

effectiveness of irrigation systems so that irrigated agriculture will make the fullest possible contribution to meeting the needs of the 8 to 10 billion inhabitants in the developing countries in the middle of the next century.

References

Ahmad, A. and D. Kutcher. 1991. *Irrigation Planning with Environmental Considerations: A Case Study of Pakistan's Indus Basin*. World Bank, Washington D.C., Technical Note 166.

Anderson, Per Pinstrup. 1992. *Global Perspectives for Food Production and Consumption*. IFPRI, Washington D.C. mimeo.

Crosson, P. and J. Anderson. 1992. *Resources and Global Food Prospects Supply and Demand for Cereals to 2030*. World Bank Technical Paper No 154, Washington D.C.

Gleick, P. 1992. Climate Change on Shared Water Resources. In: *Climate Change*, Ed., I Mintzer. Cambridge University Press, Cambridge U.K.

Olivares, J. 1987. *Options and Investment Priorities in Irrigation Development*. World Bank/UNDP, World Bank, Washington D.C.

Population Reference Bureau. 1992. *Population Data Sheet*. Washington D.C.

World Bank. 1991. *Annual Review of Project Performance Audit Results*. Operations Evaluation Department, Washington D.C.

World Bank. 1992a. *World Development Report*. Washington D.C.

World Bank. 1992b. *World Development Report*. Oxford Press, Washington D.C.

Yudelman M. 1973. Based on the author's notes on presentations at the World Food Conference at FAO Rome in 1973.

Yudelman, M. 1991. The Sahel and the Environment—The Problem of Desertification. In: *Social Strategies Vol 4 No 9*, University of Basel, Basel, Switzerland.

2020 Vision—Dramatic Changes in the World Agricultural and Industrial Production Systems

Ian Carruthers and Jamie Morrison
Wye College, University of London

Food from the North, Goods and Services from the South

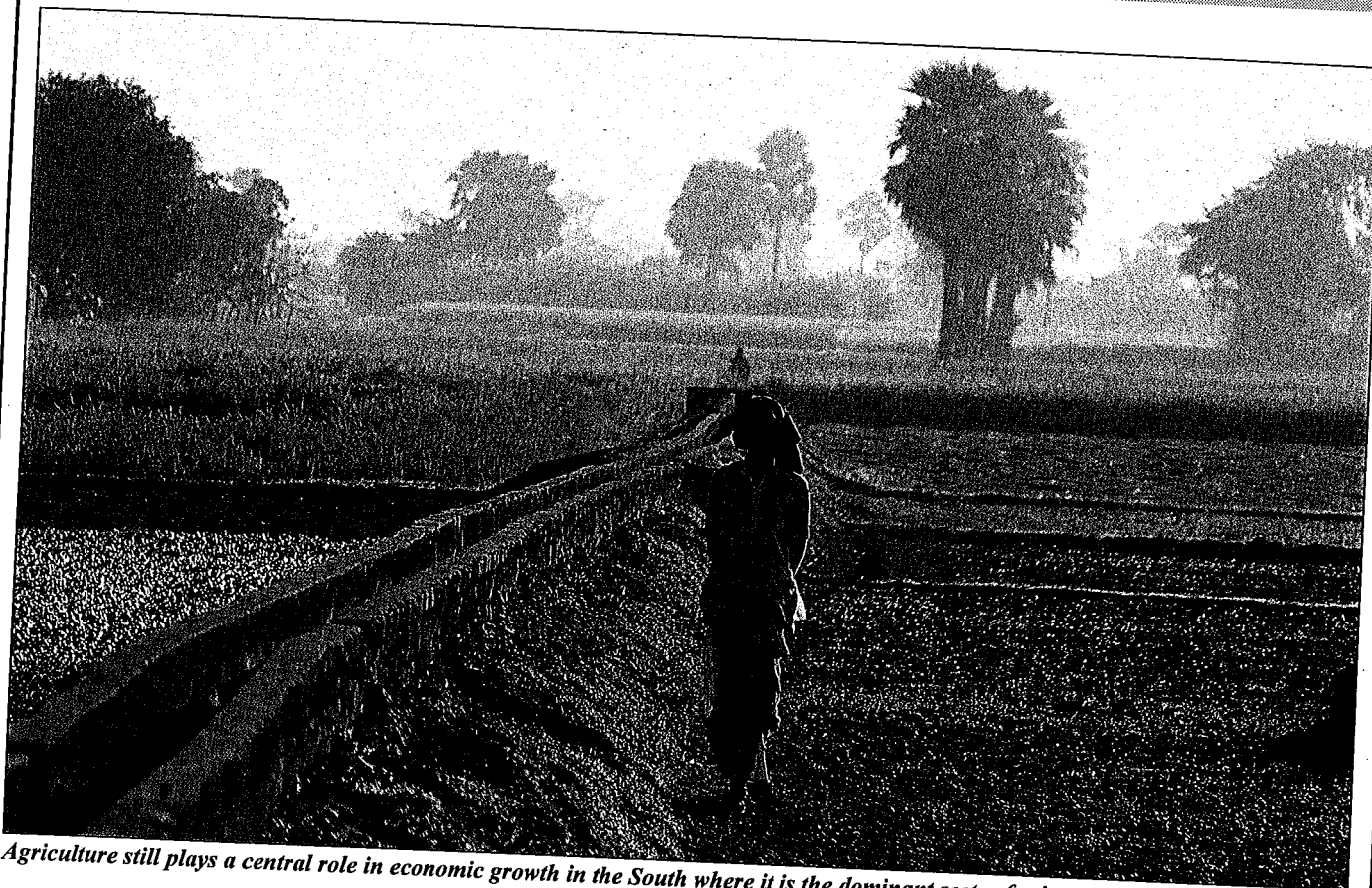
"In the conventional writing on economic development, it is generally assumed that the industrialized world will produce the manufactured goods and supply financial services and the developing world will produce the primary commodities.... I have just returned to England after spending six months travelling overseas and this experience has convinced me that the tropical and subtropical developing world will, in 20 or so years time, produce the bulk of the manufactured goods, and the temperate world will produce the bulk of the food."
(Carruthers 1993)

