 860	3 028	2 904	3 169	160	160	142	143
Norway	3 040	3 050	3 351	3 221	106	101	117	128
Sweden	2 872	2 914	3 018	2 978	85	88	90	88
Switzerland	3 537	3 470	3 560	3 508	143	128	123	119
Yugoslav SFR	3 121	3 333	3 568	3 545	245	233	228	213
Eastern Europe	**3 137**	**3 290**	**3 437**	**3 386**	**210**	**203**	**191**	**182**
Albania	2 359	2 560	2 752	2 585	215	233	249	232
Bulgaria	3 252	3 508	3 630	3 695	263	255	237	220
Czechoslovakia	3 354	3 365	3 359	3 574	191	175	162	173
Hungary	3 099	3 324	3 459	3 608	194	184	169	166
Poland	3 220	3 379	3 499	3 426	204	199	186	174
Romania	2 881	3 062	3 389	3 081	221	212	204	187
Former USSR	3 147	3 323	3 368	3 380	212	194	177	168
North America	**3 054**	**3 235**	**3 330**	**3 604**	**100**	**98**	**106**	**124**
Canada	2 923	3 084	3 107	3 242	110	110	109	116
United States	3 067	3 250	3 353	3 642	99	96	105	125
Others	**2 610**	**2 782**	**2 849**	**3 014**	**158**	**152**	**151**	**153**
Australia	3 141	3 260	3 088	3 302	122	125	111	119
Israel	2 809	3 039	3 022	3 220	147	148	143	136
Japan	2 514	2 693	2 764	2 921	159	148	144	142
New Zealand	3 316	3 409	3 480	3 462	127	117	122	123
South Africa	2 682	2 819	2 981	3 133	183	191	205	213

Table A.3 Cereals Sector Data (All Cereals, including rice in milled form)

	Production			Net Trade			Self-Sufficiency Ratio			Domestic Use				
										Total			of which in 1988/90	
	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	Food	Feed
	.... 000mt		....				.... %			.... 000mt			.... %	
World	**1 129 087**	**1 456 618**	**1 697 512**	**2 144**	**2 600**	**2 625**	**100**	**100**	**99**	**1 124 470**	**1 457 426**	**1 721 116**	**50**	**37**
All Developing Countries	**482 436**	**652 327**	**847 407**	**-20 367**	**-66 829**	**-89 931**	**97**	**91**	**91**	**497 705**	**719 587**	**930 622**	**72**	**17**
93 Developing Countries	**479 886**	**649 583**	**844 505**	**-16 832**	**-59 393**	**-80 361**	**98**	**92**	**92**	**491 747**	**709 469**	**917 965**	**73**	**17**
Sub-Saharan Africa	**36 465**	**40 839**	**54 371**	**-2 508**	**-7 838**	**-7 717**	**97**	**86**	**86**	**37 449**	**47 740**	**62 957**	**86**	**3**
Angola	574	373	296	59	-365	-478	113	60	38	508	627	775	93	1
Benin	264	363	547	-22	-68	-98	93	85	88	286	426	625	74	3
Botswana	53	35	79	-71	-119	-186	44	23	30	119	152	262	88	2
Burkina Faso	983	1 152	1 843	-27	-96	-152	97	92	92	1 011	1 247	2 006	90	0
Burundi	157	216	288	-14	-29	-20	93	88	92	170	245	314	91	1
Cameroon	771	850	846	-106	-198	-490	89	80	60	867	1 060	1 406	93	0
Central African Rep.	93	99	125	-14	-18	-45	87	87	65	106	114	193	91	0
Chad	671	495	651	-12	-24	-46	98	86	92	682	576	711	85	2
Congo	8	14	24	-31	-76	-113	20	16	18	38	87	136	97	0
Côte d'Ivoire	529	710	980	-157	-531	-573	78	56	62	679	1 264	1 575	82	4
Ethiopia	4 362	5 804	6 204	-52	-294	-741	99	99	87	4 387	5 846	7 118	91	1
Gabon	8	10	22	-16	-47	-84	37	16	20	23	63	109	93	0
Gambia	80	66	88	-16	-47	-81	89	57	52	90	116	170	89	4
Ghana	720	697	1 041	-126	-209	-299	88	77	78	821	909	1 341	85	3
Guinea	466	532	626	-37	-138	-226	93	85	73	501	630	862	79	0
Kenya	2 132	2 268	3 232	91	-137	-20	106	85	100	2 014	2 667	3 238	93	2
Lesotho	208	198	177	-76	-166	-201	77	55	47	271	363	376	91	1
Liberia	123	169	151	-55	-108	-112	74	62	49	167	271	307	91	0
Madagascar	1 388	1 494	1 704	-21	-209	-106	99	89	92	1 396	1 687	1 855	76	4

Table A.3 Cereals Sector Data (All Cereals, including rice in milled form) (cont.)

	Production			Net Trade			Self-Sufficiency Ratio			Domestic Use				
										Total			of which in 1988/90	
	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	Food	Feed
	.... 000mt						.... %			.... 000mt			.... %	
Malawi	1 160	1 328	1 485	-32	-39	-106	101	99	94	1 149	1 339	1 578	88	3
Mali	998	1 007	1 941	-59	-132	-89	98	82	96	1 022	1 222	2 020	88	0
Mauritania	86	44	137	-69	-147	-231	57	22	37	150	202	369	83	10
Mauritius	1	1	3	-127	-173	-204	1	1	1	129	166	197	95	2
Mozambique	652	625	603	-107	-360	-460	89	65	54	732	966	1 126	92	1
Namibia	68	90	137	-67	-56	-84	61	61	62	111	147	222	94	0
Niger	1 261	1 692	1 886	39	-67	-193	108	106	93	1 166	1 599	2 033	88	2
Nigeria	8 606	7 118	12 403	-366	-2 073	-495	103	79	97	8 363	9 027	12 780	80	3
Rwanda	198	267	276	-11	-21	-54	97	94	79	204	283	350	92	0
Senegal	664	818	909	-295	-498	-587	74	65	60	901	1 252	1 508	87	1
Sierra Leone	340	374	386	-69	-112	-149	87	75	72	390	502	535	86	0
Somalia	241	299	606	-90	-258	-210	80	53	71	303	569	856	92	0
Sudan	2 116	2 959	2 932	-164	3	-388	98	108	78	2 164	2 736	3 784	90	2
Swaziland	83	91	145	-34	-69	-102	75	61	62	111	149	236	54	33
Tanzania	1 059	2 927	3 884	-31	-211	-54	78	97	95	1 352	3 017	4 099	85	7
Togo	296	296	509	-20	-60	-71	95	83	88	310	357	579	81	1
Uganda	1 571	1 166	1 519	-51	-37	-21	115	91	99	1 363	1 280	1 541	84	5
Zaire	683	930	1 272	-234	-446	-406	75	73	75	913	1 282	1 704	93	1
Zambia	915	990	1 738	-205	-343	-120	92	75	97	995	1 328	1 788	89	4
Zimbabwe	1 881	2 273	2 678	184	139	376	127	116	118	1 488	1 967	2 274	73	14
Near East/North Africa	**45 768**	**57 909**	**73 131**	**-6 337**	**-22 944**	**-37 923**	**87**	**73**	**65**	**52 660**	**79 773**	**111 738**	**57**	**28**
Afghanistan	3 498	3 922	2 718	-225	-93	-276	88	98	87	3 971	4 014	3 111	87	2
Algeria	1 881	1 957	1 492	-493	-2 979	-6 100	74	42	20	2 542	4 722	7 551	68	22
Egypt	6 530	7 340	10 404	-1 089	-5 947	-8 335	77	55	56	8 460	13 287	18 591	67	23
Iran	5 804	8 448	11 623	-452	-2 700	-5 387	90	76	68	6 484	11 177	17 216	67	25
Iraq	1 969	1 749	2 453	-427	-2 687	-4 079	82	42	37	2 410	4 150	6 714	60	27
Jordan	152	91	113	-150	-498	-1 071	48	16	9	319	564	1 212	43	51

Table A.3 Cereals Sector Data (All Cereals, including rice in milled form) (cont.)

	Production			Net Trade			Self-Sufficiency Ratio			Domestic Use				
										Total			of which in 1988/90	
	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	Food	Feed
	000mt						%			000mt			%	
Lebanon	50	41	76	-535	-581	-504	9	7	12	538	615	620	63	29
Libya	113	225	293	-348	-713	-1 759	26	24	15	436	946	1 997	43	50
Morocco	4 554	3 575	7 221	-310	-2 044	-1 408	95	61	86	4 810	5 901	8 369	72	12
Saudi Arabia	428	303	3 769	-515	-3 145	-3 608	53	9	49	813	3 385	7 701	30	59
Syria	1 229	3 069	3 177	-394	-664	-1 378	76	101	69	1 628	3 025	4 608	55	30
Tunisia	724	1 146	857	-422	-889	-1 749	62	59	32	1 173	1 938	2 715	63	26
Turkey	17 945	25 130	28 111	-758	649	-760	100	102	97	17 987	24 624	29 133	38	34
Yemen	891	913	825	-219	-655	-1 511	82	64	37	1 090	1 427	2 203	92	4
East Asia	**210 524**	**307 394**	**409 090**	**-6 635**	**-19 432**	**-20 057**	**98**	**94**	**96**	**214 976**	**326 718**	**425 420**	**73**	**17**
Cambodia	2 137	863	1 674	110	-250	-61	127	78	100	1 690	1 103	1 667	88	0
China (Mainland)	157 863	235 881	313 379	-2 482	-11 828	-10 423	98	95	98	160 511	247 816	319 553	74	17
Indonesia	15 381	23 873	35 936	-867	-2 622	-1 765	94	90	95	16 458	26 529	37 660	88	6
Korea DPR	4 049	7 425	8 574	-182	-280	-568	94	97	94	4 303	7 655	9 126	44	38
Korea Republic	5 652	5 815	5 983	-2 510	-5 725	-9 559	72	51	41	7 823	11 332	14 757	46	40
Laos	606	715	921	-71	-117	-58	91	91	88	663	785	1 043	80	4
Malaysia	1 146	1 378	1 186	-933	-1 536	-2 448	57	48	32	2 015	2 897	3 677	58	39
Philippines	5 664	8 460	10 771	-802	-929	-2 109	94	91	83	6 001	9 335	12 958	70	22
Thailand	11 219	14 694	17 592	2 895	5 195	6 218	159	153	140	7 073	9 635	12 555	60	27
Viet Nam	6 807	8 292	13 077	-1 792	-1 340	716	81	86	105	8 440	9 633	12 426	85	5
South Asia	**121 242**	**156 288**	**209 312**	**-4 835**	**-1 086**	**-4 611**	**98**	**97**	**102**	**123 851**	**161 460**	**205 337**	**88**	**1**
Bangladesh	11 220	14 281	18 442	-1 301	-1 373	-2 314	97	88	87	11 630	16 268	21 144	92	0
India	90 218	113 360	156 390	-3 622	383	-733	98	96	106	92 034	118 496	148 136	87	1
Myanmar	5 551	8 776	9 568	653	650	155	112	113	99	4 946	7 750	9 625	86	6
Nepal	2 710	2 853	4 480	253	-6	-31	112	99	100	2 425	2 877	4 491	81	4

Table A.3 Cereals Sector Data (All Cereals, including rice in milled form) (cont.)

