WORLD AGRICULTURE TOWARDS 2010. OVERVIEW OF A FAO STUDY

NIKOS ALEXANDRATOS (*)

Abstract

This paper is an overview of an assessment by FAO of prospects in world food and agriculture to 2010, with particular reference to the nutrition, agricultural resource use and sustainability of agriculture in the developing countries. Significant progress in raising world food consumption and nutrition standards has been made in the past, but many developing countries and population groups have still food consumption levels well below what is required for adequate nutrition. The incidence of undernutrition (at some 800 million persons in the developing countries, or about 20 percent of their population) is till very significant. Progress in raising food consumption levels is expected to continue, though it will be too slow and uneven. Significant undernutrition could persist up to 2010 and beyond with only a small reduction in the absolute numbers affected, though a more significant reduction as a proportion of the population, seeing that world population would increase to 7 billion by 2010. Inadequate growth of incomes and persistence of poverty (often related to agricultural development failures, frequent occurrence of war and unsettled political conditions and an unfavourable policy environment for agriculture in the countries concerned) are the main factors that explain the failure of food consumption levels to rise in many countries by as much as required for good nutrition. With the growth rate of world population on the decline, and given the likely inadequate growth of incomes in the countries with low food consumption, it is foreseen that the growth rate of world agriculture will be lower in the period to 2010 compared with that achieved in the longer-term historical past. Net food exports from the main food exporting developed to the developing countries will continue to grow. Like in the past, and more so, production growth will depend on the growth of yields, the continuation of the agricultural research and technology diffusion effort and the adoption of policies, both general and sectoral ones, which do not discriminate against agriculture.

Résumé

Ce travail fournit une vue d'ensemble sur une évaluation faite par la FAO concernant les perspectives de l'agriculture et de l'alimentation mondiale jusqu'à l'année 2010. Il porte notamment sur la nutrition, l'utilisation des ressources agricoles et la durabilité de l'agriculture dans les pays en développement. Un progrès significatif a été fait pour augmenter au niveau mondial la fourniture de denrées alimentaires et le standard nutritionnel, mais un grand nombre de pays en développement et de populations sont à des niveaux de consommation alimentaire bien au-dessous de ce qui est requis pour une nutrition adéquate. L'incidence de la sous-alimentation (pour environ 800 millions de personnes dans les pays en voie de développement, ou à peu près 20 pour cent de leur population) reste significative. On prévoit encore augmenter les niveaux de fourniture de denrées alimentaires même s'il s'agit d'un processus très lent et irrégulier. Des niveaux significatifs de sous-alimentation pourraient persister jusqu'à l'année 2010 et même plus, avec une faible réduction seulement en termes de chiffres absolus, vu que la population mondiale s'élèvera à 7 milliards de personnes d'ici à l'année 2010. Une croissance inadéquate des revenus et la persistance de la pauvreté (souvent liées à des insuccès dans le développement agricole, au déclenchement fréquent de guerres et à la présence de conditions politiques instables ainsi qu'à un milieu politique défavorable à l'agriculture dans les pays concernés) sont les principaux facteurs qui expliquent pourquoi l'augmentation des niveaux de consommation alimentaire dans certains pays ne atteint pas les valeurs requises pour une bonne nutrition. Face à un taux d'accroissement de la population mondiale décroissant et étant donné la prévision d'une croissance inadéquate des revenus dans les pays ayant une faible consommation alimentaire, on prévoit que d'ici l'année 2010, le taux de croissance de l'agriculture mondiale sera plus faible que celui atteint à plus long terme dans le passé. Les exportations nettes de denrées alimentaires des principaux pays développés exportateurs vers les pays en développement continueront à augmenter. Comme dans le passé, et même plus, la croissance de la production dépendra de l'augmentation des rendements, de la poursuite de la recherche agricole et de l'effort de diffusion de la technologie ainsi que l'adoption de politiques tant régionales que sectorielles, qui ne font pas de discrimination contre l'agriculture.

1. Introduction

This paper is a somewhat amended version of Chapter 1 (the "Overview") of the FAO Study *World Agriculture: Towards 2010*, completed in 1993 and published with revisions in 1995 (Alexandratos, 1995, hereafter referred to as "the Study") (1). The main amendments made are the inclusion of three tables and four figures, using revised and more recent data. The text of **box 1** is new. Otherwise, amendments in the text are limited to those necessary to take into account developments to the mid-1990s. A small list of references has been added.

The Study is world wide in coverage but focuses particularly on the assessment of prospects in the developing countries (2) because this is where the major problems of food security and agricultural development are. 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, while satisfying food and other needs, the very essence of sustainability.

The importance of these issues is

(*) FAO, Rome.

(1) For recent reviews of this book see *American Journal of Agricultural Economics*, February 1996 and *Population and Development Review*, September 1996.

(2) The regional classification of the developing countries used here for presentation are given in Table 1. The rest of the world is classified as "developed countries", including the Western industrialized countries (largely, the OECD area) and the formerly centrally planned economies of Eastern Europe and the former USSR (hereafter referred to as ex-CPEs).

underlined by a number of major international conferences of recent years, e.g. the United Nations Conference on Environment and Development (UNCED), the FAO/WHO International Conference on Nutrition (ICN) and the forthcoming World Food Summit.

2. Historical developments and issues in the early 1990s

2.1 Food and nutrition: progress and failures in the historical period

World per capita supplies of food for direct human consumption are today (average 1992/94) some 19 percent above what they were 30 years ago (in 1961/63). The majority of the developing countries participated in this progress and improved nutrition. Their per capita food supplies grew by 32 percent over the same period. Another way of looking at the progress made is to note that today (in 1992/94) only 10% of the world population lives in countries with "very low" per capita food supplies (under 2200 calories/day), down from 56% in 1969/71 (see **table 1**). At the other extreme 55% of world population is in countries with "medium-high" food supplies (over 2700 calories), up from 30% in 1969/71. The great strides made by China have been a significant component of this progress.

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 no better off nutritionally than 20 years ago; and South Asia is still in a mid-low position as regards per capita food supplies (**table 1**). In parallel, continuous population growth has meant that the declines in the percentage of the population undernourished, which accompanied these increases in apparent food consumption per capita, 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.

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, up to quite recently, 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 capita 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, the development of agriculture and the increase of food production are 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.

