



IFA-FAO AGRICULTURE CONFERENCE

“Global Food Security and the Role of Sustainable Fertilization”

Rome, Italy, 26-28 March 2003

"WORLD AGRICULTURE: TOWARDS 2015/30"

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IFA-FAO AGRICULTURE CONFERENCE
Rome, Italy

“World Agriculture: Towards 2015/30”
Highlights¹

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1. Introduction

This paper presents in telegraphic style highlights of the just published FAO study “World Agriculture: Towards 2015/2030” (Bruinsma, 2003; Summary version in FAO, 2002a). The study is the latest in a series of long term assessments of world food and agriculture prospects undertaken in FAO at intervals of 5-10 years starting from the mid-1960s. The immediately preceding one, “World Agriculture: Towards 2010”, was published in 1995 (Alexandratos, 1995). These assessments cover many aspects of the food and agriculture sector drawing on contributions from all the technical divisions of FAO and from a number of non-FAO persons/institutions. The topics covered range from issues of food security and poverty to those of natural resources, technology, the environment and climate change to those of international trade and globalization.

In what follows, the possible evolution over the next three decades is presented of the key parameters of food and agriculture: food consumption and implications for the incidence of undernourishment, production, imports and exports of food, use of natural resources (land, water) and fertilizer, and productivity (yields). In order to better appreciate the extent to which the future may differ from past and present, the projected evolution of these variables over the next three decades is contrasted with that of the preceding three decades. Naturally, describing the historical evolution over the past three decades in terms of a single average growth rate, or by contrasting initial and terminal values, of each variable misses many essential characteristics like fluctuations and breaks in trends within the historical period, e.g. the growth up to the early nineties of the transition countries and then the sudden collapse of their agricultures, food consumption and trade during the period of systemic reforms. The reader is referred to the full study for a more meaningful interpretation incorporating more detail of time periods and more refined geographical and commodity aggregates.

In the past few decades the world made considerable progress in raising food consumption per person. Underlying this progress were quantum jumps in production. For example, world production/consumption of cereals doubled since the mid-sixties and that of meat grew 170 percent. However, these increases in production were often associated with adverse effects on the resource base of agriculture and the wider environment while at the same time exploiting a good part of the scope for productivity growth offered by known technology. Serious concerns are expressed as to the scope existing for further growth as well as whether the resource base and the wider environment can take the additional strains that would accompany future production increases without compromising the sustainability of the

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system. The first thing to ask is, therefore, how much more food the world may demand in the next three decades. This is the subject of the next Section.

2. Demand Growth and Food Consumption Levels

The developing countries will account for almost the totality of the 2.2 billion additions to world population in the three decades to 2030. Many of these countries have still low food consumption levels and therefore considerable scope for increases in per capita consumption, including for shifts of diets from staples to livestock products. The developed countries have much less scope. It follows that the bulk of the growth of the demand will originate in the developing countries¹. However, both these fundamental factors making for growth in the demand for food (the population growth and the scope for increases in per capita consumption) will be weaker forces than in the past in driving the growth of the demand for food, because:

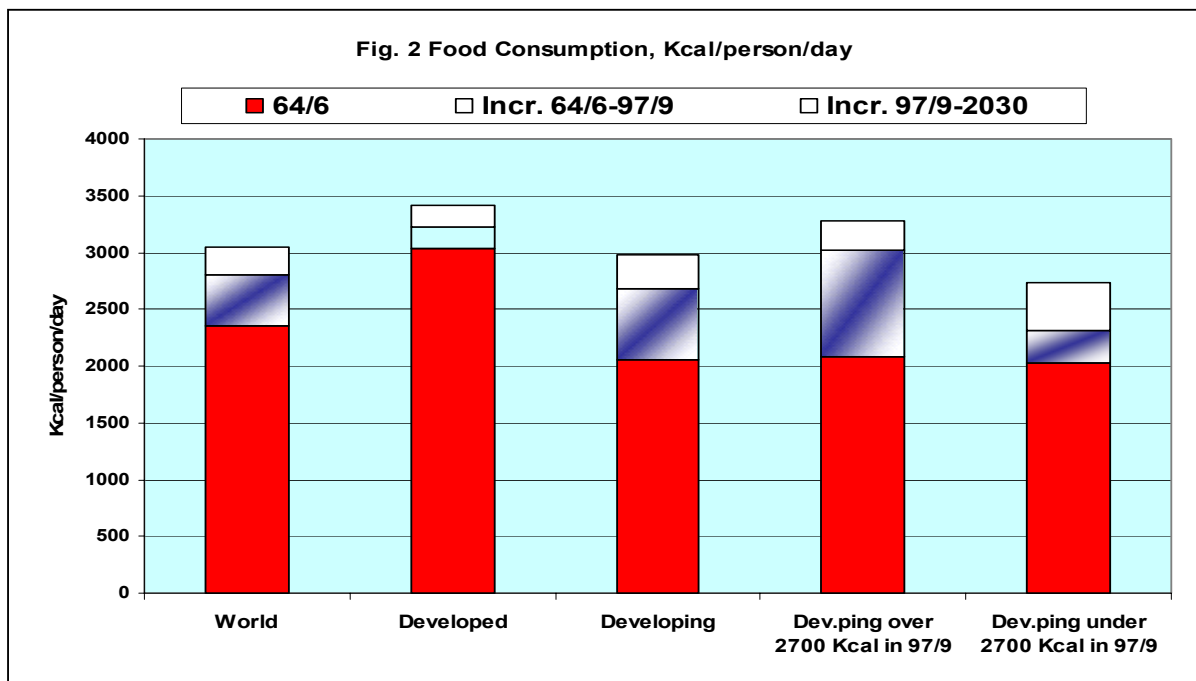
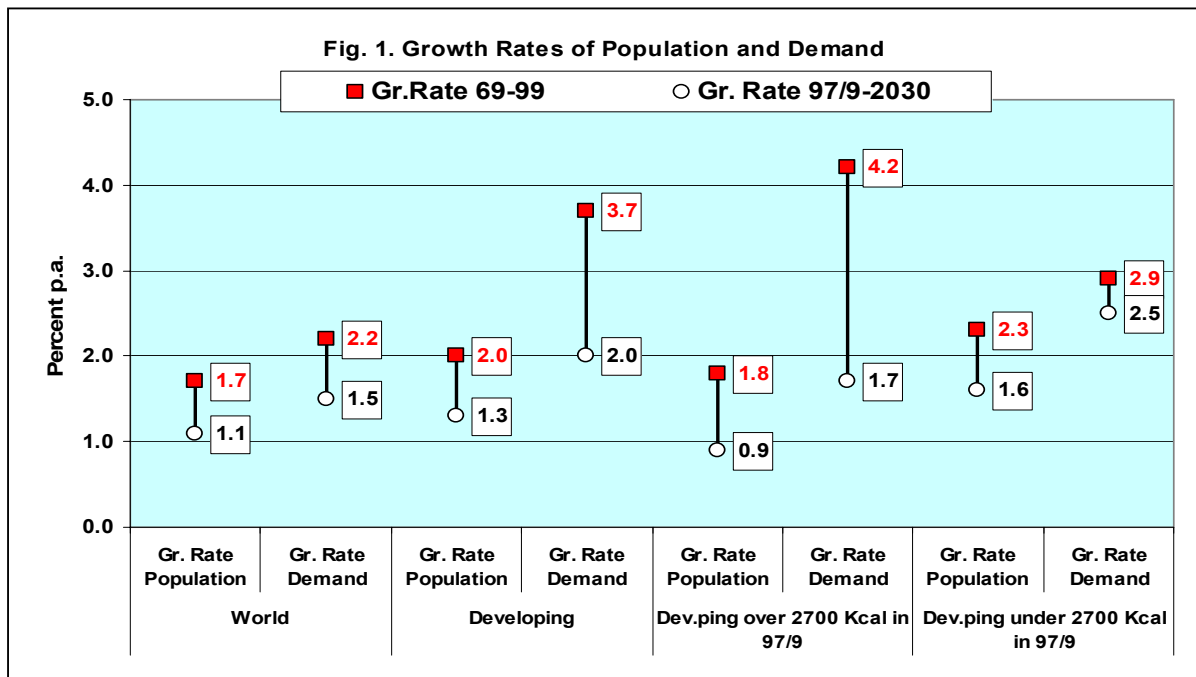
- a) The growth rate of population will be lower than in the past, and
- b) Several countries have by now attained mid-high levels of per capita consumption that leaves less scope than in the past for further increases.

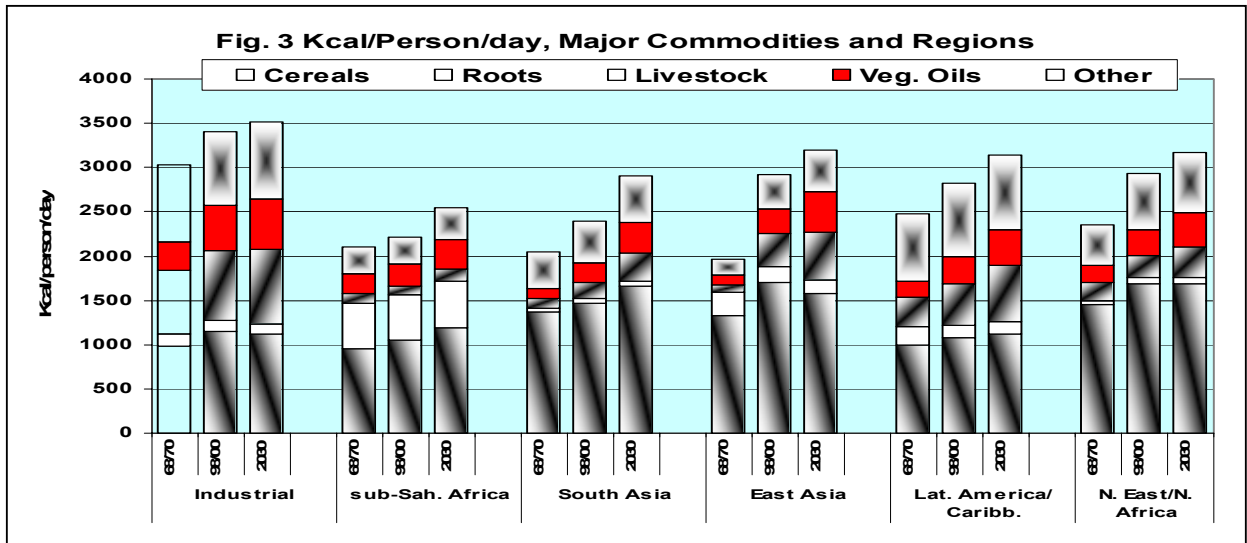
The latter point is important. To illustrate it we divide the developing countries into two groups: (a) those, foremost among them China, that in the past accounted for a good part of the growth in world demand and have by now attained mid-high levels of consumption (over 2700 Kcal/person/day each of them and a group average of Kcal 3030, having started from an average of only 2075 Kcal thirty years ago); and (b) the rest of the developing countries (those with present Kcal under 2700, many of them under 2200 Kcal, 2320 Kcal on average for the whole group). The latter group, in addition to having low food consumption levels, also has a projected population growth rate almost double that of the former group. Therefore, these countries have still considerable scope for growth in the demand for food. Such potential will materialize as actual increases in consumption fully or partially, depending on how propitious other circumstances are, e.g. income growth, poverty reduction, development of their own food agriculture, etc. For countries in this group, demand is projected to grow at 2.5 percent p.a., compared with 2.9 percent in the past. As a group, they may attain an average of 2740 Kcal by 2030, an increase of 425 Kcal in the next three decades compared with an increase of 290 Kcal in the preceding three decades.