This experience led to the development of a thesis that formed the platform for this paper. In essence, it was argued that we are seeing a switch in the global production base which will lead to the cities of the

South producing the bulk of manufactured goods and services (e.g., routine banking, insurance, travel, software development, etc.) and the North supplying the bulk of their food; local food supplies will increasingly fail to satisfy Southern urban demand because of continuing rapid population growth of the cities. Expansion of area cropped is virtually finished; yield increases now depend mainly on institutional reform and management improvement which will be much more difficult to achieve than using new seeds and nitrogen fertilizer which provided the green revolution to wheat and rice. Public and private agricultural research in the North and the South, it was argued, will continue to receive diminishing resources, and new biotechnology appears to stumble along with few practical innovations and with growing consumer resistance. All in all the prospect for a second phase of the green revolution is remote (see Carruthers [1993] for the full text).

This thesis, would appear consistent with the views of a growing number of politicians, economists and others who argue for a shift of resources away from irrigation and indeed from other big agricultural or rural investments, in favor of urban priorities, especially, in the manufacturing and social sectors. They worry little about food imports and indeed see merit in trade-led growth as a precondition for poverty alleviation. Although industrial growth in the developing world is vitally important, we will claim in this article that continuing investment in irrigation and other agriculture developments are important components of any urban-based development strategy. We call for a recognition of the positive contribution of irrigated agriculture in terms of income, employment, and at least potentially, for environmental protection.

The argument presented below comprises three strands. First, that as the process of development progresses, the structure of an economy in terms of



Agriculture still plays a central role in economic growth in the South where it is the dominant sector for income and employment.

production, consumption, and trade changes markedly. Second, that the resulting changes in the relative proportions of the factors of production, both within and between countries, initiate important shifts in the comparative advantage of sectors within and between countries. Third, that a vibrant agricultural sector, which itself is dependent upon technological change, will stimulate and support the changes outlined above. Agriculture still has a central role to play in economic growth in regions within the South where it is the dominant sector for income and employment. Indeed, irrigation can be regarded as the industrialization of agriculture. The injection of capital and the intensification of production should produce a shift in the yields to a new plateau, releasing resources to support other elements in the economy.