2.2 The role of world food markets

However, global food production capabilities will continue to be important, even if the main focus is on the nutrition problem in the developing countries. The fact that in a number of countries success in improving food consumption and nutrition 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.

In particular the historical evidence needs to be interpreted with care, because the behaviour of world food markets in the past was influenced by the agricultural support policies of major cereals exporting countries. This led to surplus production, stock accu-

Table 1 ***Population and per capita food supplies*** (1)

	Population (million)			Per capita food supplies (calories/day)		
	A. Population living in Countries with given per capita food supplies					
Calories/capita/day	in 1970	in 1980	in 1993	69/71	79/81	92/94
Under 2000	1087	204	219	1950	1865	1780
2000-2200	967	1028	334	2080	2090	2075
2200-2500	362	1445	1498	2355	2305	2380
2500-2700	153	224	425	2660	2660	2605
Sub-Total	2569	2901	2477	2100	2225	2325
2700-3000	220	389	1842	2845	2820	2795
Over 3000	897	1141	1212	3245	3315	3365
World Total (2)	3686	4431	5530	2420	2560	2710
	B. Population and food supplies by developing region					
Developing Countries (3)	2583	3226	4208	2115	2310	2550
Sub-Saharan Africa	267	351	517	2120	2100	2130
Near East/N. Africa	180	235	338	2345	2820	2960
South Asia	711	892	1188	2060	2070	2355
East Asia	1147	1395	1706	2020	2320	2690
Latin Amer./Caribbean	278	353	459	2495	2720	2720
Rest of world	1103	1205	1322	3140	3230	3215

(1) Data fromUN (1994) for population and from the latest FAO Food Balance Sheets. Assuch they are somewhat different from those published in the Study.
(2) Countries with Food Balance Sheets (99.7% ofworld population in 1993).
(3) Developing countries of the Study (98.5% ofthe population of all developing countries).

mulation, subsidized exports and depressed world market prices. In addition, environmental and resource degradation problems were less of an issue than at present in the decision to support increases in production. Policy reforms under way and in prospect would contribute to all these factors playing a less important role in the future compared with the past in increasing supplies to world markets. Already such policy changes, together with a slowdown in world demand for cereal imports, have led to a decline in recent years in cereals production of the main exporting countries. These declines have been a major factor behind the fact that world per caput production of cereals is today below its peak of the mid-1980s (see below). The other major factor has been the drastic decline of both production and consumption in the formerly Centrally Planned Economies (ex-CPEs, i.e. Eastern Europe and ex-USSR) in the course of the drastic systemic reforms in their economies.

2.3 The significance of agricultural resources in the food security *problematique*

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 globally for more people but rather the fact that the population dependent on agriculture for a living continues to grow, particularly in low-income countries with poor endowments in agricultural resources, technology, etc.

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 solv ing 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 capita 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.

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.

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.

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 paper summarize, and several chapters of the Study 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

3.1 Continuing, but slower, growth in world population

The growth rate of world population has been on the decline since the second half of the 1960s and this is also true for the developing countries (**figure 1**). But the absolute annual increments are currently at their highest level, with 85-90 million persons added to the world population every year. Annual increments of over 80 million may persist for about another 20 years after which the annual growth of world population may decline also in absolute terms to reach some 50 million persons by 2050, according to the Medium Variant projections of the UN (UN, 1994). The period to 2010 is therefore at the peak of the historical evolution of world population in terms of absolute annual increments. By the year 2010 world population is projected to grow to 7.0 billion (3), up from the 5.3 billion of 1990 and the 3.7 billion of only 20 years earlier. 94 percent,

(3) The Study used a world population projection of 7.2 billion for 2010 from the UN demographic projections of 1990 (UN, 1991).

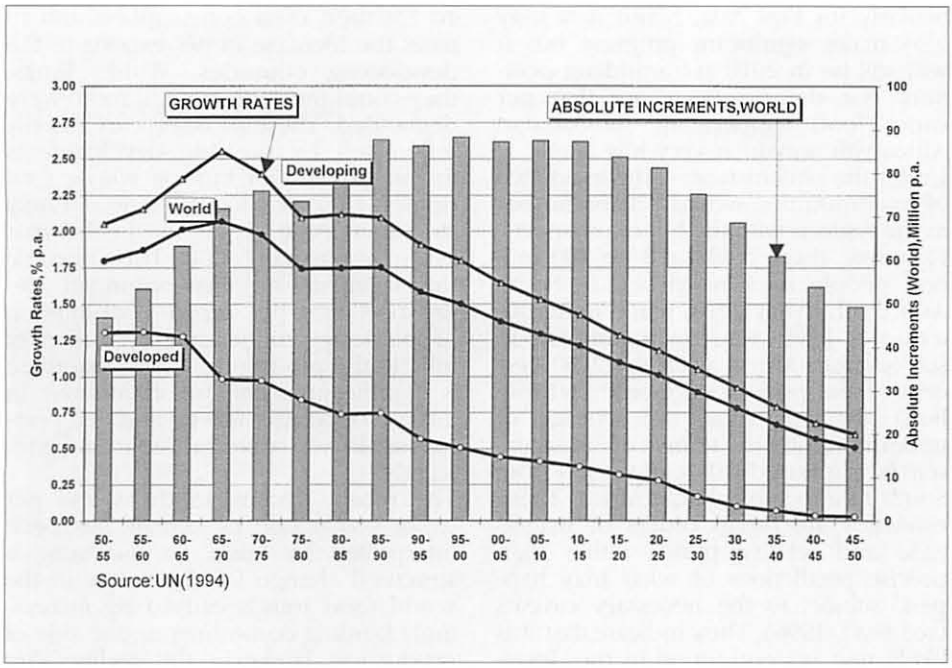

Figure 1 - Population 1950-2050: absolute annual increments and growth rates.

or 1.6 billion, of the total increment in world population between 1990 and 2010, will be in the developing countries. Moreover, the regional patterns of population growth are very disparate, e.g. 2.9 percent p.a. in sub-Saharan Africa, 1.1 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 availabilities 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.

3.2 Better prospects for overall economic growth in the Developing Countries but with significant exceptions

In the crisis decade of the 1980s, all developing regions experienced declines in per capita 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 (World Bank, 1996) indicates that Asia would continue to perform at fairly high rates of economic growth while the prospects are for only a modest recovery in the Near East/North Africa and a somewhat more substantial one in Latin America/Caribbean. 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.