	Production			Net Trade			Self-Sufficiency Ratio			Domestic Use				
										Total			of which in 1988/90	
	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	Food	Feed
	.... 000mt						.... %			.... 000mt			.... %	
Pakistan	10 536	15 584	18 809	136	110	-674	96	112	97	10 989	13 930	19 319	88	3
Sri Lanka	1 008	1 435	1 625	-953	-850	-1 015	55	67	62	1 828	2 140	2 624	92	1
Latin America and Caribb.	**65 890**	**87 157**	**98 604**	**3 482**	**-8 094**	**-10 055**	**105**	**93**	**88**	**62 817**	**93 784**	**112 519**	**50**	**40**
Argentina	20 090	24 361	19 677	9 401	14 375	9 223	182	219	175	11 051	11 121	11 256	37	45
Bolivia	471	632	746	-185	-322	-132	74	68	74	635	930	1 014	69	24
Brazil	20 074	27 971	36 414	-996	-6 315	-2 650	94	83	89	21 297	33 849	40 822	41	48
Chile	1 767	1 700	2 922	-483	-1 144	-188	77	61	93	2 285	2 807	3 153	60	34
Colombia	1 689	2 729	3 245	-383	-656	-873	82	84	81	2 049	3 269	4 030	73	23
Costa Rica	142	262	220	-110	-123	-352	59	68	40	242	388	546	62	33
Cuba	300	399	435	-1 236	-2 146	-2 468	20	16	15	1 485	2 557	2 903	48	47
Dominican Republic	196	317	393	-111	-377	-658	64	47	35	307	677	1 125	56	40
Ecuador	555	560	1 131	-78	-332	-480	88	68	75	629	829	1 504	67	18
El Salvador	514	700	791	-47	-130	-186	98	83	81	523	843	981	73	22
Guatemala	849	1 109	1 504	-99	-200	-325	91	88	81	929	1 264	1 860	72	23
Guyana	132	179	138	27	31	-8	120	124	92	110	144	150	77	19
Haiti	509	380	368	-47	-193	-231	93	68	61	550	557	605	90	3
Honduras	395	481	613	-45	-113	-167	90	83	79	439	577	778	82	11
Jamaica	5	6	3	-294	-394	-340	2	2	1	294	411	382	66	30
Mexico	14 422	20 516	22 543	163	-5 908	-6 676	100	83	74	14 426	24 747	30 307	52	36
Nicaragua	351	355	467	-20	-129	-171	97	81	72	361	437	652	74	17
Panama	162	194	245	-72	-94	-125	68	73	68	240	267	363	74	22
Paraguay	273	643	1 628	-58	-74	293	82	88	125	334	734	1 302	31	55
Peru	1 275	1 229	1 847	-699	-1 313	-1 366	68	50	56	1 870	2 467	3 324	68	28
Suriname	88	172	161	-5	57	25	107	144	122	83	120	132	50	26
Trinidad and Tobago	9	10	11	-184	-248	-268	5	4	4	186	260	299	63	32
Uruguay	780	916	1 195	91	190	487	111	132	162	704	692	740	59	24
Venezuela	842	1 338	1 910	-1 048	-2 537	-2 418	47	35	44	1 789	3 841	4 296	61	32

Table A.3 Cereals Sector Data (All Cereals, including rice in milled form) (cont.)

	Production			Net Trade			Self-Sufficiency Ratio			Domestic Use				
										Total			of which in 1988/90	
	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	Food	Feed
	000mt						%			000mt			%	
Developed Countries	**646 690**	**804 337**	**850 164**	**22 511**	**69 430**	**92 561**	**103**	**109**	**108**	**626 862**	**737 959**	**790 615**	23	61
Western Europe	**143 569**	**178 501**	**206 382**	**-23 790**	**-11 448**	**24 386**	**86**	**94**	**113**	**166 338**	**189 126**	**182 620**	29	60
EC-12	**118 005**	**148 219**	**174 338**	**-21 545**	**-8 722**	**24 129**	**85**	**95**	**115**	**139 179**	**156 191**	**151 293**	30	59
Belgium-Luxembourg	1 923	2 070	2 312	-2 683	-2 052	-1 968	42	52	57	4 611	3 966	4 088	29	47
Denmark	6 678	7 347	8 822	-312	492	2 383	95	106	142	7 043	6 960	6 204	10	81
France	33 951	46 203	56 345	10 790	18 948	29 781	149	172	215	22 769	26 848	26 219	26	64
Germany	26 102	32 052	37 036	-7 690	-5 990	-879	77	82	96	33 976	38 885	38 619	28	63
Greece	3 203	4 923	5 246	-256	-160	453	96	103	111	3 352	4 782	4 708	33	55
Ireland	1 452	2 009	2 118	-417	-324	90	78	89	105	1 857	2 248	2 016	26	60
Italy	15 831	17 697	16 918	-6 029	-5 586	-3 682	72	75	81	22 138	23 486	20 957	45	47
Netherlands	1 584	1 344	1 370	-2 934	-3 308	-2 926	36	28	33	4 430	4 811	4 206	31	46
Portugal	1 663	1 167	1 508	-838	-3 494	-1 446	70	26	49	2 388	4 533	3 102	46	46
Spain	11 679	14 570	20 555	-2 010	-4 909	-670	84	74	98	13 914	19 670	21 009	22	69
United Kingdom	13 941	18 840	22 110	-9 166	-2 339	2 994	61	94	110	22 704	20 003	20 166	33	51
Other Western Europe	**25 565**	**30 282**	**32 045**	**-2 245**	**-2 727**	**258**	**94**	**92**	**102**	**27 161**	**32 937**	**31 329**	28	62
Austria	3 342	4 393	5 207	-268	145	966	94	103	122	3 552	4 279	4 255	20	70
Finland	2 875	2 993	3 636	58	-336	159	106	89	125	2 713	3 368	2 913	18	68
Iceland	0	0	0	-41	-50	-71	0	0	0	41	50	71	65	34
Malta	4	8	9	-114	-120	-143	3	6	6	116	132	151	33	60
Norway	777	1 130	1 262	-668	-778	-597	53	59	68	1 462	1 911	1 858	29	66
Sweden	4 789	5 407	5 538	611	754	673	116	115	124	4 140	4 695	4 454	17	71
Switzerland	672	843	1 312	-1 498	-1 378	-821	31	38	61	2 141	2 230	2 137	37	56
Yugoslav SFR	13 105	15 510	15 081	-323	-965	92	101	95	97	12 995	16 271	15 490	33	57

Table A.3 Cereals Sector Data (All Cereals, including rice in milled form) (cont.)

	Production			Net Trade			Self-Sufficiency Ratio			Domestic Use				
										Total			of which in 1988/90	
	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	1969/71	1979/81	1988/90	Food	Feed
	.... 000mt						.... %			.... 000mt			.... %	
Eastern Europe	**55 109**	**68 344**	**80 528**	**-3 017**	**-9 185**	**-2 212**	**95**	**88**	**99**	**58 011**	**77 622**	**81 288**	**22**	**63**
Albania	534	912	919	-67	13	-99	85	101	92	626	899	1 005	74	18
Bulgaria	6 627	8 107	8 400	230	-387	-711	103	99	95	6 435	8 182	8 873	22	62
Czechoslovakia	8 035	9 771	12 155	-1 428	-1 344	20	88	84	101	9 169	11 613	12 056	22	67
Hungary	9 039	12 989	14 301	21	787	1 443	104	107	114	8 661	12 128	12 504	14	73
Poland	18 236	18 466	26 497	-2 349	-7 345	-2 647	88	72	92	20 652	25 620	28 683	23	65
Romania	12 639	18 100	18 256	576	-910	-218	101	94	101	12 469	19 180	18 168	24	55
Former USSR	168 896	169 604	204 029	5 389	-31 096	-34 172	100	79	85	169 199	214 694	238 817	20	58
North America	**243 319**	**341 922**	**313 505**	**49 573**	**129 372**	**118 666**	**127**	**169**	**138**	**191 594**	**202 328**	**227 299**	**15**	**69**
Canada	34 518	42 778	47 742	13 314	19 579	20 556	151	179	191	22 863	23 872	25 062	12	74
United States	208 801	299 144	265 762	36 260	109 793	98 110	124	168	131	168 731	178 456	202 237	15	68
Others	**35 799**	**45 968**	**45 723**	**-5 645**	**-8 207**	**-14 102**	**86**	**85**	**76**	**41 723**	**54 192**	**60 594**	**46**	**46**
Australia	13 905	20 878	22 109	8 980	14 600	14 651	250	316	288	5 565	6 611	7 674	26	54
Israel	199	239	245	-1 156	-1 690	-2 060	15	13	11	1 351	1 911	2 249	27	59
Japan	12 182	9 890	9 945	-14 378	-24 476	-28 051	46	28	26	26 764	35 234	38 139	46	48
New Zealand	709	785	771	-17	41	-128	96	107	83	737	736	924	45	49
South Africa	8 804	14 175	12 653	926	3 318	1 487	121	146	109	7 307	9 700	11 608	63	29