The Sectoral Decline of Agriculture

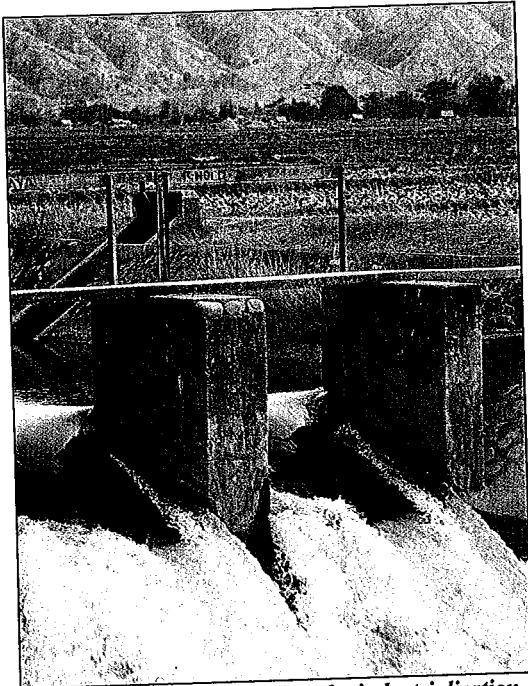
Following research by Chenery and Syrquin (1975), it is now widely

recognized that one indicator of a country's development is the *successful* transformation of its economy. Chenery (1979) defines transformation as the set of changes in economic structures required to sustain a continued increase in income. With regard to the agricultural sector, transformation is characterized by a declining contribution to GDP, a decreased proportion of the total workforce engaged in agriculture and a reduced proportionate contribution to external trade. Thus, implicitly, the manufacturing and service sectors' relative contributions increase. It is a serious mistake, however, to assume that the agricultural sector contracts in absolute size during this transformation or that it can be a passive sector, a resource reserve to be mined of its resources as urban needs grow.

The "Patterns of Development Approach" to analysis of change (after Chenery and Syrquin 1975) is a series of comparative studies of various countries which identifies similarities and differences in economic structures at different levels of development as

denoted by the level of per capita income. These observations can then be analyzed to develop and test a number of underlying processes found in all countries undergoing development. Chenery (1979) used Kuznet's framework, which, by analyzing the elements of national accounts, measured changes in the sectoral composition of production, consumption, investment and trade as income rises.

The value of comparisons between countries can of course be exaggerated. Variation in social objectives, the choice of government policies, the country's resource endowments, country size with respect to trade, and access to external capital will inevitably cause the outcomes of the development processes to differ somewhat (Johnston and Kilby 1975). This makes it difficult to make generalizations about the South since its many countries are in different phases of development and on somewhat different pathways.



Irrigation can be regarded as the industrialization of agriculture.

The original analyses were, however, based upon the observation that the structure of the economy of countries at the same level of development, as characterized by per capita GDP, had a high degree of similarity. As per capita income increases, primary industry declines in relative importance. Average per capita GDP in the South rose by 2.7 percent per annum over the three decades to 1990. Asia, to which most of the research related, achieved growth rates of 5.7 percent in the 1970s and 7.3 percent in the 1980s, and, as might be expected, has seen faster growth in its industrial sectors than in its agricultural sectors. However, in Sub-Saharan Africa, similar growth rates have not been achieved, and the structure of the economies is roughly the same now as it was 30 years ago. What is the outlook for the next few decades?

The World Bank forecasts that over the next 40 years, the South's average income could triple in real terms from today's US\$750 (as in Cote d'Ivoire) to about US\$2,500 (similar to Mexico now, 1992 prices) (World Bank 1992). The Bank's report recognizes that substantial regional differences may persist. In East Asia, per capita income could increase to US\$3,300, but in Sub-Saharan Africa, the regional

outlook is much less optimistic and per capita income is likely to increase to only US\$400.

The argument of this paper relating to change is therefore necessarily general in its interpretation recognizing that the rate of change in economic structures will differ across and within regions. The commentary also assumes a "favorable" (i.e., neutral) policy environment, but recognizes that some regions will take longer to undergo structural transformation because of unfavorable macroeconomic policies. In reality, some are at risk of never managing sustained GDP improvement.

What then are the implications for a country's comparative advantage in food production given that "industrialization," that is the relative growth of the manufacturing and service sectors, will occur as economic growth and per capita GDP increases? Within agriculture, will we see a parallel increased capitalization with increased use of fixed capital including irrigation equipment and increased use of variable recurrent investment such as fertilizer, crop protection and the rest? Will this investment be labor absorbing or labor displacing?