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 thought to be at present (mid-1990s) about 40% below that of the pre-reform period. Although the decline is bottoming-out, it may take a long time before sustained growth re-establishes per capita incomes of the entire region at the pre-reform levels; and, of course, there are under way drastic structural changes affecting the distribution of income, food trade and modalities of access to food. These changes will have some profound influences in the demand-supply balance and agricultural trade of the region.

3.3 World agricultural growth will continue to slow down

The detailed assessments of the study indicate that the growth rate of world agricultural production at 1.8 percent p.a. in the period 1988/90-2010 will be lower than in the past. This slowdown is largely a continuation of long term historical trends. World production (gross) grew at 3.0 percent p.a. in the 1960s, 2.3 percent p.a. in the 1970s and 2.2 percent p.a. in the 1980s. There has been futher deceleration in the first half of the 1990s (mainly due to the collapse of production in the ex-CPEs), so that the growth rate of world production measured over the last 10 years 1985-95 was only 1.6% p.a., i..e. nearly zero in per capita terms. Some slowdown in world production 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 capita 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.

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. World output could expand at higher rates than envisaged in this study if effective demand were to grow faster.

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.

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 (see, for example, Lewis, 1953). 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.

3.4 Progress in food and nutrition, but not for all

The implications of the demographic and overall development prospects, together with the assessments of this study for production, consumption and trade are that per capita 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 the nearly 2500 calories of 1988/90 and the 2550 calories of 1992/94 to a little over 2700 calories by the year 2010 (*). It is likely that by the year 2010 the Near East/North Africa, East Asia (including China) and Latin America/Caribbean regions will be at or above the 3000 calorie mark, a significant progress particularly for East Asia. South Asia may also make significant progress but it will still be in 2010 at a middling position. But the prospects are that per caput food supplies in sub-Saharan Africa will remain at very low levels.

Under the circumstances, the incidence of undernutrition would decline further in the regions with the better prospects. However, there could still be 200 million people undernourished in South Asia by the year 2010, while undernutrition is likely to remain rampant in sub-Saharan Africa, with about 30 percent of the population (some 260 million) affected. Thus, the scourge of 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 (see FAO, 1996). They indicate that it is likely that undernutrition in the developing countries as a whole will persist in 2010, perhaps at somewhat lower absolute levels that at present. 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.

3.5 World production of cereals to continue to grow, but not in per capita terms

In the past 25 years, per capita production of cereals for the world as a whole grew from 302 kg in 1969/71 to a peak of 342 kg in 1984/86 but then it declined to 327 kg in 1990/92 and to 309 kg in 1993/95. The Study projected world production of cereals of 2334 million tons for 2010. With the new population projections, this translates into 332 kg per capita. The implied increase from the depressed levels of the mid-1990s includes a strong element of recovery (the 1996 forecast is for 314 kg) but even so per capita production in 2010 would still be below the peak of the mid-1980s. This projected lack of strong growth in world per caput production of cereals is, however, no cause for general alarm for the reasons discussed earlier in connection with the progre ssive slowdown in world agricultural growth. In particular, the consumption requirements for all uses in the developed countries (which had in 1988/90 625 kg of per capita total use of cereals and accounted for 46 percent of world consumption) grow only slowly and may fall in per caput terms. These countries produce collectively as much as needed for their own consumption and to meet the increase in net exports to the developing countries. Within limits, 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. This possible development has its origin in the prospect that per capita consumption of livestock products may not recover fully to the pre-reform levels, that there is significant scope for economies in the use of cereals as feed and that post-harvest losses could be reduced significantly.

The recent decline in the world per caput production of cereals has been interpreted by some as indicating a structural change for the worse in the world food trends caused by increasingly binding constraints on the side of production. However, the decline after the mid-1980s had not been associated until quite recently with rises in world market prices and was to a large measure related to policies of some major countries to control the growth of production in that period (for developments in more recent years, see **box 1**). Therefore, the decline was not signalling the onset of constraints on the production side which made it difficult to meet the growth of effective demand. The real problem must be seen in the too slow growth of effective demand on the part of those countries and population groups with low levels of food consumption.

The preceding discussion indicates that the world average per capita production has only limited value for measuring trends in world food security. It can also be misleading if it conveys the idea that with the world average constant, any gains in per caput production of one group of countries must be counterbalanced by declines in another group. This need not be the case. It was not so in the 1980s and it will likely not be so in the future. This paradox is due to the fact that the developing countries start with low per caput production and have high population growth rates, and the developed countries are in the opposite situation (for an illustration, see **table 2.1** in the Study).

In the event, per capita production of cereals in the developing countries is foreseen to continue growing, from the 216 kg in 1988/90 to 229 kg in 2010, orto 233 kg with the lower projected population of UN(1994). But their per capita consumption for all uses may grow faster than production, from 235

(*) The downward revision of the population projections (referred to in footnote 2 above) reduced the year 2010 population of the developing countries of the Study by 2.9%. The most significant decline is for sub-Saharan Africa (minus 9%), in part due to the foreseen effects of the AIDS pandemic. Obviously, if the aggregate food supplies projected for 2010 were not to be affected by the lower projected population (an assumption of doubtful validity), then the per caput food supplies would be higher than the just over 2700 calories indicated here.

THE CEREALS SECTOR OUTLOOK TO 2010 SEEN FROM MID-1996

Developments in 1990-95

World production was projected in WAT 2010 to be 2334 million tons in 2010 compared with 1679 million tons in the 3-year average 1988/90, the base year of the Study. If world production had evolved along a smooth expansion path (but this was not what the Study said, on the contrary), it should have reached a level of 1845 million tons in 1995. In the event, world production was only 1712 million tons in 1995 or, more appropriately 1770 million tons in the 3-year average 94, 95 and forecast 96. This significant shortfall raises the question whether the level projected for 2010 is still a realistic one.