Table A.4.1 Wheat: Area, Yield and Production (countries with more than 10 000 ha wheat)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
World	**212 230**	**234 848**	**226 966**	**1 544**	**1 863**	**2 464**	**327 716**	**437 557**	**559 226**
All Developing Countries	**83 840**	**96 054**	**102 305**	**1 152**	**1 634**	**2 286**	**96 551**	**156 922**	**233 858**
93 Developing Countries	**83 378**	**95 598**	**101 767**	**1 154**	**1 638**	**2 292**	**96 228**	**156 606**	**233 290**
Sub-Saharan Africa	**1 271**	**1 067**	**1 346**	**982**	**1328**	**1563**	**1 249**	**1 417**	**2 104**
Angola	14	12	3	909	574	806	13	7	3
Burundi	8	9	10	578	671	827	5	6	9
Ethiopia	795	570	683	822	1092	1269	653	623	867
Kenya	133	106	120	1 678	2 011	1 747	223	212	210
Lesotho	89	28	26	634	936	988	56	26	26
Mozambique	10	4	3	959	1238	1303	9	5	4
Nigeria	11	10	53	1 759	2 400	1 064	20	24	57
Sudan	118	205	296	1 135	998	1 506	134	205	445
Tanzania	59	57	49	896	1 605	1 840	53	91	90
Zambia	0	3	12	1 000	3 481	4 484	0	9	56
Zimbabwe	17	37	51	3 642	4 783	5 714	60	179	290
Near East/North Africa	**24 544**	**25 333**	**26 696**	**1 022**	**1 347**	**1 709**	**25 089**	**34 114**	**45 612**
Afghanistan	2 199	2 065	1 623	978	1 240	1 063	2 150	2 561	1 725
Algeria	2 214	1 943	1 534	614	654	818	1 359	1 270	1 255
Egypt	551	577	799	2 741	3 193	4 980	1 509	1 844	3 977
Iran	5 183	5 858	6 243	776	997	1 218	4 021	5 843	7 605
Iraq	1 216	1 215	1 200	888	703	879	1 080	854	1 055
Jordan	168	99	54	759	673	1 230	127	67	66
Lebanon	46	26	26	842	1 257	2 179	39	32	57
Libya	160	251	154	257	497	1 002	41	125	155
Morocco	1 952	1 673	2 663	932	897	1 562	1 819	1 500	4 160
Saudi Arabia	57	71	775	1 774	2 254	4 748	101	160	3 678
Syria	1 271	1 383	1 283	649	1 358	1 359	825	1 878	1 743
Tunisia	817	887	830	677	944	1 337	553	837	1 109
Turkey	8 671	9 208	9 419	1 317	1 852	2 005	11 423	17 058	18 887
Yemen	40	78	93	1 053	1 113	1 496	42	87	139
East Asia	**25 532**	**29 000**	**30 567**	**1 174**	**2 048**	**3 115**	**29 983**	**59 380**	**95 205**
China (Mainland)	25 395	28 929	30 514	1 169	2 046	3 113	29 682	59 193	94 995
Korea DPR	45	50	52	1 949	2 454	4 006	88	123	208
Korea Republic	92	20	0	2 305	3 153	3 000	213	64	1
South Asia	**23 465**	**30 120**	**33 003**	**1 194**	**1 548**	**2 097**	**28 022**	**46 641**	**69 199**
Bangladesh	121	430	584	854	1 869	1 665	103	803	972
India	16 941	22 364	23 863	1 231	1 545	2 214	20 859	34 550	52 827
Myanmar	60	90	129	553	923	974	33	83	126
Nepal	221	372	599	1 044	1 195	1 403	230	444	840
Pakistan	6 122	6 865	7 829	1 110	1 567	1 844	6 796	10 760	14 433
Latin America and Caribb.	**8 566**	**10 078**	**10 155**	**1 387**	**1 494**	**2 085**	**11 885**	**15 054**	**21 170**
Argentina	4 396	5 245	5 255	1 318	1 537	1 977	5 793	8 060	10 392
Bolivia	67	98	92	725	661	792	48	65	73
Brazil	1 857	2 958	2 652	939	883	1 454	1 743	2 613	3 856

Table A.4.1 Wheat: Area, Yield and Production (countries with more than 10 000 ha wheat) (cont.)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
Chile	737	513	530	1 759	1 721	3 191	1 296	882	1 691
Colombia	54	36	50	1 201	1 397	1 852	65	50	93
Ecuador	84	33	38	966	1 042	708	81	35	27
Guatemala	31	36	16	1 118	1 461	2 031	35	52	32
Mexico	781	723	1021	2 918	3 808	4 040	2 278	2 754	4 125
Paraguay	44	55	207	911	1 222	1 568	40	68	324
Peru	138	98	101	906	1 011	1 283	125	99	129
Uruguay	376	281	191	1 009	1 340	2 238	379	377	428
Developed Countries	**128 390**	**138 794**	**124 661**	**1 801**	**2 022**	**2 610**	**231 166**	**280 634**	**325 368**
Western Europe	**19 677**	**18 324**	**19 140**	**2 721**	**3 742**	**5 060**	**53 534**	**68 568**	**96 855**
EC-12	**16 924**	**16 111**	**16 767**	**2 723**	**3 792**	**5 137**	**46 079**	**61 088**	**86 123**
Belgium-Luxembourg	209	189	219	4 058	5 019	6 577	848	949	1 438
Denmark	111	135	499	4 583	5 143	7 250	509	692	3 616
France	3 892	4 473	5 103	3 626	4 999	6 501	14 112	22 362	33 175
Germany	2 108	2 340	2 479	4 019	4 798	6 235	8 471	11 229	15 454
Greece	1 010	1 022	976	1 848	2 710	2 676	1 867	2 770	2 613
Ireland	89	50	74	4 191	5 357	8 120	375	270	602
Italy	4 089	3 373	2 800	2 386	2 665	2 969	9 756	8 989	8 312
Netherlands	146	138	134	4 617	6 271	7 635	675	867	1 022
Portugal	561	328	275	1 094	1 020	1 857	614	335	511
Spain	3 727	2 628	2 182	1 264	1 716	2 399	4 713	4 510	5 237
United Kingdom	980	1434	2025	4 223	5 659	6 983	4 140	8 116	14 143
Other Western Europe	**2 754**	**2 212**	**2 374**	**2 707**	**3 381**	**4 521**	**7 455**	**7 480**	**10 732**
Austria	279	271	276	3 274	3 782	5 007	912	1 025	1 381
Finland	184	110	150	2 417	2 418	3 728	445	267	559
Norway	4	15	46	3 143	4 213	4 441	11	63	206
Sweden	259	252	294	3 706	4 324	6 199	958	1 088	1 825
Switzerland	100	88	99	3 682	4 654	6 111	368	409	604
Yugoslav SFR	1 928	1 476	1 507	2 469	3 134	4 082	4 760	4 625	6 152
Eastern Europe	**8 062**	**7 169**	**8 310**	**2 399**	**3 238**	**4 096**	**19 344**	**23 215**	**34 042**
Albania	144	196	187	1 680	2 514	2 715	242	492	509
Bulgaria	1 022	986	1 167	2 836	3 937	4 346	2 898	3 881	5 071
Czechoslovakia	1 076	1 121	1 227	3 193	3 998	5 236	3 436	4 482	6 423
Hungary	1 289	1 187	1 205	2 645	4 043	5 186	3 410	4 800	6 249
Poland	2 004	1 525	2 305	2 458	2 747	3 870	4 924	4 189	8 919
Romania	2 527	2 154	2 220	1 754	2 494	3 096	4 433	5 371	6 871
Former USSR	64 832	59 439	47 245	1 431	1 425	1 842	92 804	84 679	87 018
North America	**26 338**	**40 284**	**39 511**	**2 048**	**2 151**	**2 300**	**53 935**	**86 659**	**90 886**
Canada	7 669	11 386	13 992	1 813	1 794	2 116	13 901	20 430	29 613
United States	18 669	28 898	25 519	2 144	2 292	2 401	40 034	66 229	61 273
Others	**9 481**	**13 579**	**10 455**	**1 218**	**1 290**	**1 585**	**11 549**	**17 514**	**16 568**
Australia	7 701	11 440	8 469	1 171	1 265	1 573	9 014	14 468	13 323
Israel	111	96	89	1 442	2 095	2 520	160	201	224
Japan	227	188	261	2 452	3 031	3 440	557	571	898
New Zealand	112	85	37	3 192	3 642	4 538	357	309	168
South Africa	1 330	1 770	1 599	1 098	1 111	1 222	1 461	1 966	1 954

Table A.4.2 Rice (paddy): Area, Yield and Production (countries with more than 10 000 ha rice)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
World	**133 101**	**143 787**	**147 588**	**2 329**	**2 753**	**3 515**	**309 992**	**395 862**	**518 744**
All Developing Countries	**128 565**	**138 942**	**143 249**	**2 228**	**2 667**	**3 447**	**286 392**	**370 624**	**493 787**
93 Developing Countries	**127 701**	**138 138**	**142 679**	**2 218**	**2 660**	**3 443**	**283 285**	**367 460**	**491 265**
Sub-Saharan Africa	**3 477**	**4 465**	**6 144**	**1 344**	**1 356**	**1 579**	**4 673**	**6 054**	**9 703**
Angola	21	20	18	1 188	1 000	1 039	25	20	19
Burkina Faso	40	39	21	933	1 140	2 083	37	44	43
Burundi	3	4	12	1 586	2 366	3 260	5	10	40
Cameroon	16	21	12	841	2 272	5 565	13	48	69
Central African Rep.	14	14	8	647	1 000	1 183	9	14	10
Chad	44	43	39	964	896	2 038	42	39	80
Côte d'Ivoire	287	383	563	1 168	1 171	1 174	335	448	661
Gambia	28	23	14	1 414	1 603	1 493	39	37	21
Ghana	55	107	72	1 000	837	1 418	55	89	102
Guinea	411	486	800	886	899	756	364	438	605
Kenya	6	8	15	4 754	4 631	4 027	27	39	59
Liberia	154	203	168	1 194	1 252	969	184	254	163
Madagascar	992	1 182	1 140	1 911	1 738	2 089	1 894	2 055	2 381
Malawi	23	37	29	1 036	1 074	1 735	23	39	51
Mali	158	165	222	1 017	1 026	1 614	161	169	358
Mauritania	1	3	14	1 000	3 656	3 476	1	12	50
Mozambique	76	92	109	1 303	810	758	99	74	83
Niger	16	20	31	2 092	1 537	2 463	34	31	76
Nigeria	272	517	1 567	1 293	1 988	1 912	352	1 027	2 996
Senegal	91	74	75	1 293	1 300	2 300	118	96	173
Sierra Leone	331	403	384	1 432	1 250	1 243	474	504	478
Sudan	5	11	1	1 111	845	1 286	5	9	1
Tanzania	144	262	348	991	959	2 039	143	251	709
Togo	25	18	22	709	798	1 437	18	15	31
Uganda	16	12	35	819	1 342	1 331	13	16	46
Zaire	236	293	393	755	806	891	178	236	350
Zambia	1	5	12	400	489	992	0	2	12
Near East/North Africa	**1 219**	**1 170**	**1 282**	**3 728**	**4 006**	**4 660**	**4 545**	**4 686**	**5 974**
Afghanistan	203	190	173	1 847	2 179	1 907	374	415	329
Egypt	487	416	437	5 275	5 709	7 086	2 566	2 377	3 098
Iran	362	434	539	2 875	3 211	3 831	1 041	1 394	2 064
Iraq	97	56	79	2 775	2 888	2 731	268	162	217
Turkey	63	67	51	4 106	4 721	4 976	257	314	253