By contrast, the former group should experience a drastic decline in the growth rate of their demand and a comparatively small addition of 250 Kcal by 2030, down from the huge 950 Kcal they added in the preceding three decades. Even so, this group should attain a fairly high level of food consumption – 3275 Kcal by 2030. All in all, aggregate world demand (all countries, all products, all uses) should grow at 1.5 percent p.a., down from 2.2 percent in the preceding three decades. Future developments in China (low population growth – 0.5 percent p.a. – and high consumption levels already achieved – 3030 Kcal/person/day) are instrumental in bringing about this expected deceleration (see Alexandratos *et al*, 2000). Excluding China from the world totals, the deceleration is much less pronounced. These declines in the growth rates of population and the demand for food are shown in *Figure 1*.

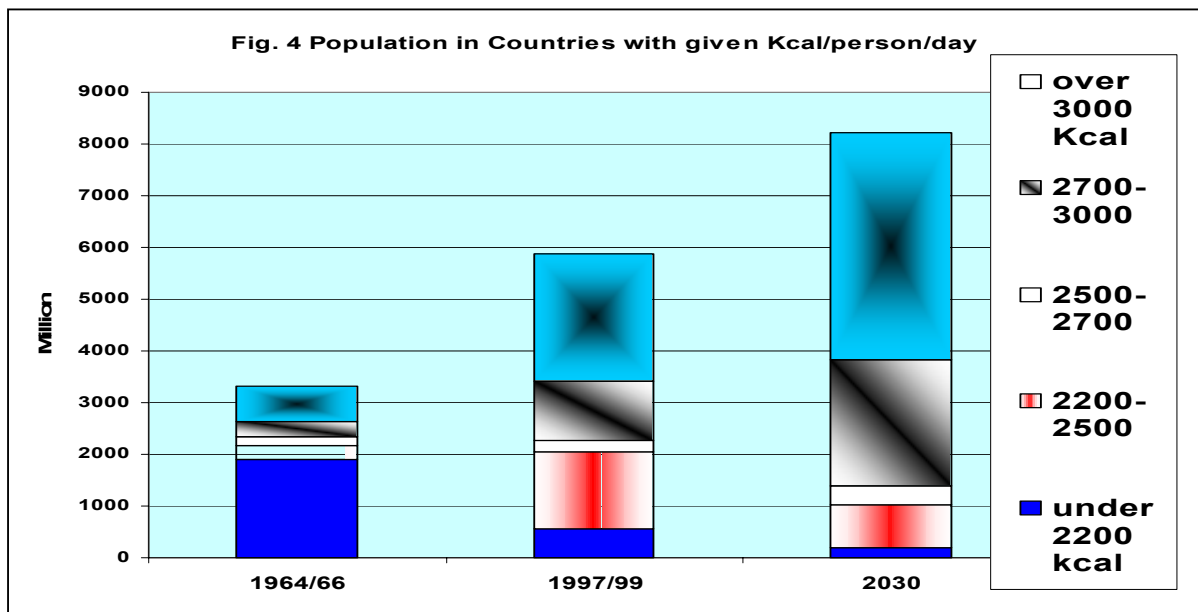
¹ For example, 82 percent of the world increment in the demand for cereals will originate in the developing countries. The proportions are 85 percent for meat, 90 percent for milk/dairy, 97 percent for sugar and 78 percent for vegetable oils.

Figures 2 and 3 give the overall picture of how the food consumption per capita may evolve over the next three decades compared to the present and to the situation prevailing 30 years ago. The world average Kcal/person/day, which grew 19 percent to 2800 Kcal in the preceding three decades (31 percent to 2680 Kcal for the developing countries), should grow by a further 9 percent in the next three decades to reach 3050 by 2030 (11 percent to 2980 Kcal for the developing countries). Like in the past, future increases in demand will reflect primarily gains in the developing countries, including structural shifts in demand and diets towards more livestock products (Figure 3). They will also reflect, but to a smaller extent, the reversal of declines in the transition economies. In the evolution of aggregate global demand, China will play a much smaller role than in the past and India a larger one.





If these projections materialized, the world food situation would continue to be transformed towards one whereby the great majority of the world population would be living in countries with “comfortable” averages. This would be in sharp contrast with the past. Three decades ago, the world was one of very pronounced inequality with, at the bottom, masses of poor (57 percent of world population lived in countries with national averages under Kcal 2200), a very thin middle class and, at the other end, a sizeable group of well to do population. By the late nineties, the situation had changed radically. Only 10 percent of a much larger global population lives now in countries with food consumption below 2200 kcal, while those in countries with over 2700 kcal account for 61 percent of world population. By 2030, those at the very bottom (in countries with under 2200 Kcal) will have declined further to 2.4 of the global population and those in the over 2700 Kcal range would have risen to 83 percent. These historical developments and the projections are shown in *Figure 4*.



3. Incidence of Undernourishment

This outlook for the broad aggregates and the prospect that ever higher proportions of world population will be well fed could lead one to expect that the problem of undernourishment would be solved or be well on its way to solution in the not too distant future, in the sense that the numbers undernourished should show significant declines. Unfortunately this is not to be. The slowdown in the growth of demand will occur even though significant parts of world population will still have not met fully their nutritional needs. If they could express their latent demand as effective demand, then world agriculture would grow a little faster than projected here. The phenomenon of demand-constrained global agriculture in the midst of widespread food deprivation affecting parts of world population is, of course, nothing new. It has been a constant feature of the world food and agriculture scene for several decades.

The latest FAO estimate of undernourishment (FAO, 2002b) indicates that 800 million persons were undernourished in 1998/00 in the developing countries. This number is not much below the estimate of 820 million for 90/92, the base used for setting the World Food Summit (WFS) target of halving the number by not later than 2015. Will this target be attained? Not according to the projections. The main reason is that poverty will continue to be widespread (see below). Several countries, many in sub-Saharan Africa, start with very adverse initial conditions: very low national average food consumption (typically under 2200 kcal/person/day, some under 2000), high incidence of undernourishment, high population growth rates and poor overall economic prospects. In these circumstances the prospects are poor that their food consumption could grow at the rates required to raise within a reasonable time span their national average Kcal/person/day to the mid-high levels normally associated with low undernourishment. As noted in the preceding section, there might still be in 2030 2.4 percent of world population (some 200 million) in countries with under 2200 Kcal, hence with high incidence of undernourishment.

We have been speaking of the national average food consumption (kg/person/year of the different food products expressed as Kcal/person/day) because FAO uses this key variable as the main piece of data, available for all countries in the world, for measuring/estimating the incidence of undernourishment. A low national average that is not much above the minimum requirement is bound to be associated with significant undernourishment (for more discussion and issues relating to the method see Bruinsma, 2003, Box 2.1; also Mason, 2002). A mid-high national average can be associated with undernourishment of part of the population in the presence of poverty and inequality of incomes and access to food, a common characteristic in varying degrees in almost all countries. In practice, some large countries with high national average Kcal (e.g. China with 3030 Kcal) or middling ones (e.g. India with 2430 Kcal) account for a good part of the 800 million undernourished (120 million and 233 million, respectively – FAO, 2002b, Table 1).