To answer this question, the evolution of production must be observed at a more disaggregated level. This is done in figure 2, where it is seen that the world shortfall is mostly attributable to developments in the region E. Europe/former USSR. The Study emphasized that the early years of the projection period would be characterized by production declines occurring in the economies in transition. It also warned that structural surpluses would be lower or could even disappear and that publicly-held stocks could decrease as a result of policy reforms in the major exporting countries. These developments have happened in the first half of the 1990s and they coincided with weather-induced production declines mainly in the United States, the world's largest cereals exporter. The actual production of the developing countries has been tracking very closely the projection trajectory of the Study. Their net imports for the average of the latest two years (July/June years 1994/95 and – forecast – 95/96) are estimated to be 107 million tons, i.e. again close to what could be deduced from a smooth interpolation for 1995 along the net imports trajectory of the Study (from 90 million tons in 88/90 to 162 million tons in 2010). By implication, also their total cereals consumption (production plus net imports) has been evolving as indicated by the Study.

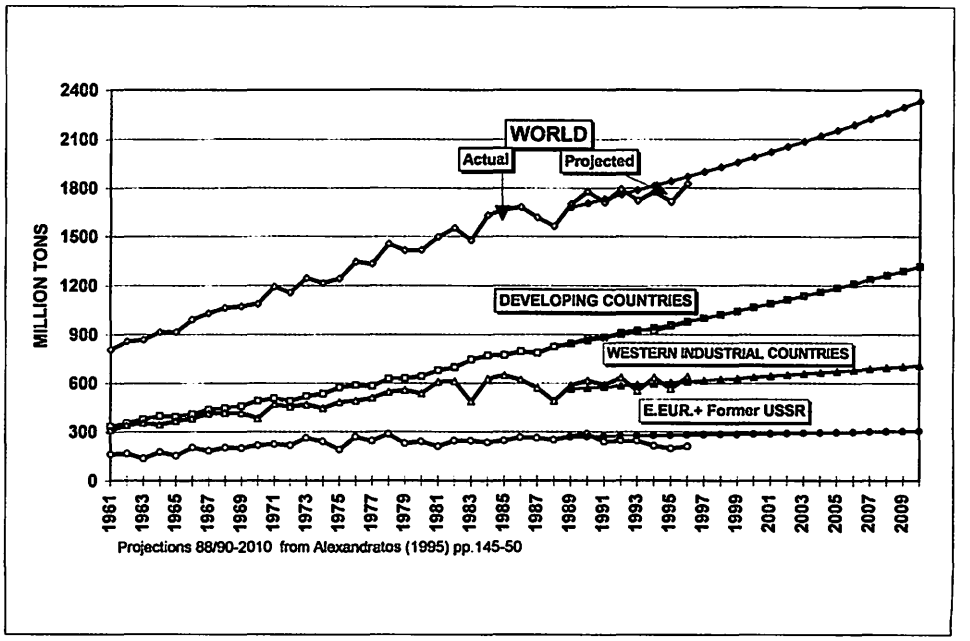

Figure 2 - Cereals production (with rice in milled equivalent).

Re-evaluating the world production outlook for 2010

The extent to which these recent developments should lead to any significant revisions of the above-indicated world cereals production projections for 2010 depends on whether any and all of the factors behind the production shortfalls in recent years (reforms in the formerly Centrally Planned Economies, weather shocks, policy reforms in the major exporting countries leading to lower publicly-held stocks) can be considered to be in the nature of a permanent structural change in the fundamentals of the world cereals economy, naturally beyond the changes already incorporated in the projections. Obviously, the production declines in the region E. Europe/former USSR are not in that category. It can be fairly safely assumed that the eventual recovery will put the region on a trajectory that would lead its production to be near the just over 300 million tons projected for 2010. However, part of the declines in the region's apparent consumption (mostly in feed and waste) are likely to prove permanent and this would lead to the emergence of the region as a small net exporter, compared with its status as a large net importer in the pre-reform period, as foreseen by the Study.

There is no hard evidence that weather-induced production shortfalls are likely to be more frequent in the future than in the past, nor that weather may affect the foreseen trend in production per se. Therefore, there is no compelling reason to assume that the projected world production for 2010 (to be understood as an average of at least 3 years) needs to be revised for this reason alone. Finally, whatever the pattern of weather fluctuations in the future, their importance for world markets must be examined in conjunction with the third above mentioned factor, i.e. the policy reforms away from the production of surpluses and towards reduced publicly-held stocks in major exporting countries. This is indeed a factor that may prove to be a permanent structural change in the fundamentals of the world cereals economy. There is at least a risk that for this reason the world cereals markets could become more volatile in the future, despite the stabilizing effect of an increasingly liberalized trading system. The magnitude of this risk is a moot point at the moment but it is the subject, together with the required measures to safeguard world food se curity, of particular attention by FAO.

kg in 1988/90 to 260 kg in 2010 (on the basis of the lower projected population of UN, 1994), a good part 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 and the 105-110 million tons of the last three years to about 160 million tons in 2010. 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. It is slightly higher than what we had projected in the mid-80s for the period 83-2000 (see **figure 3**). 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 decision included in the Final Act of the Uruguay Round of Multilateral Trade Negotiations about measures to attenuate the effects on the food importing developing countries of an eventual rise in world market prices and the provisions which favour the holding of food security stocks and the continuation of food aid flows, assumes particular importance.

3.6 Modest growth in the demand for exports of cereals from the major exporting developed regions

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 aggregate net exports to the rest of the world to grow by much less. This is because part of the increments in the net imports of the developing countries will be offset by declines in those of the ex-CPEs of Europe. This region would cease to be a large net importer in the future and there is a possibility that it could turn into a modest net exporter of cereals by 2010. Its net imports had fallen from the about 35 million tons in the pre-reform period (1979-81) to insignificant levels by the mid-1990s.

There might be some 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, in particular in the context of the provisions of the Final Act of the Uruguay Round, would probably lead to W. Europe having a smaller share in total exports in the future compared with that of the late 1980s. 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. Indeed, some more recent studies indicate that, under further policy reforms, the European Union could increase further its net exports of cereals, part of which without export subsidies, after the year 2000 (Folmer *et al.*, 1995; CARD, 1996).

3.7 Continuing strong growth in the livestock sector

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 their cereal imports will be for feed to support the 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 with East Asia, particularly China, surging ahead (see Alexandratos, 1996a) while 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.

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.