Table A.4.2 Rice (paddy): Area, Yield and Production (countries with more than 10 000 ha rice) (cont.)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
East Asia	**61 002**	**65 362**	**66 863**	**2 760**	**3 436**	**4 428**	**168 373**	**224 575**	**296 039**
Cambodia	2 074	1 262	1 543	1 454	1 071	1 568	3 016	1 352	2 420
China (Mainland)	32 537	33 648	32 785	3 281	4 236	5 625	106 753	142 538	184 424
Indonesia	8 158	9 064	10 438	2 346	3 262	4 298	19 136	29 570	44 864
Korea DPR	563	635	667	4 246	7 454	7 950	2 392	4 733	5 300
Korea Republic	1 204	1 230	1 237	4 628	5 512	6 231	5 574	6 780	7 705
Laos	665	722	597	1 309	1 419	2 299	870	1 025	1 373
Malaysia	708	722	665	2 397	2 844	2 842	1 696	2 053	1 891
Philippines	3 241	3 513	3 414	1 683	2 205	2 778	5 456	7 747	9 484
Thailand	7 070	8 986	9 443	1 933	1 888	2 034	13 668	16 967	19 205
Viet Nam	4 782	5 579	6 075	2 052	2 117	3 189	9 812	11 809	19 374
South Asia	**55 629**	**59 160**	**61 721**	**1 702**	**1 972**	**2 626**	**94 698**	**116 659**	**162 076**
Bangladesh	9 842	10 310	10 386	1 681	1 952	2 593	16 540	20 125	26 935
India	37 677	40 091	42 318	1 668	1 860	2 621	62 861	74 557	110 921
Myanmar	4 748	4 684	4 709	1 707	2 698	2 900	8 107	12 637	13 656
Nepal	1 186	1 275	1 433	1 937	1 851	2 352	2 296	2 361	3 372
Pakistan	1 527	1 981	2 106	2 246	2 465	2 309	3 431	4 884	4 862
Sri Lanka	650	819	770	2 252	2 557	3 028	1 463	2 093	2 330
Latin America and Caribb.	**6 375**	**7 981**	**6 669**	**1 725**	**1 940**	**2 620**	**10 996**	**15 487**	**17 473**
Argentina	89	89	108	3 900	3 244	3 844	347	288	415
Bolivia	54	60	111	1 478	1 507	2 098	80	91	232
Brazil	4 788	5 932	4 441	1 430	1 438	2 099	6 847	8 533	9 320
Chile	23	40	35	2 620	3 151	4 162	60	125	146
Colombia	246	428	491	3 190	4 277	4 047	784	1 831	1 986
Costa Rica	44	73	53	2 018	3 059	3 586	88	224	190
Cuba	164	146	151	1 937	3 105	3 130	317	455	471
Dominican Republic	80	111	98	2 562	3 534	4 453	206	392	438
Ecuador	78	123	277	2 989	3 074	3 077	234	378	852
El Salvador	12	15	15	3 621	3 735	4 045	45	56	62
Guatemala	12	14	16	2 183	2 770	2 839	25	37	46
Guyana	109	91	65	1 800	2 924	3 221	195	266	210
Haiti	38	51	52	2 139	2 324	2 396	81	119	125
Honduras	11	20	19	1 304	1 735	2 627	15	35	49
Mexico	152	153	114	2 561	3 453	3 713	390	528	423
Nicaragua	26	37	42	3 008	3 545	2 737	77	130	115
Panama	105	96	90	1 376	1 834	2 247	144	175	203
Paraguay	19	26	27	2 145	1 837	2 684	40	47	72
Peru	130	132	186	4 141	4 410	5 160	539	580	957
Suriname	37	65	61	3 540	3 975	3 772	132	258	232
Uruguay	34	63	92	3 899	4 566	4 984	132	289	459
Venezuela	121	214	120	1 724	2 985	3 814	208	638	458
Developed Countries	**4 892**	**5 481**	**4 963**	**5 085**	**5 039**	**5 459**	**24 872**	**27 617**	**27 093**

Table A.4.2 Rice (paddy): Area, Yield and Production (countries with more than 10 000 ha rice) (cont.)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
Western Europe	**322**	**309**	**366**	**5 037**	**5 540**	**5 882**	**1 622**	**1 710**	**2 155**
EC-12	**315**	**300**	**358**	**5 055**	**5 567**	**5 926**	**1 590**	**1 670**	**2 124**
France	22	6	20	4 070	3 905	5 677	88	25	112
Greece	17	17	16	4 832	4 867	6 208	84	84	99
Italy	172	176	208	4 977	5 615	6 034	858	989	1 257
Portugal	41	32	34	4 380	4 359	4 670	177	137	157
Spain	63	69	81	6 100	6 328	6 175	384	435	498
Eastern Europe	**429**	**694**	**685**	**3 426**	**3 672**	**3 297**	**1 470**	**2 549**	**2 257**
Bulgaria	17	17	11	3 843	4 327	2 741	64	71	30
Hungary	24	16	11	2 250	2 148	2 722	54	35	29
Romania	28	21	37	2 374	2 346	1 514	67	49	56
Former USSR	356	637	623	3 573	3 738	3 426	1 272	2 380	2 135
North America	**777**	**1 345**	**1 117**	**5 087**	**5 179**	**6 334**	**3 953**	**6 968**	**7 077**
United States	777	1 345	1 117	5 087	5 179	6 334	3 953	6 968	7 077
Others	**3 008**	**2 496**	**2 172**	**5 505**	**5 613**	**6 202**	**16 555**	**14 011**	**13 469**
Australia	38	111	97	7 139	6 205	8 021	273	688	778
Japan	2 968	2 384	2 073	5 485	5 587	6 120	16 280	13 320	12 688

Table A.4.3 Maize: Area, Yield and Production (countries with more than 10 000 ha maize)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
World	**114 854**	**126 287**	**128 917**	**2 468**	**3 342**	**3 735**	**283 451**	**422 079**	**481 568**
All Developing Countries	**70 131**	**75 896**	**83 332**	**1 464**	**1 978**	**2 448**	**102 660**	**150 158**	**204 032**
93 Developing Countries	**70 020**	**75 755**	**83 146**	**1 464**	**1 979**	**2 449**	**102 491**	**149 913**	**203 595**
Sub-Saharan Africa	**12 070**	**12 155**	**16 458**	**981**	**1 135**	**1 199**	**11 843**	**13 793**	**19 731**
Angola	540	600	756	864	506	301	467	303	228
Benin	360	407	467	561	709	903	202	289	422
Botswana	34	42	33	310	279	320	11	12	11
Burkina Faso	92	123	208	659	875	1 330	60	108	277
Burundi	112	127	124	1 071	1 109	1 368	120	141	170
Cameroon	460	495	221	911	844	1 835	419	418	405
Central African Rep.	62	108	68	711	373	860	44	40	59
Chad	6	32	32	1 952	842	1 000	12	27	32
Congo	7	16	28	597	758	893	4	12	25
Côte d'Ivoire	333	514	683	773	684	728	257	352	497
Ethiopia	850	753	1 037	1 071	1 626	1 708	910	1 224	1 771
Gabon	6	6	14	1 473	1 672	1 543	8	10	22
Gambia	3	7	13	1 063	1 477	1 238	3	10	16
Ghana	387	390	547	1 078	974	1 339	417	380	733
Guinea	59	87	91	1 153	1 000	831	68	87	76
Kenya	1 233	1 273	1 447	1 241	1 346	1 673	1 530	1 714	2 420
Lesotho	143	116	107	651	967	1 296	93	112	139
Madagascar	121	124	152	1 004	982	1 013	122	122	154
Malawi	1 039	1 077	1 332	1 025	1 184	1 112	1 066	1 275	1 481
Mali	78	52	172	865	1 171	1 319	67	61	226
Mozambique	363	674	1 008	1 003	569	367	364	383	370
Namibia	93	100	120	400	487	501	37	49	60
Niger	3	15	5	607	703	688	2	10	3
Nigeria	1 346	443	1 550	983	1 353	1 261	1 323	599	1 955
Rwanda	50	73	73	1 085	1 159	1 364	54	84	100
Senegal	52	75	100	814	885	1 223	42	66	122
Sierra Leone	11	13	11	981	977	1 054	10	13	12
Somalia	124	151	213	895	794	1 116	111	120	238
Sudan	39	67	73	779	584	608	31	39	44
Swaziland	89	66	90	846	1 291	1 358	75	85	122
Tanzania	1 005	1 350	1 820	612	1 305	1 447	615	1 762	2 634
Togo	144	147	273	1 109	1 020	982	160	150	268
Uganda	310	263	417	1 349	1 368	1 393	418	360	581
Zaire	595	745	1 211	716	811	722	426	604	874
Zambia	992	523	808	792	1 799	1 665	786	941	1 345
Zimbabwe	923	1 097	1 150	1 629	1 667	1 598	1 504	1 829	1 837

Table A.4.3 Maize: Area, Yield and Production (countries with more than 10 000 ha maize) (cont.)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
Near East/North Africa	**2 284**	**2 350**	**2 237**	**2 012**	**2 392**	**3 718**	**4 597**	**5 623**	**8 316**
Afghanistan	470	447	264	1 506	1 649	1 713	707	738	453
Egypt	634	800	847	3 741	3 949	5 687	2 370	3 159	4 817
Iran	25	35	37	1 400	1 499	3 412	35	52	126
Iraq	6	22	75	1 508	2 431	2 561	9	53	191
Morocco	474	396	389	801	618	1 006	380	245	391
Syria	6	21	59	1 407	2 083	2 906	8	43	171
Turkey	646	583	512	1 639	2 168	4 087	1 058	1 263	2 093
Yemen	8	38	47	2 200	1 673	1 271	17	64	60
East Asia	**22 850**	**28 562**	**30 647**	**1 817**	**2 641**	**3 653**	**41 524**	**75 446**	**111 968**
Cambodia	94	87	40	1 331	980	1 293	125	85	52
China (Mainland)	16 175	19 950	21 109	2 005	3 038	4 335	32 433	60 617	91 506
Indonesia	2 667	2 761	3 004	965	1 461	2 129	2 575	4 035	6 394
Korea DPR	383	633	708	5 305	6 053	6 283	2 033	3 833	4 450
Korea Republic	44	34	24	1 450	4 436	4 339	63	150	105
Laos	15	29	34	1 713	1 062	1 772	26	31	60
Malaysia	8	7	20	1 935	1 143	1 761	15	8	35
Philippines	2 434	3 267	3 699	828	972	1 264	2 015	3 174	4 677
Thailand	793	1 412	1 551	2 502	2 198	2 559	1 984	3 103	3 969
Viet Nam	237	383	457	1 075	1 071	1 576	255	410	720
South Asia	**6 967**	**7 230**	**7 738**	**1 098**	**1 147**	**1 521**	**7 647**	**8 292**	**11 770**
India	5 794	5 887	5 970	1 051	1 102	1 531	6 087	6 486	9 141
Myanmar	71	128	125	714	1 295	1 538	51	166	192
Nepal	439	455	754	1 812	1 516	1 607	796	690	1 212
Pakistan	640	736	856	1 088	1 257	1 390	697	925	1 189
Sri Lanka	19	21	30	774	1 086	1 084	15	23	32
Latin America and Caribb.	**25 850**	**25 457**	**26 066**	**1 427**	**1 837**	**1 988**	**36 880**	**46 759**	**51 810**
Argentina	3 880	2 895	1 758	2 247	3 224	3 359	8 717	9 333	5 905
Bolivia	223	295	270	1 306	1 430	1 629	291	422	439
Brazil	10 021	11 430	12 479	1 365	1 685	1 914	13 680	19 265	23 887
Chile	70	124	109	3 109	3 798	7 980	217	471	866
Colombia	684	620	806	1 251	1 401	1 460	856	868	1 177
Costa Rica	57	43	39	1 278	1 778	1 815	73	77	72
Cuba	100	77	77	853	1 239	1 234	85	95	95
Dominican Republic	27	32	35	1 712	1 184	1 403	46	38	49
Ecuador	312	230	452	767	1 075	1 082	239	247	490
El Salvador	203	281	288	1 670	1 840	1 961	340	517	565
Guatemala	672	627	629	1 118	1 511	1 952	751	947	1 228
Haiti	231	207	208	1058	868	807	245	179	168
Honduras	283	339	382	1 199	1 201	1 425	339	407	545
Mexico	7 412	6 836	6 919	1 218	1 736	1 920	9 025	11 866	13 282