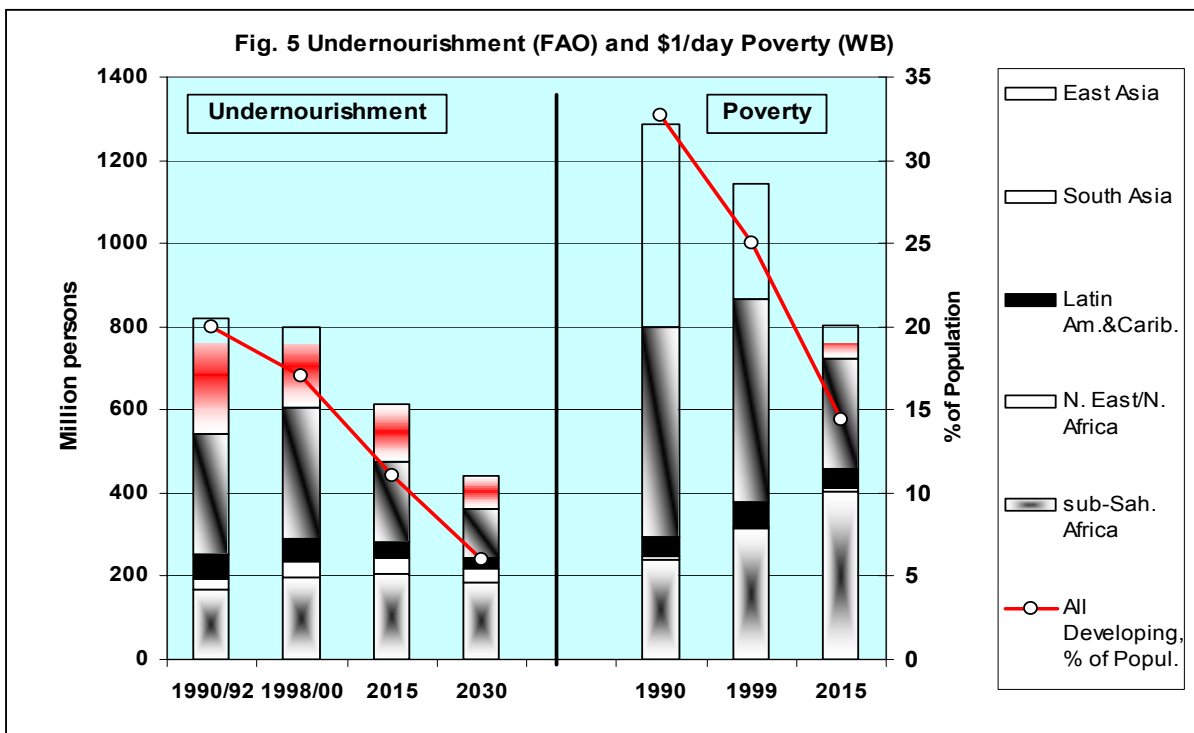
Historical values of the national average food consumption are estimated from the primary food production and trade statistics of the different countries. These primary data are processed in the food balance sheets to generate the national average food consumption of the different commodities in kg/person/year, subsequently converted into Kcal/person/day. Obviously, the accuracy of the primary data is of the utmost importance¹. For the projections,

¹ If the primary country data on production and trade (as well as the population data used to derive the per capita numbers) contain errors, so will the estimates of undernourishment (see discussion in Bruinsma, 2003, Box 2.2).

the Kcal/person/day are derived from the projected consumption per capita of the individual commodities of the study. In translating these projected national averages of food consumption into projections of undernourishment, account is taken of the prospect that the inequality of access to food will be somewhat less pronounced than at present, because the incidence of poverty, although still widespread, will also be less.

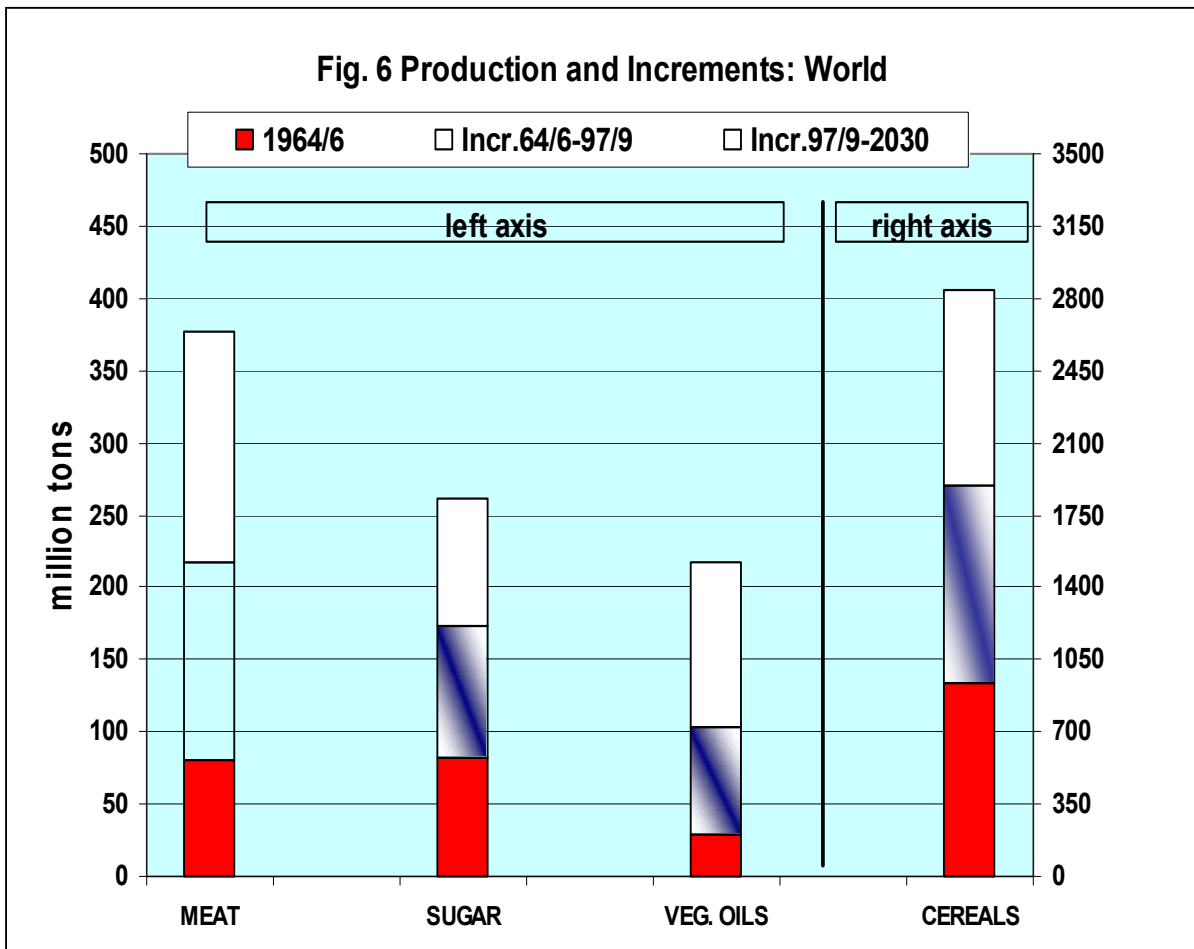
Figure 5 indicates that the reductions in the numbers undernourished in the developing countries will likely be rather modest, though the percentage of the population affected will decline significantly. Thus, the percentage could fall to 11 percent in 2015 and to 6 percent by 2030, i.e. fall by 2030 to almost one third its current value of 17 percent. However, population growth means that these rather significant declines in relative incidence (percent of population), when applied to the ever growing population, translate into only modest reductions in absolute incidence (numbers affected). Thus, there might still be some 610 million undernourished in 2015, i.e. falling well short of the WFS target of halving the 820 million of 90/92 by 2015 at the latest. We may have to wait until 2030 before the numbers of undernourished are reduced to some 440 million, i.e. to nearly the WFS target.

These findings indicate that achieving significant declines in the incidence of undernourishment may prove to be more arduous than commonly thought. The main reason is that poverty will continue to be widespread. By implication, so will be the persistence of significant parts of the population having inadequate access to food, although targeted policies (predominantly those giving priority to local agricultural development) can mitigate the impact of poverty on undernourishment – see concluding section. *Figure 5* also shows the poverty projections of the latest World Bank assessment (World Bank 2002, Table 1.9). It shows that by 2015 there may still be some 800 million persons in the developing countries (14 percent of their population) below the \$1/person/day poverty line, compared with the 1150 million of 1999 (25 percent of the population).



4. Production

As noted, the world produces currently volumes of agricultural products that are twice, or more than twice, as large as those produced in the mid-sixties. These huge increases were part and parcel of the process towards a better fed world at a time when world population was growing at record levels, going from 3.3 billion to 6 billion. The feat must now be repeated because production increases of similar orders of magnitude or higher are in prospect for the main commodity groups over the next 3 decades. Thus, almost another billion tons of cereals must be produced annually by 2030, another 160 million tons of meat, and so on (*Figure 6*). The growth rates will, of course, be lower than those of the historical period because of the much larger base from which the projections start (*Figure 1*). A growing part of world production will originate in the developing countries (*Figure 7*). For example, two thirds of world meat output will originate in the developing countries by 2030. The share was only thirty percent 30 years ago. Similar, though less pronounced increases in the shares are in prospect for all commodity groups, e.g. the shares are 72 percent vs. 59 percent for oilcrops, 81 percent vs. 59 percent for sugar and 58 percent vs. 42 percent for cereals.