Changing Comparative Advantage

Neoclassical economics, presently the dominant theory supporting public policy in most of the world, suggests that within a country comparative advantage in a certain sector is determined by the domestic resource endowments. According to the primary model (Heckscher-Ohlin-Samuelson described in Ethier 1988), a country will export commodities requiring intensive use of the country's relatively abundant factors of production. For example, initially, a country with a low capital-to-land ratio will export primary commodities and, as capital accumulates, there will be a shift

towards the production of more capital-intensive manufactured goods and, as described in the previous section, agriculture's relative contribution to external trade falls.

This transformation is likely to begin quite early in the development process when there are low levels of capital per labor unit. The first manufactured goods will be labor intensive, such as, textiles and clothing. As capital accumulates, so will the capital intensity of manufacturing, and we may see a shift in due course to the manufacturing of complex items such as cars. Indeed, by Rybczynski's Theorem, "at constant prices, an increase in one factor endowment will increase by a greater proportion the output of the good intensive in that factor and reduce the output of the other good" (Ethier 1988).

As industrialization begins, agriculture does not remain static. Investment in agriculture includes irrigation investment and this process is stimulated by the growth of effective demand—demand backed up by money—in the emerging urban sector.

But what about the comparative advantage between countries? The application of the theories of comparative advantage, when discussing the agricultural sector, is complicated. The theories rely upon assumptions of free trade and upon the validity of the free market assumptions of perfect information, lots of buyers and sellers, and homogeneity of products. It could be hypothesized that with the shift towards freer trade (post-GATT), better telecommunication, computer technology and so forth, then the information is more perfect, products are generally more standardized, and even copied. Thus, these assumptions are less farfetched than they at first appear. Capital is accumulating in many of the technologically more advanced developing countries and can be readily moved from North to South, and yet wage rates are still low due to the relatively large and growing work forces. Work forces of the South are

becoming more highly skilled and technology can migrate quickly and easily. It is therefore likely that in the future, comparative advantage in manufactured goods will reside in the South rather than in the North.

The real practical value of this theory of comparative advantage is difficult to assess, for the model assumptions are essentially static in nature but the questions we have posed are concerned with the long-run changes in comparative advantage. Long-run changes are more likely to be driven by the propensity to save and by population growth than by relative factor endowments. However, the concept of revealed comparative advantage has been found useful in examining the trade performance of individual countries.

Another interesting aspect of comparative advantage relates to technical change. The influence of technological advance upon trade is sometimes described in terms of a product cycle (Vernon 1966, discussed in Abbott and Thompson 1987). A new product, often highly technical, is developed in the North because of its comparative advantage in R&D (as characterized by the proportion of scientists in employment, the expenditure on R&D, the degree of product differentiation, etc.). The

product is initially produced at home for the domestic market because direct communication between producer and consumer is essential to the development of the good. As development of the good proceeds and the good is perfected, production expands and an export market develops. Eventually, the good becomes standardized and constant communication between buyer and seller declines in importance relative to lower production costs. Production therefore begins to take place abroad where lower labor costs allow mass production, first displacing exports and then causing a reversal of trade, with imports going back into the original country (Ethier 1988). It is the speed of completion of the cycle which has increased since Vernon's observation. A new high-tech carbon fibre fishing rod maybe developed in Massachusetts, but nowadays as high-tech travels fast, it can be manufactured in Jakarta, to high quality standards perhaps a month later.

Within the agricultural sector, we also see technical change. The "green revolution" was essentially a seeds and fertilizer revolution that moved fast because the innovations were profitable, cheap to acquire and could be broken down into small-scale packages for on-farm trials. Today, we are in the middle of a plastic

revolution shifting from the agriculture of the North to the South, with cheap plastic increasingly used to convey, apply and drain water, to mulch soils, and to package products. High quality products developed in the North such as mangetout peas, green beans, spring onions and fresh herbs are being grown all the year round in the South and air freighted for sale on supermarket shelves.

Agricultural export growth may not continue to flow from South to North. If we assume a simple, two-sector global economy, and if the South's comparative advantage does indeed change in favor of industry, the most intensive user of the country's relatively abundant resource, now capital (and/or urban labor), then agriculture, now has a comparative disadvantage. If the South then has a comparative advantage in the production of industrial goods, then by default, the North must have a comparative advantage in basic agricultural production.