Table A.4.3 Maize: Area, Yield and Production (countries with more than 10 000 ha maize) (cont.)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
Nicaragua	260	179	215	912	1 022	1 230	238	183	265
Panama	77	62	74	859	953	1 249	66	59	93
Paraguay	162	340	420	1 246	1 572	2 015	201	535	847
Peru	373	341	386	1 621	1 665	1 995	605	569	770
Uruguay	194	124	59	832	1 015	1 684	161	126	99
Venezuela	606	372	455	1 152	1 471	2 117	698	547	963
Developed Countries	**44 724**	**50 390**	**45 586**	**4 042**	**5 396**	**6 088**	**180 791**	**271 921**	**277 536**
Western Europe	**6 172**	**6 256**	**6 190**	**3 818**	**5 131**	**5 951**	**23 561**	**32 100**	**36 836**
EC-12	**3 649**	**3 799**	**3 745**	**4 227**	**5 503**	**6 890**	**15 424**	**20 905**	**25 805**
France	1 436	1 774	1 757	5 148	5 434	6 720	7 394	9 641	11 808
Germany	102	122	234	4 973	6 173	7 217	509	753	1 687
Greece	162	157	221	3 074	7 423	10 071	498	1 165	2 225
Italy	986	956	810	4 665	6 897	7 594	4 601	6 590	6 154
Portugal	433	333	220	1 385	1 458	3 032	599	486	666
Spain	526	450	495	3 432	4 950	6 462	1 804	2 227	3 201
Other Western Europe	**2 523**	**2 457**	**2 445**	**3 226**	**4 557**	**4 512**	**8 138**	**11 195**	**11 032**
Austria	122	190	193	5 545	7 045	8 109	677	1 338	1 561
Switzerland	10	17	28	6 140	7 226	8 614	61	121	239
Yugoslav SFR	2 391	2 250	2 225	3 095	4 327	4 150	7 399	9 736	9 232
Eastern Europe	**5 307**	**5 399**	**4 488**	**2 841**	**3 905**	**3 974**	**15 074**	**21 086**	**17 836**
Albania	111	100	59	1 988	3 175	4 169	220	318	245
Bulgaria	623	605	516	3 913	4 344	4 046	2 436	2 627	2 087
Czechoslovakia	127	173	164	4 020	4 638	4 743	511	800	777
Hungary	1 272	1 270	1 098	3 570	5 528	5 841	4 542	7 022	6 414
Poland	5	26	60	2 449	3 889	4 847	12	102	291
Romania	3 170	3 226	2 592	2 320	3 168	3 096	7 354	10 218	8 023
Former USSR	3 617	3 058	3 310	2 763	2 970	3 520	9 993	9 082	11 650
North America	**24 238**	**30 700**	**28 103**	**5 163**	**6 449**	**7 157**	**125 137**	**197 988**	**201 144**
Canada	490	1 039	1 057	5 079	5 685	6 580	2 488	5 904	6 953
United States	23 749	29 661	27 046	5 164	6 476	7 180	122 649	192 084	194 191
Others	**5 390**	**4 978**	**3 495**	**1 304**	**2 344**	**2 881**	**7 026**	**11 666**	**10 069**
Australia	77	54	51	2 383	3 069	4 128	184	164	210
Japan	12	2	0	2 664	2 294	2 667	33	4	1
New Zealand	9	20	17	7 725	8 291	9 711	70	163	161
South Africa	5 290	4 900	3 426	1 273	2 311	2 830	6 734	11 322	9 695

Table A.4.4 Barley: Area, Yield and Production (countries with more than 10 000 ha barley)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
World	**66 609**	**81 243**	**74 390**	**1 886**	**1 893**	**2 284**	**125 596**	**153 790**	**169 927**
All Developing Countries	**17 548**	**16 706**	**19 262**	**1 095**	**1 289**	**1 287**	**19 208**	**21 535**	**24 799**
93 Developing Countries	**17 435**	**16 553**	**19 132**	**1 096**	**1 292**	**1 287**	**19 101**	**21 394**	**24 632**
Sub-Saharan Africa	**931**	**910**	**988**	**803**	**1 226**	**1 009**	**748**	**1 115**	**996**
Ethiopia	913	850	950	796	1 200	978	727	1 021	929
Kenya	14	49	24	1 133	1 301	1 363	15	64	32
Near East/North Africa	9 270	10 908	14 667	1 006	1 108	1 145	9 323	12 081	16 798
Afghanistan	316	296	207	1 151	1 057	1 071	363	313	221
Algeria	773	875	1 217	608	677	915	470	592	1 114
Egypt	44	41	56	2 126	2 692	2 177	93	111	122
Iran	1 532	1 727	2 479	680	902	1 277	1 042	1 558	3 166
Iraq	582	858	1 382	1 190	846	793	692	726	1 095
Jordan	50	52	55	492	395	629	25	21	34
Lebanon	7	6	11	863	1 000	1 714	6	6	19
Libya	213	284	283	326	342	496	70	97	140
Morocco	2 003	2 190	2 390	1 093	782	1 170	2 190	1 712	2 796
Saudi Arabia	14	7	65	908	1 171	5 649	13	8	366
Syria	784	1 220	2 618	478	926	259	375	1 129	678
Tunisia	243	457	491	571	609	949	139	279	466
Turkey	2 597	2 846	3 365	1 432	1 926	1 942	3 720	5 480	6 533
Yemen	111	49	49	1 125	1 000	967	125	49	48
East Asia	**3 097**	**1 752**	**1 299**	**1 599**	**2 697**	**2 625**	**4 954**	**4 726**	**3 409**
China (Mainland)	2 285	1 295	1 083	1 150	2 420	2 462	2 627	3 133	2 667
Korea DPR	90	72	60	1 333	2 162	2 472	120	155	148
Korea Republic	723	386	155	3 054	3 728	3 832	2 207	1 438	593
South Asia	**2 902**	**2 046**	**1 221**	**959**	**1 073**	**1 464**	**2 784**	**2 196**	**1 787**
Bangladesh	32	19	18	672	637	623	21	12	11
India	2 693	1 802	1 016	981	1 121	1 591	2 642	2 020	1 616
Nepal	26	26	30	924	875	929	24	23	27
Pakistan	151	199	157	642	709	842	97	141	132
Latin America and Caribb.	**1 235**	**936**	**959**	**1 046**	**1 362**	**1 713**	**1 292**	**1 275**	**1 642**
Argentina	431	178	180	1 153	1 289	2 282	497	229	411
Bolivia	94	80	83	668	653	659	63	53	55
Brazil	26	84	105	985	1 120	1 635	26	94	172
Chile	48	51	28	2 017	2 000	3 436	97	103	95
Colombia	53	58	51	1 733	1 753	1 871	92	101	96
Ecuador	127	29	56	596	843	850	75	24	48
Mexico	230	281	270	1 043	1 726	1 858	240	486	502
Peru	184	127	104	894	903	1 015	164	115	105
Uruguay	42	48	81	898	1 474	1 960	38	71	158
Developed Countries	**49 061**	**64 538**	**55 128**	**2 168**	**2 049**	**2 633**	**106 388**	**132 255**	**145 127**
Western Europe	**13 724**	**16 566**	**14 088**	**3 007**	**3 453**	**4 127**	**41 274**	**57 199**	**58 142**
EC-12	**11 931**	**14 396**	**12 328**	**3 051**	**3 514**	**4 151**	**36 405**	**50 583**	**51 171**
Belgium-Luxembourg	174	173	108	3 488	4 877	5 779	608	844	626
Denmark	1 342	1 580	942	3 856	3 956	5 301	5 175	6 250	4 996
France	2 825	2 670	1 781	3 138	4 119	5 711	8 865	10 997	10 169

Table A.4.4 Barley: Area, Yield and Production (countries with more than 10 000 ha barley) (cont.)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
Germany	2 101	2 971	2 596	3 480	4 093	5 506	7 313	12 158	14 295
Greece	335	344	194	1 955	2 434	2 397	655	838	465
Ireland	216	349	243	3 954	4 709	5 679	854	1 643	1 378
Italy	180	325	470	1 816	2 817	3 646	326	914	1 713
Netherlands	101	56	44	3 627	4 693	5 349	366	265	236
Portugal	105	75	68	614	603	1 198	65	45	82
Spain	2 235	3 520	4 361	1 755	1 867	2 143	3 922	6 571	9 346
United Kingdom	2 317	2 333	1 521	3 564	4 310	5 171	8 257	10 058	7 866
Other Western Europe	**1 793**	**2 170**	**1 760**	**2 716**	**3 049**	**3 960**	**4 868**	**6 617**	**6 971**
Austria	286	370	294	3 333	3 482	4 959	954	1 288	1 456
Finland	395	579	514	2 388	2 455	3 477	943	1 421	1 789
Norway	183	186	178	2 985	3 424	3 810	545	636	678
Sweden	602	678	471	3 049	3 427	4 198	1 836	2 323	1 976
Switzerland	39	48	58	3 777	4 589	6 045	147	220	352
Yugoslav SFR	287	309	244	1 540	2 351	2 934	442	726	716
Eastern Europe	**2 726**	**3 869**	**3 495**	**2 644**	**3 029**	**3 976**	**7 207**	**11 719**	**13 896**
Albania	9	12	12	908	2 025	2 785	8	24	34
Bulgaria	416	425	368	2 662	3 386	4 043	1 109	1 439	1 487
Czechoslovakia	810	972	763	3 141	3 627	4 989	2 543	3 524	3 805
Hungary	322	265	312	2 329	3 202	4 554	749	848	1 421
Poland	861	1 362	1 195	2 536	2 616	3 453	2 182	3 563	4 128
Romania	309	833	845	1 994	2 786	3 577	615	2 321	3 022
Former USSR	21 794	33 420	26 962	1 612	1 175	1 717	35 141	39 254	46 305
North America	**8 446**	**7 845**	**7 740**	**2 309**	**2 554**	**2 792**	**19 500**	**20 037**	**21 611**
Canada	4 483	4 631	4 468	2 236	2 418	2 740	10 024	11 199	12 244
United States	3 963	3 214	3 272	2 391	2 750	2 863	9 476	8 838	9 367
Others	**2 372**	**2 838**	**2 843**	**1 378**	**1 425**	**1 820**	**3 267**	**4 045**	**5 173**
Australia	2 019	2 540	2 522	1 175	1 291	1 668	2 372	3 279	4 208
Israel	20	27	14	882	681	413	17	18	6
Japan	224	120	105	2 807	3 261	3 184	629	392	333
New Zealand	67	71	88	3 310	3 610	4 332	222	255	381
South Africa	42	81	114	643	1 258	2 152	27	102	245