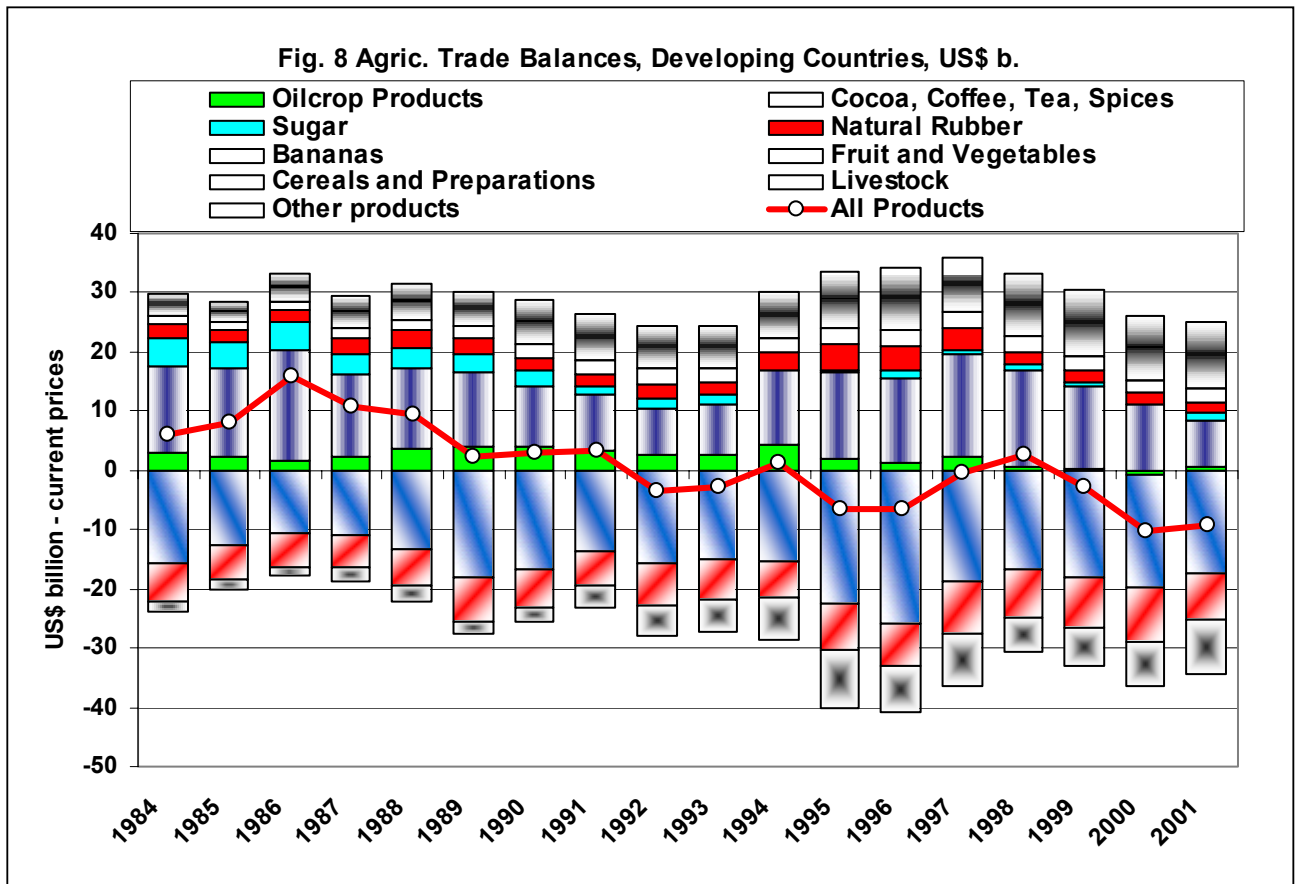
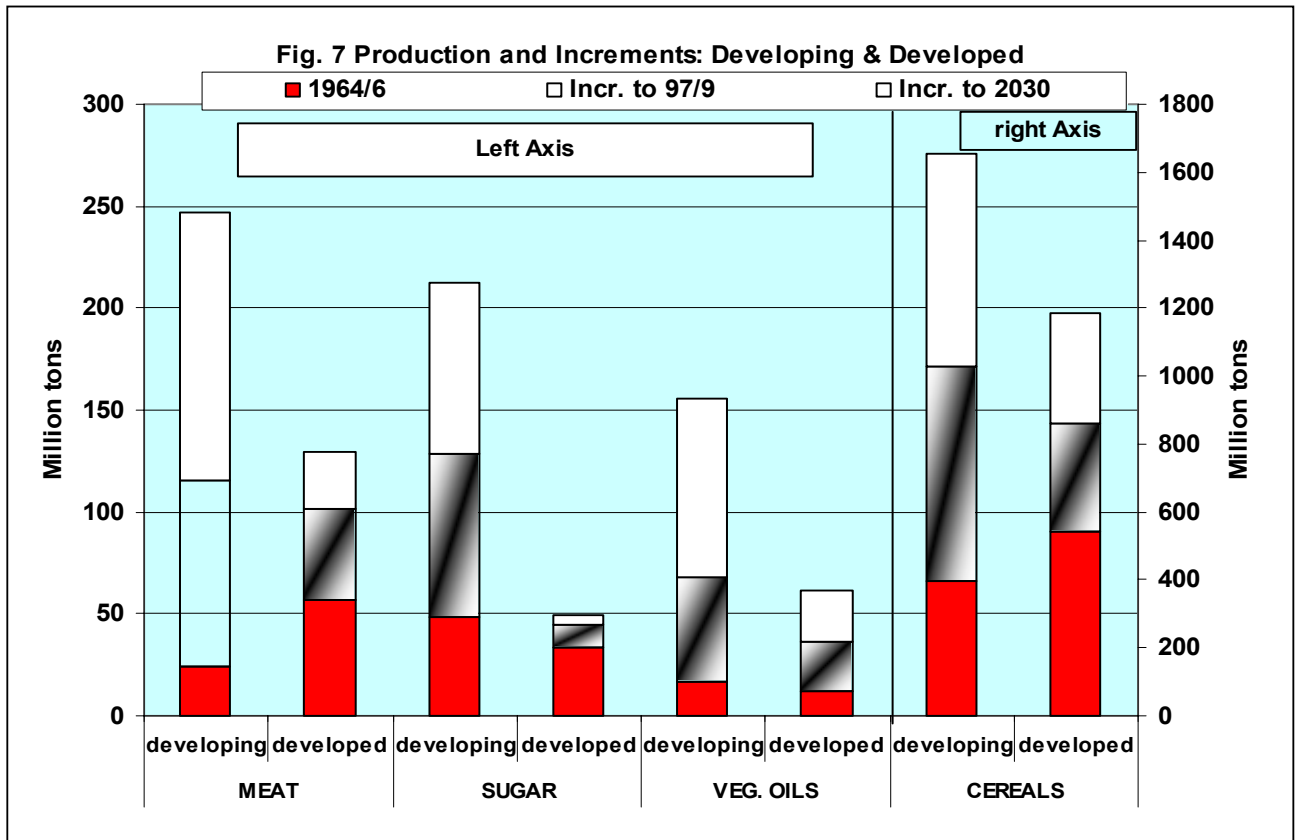
5. Imports and Exports

Since the turn of the 1990s and in most years of the decade the developing countries have turned from their traditional status as net exporters of agricultural products into net importers¹ (*Figure 8*). Traditionally and up to the early 1990s, their exports of mainly tropical products (beverages, bananas, sugar, oils and oilseeds, rubber, etc) usually exceeded their imports of temperate zone foodstuffs, mainly cereals and livestock products. However, the trend has been for imports to grow faster than exports. The main reasons are as follows:

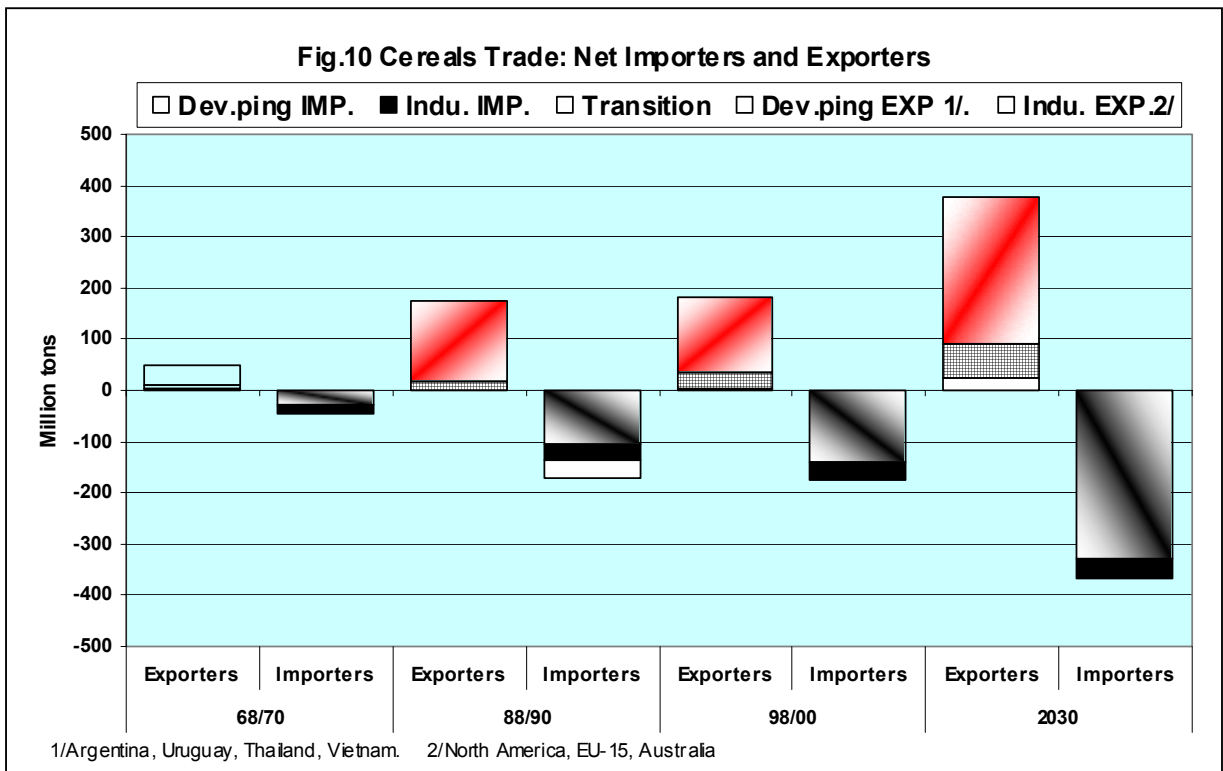
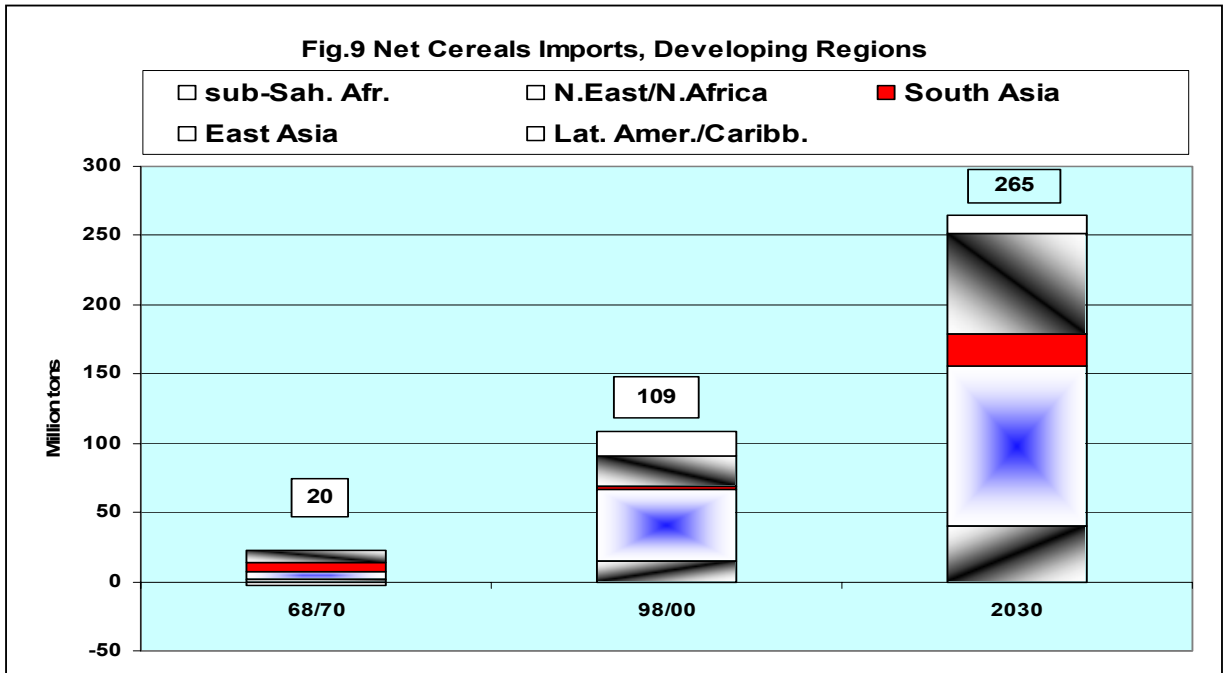
- a) Their net exports reflect the evolution of demand for their main exportables (tropical products, etc) in the developed countries, which has been growing slowly (low population growth, saturation of consumption). In parallel, their imports reflect the evolution of their own demand for food, which has been growing fairly fast, particularly for commodities like wheat and livestock products, of which the industrial countries are the main surplus producers and exporters.
- b) Support and protection policies in the main industrial countries have discouraged imports, particularly of commodities like sugar, while they provided subsidized exports to them of cereals and livestock products but also of sugar.
- c) The net balance in current prices reflects also movements in prices in world markets. Part of the fall in the net agricultural trade balance of the developing countries is attributable to price declines of their exports, the latest example being the collapse of coffee prices in recent years.
- d) Finally, several developing countries emerged as major importers of commodities exported by other developing countries (e.g. sugar and vegetable oils – for details see Bruinsma, 2003, Tables 3.20-3.25). The result has been that net exports from the developing countries as a whole of some key commodities like sugar and oilseeds/oils have virtually stagnated, no matter that the developing country exporters of these commodities have increased their exports very fast, e.g. sugar from Brazil, and oils/oilseeds from Malaysia, Indonesia, Argentina and Brazil.