This is all very well in principle, but such a shift in a region's production base is unlikely unless the relative profitability of production is favorable. The optimal pattern of production and trade for a country is determined by the relationships between the opportunity cost of producing a given commodity and the price at which the commodity can be imported or exported. Is it likely that the demand for food from the South for the North's exports of temperate food will rise to a degree as to make temperate food production and export profitable even in the absence of subsidies? Perhaps more importantly, will the South's consumers be able to pay for such imports?

Consumption and Production Trends

What evidence is there that the South will need to import more food from the North in years to come? To answer this question it is necessary to compare future consumption and production patterns.



Much of the future increase in production will have to come from increased yield rather than crop area.

Over the past two decades, growth rates in consumption in the South have exceeded those in the North. Over the period 1970-84, world growth rate in consumption was running at 2.9 percent, with the OECD at 1.8 percent and LDCs at 4.0 percent, albeit from a low level. Thus the share of world consumption increased from 43.7 to 50.1 percent in LDCs and fell from 35.1 to 30.1 in OECD countries (Brown and Goldin 1992).

In addition, there has been a shift in the pattern of consumption from staples to animal products as incomes have risen.

The causes of the growth and shifts in consumption can be disaggregated into: (i) population growth, (ii) income growth, and (iii) income elasticities of demand for food.

Urbanization provides a focus for the discussion of the three criteria. Urbanization is in part a result of changing economic structure; manufacturing tends to be urban based and has thus created a new market for food. Traditionally, a large proportion

of the population was engaged in subsistence farming. Urbanization has created new demand patterns. Urbanization in Asia is well documented, but even in Africa where urbanization has been relatively less apparent forecasts indicate that in 30 years' time there will be at least 30 cities with greater than one million inhabitants and several with populations of over ten million (World Bank 1989). This view is however contentious with other commentators seeing little evidence of this occurring and preferring the scenario of many relatively smaller cities (e.g., Trotter 1992).

The associated income growth in many urban areas has created additional demand. One commonly cited estimate is a 100 million tonne increase in cereal consumption for a one percentage point increase in the GDP growth rate of LDCs (Brown and Goldin 1992). In part, this is due to the increased use of cereal for animal feed, which the FAO predicts to rise even faster than direct consumption of cereals (a 5.5 percent increase per year as opposed to a 1.9 percent annual increase in direct consumption). Indeed, the share of total cereal consumption by livestock is forecast to increase from the current 15 percent to 24 percent by the year 2000.

This is a result of the assumed higher income elasticity of demand for animal products than for basic foods. However, forecasting income elasticities is problematic. Generally, a national average is used which reflects assumptions about income distribution. But if we consider that the income elasticity of demand for cereals is high for the poor, moderate for middle-income groups, but high for the rich (a derived demand from grain-fed meat), the actual level of income distribution is very important. However, forecasters generally believe that overall consumption growth will decelerate to some degree (down to 3.1 percent per annum

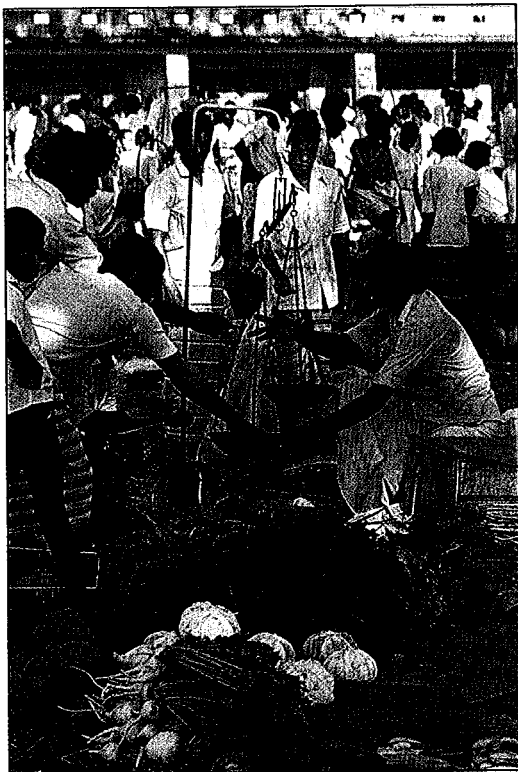
in LDCs and 0.8 percent per annum in OECD, to the year 2000), perhaps on the assumption of a deceleration in population growth rates.