Table A.4.5 Millet: Area, Yield and Production (countries with more than 10 000 ha millet)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
World	**44 636**	**37 646**	**36 537**	**702**	**677**	**791**	**31 354**	**25 468**	**28 899**
All Developing Countries	**41 596**	**34 718**	**33 421**	**688**	**682**	**772**	**28 613**	**23 678**	**25 790**
93 Developing Countries	**41 575**	**34 689**	**33 393**	**688**	**682**	**771**	**28 596**	**23 655**	**25 762**
Sub-Saharan Africa	**13 349**	**11 513**	**14 701**	**596**	**666**	**698**	**7 957**	**7 662**	**10 266**
Angola	92	80	120	845	613	536	78	49	64
Benin	17	13	38	376	500	623	6	7	24
Botswana	19	12	9	245	145	176	5	2	2
Burkina Faso	843	803	1 212	426	486	535	360	390	649
Burundi	10	10	12	897	980	1 065	9	10	13
Cameroon	123	130	60	697	753	1 062	86	98	64
Central African Rep.	12	16	12	795	682	870	9	11	11
Chad	430	360	543	635	505	352	273	182	191
Côte d'Ivoire	63	64	77	487	581	613	31	37	47
Ethiopia	197	226	253	596	899	953	117	203	241
Gambia	35	28	53	1 049	914	974	36	26	52
Ghana	218	182	192	549	641	636	120	117	122
Guinea	35	35	31	1 429	1 409	1 521	50	49	47
Kenya	75	80	100	1 683	1 049	658	127	84	66
Malawi	0	11	18	0	593	554	0	7	10
Mali	569	643	1 174	793	716	701	451	461	823
Mauritania	34	12	16	178	254	409	6	3	7
Mozambique	19	20	20	526	250	250	10	5	5
Namibia	57	77	93	453	447	604	26	34	56
Niger	2 313	3 011	3 711	422	435	383	975	1 311	1 422
Nigeria	4 887	2 366	3 783	615	1 055	1 181	3 007	2 496	4 468
Senegal	874	932	899	503	595	644	440	555	579
Sierra Leone	6	9	26	1 103	1 398	884	6	13	23
Sudan	745	1 098	1 113	567	397	166	423	436	185
Tanzania	211	450	255	663	800	982	140	360	250
Togo	190	121	134	638	364	510	121	44	68
Uganda	739	297	379	1 024	1 592	1 534	757	473	582
Zaire	27	36	43	699	668	728	19	24	31
Zambia	128	34	51	619	638	556	79	22	28
Zimbabwe	380	353	271	500	432	501	190	153	136
Near East/North Africa	**273**	**191**	**187**	**1 150**	**1 007**	**610**	**314**	**192**	**114**
Afghanistan	33	39	30	843	860	865	28	33	26
Iran	15	8	7	753	1 114	1 940	11	9	13
Saudi Arabia	110	25	7	1 137	412	1 597	125	10	12
Syria	25	15	7	706	1 047	577	18	16	4
Turkey	39	16	4	1 385	1 342	1 357	54	21	6
Yemen	39	81	122	1 787	1 185	365	70	96	45
East Asia	**7 089**	**4 043**	**2 354**	**1 324**	**1 448**	**1 772**	**9 387**	**5 856**	**4 173**
China (Mainland)	6 937	3 978	2 302	1 333	1 455	1 785	9 250	5 787	4 109
Korea DPR	93	62	50	961	1 065	1 214	90	66	61
Korea Republic	59	3	3	798	1 147	1 154	47	4	3
South Asia	**20 704**	**18 740**	**16 109**	**520**	**518**	**692**	**10 771**	**9 699**	**11 152**
Bangladesh	76	61	89	784	648	713	60	40	63
India	19 618	17 845	15 202	519	515	694	10 182	9 189	10 551
Myanmar	161	179	172	291	447	707	47	80	121

Table A.4.5 Millet: Area, Yield and Production (countries with more than 10 000 ha millet) (cont.)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
Nepal	114	122	197	1 123	989	1 160	128	121	228
Pakistan	713	509	438	476	500	410	339	255	180
Sri Lanka	23	24	11	719	612	688	17	15	8
Latin America and Caribb.	**160**	**203**	**42**	**1 049**	**1 211**	**1 371**	**168**	**245**	**57**
Argentina	160	203	42	1 049	1 211	1 360	168	245	57
Developed Countries	**3 040**	**2 928**	**3 116**	**902**	**611**	**998**	**2 741**	**1 790**	**3 110**
Eastern Europe	**29**	**7**	**8**	**1 146**	**1 300**	**2 145**	**33**	**9**	**18**
Poland	21	0	0	1 224	0	0	26	0	0
Former USSR	2 821	2 777	2 901	878	583	985	2 477	1 620	2 859
North America	**110**	**89**	**152**	**1 324**	**1 200**	**1 231**	**145**	**107**	**187**
United States	110	89	152	1 324	1 200	1 231	145	107	187
Others	**68**	**49**	**54**	**941**	**863**	**809**	**64**	**42**	**43**
Australia	39	26	31	951	1 000	877	37	26	27
South Africa	22	22	22	682	682	682	15	15	15

Table A.4.6 Sorghum: Area, Yield and Production (countries with more than 10 000 ha sorghum)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
World	**50 343**	**45 062**	**42 399**	**1 143**	**1 454**	**1 344**	**57 567**	**65 525**	**57 002**
All Developing Countries	**43 590**	**38 588**	**37 348**	**840**	**1 139**	**1 068**	**36 633**	**43 948**	**39 889**
93 Developing Countries	**43 579**	**38 555**	**37 311**	**840**	**1 139**	**1 066**	**36 622**	**43 918**	**39 778**
Sub-Saharan Africa	**15 094**	**13 122**	**17 046**	**672**	**852**	**747**	**10 138**	**11 180**	**12 729**
Benin	91	90	140	565	649	762	52	59	107
Botswana	133	98	140	278	209	320	37	21	45
Burkina Faso	1 054	1 051	1 325	501	590	750	528	620	993
Burundi	21	53	58	986	1 000	1 117	21	53	65
Cameroon	353	374	515	727	805	707	257	301	364
Central African Rep.	42	57	37	787	675	628	33	39	23
Chad	495	414	456	691	507	587	342	210	268
Côte d'Ivoire	28	40	45	507	606	579	14	24	26
Ethiopia	950	1 048	810	877	1 355	1 086	833	1 419	880
Gambia	7	6	12	905	783	881	7	5	10
Ghana	209	223	255	705	628	775	147	140	197
Guinea	20	20	21	1 250	1 250	1 110	25	25	23
Kenya	201	168	124	1 070	951	932	215	160	116
Lesotho	75	58	34	756	1 021	781	57	59	26
Malawi	107	30	31	730	667	590	78	20	18
Mali	384	434	811	868	785	835	333	341	677
Mauritania	229	102	120	327	279	600	75	28	72
Mozambique	261	288	422	774	630	396	202	182	167
Namibia	10	15	16	433	422	500	4	6	8
Niger	589	822	1 512	445	422	280	262	347	423
Nigeria	6 303	2 683	4 318	631	1 224	1 032	3 980	3 284	4 454
Rwanda	132	159	154	1 068	1 123	1 157	141	178	178
Senegal	122	130	135	821	1 014	897	100	131	121
Sierra Leone	5	7	34	1 250	1 571	634	6	11	22
Somalia	367	478	450	352	350	540	129	167	243
Sudan	1 888	3 054	3 904	808	744	534	1 525	2 273	2 085
Tanzania	310	713	479	503	762	978	156	543	468
Togo	0	122	190	0	714	717	0	87	136
Uganda	299	175	239	1 271	1 784	1 495	381	312	357
Zaire	29	36	77	819	899	637	24	32	49
Zambia	76	31	44	649	534	562	49	16	25
Zimbabwe	294	140	138	415	611	579	122	85	80
Near East/North Africa	**1 363**	**1 153**	**784**	**1 287**	**1 232**	**1 557**	**1 754**	**1 420**	**1 220**
Egypt	206	172	133	4 121	3 740	4 746	847	644	631
Morocco	67	45	27	1 048	436	546	70	20	15
Saudi Arabia	174	281	139	1 059	437	1 176	185	123	164
Tunisia	13	14	8	551	427	390	7	6	3
Yemen	895	631	470	712	977	854	637	617	402
East Asia	**5499**	**3 076**	**1 728**	**1 591**	**2 376**	**3 060**	**8 749**	**7 307**	**5 287**
China (Mainland)	5 407	2 825	1 525	1 591	2 487	3 296	8 600	7 025	5 025
Korea DPR	25	13	10	1 188	1 331	1 530	30	18	15
Thailand	48	220	188	1 961	1 074	1 275	95	237	239
South Asia	**18 106**	**16 766**	**14 316**	**487**	**693**	**789**	**8 825**	**11 616**	**11 302**
India	17 585	16 361	13 902	484	696	795	8 516	11 380	11 059
Pakistan	518	403	413	594	582	586	308	235	242

Table A.4.6 Sorghum: Area, Yield and Production (countries with more than 10 000 ha sorghum) (cont.)