These trends are set to continue in the future. Net imports of cereals and livestock products would continue to grow fairly fast, while net exports of tropical products to the developed countries will continue to expand at slow rates. In parallel, the importing developing countries will continue to increase their imports of key exports of other developing countries. For example, the developing exporters of vegetable oils may double net exports but the deficit developing countries will more than double their net imports by 2030. In parallel, net cereal imports of the developing countries as a whole, which grew more than 5-fold in the preceding three decades (from 20 million tons in 68/70 to 109 million tons in 98/00), may grow 2.5-fold again in the next three decades to 265 million tons (*Figure 9*). The Near East/North Africa region will continue to predominate as the major importing region, followed by East Asia. Net imports of meat may exhibit even faster growth.

¹ All crop and livestock products, primary and processed. Fisheries and forestry trade not included.



A major structural change in the world cereals economy is the expected transformation of the region E. Europe/former USSR (transition economies) from the large net importer it had become up to the early 1990s (net imports of 38 million tons in 90/92) to a significant net exporter. This process is already underway: preliminary estimates for 2001/02 trade year (July-June) suggest net exports of over 20 million tons following record harvests. The transformation of this group of countries from large net importer to a sizeable net exporter is replicating, although for different reasons, the experience of the EU (from net importer up to the early eighties to a sizeable net exporter currently) and will likely contribute to keeping an easy balance between demand and supply in world markets (*Figure 10*).



6. Land

As noted, the production increases in the next three decades are to be no smaller than those of the past three decades in absolute terms (Figure 6), no matter that the growth rates will be significantly lower (Figure 1). These future increases must be achieved starting from a resource base that is today much more stretched than in the past. It can therefore be deduced that the task of obtaining these production increases while minimizing adverse effects will prove more arduous than in the past. Risks are further enhanced by the prospect that growing shares of the increments in world production will originate in the developing countries (two thirds of the additional production of cereals, about four fifths of that of meat and vegetable oils/oilseeds, 95 percent of sugar, etc – Figure 7). This means that pressures will be increasingly gathering in the agro-ecological environments of the tropics which are more fragile than the temperate ones and contain much of the world's biodiversity. In addition, in the developing countries, conventional objectives of agricultural development (food security, employment, export earnings) usually take precedence over those of sustainability and environmental conservation, no matter that for them the preservation of the productive potential of their agriculture is much more crucial for their survival than it is for the industrial countries where agriculture is a small part of the economy.

Given scarcities of suitable agricultural land in several developing countries, there is no escape from the necessity for a good part of the required production increases to come by extracting more output from each ha cultivated. That is, agriculture will be becoming ever more intensive. Obviously, what is required is intensification that can keep threats to the resource base and the wider environment within bounds not threatening the sustainability of the system. This means more emphasis on science-based agriculture, not less. The problem here is that the research and technology capabilities for finding solutions to respond to the problems reside predominantly, though not exclusively, in the industrial countries, not in the developing ones where they are most needed¹. The problem may be compounded by the fact that many of the technologically advanced societies, at least the well-fed ones, are increasingly questioning the wisdom of pursuing along the path of ever more intensification. As more and more well-to-do societies enter the stage when they have no use, or in any case a low preference, for more and cheaper food, dimensions of agricultural resource use other than just producing more food and/or reducing production costs tend to take precedence in their hierarchy of values and preferences. Rural development, environmental conservation, animal welfare, food quality and safety are among those other dimensions. It is no wonder that the most vocal opposition to the conventional agricultural practices and to further applications of modern biotechnology has originated in such well-to-do societies.

Here follow some indications of how the land, water and yield combinations underlying the production increases in the developing countries may evolve in the period to 2030:

Land: Harvested Area - Main Crops. Land in crop production has been growing, with all increases originating in the developing countries. Such increases more than offset declines in the industrial countries and the transition economies. Overall, in the developing countries harvested area, both rainfed and irrigated, under the main crops (cereals, oilcrops, fiber crops,

¹ Louise Fresco (2003) speaks of a “molecular divide” referring to the gap between developed and developing countries.

sugar crops, root crops and pulses – 84 percent of the total under all crops) increased by 151 million ha in the last three decades, while that in the rest of the world (the industrial countries and the transition economies of E. Europe and the former USSR) declined by 35 million ha. The decline in the industrial countries has been the result of inadequate growth of demand for the output that the land could produce, as witnessed by the land set-aside policies. In addition, the incessant growth of yields meant that it has been more economical for farmers to obtain whatever increases in output the market demanded through yield growth using less land. These trends in no way indicate that the process of land expansion was reversed because it hit resource limits. In the transition economies the decline was largely the result of the shrinkage and collapse of their agriculture, following the more general economic dislocations associated with the systemic reforms of the 1990s.

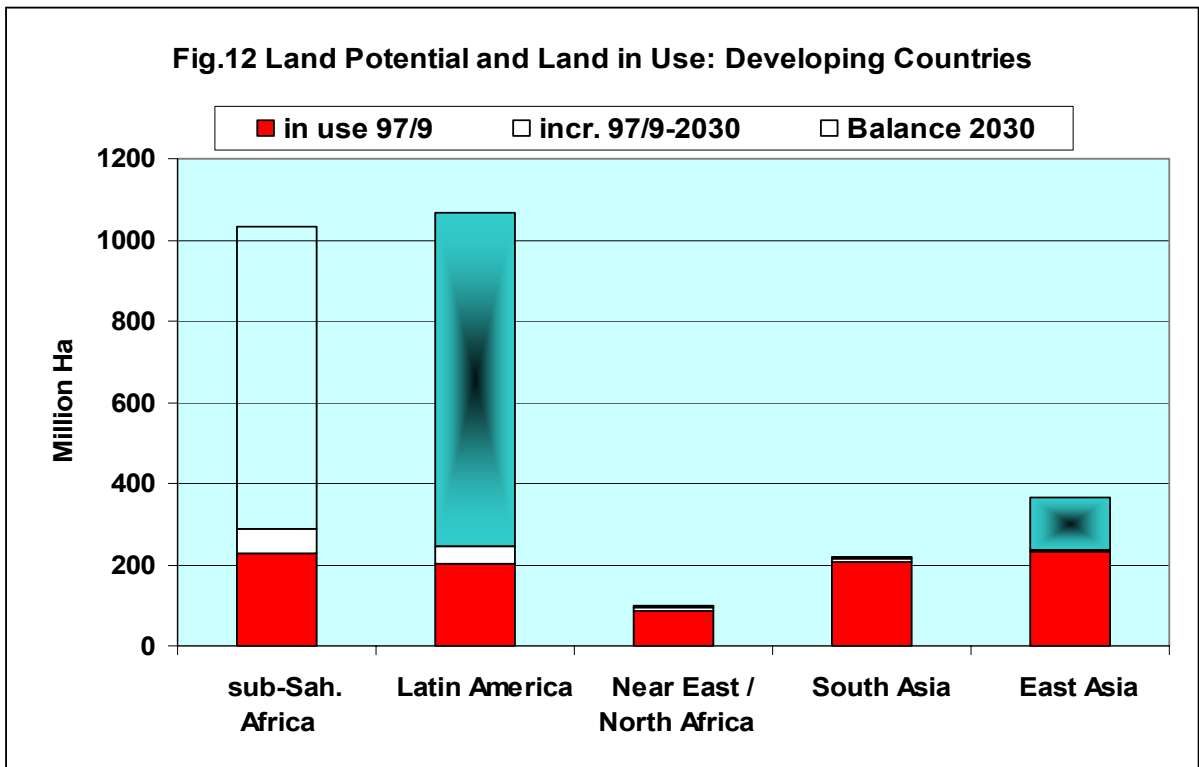
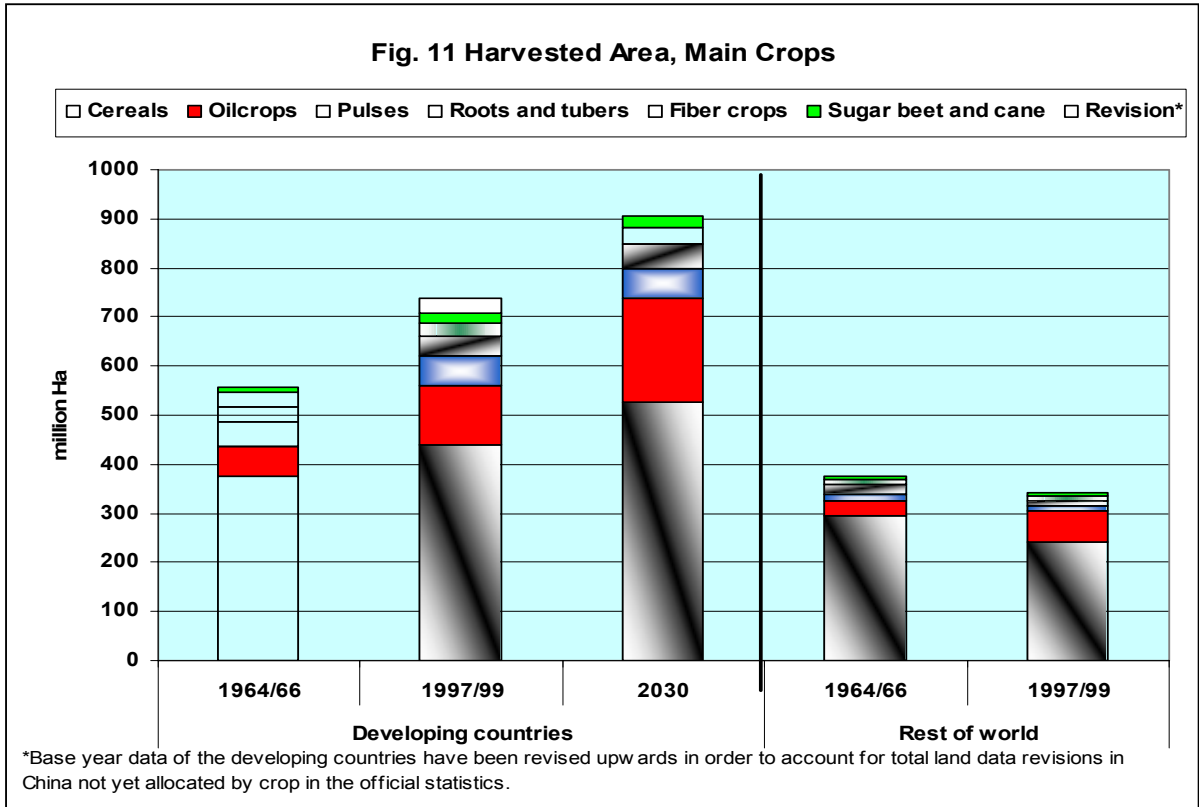
Land expansion will continue to be a significant factor in the growth of agriculture in those developing countries where the potential for expansion exists, the population dependent on agriculture continues to grow, or in any case is not declining fast enough, and the prevailing farming systems and more general demographic and socio-economic conditions do not favour intensification and associated yield growth. In the projections, the harvested area under the above-mentioned crops in the developing countries should increase by another 165 million ha (or 180 million ha for all crops) in the next three decades (*Figure 11*; no projections were made for the industrial and transition countries).