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

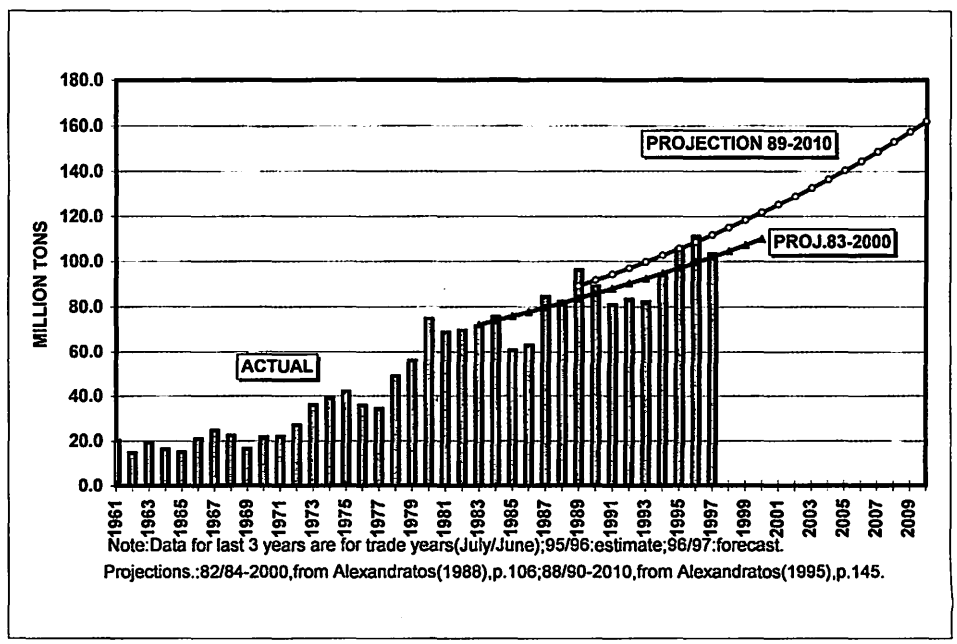

Figure 3 - Developing Countries, net imports of cereals.

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.

3.8 Roots, tubers, plantains: continuing importance in the total food supplies of countries in the humid tropics

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. Some other countries in both Africa and Latin America/Caribbean also depend significantly on these staples. Production could be increased, and will do so, 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 the 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.

3.9 The oilcrops sector of the Developing Countries: continued rapid growth in prospect

In the 20 years to 1990 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.
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.

3.10 Slower growth in the other main agricultural exports of the Developing Countries

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 less-than-average reduction in support and protection and in the 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 four-fold in the last 20 years.
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, thmre 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. 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.
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.
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.

3.11 The Developing Countries likely to turn from net agricultural exporters to net importers

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). These trends may be attenuated by the emergence as major agricultural exports of the developing countries of more dynamic products with significant market potential in the developed countries, e.g. cut flowers and tropical fruit. 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

4.1 Further intensification in prospect, with yield growth the mainstay of production increases

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). 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. However, comparisons of average yields convey only limited information about the potential for lagging countries to catkh up with the ones achieving higher yields. This is because agroecological 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 agroecological conditions.
Therefore, agroecological 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 agroecological environments (five rainfed and one irrigated - hereafter referred to as "land classes", see below) 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. The resulting trajectory of the aggregate yield of the main cereals (wheat, rice and maize) of the developing countries is depicted in **figure 4**, which also shows our projection of the mid-1980s for the period 1983-2000 (Alexandratos, 1988). 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 under 2.0 tons 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 (data and projections for cereals yields are shown in **table 2**; for more details see Chapter 4 of the Study). Naturally, further growth in yields, even at the lower rates projected here compared with the past, will not come about unless the research effort continues unabated. The effects of research on yield growth may manifest themselves in different ways compared with the past: more impact through lower, evolutionary growth in average yields based on adaptive and maintenance research and less through the achievement of quantum leaps in yield ceilings. As a result, the inter-country differentials in average yields may narrow a little, though they will remain very wide. For example, for wheat and rice, average yields of countries at the bottom of the yield league may still be in 2010 only one fifth of those achieved by the ten percent of countries at the top; and those of the largest producers may still be only one half those achieved by the countries at the top. 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 maintain-

ing and perhaps increasing yields in those farming conditions where yields achieved are near the ceilings of experiment station yields.

4.2 Land in crop production to expand and to be used more intensively

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 (see **table 3**). Over 80 percent of it is in the two land-abundant regions, sub-Saharan Africa and Latin America/Caribbean. The differences in land/person ratios among regions are enormous, with Asia and the Near East/North Africa region having particularly low land availabilities per caput. Of this total land, with rainfed production potential, 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. 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 and agroecological zones. 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 (the ratio of harvested area to arable land) 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. Achievement of the increased intensities and higher yields depends crucially on maintenance of irrigation and its further expansion by 23 million

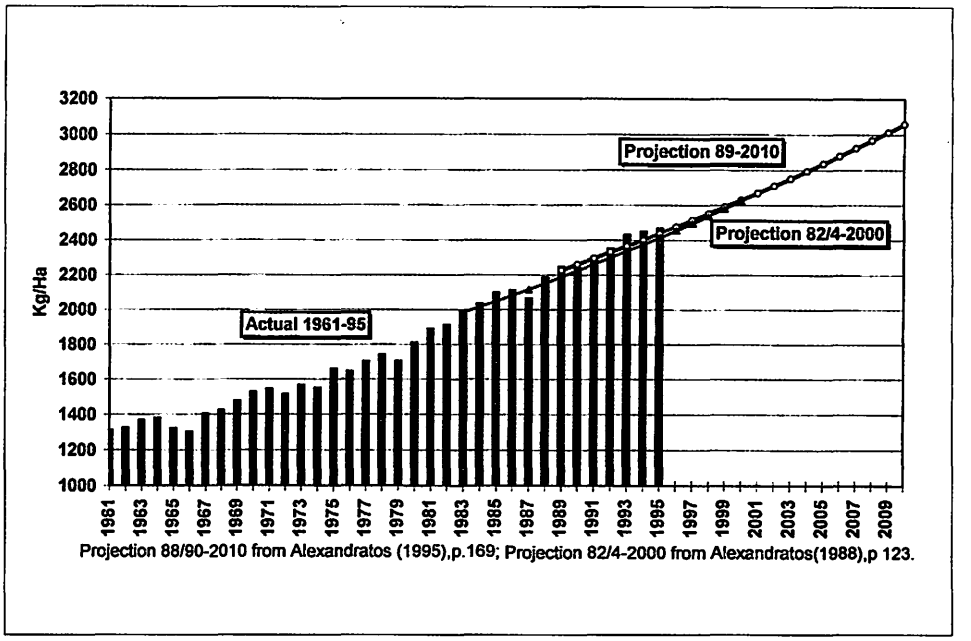

Figure 4 - Yield of wheat, rice (paddy) and maize, Developing Countries (excluding China).