	Area (Harvested) 000ha			Yield (kg/ha)			Production (000mt)		
	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91	1969/71	1979/81	1989/91
Latin America and Caribb.	**3 518**	**4 438**	**3 438**	**2 034**	**2 793**	**2 688**	**7 155**	**12 394**	**9 241**
Argentina	1 979	1 866	653	1 932	3 023	2 947	3 823	5 641	1 923
Bolivia	0	5	15	0	4 059	3 946	0	21	58
Brazil	1	81	158	2 222	2 128	1 543	2	172	244
Colombia	64	220	256	2 407	2 223	2 878	153	488	737
Costa Rica	7	20	2	1 631	1 806	2 067	11	35	3
Dominican Republic	4	6	10	3 553	2 983	2 564	14	18	26
El Salvador	121	126	124	1 186	1 152	1 272	144	145	158
Guatemala	50	39	56	916	2 036	1 519	46	80	84
Haiti	214	158	122	981	762	743	210	121	90
Honduras	36	61	73	1 271	809	982	46	49	71
Mexico	930	1 491	1 607	2 767	3 347	3 172	2 573	4 991	5 096
Nicaragua	56	51	48	1 016	1 561	1 546	57	80	74
Panama	0	9	11	0	2 149	2 457	0	19	26
Paraguay	4	7	19	1 256	1 278	1 244	5	9	24
Peru	4	14	9	3 056	3 324	3 188	11	46	27
Uruguay	42	56	31	1 259	2 018	2 479	53	112	76
Venezuela	4	227	243	1 333	1 605	2 123	5	365	516
Developed Countries	**6 754**	**6 474**	**5 051**	**3 100**	**3 333**	**3 388**	**20 934**	**21 576**	**17 114**
Western Europe	**119**	**134**	**117**	**3 411**	**4 481**	**4 839**	**405**	**601**	**568**
EC-12	**112**	**129**	**114**	**3 498**	**4 580**	**4 922**	**393**	**589**	**561**
France	55	75	70	3 709	4 436	4 577	203	332	320
Italy	5	14	24	3 104	5 127	5 545	15	73	134
Spain	46	38	19	3 681	4 736	5 559	168	181	105
Eastern Europe	**34**	**49**	**50**	**1 414**	**1 635**	**1 725**	**48**	**81**	**85**
Albania	24	25	24	1 112	1 200	1 173	27	30	29
Hungary	1	7	18	1 625	3 041	2 888	1	22	52
Romania	2	17	7	1 130	1 659	681	3	28	5
Former USSR	43	90	120	1 425	1 189	1 136	62	107	136
North America	**5 820**	**5 273**	**4 055**	**3 318**	**3 633**	**3 703**	**19 314**	**19 157**	**15 017**
United States	5 820	5 273	4 055	3 318	3 633	3 703	19 314	19 157	15 017
Others	**738**	**928**	**709**	**1 499**	**1 757**	**1 845**	**1 106**	**1 630**	**1 308**
Australia	374	549	461	1910	1 976	2 126	713	1 084	980
South Africa	358	377	248	1 050	1 434	1 320	376	540	327

Table A.5 Land with Rainfed Crop Production Potential: 91 Developing Countries

('000 ha)

	Land with Rainfed Crop Production Potential by Land Class								Irrigated Desert	Total with Crop Prod. Potential	Currently in Use for Crop Production				Balance[1]
	AT1 Dry Semi-Arid	AT2 Moist Semi-Arid	AT3 Sub-Humid	AT4 Humid	AT5 Marginal in AT2-AT4	AT6 Fluvisols/ Gleysols	AT7 Marginal Fluvisols/ Gleysols	Total Rainfed Potential			Rainfed	Irrigated[3]	Total		
	MS,S,VS[2]	S,VS	S,VS	S,VS	MS	S,VS	MS							(weighted)[4]	
91 Developing Countries	**153 915**	**350 226**	**593 415**	**597 949**	**517 817**	**258 130**	**65 161**	**2 536 613**	**35 870**	**2 572 483**	**633 566**	**123 012**	**756 578**	**747 019**	**1 815 905**
Sub-Saharan Africa	**88 989**	**178 969**	**294 144**	**171 096**	**155 227**	**104 521**	**15 356**	**1 008 302**	**706**	**1 009 008**	**207 203**	**5 278**	**212 481**	**159 810**	**796 527**
Angola	3 267	9 382	51 279	4 849	13 815	7 885	2 171	92 648	0	92 648	4 809	0	4 809	4 233	87 839
Benin	126	2 312	4 727	185	1 359	291	16	9 016	0	9 016	3 151	6	3 157	2 469	5 859
Botswana	5 773	36	0	0	6	1 325	9	7 149	0	7 149	1 431	3	1 434	456	5 715
Burkina Faso	2 835	10 581	3 418	0	1 833	30	0	18 697	0	18 697	6 815	18	6 833	5 446	11 864
Burundi	0	0	674	38	452	80	40	1 284	0	1 284	1 129	71	1 200	923	84
Cameroon	86	2 488	6 703	13 783	6 954	1 324	391	31 729	0	31 729	8 250	28	8 278	6 049	23 451
Central African Rep.	0	1 297	15 784	11 822	10 598	2 588	152	42 241	0	42 241	5 174	0	5 174	4 022	37 067
Chad	4 257	14 594	4 790	0	3 553	3 038	79	30 311	0	30 311	8 129	10	8 139	6 590	22 172
Congo	0	0	558	10 662	4 664	7 391	773	24 048	0	24 048	778	4	782	574	23 266
Côte d'Ivoire	0	0	5 696	9 727	5 353	590	83	21 449	0	21 449	7 131	62	7 193	5 649	14 256
Ethiopia	5 270	5 730	14 427	199	6 244	3 975	6	35 851	0	35 851	15 246	162	15 408	11 040	20 443
Gabon	0	0	0	5 631	6 021	3 253	250	15 155	0	15 155	373	0	373	221	14 782

Note: The methodology used to derive estimates of land with rainfed crop production potential is explained in Chapter 4. Given the limitations of the basic data, the estimates in this table should be interpreted with care.

1/ In some countries the balance may be negative. For an explanation see Chapter 4 (paragraphs 4.64 and 4.65).

2/ MS: Marginally Suitable; S: Suitable; VS: Very Suitable. Class AT5 contains the areas considered marginally suitable in classes AT2, AT3 and AT4.

3/ Including irrigated desert land.

4/ Land-in-use in the different classes aggregated using the following weights: 1.0 for AT3, 0.31 for AT1, 0.88 for AT2, 0.85 for AT4, 0.35 for AT5, 0.81 for AT6, 0.35 for AT7 and 2.2 for irrigated. These weights roughly reflect potential cereal yields. The thus weighted land-in-use is more comparable over countries than the unweighted total (see also Chapter 2, paragraph 2.52).

Table A.5 Land with Rainfed Crop Production Potential: 91 Developing Countries (cont.)

('000 ha)

	Land with Rainfed Crop Production Potential by Land Class								Irrigated Desert	Total with Crop Prod. Potential	Currently in Use for Crop Production				Balance
	AT1 Dry Semi-Arid	AT2 Moist Semi-Arid	AT3 Sub-Humid	AT4 Humid	AT5 Marginal in AT2-AT4	AT6 Fluvisols/ Gleysols	AT7 Marginal Fluvisols/ Gleysols	Total Rainfed Potential			Rainfed	Irrigated	Total		
	MS,S,VS	S,VS	S,VS	S,VS	MS	S,VS	MS							(weighted)	
Gambia	0	373	0	0	51	232	2	658	0	658	322	12	334	286	324
Ghana	0	640	6 136	5 325	3 050	694	57	15 902	0	15 902	4 868	8	4 876	3 803	11 026
Guinea	0	358	8 901	1 204	2 535	305	20	13 323	0	13 323	4 567	25	4 592	3 699	8 731
Kenya	3 145	2 187	1 858	58	1 165	1 109	98	9 620	0	9 620	4 789	52	4 841	3 027	4 779
Lesotho	0	260	374	0	425	0	0	1 059	0	1 059	341	0	341	282	718
Liberia	0	0	0	2 658	1 037	1 551	186	5 432	0	5 432	637	2	639	458	4 793
Madagascar	3 164	5 712	13 140	4 910	7 560	3 142	225	37 853	0	37 853	2 790	903	3 693	4 089	34 160
Malawi	0	1 101	2 811	169	1 156	746	9	5 992	0	5 992	2 654	20	2 674	2 426	3 318
Mali	9 095	9 892	2 319	0	4 055	624	338	26 323	0	26 323	8 113	205	8 318	4 513	18005
Mauritania	2 314	436	0	0	24	290	14	3 078	0	3 078	1 067	12	1 079	634	1 999
Mauritius	0	0	0	46	16	5	0	67	0	67	88	17	105	101	-38
Mozambique	2 929	19 066	19 879	953	9 197	2 463	232	54 719	0	54 719	6 168	113	6 281	5 066	48 438
Niger	10 920	448	0	0	29	176	140	11 713	13	11 726	11 059	38	11 097	3 753	629
Nigeria	4 651	17 746	23 240	5 904	7 803	5 153	392	64 889	0	64 889	31 609	865	32 474	25 891	32 415
Rwanda	0	0	266	81	326	76	13	762	0	762	997	4	1 001	633	-239
Senegal	2 183	8 471	913	0	1 188	403	56	13 214	0	13 214	5 244	178	5 422	4 122	7 792
Sierra Leone	0	0	434	1 138	1 786	521	25	3 904	0	3 904	1 901	30	1 931	1 255	1 973
Somalia	91	0	0	0	0	1 462	0	1 553	27	1 580	1 075	58	1 133	960	447
Sudan	17 136	28 784	14 983	678	7 199	11 433	1045	81 258	666	81 924	13 058	1 889	14 947	9 831	66 977
Swaziland	158	98	390	11	377	0	0	1 034	0	1 034	177	56	233	263	801
Tanzania	5 726	12 671	21 475	352	10 280	2 813	1878	55 195	0	55 195	10 653	148	10 801	8 817	44 394
Togo	0	49	2 257	843	701	158	1	4 009	0	4 009	1 991	7	1 998	1 658	2 011
Uganda	456	1 466	5 113	1 283	3 702	1 215	513	13 748	0	13 748	5 816	9	5 825	4 820	7 923
Zaire	0	0	26 206	88 587	23 797	28 202	5678	172 470	0	172 470	15 302	14	15 316	12 664	157 154
Zambia	662	14 653	27 112	0	6 387	9 977	463	59 254	0	59 254	5 540	31	5 571	5 207	53 683
Zimbabwe	4 745	8 138	8 281	0	529	1	1	21 695	0	21 695	3 961	218	4 179	3 880	17 516

Table A.5 Land with Rainfed Crop Production Potential: 91 Developing Countries (cont.)