Land Expansion in Relation to Potentials. About one third, or some 60 million ha, of the increment in harvested area of the developing countries should come from higher cropping intensities (reduced fallows and growing more than one crop per year on the same piece of land). The rest (120 million ha) should represent expansion of crop production into land not yet under crops. This is a small part of the total land of the developing countries which is classified as being suitable, in varying degrees, for growing rainfed crops. Estimates by the FAO and IIASA in the agroecological zones study (Fischer *et al*, 2000) indicate that the developing countries have some 2.8 billion ha of land (38 percent of their total land area) with varying potentials for growing rainfed crops, of which about 1 billion ha is already in crop production use.

Naturally, the mere existence of land with agricultural potential does not imply that it is readily available for crop production. Much of the yet unused land is concentrated in a small number of countries, mainly in South America and sub-Saharan Africa. Therefore, it is not available for agricultural expansion in the countries facing severe land scarcities. These two regions will account for the great bulk of the 120 million ha expansion. In contrast, there is virtually no spare land in South Asia and the Near East/North Africa. *Figure 12* shows the relevant data and projections.

There are further factors limiting the expansion of agriculture into new land. Where spare land exists, it can be under forest and subject to several constraints severely limiting its ready availability for agricultural expansion without significant investment (e.g. ecological fragility, soil toxicity, high incidence of disease and non-accessibility due to lack of infrastructure). It is noted that the very concept of suitability of land for producing any given crop varies with socioeconomic conditions and the evolution of technology. For example, sloping land on hillsides with low yield potential may be terraced and exploited in low income countries but not in high income ones (see Alexandratos and Bruinsma, 1999).

Such land will tend to become unsuitable (economically) for agricultural exploitation over time and may be abandoned (e.g. in the Andes or in the Mediterranean) as development offers alternative income-earning opportunities.



7. Water and Irrigation

Water scarcities are becoming increasingly severe in many parts of the world. This notwithstanding, estimates indicate that there is still potential for expansion of irrigation in several countries. FAO has evaluated potentials using predominantly national data combining water resources and land suitability¹. The estimates suggest that the developing countries (where the bulk of world irrigated area is) have a potential of about 400 million ha, of which about one half is currently being exploited. The attainment of the production increases would require that another 40 million ha be brought under irrigation in the developing countries by 2030, the bulk of it in Asia (*Figure 13*). This is a 20 percent increase over present levels and it is considered that it can be achieved with a 14 percent increase in water withdrawals for irrigation by increasing water use efficiency from 38 percent at present to 42 percent in 2030².

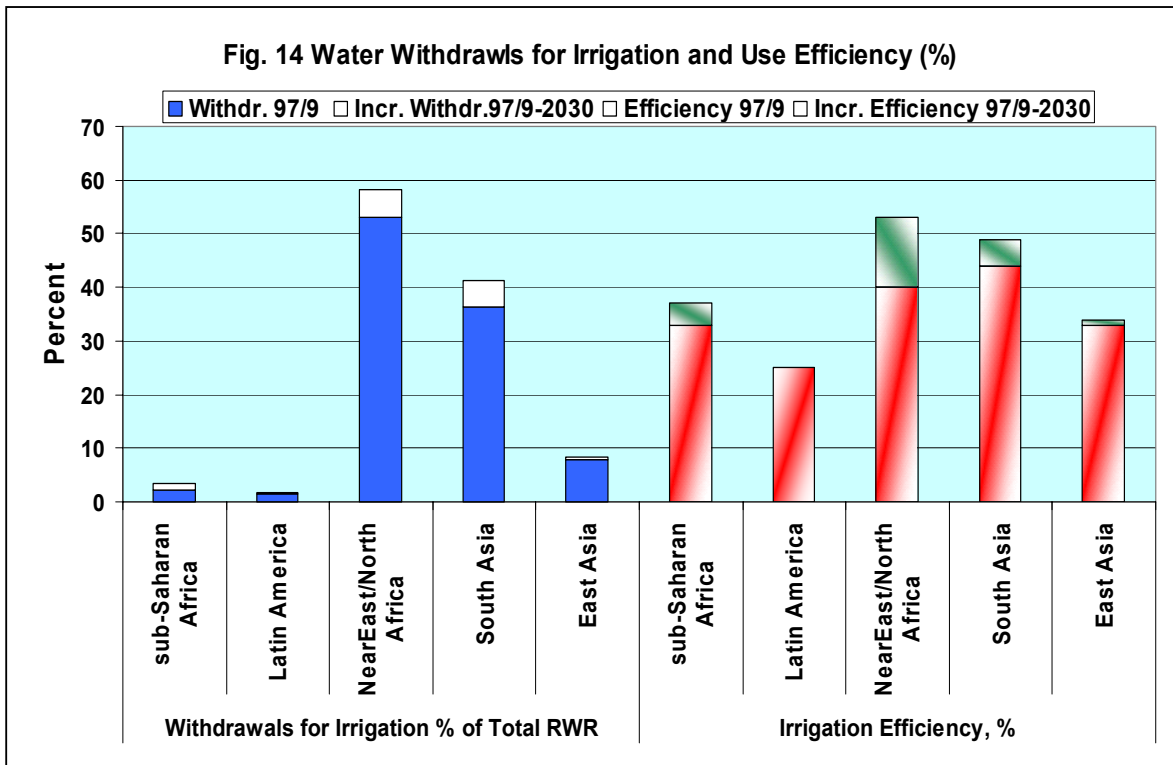
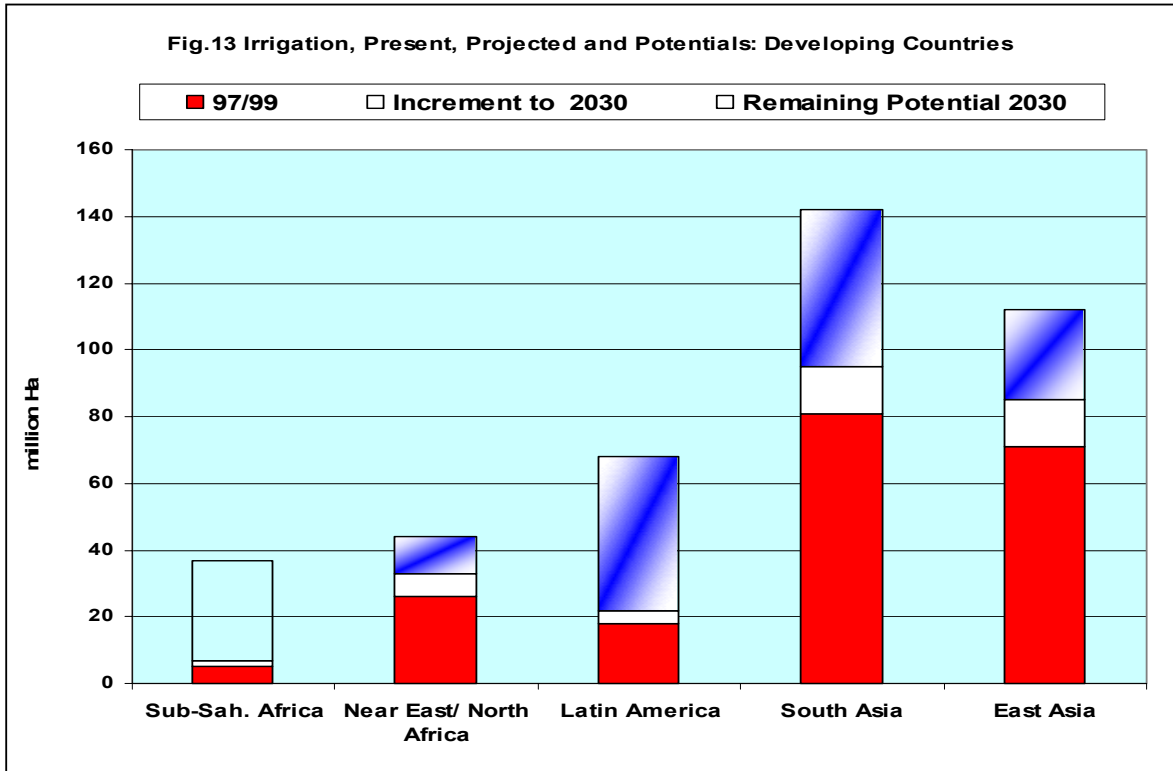
Figure 14 highlights the great inter-regional differences in the amount of water used for irrigation (as percent of total renewable water resources - RWR). Such use ranges from a very high 53 percent of total resources going to irrigation in the Near East/North Africa region (the proportion may rise further to 58 percent by 2030) to only 1 percent in Latin America. Irrigation withdrawals in excess of 20 percent of RWR often denote impending water scarcities. Overall, there are 18 developing countries (of the 93 of the study) with irrigation withdrawals exceeding 20 percent of their RWR, of which 10 exceed 40 percent. Naturally, indicators of scarcity or abundance at the level of large regions convey little useful information because these concepts have an operational meaning only for areas within which there is a potential for matching needs with availabilities. The country level estimates underlying these regional numbers come closer to fulfilling the need for a more purposeful measure, although for large countries much finer sub-national data would be needed. For example, South China has good water resource potential but this is poor consolation to the water-scarce northern regions, in the absence of inter-basin water conveyance infrastructure. A major project (USD 59 billion) in this direction was to start at end-2002³. Likewise, India's Eastern Himalayan region is abundantly supplied and flood-prone while the western and southern regions face scarcities and risks of drought. It is reported that India is contemplating a giant scheme⁴ that would control floods in the flood-prone regions and convey water to the drought-prone ones.