Table 2 ***Cereal yields in major agro-ecological land classes and inter-country differences, Developing Countries (excluding China).***

Product/land class	Percent of production coming from the given land class, 1988-90	Yields (1) (tons/ha)				
		Average (weighted)		Country range (2)		
		1988-90	2010	1969-71	1988-90	2010
Rice (paddy), all land classes	100	2.8	3.8	0.9 - 4.6	0.9 - 6.6	1.5 - 7.2
Irrigated	58	3.7	5.2		1.7 - 7.2	3.4 - 8.0
Fluvisols and Gleysols	24	2.4	3.1		1.0 - 3.6	1.4 - 4.0
Wheat, all land classes	100	1.9	2.7	0.5 - 2.7	0.8 - 5.1	1.2 - 6.4
Irrigated	60	2.4	3.3		1.1 - 5.4	1.9 - 6.7
Rainfed, sub-humid	21	1.7	2.1		0.9 - 2.9	1.2 - 4.1
Maize, all land classes	100	1.8	2.5	0.6 - 3.1	0.6 - 4.9	1.1 - 6.0
Irrigated	24	3.8	4.6		1.6 - 7.9	2.2 - 8.4
Rainfed, sub-humid	49	1.8	2.6		0.6 - 3.7	1.2 - 4.1
Rainfed, humid	17	1.3	1.7		0.4 - 2.8	0.8 - 3.6
Millet, all land classes	100	0.7	0.8	0.4 - 1.3	0.3 - 1.4	0.6 - 1.7
Rainfed, dry semi-arid	18	0.4	0.5		0.1 - 0.6	0.3 - 0.8
Rainfed, sub-humid	27	0.9	1.1		0.6 - 1.8	0.7 - 2.2
Sorghum, all land classes	100	1.0	1.2	0.3 - 2.8	0.4 - 3.4	0.6 - 3.7
Rainfed, dry semi-arid	11	0.5	0.6		0.3 - 1.0	0.4 - 1.2
Rainfed, sub-humid	32	1.3	1.7		0.6 - 3.5	0.9 - 3.9

(1) Yields of countries with at least 50 000 ha in the land class and crop and year shown.
(2) Simple averages of the yields of the bottom 10 percent and top 10 percent of the countriesranked by yield level (not always the same countries in the top or bottom deciles in each year).

Table 3 ***Land with rainfed crop production potential, Developing Countries (excluding China).***

Class	Name	Moisture regime (LGP in days) (1)	Land quality (2)	Million ha				
				Potential	In-use		Balance	
					1988-90	2010	1988-90	2010
AT1	Dry semi-arid	75-119	VS,S,MS	154	86	92	68	62
AT2	Moist semi-arid	120-179	VS,S	350	148	161	202	189
AT3	Sub-humid	180-269	VS,S	594	222	249	372	344
AT4	Humid	270+	VS,S	598	201	232	915	883
AT5	Marginally suitable land in the moist semi-arid, sub-humid, humid classes	120+	MS	518				
AT6	Fluvisols/Gleysols	Naturally flooded	VS,S	258	64	77	259	246
AT7	Marginally suitable Fluvisols/Gleysols	Naturally flooded	MS	65				
	Total with rainfed potential (of which irrigated)			2.537	721 (87)	812 (108)	1.816	1.725
	Additional irrigation on non-suitable (arid and hyperarid) land			36	36	38		
	Grand Total			2.573	757	850	1.816	1.725

(1) LGP = length of growing period.
(2) VS = very suitable, S = suitable, MS = marginally suitable.

ha or 19 percent. 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 expanding simple water conservation and water harvesting techniques and less on indiscriminate expansion of formal irrigation. 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. It is noted that the above-mentioned 23 million ha of additional irrigation is a net increment. In practice, the gross investment requirements for irrigation will have to cover a much wider area to account for rehabilitation of existing irrigated areas and to substitute for those permanently lost because of degradation.

4.3 Would agricultural expansion encroach on the forest?

The FAO Forest Resources Assessment 1990 (FAO, 1993) produced data on the forest land of the tropical countries. Of the developing countries of the Study 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 the FAO Forest Resources Assessment. 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. Subject to the data caveats, 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 1720 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 of the Study) is about 800 million ha and the real overlap is probably much larger (5). 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 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, informal agriculture, overcutting for fuelwood and unsustainable logging continue in the future it must be expected that deforestation will continue at a much greater rate than needed for expansion of formal agriculture.

4.4 Other claims on land

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 (3000 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

(5) 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 wit0h agricultural potential but not in agricultural use.

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.

4.5 Further growth in fertilizer use and some in pesticide use in the Developing Countries

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, perhaps 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 11-13 of the Study. 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. Sub-Saharan Africa uses only 11 kg/ha. Even a doubling by 2010, as projected here, would still be too little for eliminating nutrient mining in some areas. 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 in the mid-1980s the developing countries accounted for about one fifth of world consumption of pesticides (active ingredient). They account for about 50 percent of world use of insecticides, but for much smaller proportions of fungicides and herbicides. This reflects both agroecological 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.
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

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 25 percent of the still unused land with agricultural potential in South Asia. There will be little land left for further expansion 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 112 percent to 122 percent and double the fertilizer use rate per ha.
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 in most cases it can only be accommodated by increasing the efficiency in water use. *Degradation of soils* is estimated to affect some 1.2 billion ha of land world-wide, 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 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. Degradation from nutrient mining is a serious problem, particularly in the semi-arid 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. Degradation from salinization of soils is primarily a problem of irrigated areas, but also occurs in hot dry zones. Available estimates of irrigated land losses from this cause vary widely while 10-15 percent of irrigated land is to some extent degraded through waterlogging and salinization. *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.
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.
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. 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). 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

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.