('000 ha)

	Land with Rainfed Crop Production Potential by Land Class								Irrigated Desert	Total with Crop Prod. Potential	Currently in Use for Crop Production				Balance
	AT1 Dry Semi-Arid MS,S,VS	AT2 Moist Semi-Arid S,VS	AT3 Sub-Humid S,VS	AT4 Humid S,VS	AT5 Marginal in AT2-AT4 MS	AT6 Fluvisols/ Gleysols S,VS	AT7 Marginal Fluvisols/ Gleysols MS	Total Rainfed Potential			Rainfed	Irrigated	Total	Total (weighted)	
Near East/North Africa	**18 647**	**21 526**	**17 126**	**178**	**9 581**	**9 690**	**816**	**77 564**	**14 806**	**92 370**	**56 411**	**20 089**	**76 500**	**83 082**	**15 870**
Afghanistan	296	133	0	0	29	372	0	830	2 423	3 253	484	2 750	3 234	6 300	19
Algeria	1 325	2 479	4 820	0	947	960	10	10 541	201	10 742	7 735	366	8 101	7 104	2 641
Egypt	9	0	0	0	0	103	0	112	2 559	2 671	0	2 591	2 591	5 700	80
Iran	2 217	1 931	478	59	994	715	355	6 749	5 295	12 044	5 958	5 750	11 708	16 143	336
Iraq	168	3 113	511	0	879	1 622	1	6 294	1 891	8 185	2 230	2 546	4 776	7 347	3 409
Jordan	125	164	0	0	82	0	1	372	54	426	248	63	311	265	115
Lebanon	35	190	162	0	106	6	1	500	0	500	209	83	292	353	208
Libya	1 110	381	85	0	37	663	0	2 276	117	2 393	953	241	1 194	915	1 199
Morocco	1 368	3 747	3 780	0	1 060	1 304	57	11 316	551	11 867	9 001	1 265	10 266	9 853	1 601
Saudi Arabia	1	0	0	0	0	152	0	153	850	1 003	80	850	930	1 935	73
Syria	2 047	1 563	542	0	381	345	45	4 923	500	5 423	4 445	661	5 106	4 078	317
Tunisia	153	350	850	0	306	1 062	5	2 726	102	2 828	3 035	273	3 308	2 699	-480
Turkey	9 788	7 469	5 898	119	4 747	1 812	341	30 174	0	30 174	21 410	2 340	23 750	19 211	6 424
Yemen	5	6	0	0	13	574	0	598	263	861	623	310	933	1 179	-72
East Asia	**0**	**4 043**	**37 538**	**36 917**	**45 580**	**25 720**	**2846**	**152 644**	**0**	**152 644**	**58 532**	**18 251**	**76 783**	**80 176**	**75 861**
Cambodia	0	128	3 388	1 009	2 464	3 405	175	10 569	0	10 569	3 156	92	3 248	2 528	7 321
Indonesia	0	1 786	4 392	22 262	17 341	11 507	1220	58 508	0	58 508	15 584	7 550	23 134	27 451	35 374
Korea DPR	0	134	3 405	0	1 273	105	62	4 979	0	4 979	1 743	1 393	3 136	4 288	1 843
Korea Republic	0	0	2 287	110	1 185	313	306	4 201	0	4 201	909	1 171	2 080	3 286	2 121
Laos	0	52	2 162	1 136	3 058	373	46	6 827	0	6 827	729	121	850	742	5 977
Malaysia	0	0	0	5 538	2 796	1 535	321	10 190	0	10 190	5 055	340	5 395	4 222	4 795
Philippines	0	0	6 137	3 137	5 978	997	12	16 261	0	16 261	10 071	1 537	11 608	9 795	4 653
Thailand	0	1 793	12 317	1 372	7 440	3 455	413	26 790	0	26 790	15 116	4 217	19 333	19 291	7 457
Viet Nam	0	150	3 450	2 353	4 045	4 030	291	14 319	0	14 319	6 169	1 830	7 999	8 573	6 320

Table A.5 Land with Rainfed Crop Production Potential: 91 Developing Countries (cont.)

('000 ha)

	Land with Rainfed Crop Production Potential by Land Class								Irrigated Desert	Total with Crop Prod. Potential	Currently in Use for Crop Production				Balance
	AT1 Dry Semi-Arid MS,S,VS	AT2 Moist Semi-Arid S,VS	AT3 Sub-Humid S,VS	AT4 Humid S,VS	AT5 Marginal in AT2-AT4 MS	AT6 Fluvisols/ Gleysols S,VS	AT7 Marginal Fluvisols/ Gleysols MS	Total Rainfed Potential			Rainfed	Irrigated	Total	(weighted)	
South Asia	**30 363**	**86 074**	**61 806**	**7 090**	**29 784**	**27 148**	**2158**	**244 423**	**15 291**	**259 714**	**136 878**	**64 409**	**201 287**	**249 101**	**58 427**
Bangladesh	0	0	898	724	827	6 885	150	9 484	0	9 484	6 838	2 673	9 511	11 168	-27
India	27 840	81 032	45 579	5 015	19 175	12 149	661	191 451	0	191 451	113 753	43 036	156 789	184 969	34 662
Myanmar	1 165	3 675	11 215	1 074	7 411	5 810	1262	31 612	0	31 612	9 741	1 008	10 749	9 683	20 863
Nepal	0	515	2 135	35	1 653	951	56	5 345	0	5 345	2 443	948	3 391	4 019	1 954
Pakistan	1 334	525	151	0	108	837	10	2 965	15 291	18 256	2 540	16 133	18 673	36 691	-417
Sri Lanka	24	327	1 828	242	610	516	19	3 566	0	3 566	1 563	611	2 174	2 571	1 392
Latin America and Caribb.	**15 916**	**59 614**	**182 801**	**382 668**	**277 645**	**91 051**	**43985**	**1 053 680**	**5 067**	**1 058 747**	**174 542**	**14 985**	**189 527**	**174 850**	**86 9220**
Argentina	2 203	4 947	27 297	19 933	16 432	15 119	611	86 542	709	87 251	31 123	1 668	32 791	31 035	54 460
Bolivia	2 527	4 859	16 103	9 867	14 275	5 907	1866	55 404	0	55 404	3 533	149	3 682	3 175	51 722
Brazil	2 072	16 744	84 328	252 247	165 299	30 729	30806	582 225	0	582 225	86 799	2 563	89 362	76 133	49 2 863
Chile	2 115	1 622	1 389	144	845	1 348	197	7 660	633	8 293	2 439	1 090	3 529	4 062	4 764
Colombia	1 111	1 900	6 320	24 033	17 062	9 289	2018	61 733	0	61 733	6 954	500	7 454	6 213	54 279
Costa Rica	0	0	828	794	710	304	55	2 691	0	2 691	546	117	663	661	2 028
Cuba	16	3 676	1 623	0	1 794	302	220	7 631	0	7 631	2 320	888	3 208	3 637	4 423
Dominican Republic	42	518	979	163	614	271	18	2 605	0	2 605	955	225	1 180	1 150	1 425
Ecuador	1 438	1 862	939	4 514	2 542	1 221	597	13 113	0	13 113	2 330	550	2 880	2 905	10 233
El Salvador	0	0	1 107	0	117	53	1	1 278	0	1 278	670	116	786	859	492
Guatemala	0	0	3 054	935	1 264	820	52	6 125	0	6 125	1 911	78	1 989	1 681	4 136
Guyana	0	0	352	5 493	3 139	1 412	77	10 473	0	10 473	285	130	415	497	10 058
Haiti	29	313	212	117	303	149	2	1 125	0	1 125	1 144	73	1 217	923	-92
Honduras	0	0	1 248	1 098	1 807	536	50	4 739	0	4 739	1 008	89	1 097	957	3 642
Jamaica	87	21	9	214	113	77	7	528	0	528	232	35	267	228	261
Mexico	1 646	16 252	20 849	2 442	11 947	3 286	210	56 632	2 872	59 504	19 275	4 837	24 112	26 268	35 392

Table A.5 Land with Rainfed Crop Production Potential: 91 Developing Countries (cont.)

('000 ha)

	Land with Rainfed Crop Production Potential by Land Class								Irrigated Desert	Total with Crop Prod. Potential	Currently in Use for Crop Production				Balance
	AT1 Dry Semi-Arid MS,S,VS	AT2 Moist Semi-Arid S,VS	AT3 Sub-Humid S,VS	AT4 Humid S,VS	AT5 Marginal in AT2-AT4 MS	AT6 Fluvisols/ Gleysols S,VS	AT7 Marginal Fluvisols/ Gleysols MS	Total Rainfed Potential			Rainfed	Irrigated	Total	Total (weighted)	
Nicaragua	0	0	1 533	1 648	2 200	873	293	6 547	0	6 547	1 243	85	1 328	1 132	5 219
Panama	0	0	633	1 089	1 353	484	49	3 608	0	3 608	612	32	644	491	2 964
Paraguay	226	1 309	3 260	6 814	7 482	2 129	618	21 838	0	21 838	3 671	67	3 738	3 425	18 100
Peru	1 600	2 133	706	23 912	11 897	5 928	5027	51 203	853	52 056	2 287	1 245	3 532	4 473	48 524
Suriname	0	0	0	7 549	2 982	747	92	11 370	0	11 370	29	58	87	148	11 283
Trinidad and Tobago	0	0	175	7	57	45	0	284	0	284	108	22	130	97	154
Uruguay	0	0	0	11 547	1 257	19	8	12 831	0	12 831	1 377	110	1 487	1 345	11 344
Venezuela		3 458	9 857	8 108	12 154	10 003	1111	45 495	0	45 495	3 691	258	3 949	3 355	41 546

Notes to Tables

Table A.1. Total Population and Population Economically Active in Agriculture

The population data and projections are from UN, *World Population Prospects 1990*, Population Studies No. 120, New York 1991. (The projections are those of the Medium Variant).

The data, and in particular the projections for the population economically active in agriculture, should be understood as indicative of broad orders of magnitude. They are, as far as possible, standardized for comparability among countries and regions. They may differ from those obtained from the routine labour force survey statistics. For discussion see FAO, *World-wide Estimates and Projections of the Agricultural and the Non-Agricultural Population Segments, 1950-2025*, ESS/MISC/86-2, 1986. The basis of these estimates are the historical data up to the early 1980s from ILO's work providing internationally comparable statistics. ILO is in the process of updating these data.

Data and projections for China exclude Taiwan Province.

Table A.1a. Revised Population Data and Projections to 2025 from the 1992 UN Revision

Data and projections in this table are from: United Nations, *World Population Prospects: The 1992 Revision*, New York, 1992.

Table A.3. Cereals Sector Data

Production is gross production, i.e. before any deduction of quantities used as seed and feed. Domestic use covers total domestic disappearance of cereals, i.e. both final use for direct human consumption and non-food uses and intermediate use (feed, seed) as well as an allowance for waste, but not additions to stocks. Self-sufficiency ratios are the ratios (in percent) of production over domestic use for all purposes as defined above.

Tables A.4.1 to A.4.6 Cereals crops: Area, Yield and Production

Data are shown only for countries which in at least one of the three-year averages shown (1969/71, 1979/81 and 1989/91) had 10 000 ha or more of harvested land allocated to the crop.