¹Irrigation potential is defined as "...area of land suitable for irrigation development. It includes land already under irrigation. Assumptions made in assessing irrigation potential vary country to country. In most cases, it was computed on the basis of available land and water resources, but economic and environmental considerations may also have been taken into account. Some countries include the possible use of non-conventional sources of water for irrigation. Except in a few cases, no consideration is given to the possible double counting of shared water resources between riparian countries. Wetland and floodplains are usually, but not systematically, included in irrigation potential". (FAO, 1997)

² Irrigation efficiency: ratio between consumptive water use in crop production (the amount of water needed to compensate for the deficit between potential evapotranspiration and effective precipitation during the growing period of the crop) and water withdrawals from the reservoirs (for details see Bruinsma, 2003, Box 4.3)

³ *Xinhua News Agency*, Beijing, 27 December 2002.

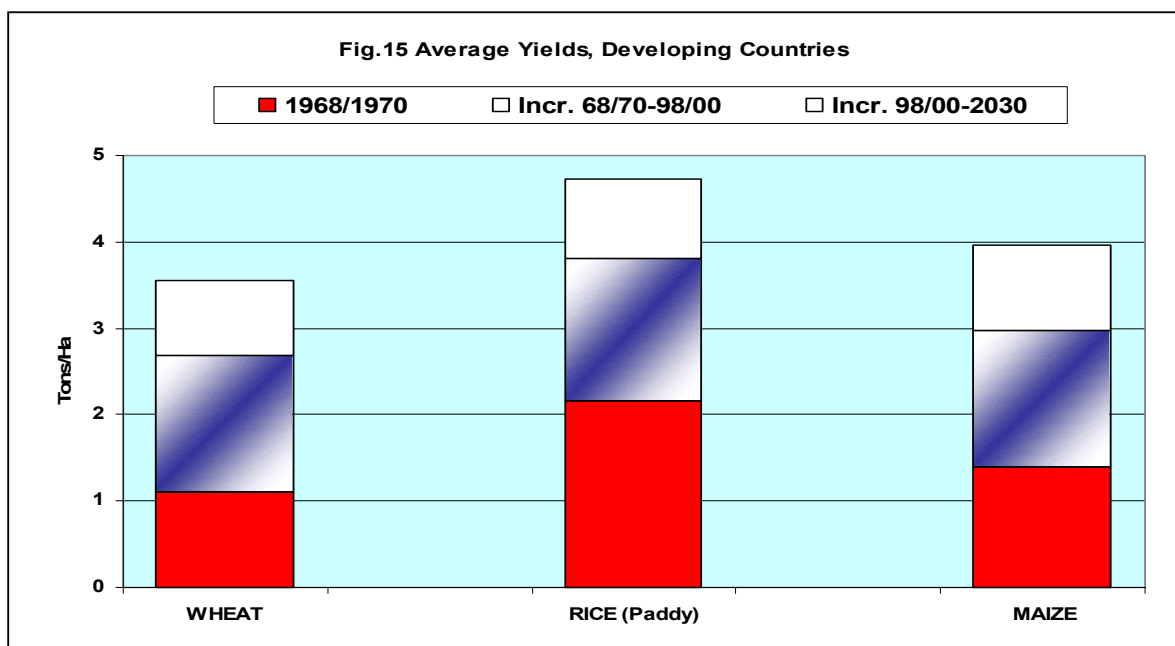
⁴ The India Rivers Interlinking Project, *Financial Times*, 4 February, 2003; *The Statesman*, New Delhi, 15 February, 2003.

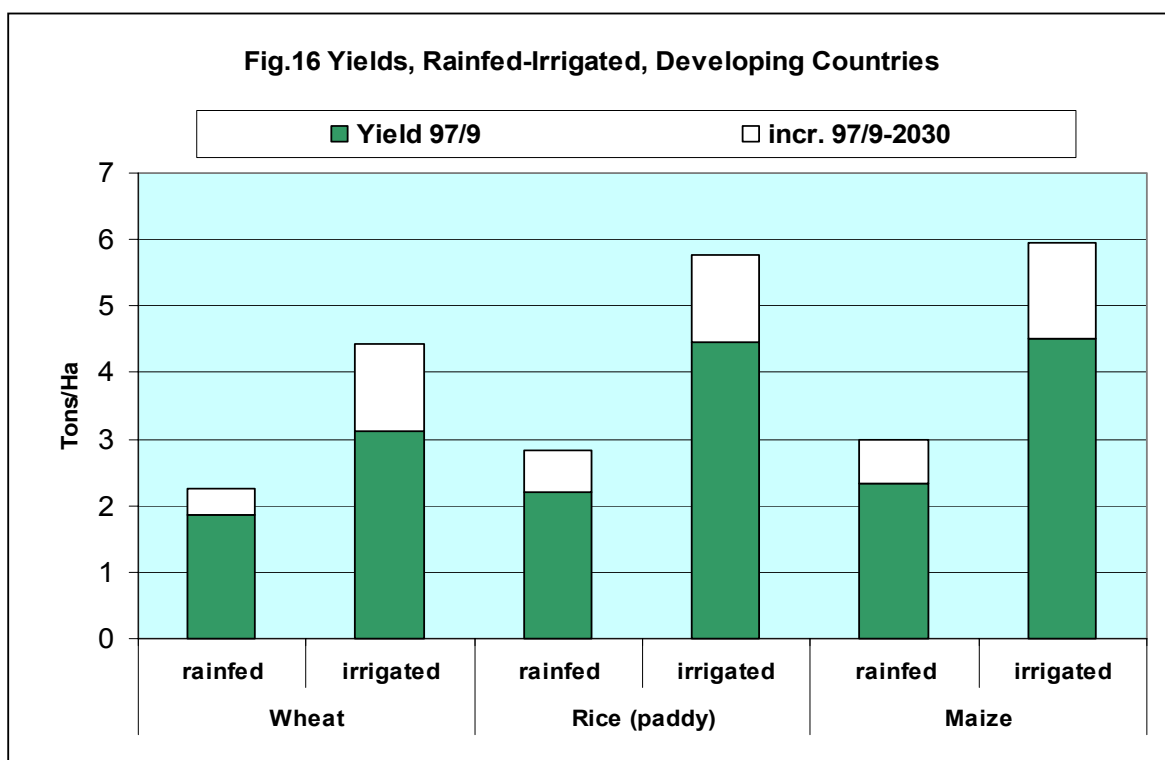


8. Yields

Yield increases will continue to be the mainstay of the production growth, no matter that the scope for yield growth is much less than in the past. The issue is not really whether the yield growth rates will be lower than in the past. They will. Rather the issue is whether such slower growth would be sufficient to deliver the required additional production. The answer is that it will, because the growth rates of demand and production will also be lower than in the past and, therefore, can be met even if yields grow at rates well below those of the past. Naturally, this slower yield growth may not happen unless we make it happen. In particular, the higher yields of the future cannot come only, or even predominantly, from the unexploited yield potential of existing varieties in the countries and agro-ecologies where such potential exists. As always, the existence of potential in some parts of the world is of limited use if those who need to improve their food security by producing more themselves live in environments with limited potential. Such limited potential can be due to agroecological constraints, e.g. in semi-arid rainfed areas for which no HYV have been developed, or to the already near-full exploitation of the yield growth potential of existing HYV, e.g. in the areas of mature green revolution. It is obvious that obtaining production increases in such situations will depend crucially on continued support to agricultural research to develop improved varieties for such environments (including those coming from modern biotechnology), no matter that significant unexploited yield growth potentials may exist in other parts of the world e.g. in Argentina or the Ukraine.