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 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).

More generally, the extent to which countries will follow more environment-friendly practices depends on their socioeconomic 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 recognise 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.

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 techni cal knowledge hold promise, but there is no guarantee that they will be sufficient in isolation.

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.

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.

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.

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. 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. 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

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. 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.

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 FAO Forest Resources Assessment 1990 (FAO, 1993) 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. 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.

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 earlier. 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. The preceding discussion is based on two premises: (a) that much of the deforestation is caused by expansion of agriculture, and (b) that it

(°) It follows, therefore, that determination of production location patterns through trade (with all countries having environmental policies reflecting their own valuations) will minimize total costs including environmental costs as perceived by the different countries, but not necessarily as measured by some universal "objective" physical yardstick. This is as it should be because sustainability and the value of the environment are anthropocentric concepts.

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. For one thing, the growing demand for forest products on the part of the rich (e.g. for tropical hardwoods) provides part of the stimulus for unsustainable forest exploitation in the poor countries. For another, it may not be concluded that the rate of damage to the forest will slow down at the initial stages 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. It appears that in the early stages of accelerated economic growth 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 (for a discussion of relevant issues see Stern *et al.*, 1996). 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

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 cons equences 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. World production of fish from capture fisheries (including fish, crustaceans, molluscs, etc.) seemed to have peaked in 1989 at about 89 million tons and by 1993 had declined to 84 to 86 million tons, but then rose again to 90 million tons in 1994. The stagnation in the capture fisheries is not temporary, but rather reflects some deep-seated structural characteristics of the resource and the way it is being exploited, the latter having much to do with the open or semi-open access regimes prevalent in the sector. However, declines in the capture fisheries have been made up to a large extent by increases in aquaculture production, which, in the last ten years, added about 1 million tons per year to aggregate fish production. In the end, aggregate production from capture fisheries and aquaculture was higher in 1994 (110 million tons) than in 1989 (100 million tons).

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), but production per caput from this source is expected to decline. It is possible for the effect on the fish supplies for human consumption to be somewhat mitigated by the addition of part of the catch of small pelagic fish, which are used in the production of fishmeal. However, the greatest scope for averting the decline in per caput production of food fish is to be found in further development of aquaculture. Continuation of the annual increase of about 1 million tons of fish from this source would be sufficient to maintain world per caput supplies for food at present levels, provided capture fishery management practices are improved and expanded, permitting capture fisheries production to remain at present levels. However, given that demand for fish products is expected to grow more rapidly than the population, particularly in Southeast Asia, unchanged per caput fish supplies will not suffike to avoid an increase in the real price of fish.

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 excentrally 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. 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. 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 de struction 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

9.1 Policies for agriculture in an economy-wide context

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 World War II 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.

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 macroeconomic 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 macroeconomic 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 macroeconomic 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 macroeconomic 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 provision of infrastructure, 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. 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 a 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 (World Bank, 1995).

9.2 Policies for, or affecting, international agricultural trade

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 agri-

cultural 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. Here belongs also the reform of the European Union's Common Agricultural Policy (CAP), with potential trade effects also noted above. These effects of the CAP reform would be for the major temperate commodities in the direction of those that are expected to be forthcoming from the application of the provisions of the agricultural part of the Final Act of the Uruguay Round of multilateral trade negotiations.

The Agreement on Agriculture of the Uruguay Round in combination with other recent policy reforms will contribute to change the structure of protection towards measures which allow an enhanced role for market forces to determine production, consumption and trade outcomes (the main provisions of the Agreement are presented in table 8.2 of the Study). But, on balance, the Agreement represents only limited progress towards free trade in agriculture. Its value is to be seen more in terms of the discipline and transparency it implies for the policies which affect trade.An important issue is the extent to which the Agreement on Agriculture may restrict the scope and flexibility of the developing countries to adopt support and protection policies to promote their agricultural development. In general terms, the provisions of the Agreement, both on border measures and domestic support, allow considerable scope for maintaining a good part of the overall support and protection existing in 1986-88, though the concrete policy instruments may have to change (Konandreas and Greeenfield, 1996). Many developing countries have set their bound tariffs well above the levels they actually applied during the base period (Alexandratos, 1996b; Ingco, 1996). In this way they reserved for themselves the opportunity to apply in the future higher levels of external protection in the form of tariffs. In addition, they could also make use of the provisions on domestic support. Of the latter, there are first those referring to green box policies which, however, are generally expensive and require considerable administrative capacity, which many developing countries lack. As regards domestic support through easily implementable policies, such as direct price support to producers (i.e. policy instruments which are considered trade-distorting and fall under the Aggregate Measure of Support – AMS – which must be reduced and, in any case, cannot be increased), developing countries are generally at a disadvantage, as they have submitted very small or mostly zero levels of AMS for the base period (1986-88). In contrast, those countries that had high AMS in the base period can, if they wish, retain a good part of it in the future (up to 80% if developed, up to 86.7% if developing). But the developing countries which had and submitted very low or zero AMS will have to resort to the special and differential provisions of the Agreement on Agriculture specific to the developing countries (e.g. investment subsidies or input subsidies, provided that they are generally available to resource poor farmers), as well as to the more generous *de minimis* clause.

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, as discussed earlier.

9.3 Issues of rural poverty and rural development

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 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 agricult ural 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. 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. 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 Programme of Action of the World Conference on Agrarian Reform and Rural Development. The report concludes that progress has been limited. 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 nonfarm 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. Beyond reforms affecting the distribution of land ownership, those of *tenancy arrangements* remain important. The lessons here are that past polacies 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.
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).
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 recognised 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. 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. *Interventions in the food and nutrition* area will continue to have a place in the total arsenal of antipoverty 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.*

9.4 Emphasis on human resources development in Developing Countries

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, in 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.
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 2500 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.

10. Concluding remarks

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. The trend could be halted or even reversed for some time if the significant part of world population with still unsatisfied food consumption needs were to be in a position to demand and/or produce food at higher rates than estimated here for up to 2010.
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 agroecological and socioeconomic 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 can be relaxed only to a limited extent through substitution by man-made resources and technology (aquaculture), 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.
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.

Finally, looking forward to the longer-term future beyond the year 2010, the Study (Chapter 3) attempts some speculative estimates of the agricultural growth requirements for up to 2025. They are meant to provide a framework for thinking about longer-term issues of world food-population balance. They are not projections of likely outcomes (*). 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 continue to fall, while the proportion of world population with relatively high levels of per caput food consumption will tend to increase, allowing limited scope for further increases. Eventually, world population growth could fall to zero and total population stabilize. If by that time all people had satisfactory levels of food consumption, there will be little further pressures for increasing agricultural production. The key issue is whether the world can tread a sustainable path to such an eventual situation of a quasi steady-state agriculture. One aspect of this issue has to do with the capability of the world's agricultural resources to underpin the growth of production to the notional steady-state level and maintain it at that level thereafter. It is not possible to give a straightforward answer to this question but the following considerations are relevant: (a) in a world without frontiers and with free movement of people and/or having conditions for greatly expanded food trade, the binding character of natural resource constraints, if they exist, will be greatly diminished; and (b) there are many countries in which both food supplies and an overwhelming part of their economy depend on local agriculture. As already noted, if their agricultural resources are poor, it is entirely appropriate to speak of agricultural resource constraints standing in the way of achieving food security for all even if one knew for certain that the world as a whole had sufficient resources to grow in sustainable ways as much food as required to meet the needs of a much larger world population. Speaking of longer-term prospects, the issue of climate change and its impact on the prospects for transiting to a situation of food security for all become important. The scientific uncertainties surrounding the extent of climate change and its impact on the production environment of agriculture are well known. What needs to be emphasized here is that eventual adverse effects of climate change on agriculture will not be confined to the countries and regions in which they occur. Impacts will be diffused throughout the world through trade and the consequent inter-regional adjustments, a factor which will play an expanding role in the future compared with the past and present. Their impact on the food security and more general welfare of individual countries and population groups will depend on the stage of development they will have reached by then which will determine their capability to take corrective action. One does not need sophisticated models to predict that any climate change that would cause the production potential of agricultural resources to deteriorate in the countries with food security problems and high dependence on agriculture can prove catastrophic for their welfare. This would still be the case even if climate change were to bring significant improvements in the productive potential of resources in the higher latitudes and result in the net increase in the global potential. In practice, the underlying theme is the same as that discussed elsewhere in this book: the link between the global production potential and food security is weak for populations trapped in a vicious circle of poverty, poor agricultural resources, high dependence on them and limited or no access to the actual or potential global plenty. Resource constraints impinging on agriculture and food production are only part of the issue whether the world can tread a sustainable path to a situation free of food insecurity. For such a world must be virtually free of poverty. The issue then becomes one of sustainable paths to poverty elimination.

This would require economic growth all round. If poverty is to be eliminated in the not-too-distant future, economic growth must be rapid in the regions with high poverty concentrations. Pressures on the wider ecosystem would increase, e.g. generation of waste from greatly increased use of energy. If the wider ecosystem had only limited capacity to absorb the impact, it is possible that environmental constraints from this origin, rather than from the agricultural resources, would condition the pace at which the world can tread a sustainable path to food security for all (for contrasting views, see Daly, 1992; Beckerman, 1995). ●

(*) For longer term projections see Crosson and Anderson, 1992, Rosegrant *et al.*, 1995 and Alexandratos and de Haen, 1995.

References

Alexandratos N. (ed.) (1988) - *World Agriculture Toward 2000, an FAO Study*, Belhaven Press, London and New York University Press, New York, and (in French) *Agriculture Mondiale: Horizon 2000, Etude de la FAO*, Economica, Paris, 1989.

Alexandratos N. (ed.) (1995) - *World Agriculture: Towards 2010, an FAO Study*, John Wiley and Sons Ltd., Chichester and FAO, Rome (published also in French by Polytechnica, Paris and in Spanish by Mundi-Prensa Libros, Madrid and Mexico).

Alexandratos N. (1996a) - "China's Future Cereals Deficits in a World Context", *Agricultural Economics*, 15, 1.

Alexandratos N. (1996b) - "Mediterranean Countries and World Food Markets", *Options Méditerranéennes*.

Alexandratos N. and H. de Haen (1995) - "World Consumption of Cereals: Will it Double by 2025?", *Food Policy*, August.

(Beckerman W. (1995) *Small is Stupid: Blowing the Whistle on the Greens*, Duckworth, London.

CARD (1996) - *FAPRI 1996 Baseline Briefing Paper (CNFAP 9/96)*, Center for Agricultural and Rural Development, Iowa State University, Ames.

Crosson P. and J. Anderson (1992) - *Resources and Global Food Prospects, Supply and Demand for Cereals to 2030*, World Bank, Washington, D.C.

Daly H. (1992) - *Steady State Economics*, Earthscan Publications, London.

FAO (1993) - *Forest Resources Assessment 1990, Tropical Countries*, FAO Forestry Paper 112, Rome.

Folmer C., M. Keyzer, M. Merbis, H. Stolvijk and P. Veenendaal (1995) - *The Common Agricultural Policy Beyond the McSharry Reform*, Elsevier North Holland, Amsterdam.

Ingco M. (1996) - "Tariffication in the Uruguay Round: How Much Liberalization?", *World Economy*, July.

Konandreas P. and J. Greenfield (1996) - "Uruguay Round Commitments on Domestic Support: Their Implications for Developing Countries", *Food Policy*, Vol. 21, No. 4/5.

Lewis W.A. (1953) - *Report on Industrialization and the Gold Coast*, Government Printing Office, Accra, Gold Coast.

Rosegrant M., M. Agcaoili and N. Perez (1995) - *Global Food Projections to 2020: Implications for Investment*, International Food Policy Research Institute, Washington, D.C.

Stern D., M. Common and E. Barbier (1996) - "Economic Growth and Environmental Degradation: the Environmental Kuznets Curve and Sustainable Development", *World Development*, 24, 7.

UN (1991) - *World Population Prospects 1990*, Population Studies No. 120, New York.

UN (1994) - *World Population Prospects: The 1994 Revision*, Annex Tables, New York.

World Bank (1995) - *A Strategic Vision for Rural, Agricultural and Natural Resources Activities of the Wordl Bank*, Washington, D.C.

World Bank (1996) - *Global Economic Prospects and the Developing Countries 1996*, Washington, D.C.