Figure 15 shows the gains expected in average yields of the developing countries for wheat, rice and maize. Increases of between 30 percent (rice) and 40 percent (wheat and maize) are foreseen for the next three decades. They contrast sharply with the much larger increases achieved in the preceding three decades: rice 76 percent, wheat 142 percent and maize 112 percent. Naturally, broad averages over many countries spanning very diverse agroecological and socioeconomic environments are not entirely suitable for drawing inferences about the scope for further yield growth. In our work we project yields separately for each country and within each country separately for irrigated and rainfed land. The averages shown in Figure 15 come from these country level and rainfed-irrigated projections of the study. A more detailed picture of possible yield increases distinguishing between irrigated and rainfed, though still aggregated over all developing countries, is given Figure 16.





9. Fertilizer

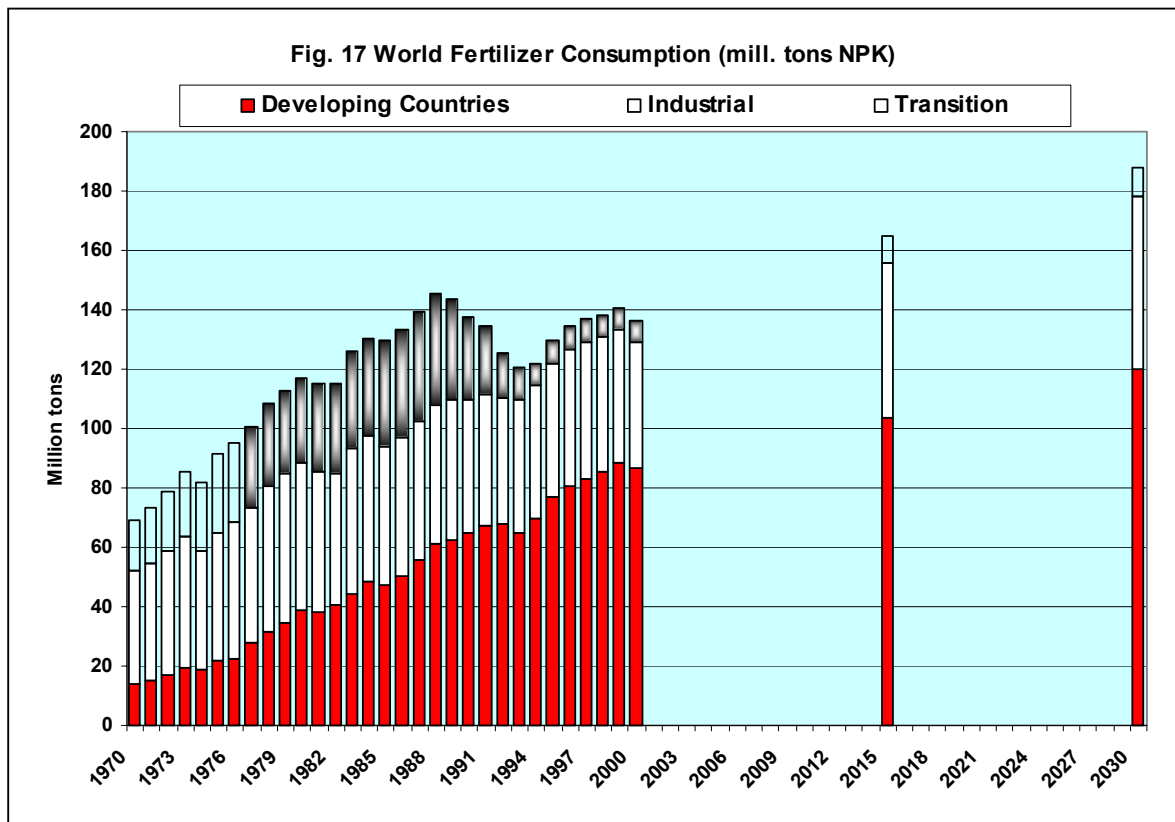
Other speakers will talk about world fertilizer prospects. Here suffice to note that the hefty increases in agricultural production foreseen for the next three decades, with yield growth as the primary contributor to such increases, can hardly be achieved without significant increases in fertilizer applications in most countries: the current annual consumption of some 140 million tons worldwide (NPK nutrient content) may increase by some 50 million tons by 2030¹, with the bulk of the growth occurring in the developing countries (*Figure 17*). The projected growth rate is 1.0 percent p.a. It is higher than the low growth rate of 0.7 percent p.a. of the 1990s (which reflected mainly the declines in the transition economies following the collapse of their agriculture) but decisively well below the 3.7 percent p.a. of the preceding two decades 1970-90. The dominant trend underlying the longer-term deceleration in the growth of world fertilizer use reflects essentially the continuation of the slowdown in the developing countries, now accounting for 63 percent of world consumption. The growth rate of their consumption has been declining rapidly: from 11 percent p.a. in the 70s to 6 percent in the 80s and to 3.6 percent in the 90s. Future growth may be just over 1 percent p.a.

In conclusion, the longer-term trend towards deceleration in the growth of global fertilizer use is likely to continue. It will reflect partly the slower growth rate of world agriculture, the gradual achievement of medium-high levels of application in several countries, the socioeconomic and other constraints standing on the way of more fertilizer use in many

¹ The fertilizer use projections of the study linked to the crop production projections were prepared by FAO's Land and Water Development Division. The approach and early estimates are given in Daberkow *et al.* 1999.

countries of Africa, the exploitation of the significant potential existing for more efficient use of fertilizer, the increasing resort to non-mineral nutrients where this is feasible and environmental regulations and related policies militating against excessive fertilizer use. The spread of organic agriculture using no mineral fertilizers is also a contributing factor to the slowdown, albeit a minor one. Organic farming may spread fairly fast in Europe but much of the growth in world farm output will be in the developing countries where further expansion of high-yielding agriculture will be a must. According to Smil, high-yielding agriculture cannot but depend substantially on growing mineral Nitrogen fertilizer inputs because “No cropping based on residue and manure recycling, on rotations of cereals with legumes, and on planting of green manures could provide a regular supply of more than 200 kg N/ha over extensive areas” (Smil, 2001, Ch. 8; see also Smil, 2002).

Key policy problems related to fertilizer are: (a) how to make it profitable for countries and farmers using too little fertilizer to use more of it in order to attain the required production increases and counteract land degradation from soil mining – a not uncommon occurrence in sub-Saharan Africa, and (b) how to economize on fertilizer use for both environmental and efficiency reasons so as to obtain in many situations output increases with less fertilizer by, in practice, substituting other inputs (including management and information technology) for fertilizer. The experience of the European Union during the 1990s is instructive: following policy reforms and enhanced emphasis on environmental issues, fertilizer consumption declined while agricultural production kept growing.



10. Concluding Remarks

The main finding of the study is that the world is not likely to run into constraints on a global scale on the production side such as to threaten global food security. The coming on stream of the production potential of the countries of the former USSR as additional supplies of grain to the world markets is an important contributing factor. The growth of world agriculture will be lower than in the past because of the lower population growth rate and the gradual attainment of mid-high levels of per capita food consumption in several countries, including some of the most populous ones. Slower growth notwithstanding, pressures on the resource base of agriculture and the broader environment will continue to build-up. However, there is scope for improved policies and technologies to cope with them. The issue is not really whether we can have the further quantum jumps in production without increasing pressures and risks. It is rather whether such threats can be contained within limits such as not to jeopardize the longer term sustainability of the system. Chapters 12 and 13 of the study are devoted to describing, and to some extent quantifying, such pressures and the possible policy responses.

Often the choices present themselves in the form of what are acceptable *trade-offs* between more production and adverse effects on the resource base and the wider environment, rather than whether we can have something for nothing. There are trade-offs over time (e.g. current forest expansion in Europe reversing in part past deforestation), among the different dimensions of sustainability (e.g. reducing soil erosion by shifting to zero tillage will likely increase use of pesticides) and across geographical space. The latter are exemplified by the potential offered by trade flows for spreading production and associated environmental impacts across the world in ways that would better match capabilities of the different countries to withstand and or respond to such pressures. This is because individual countries differ as to their agroecological endowments as well as in their technological and policy prowess for finding solutions and responding to emerging problems. Thus, if environmental considerations are taken into account in policies that affect trade flows, then the potential exists of minimizing adverse effects in obtaining any given increase in global output. In conclusion, agricultural trade, far from being detrimental to the environment – as is frequently made to be in popular perceptions, it has the potential of contributing to making global agriculture more sustainable than it would be otherwise.

Concluding that sufficient global food production potential exists, or can be created, is not saying that food insecurity related to the binding character of production constraints in several local situations will go away. Despite advances in globalization, the food insecurity prevailing in many poor countries remains very much a problem of failures in local agricultural development, simply because agriculture is their major economic sector. When such failures stem, wholly or partially, from adverse agroecological environments, one can speak of Malthusian-like conditions prevailing in the midst of global plenty. The existence of actual or potential surplus production in other parts of the world and globally can only make marginal contributions to alleviating the problem. In the longer term, for countries with severe agricultural resource limitations the solution is to be found in the development of their non-agricultural economy. However, this is hardly possible in many countries with high economic dependence on local agriculture without first increasing production and productivity in agriculture, resource-poor as it may be. When other sectors take over as the main sources of livelihood for the population, more reliance on food trade and less on the local resource-poor agriculture will become a viable option. This is the reason why a strong

case can be made that increasing agricultural production and productivity should be a policy priority for coping with many local food security problems, even in a world awash in food.

This policy approach becomes very relevant when we come to ask the question what it takes for progress in reducing undernourishment to be faster than projected here. We have seen that the incidence of poverty, as derived from evaluations of economy-wide prospects, is projected to decline but still remain significant. Therefore, policies are needed that will attenuate the depressing effects of such poverty on the food consumption and nutrition of the poor. Empirical evidence (described in Chapter 2 of the study) suggests that several countries, mainly in sub-Saharan Africa (Nigeria, Ghana, Chad, Burkina Faso, Gambia, Mali, Benin, Mauritania) have at times in the past achieved quantum jumps in their food consumption per capita over periods comparable to that from now to 2015, at a time when national average per caput incomes were not growing or outright falling. The common characteristic of these experiences has been rapid growth in the production of staple foods (cereals, roots and tubers).

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