It is harder to get agreement on production estimates. The data show that for the South as a whole, gross food production growth rates have exceeded population growth rates. However, as consumption demand is composed of more than that stimulated by increased population, it does not necessarily mean production has kept up with consumption demand. In addition, in the regions where in recent years domestic food production has exceeded consumption, this does not guarantee that it will be sustained in the future.

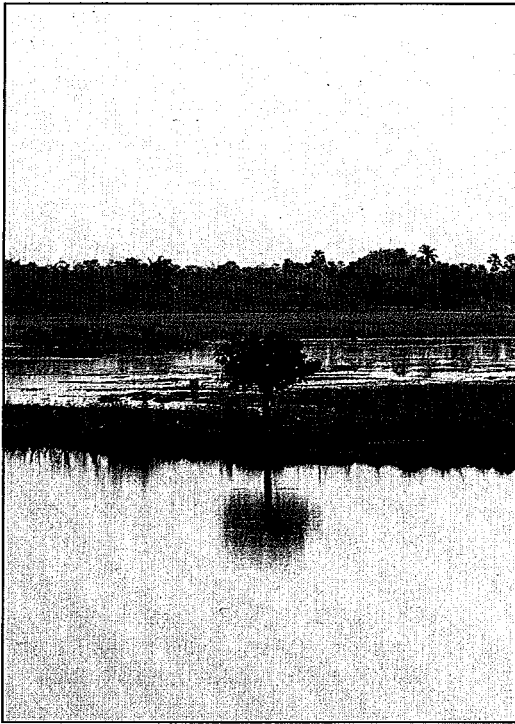
In the 24 years to 1985, gross food production grew at 2.5 percent per annum. This was primarily due to the green revolution technology, but there was a broad divergence within the South, and also across the range of cereals. For example, wheat production grew at an annual rate of 6.5 percent, as compared to coarse grain production which increased at only 2.1 percent per annum.

However, a significant decline in the rate of growth of LDC production is forecast to the year 2000 (Brown and Goldin 1992), as much of the future increase in production will have to come from increased yield rather than crop area. As recognized elsewhere (Carruthers 1994), much of the easy yield increasing gains, essentially a response to nitrogen, has already been achieved.

If these food forecast trends are borne out, there will be an increasing deficit within the South's food equation. Predictions about future food import requirements are difficult to establish, but the majority of forecasts fall within the range of 100 to 200 million tonnes of cereal by the year 2000, up from 65 million tonnes now (Brown and Goldin 1992). Beyond 2000, there is no basis for rejecting the assumption that the gap will widen still further. The imports will have to originate in the North which has the



Growth in the nonagricultural sector leads to increased demand for food.



Water problems are central to agriculture's difficulties.

proven production capacity and the appropriate mix of infrastructure, rural institutions and farm management skills to realize the production potential. Therefore, while most agricultural trade is currently between OECD countries, it will become increasingly dominated by exports from developed to developing countries.

Will the South be in a position to pay for the increased imports? Certainly, it will if the forecast of a trebling in per capita income occurs. However, this income rise is contingent upon the process of economic development continuing. While in many of the more developed countries of the South the process is in full flow, for many of the lower income countries the process has barely started and the barriers to growth are all too evident. We appear to be witnessing the reinforcing elements of successful economic growth and its reciprocal, the negative effects of the poverty trap.

The Role of the South's Agriculture

Development is creating the conditions for the emergence of a comparative

advantage for the industrial sector of the South. This development will increase the demand for imports to the South to feed the growing cities and also enable them to pay for it. The potential for sustained development and hence rising income, especially in the early stages when agriculture is the largest sector of the economy, hinges critically on the ability of the agricultural sector to fulfil its traditional role and contribute capital and labor to the emerging industries.

Agriculture thus has a crucial role to play in promoting the shift in the production base, but the proportionately declining sector does not necessarily mean a contracting sector. Mellor (1973) states that there still needs to be 4–5 percent per annum growth in agricultural

production to have beneficial effects on the economy as a whole. He discusses the differing effects of a stagnant, as opposed to vibrant, agricultural sector. He remarks that it is difficult to achieve continuous net resource flows from a technologically stagnant agriculture. If resources are invested productively in the nonagricultural sector, then growth there leads to increased demand for food and particularly so if more of the poor are employed. A highly inelastic supply from a stagnant agriculture leads to increases in the relative price of food and therefore resources flow back to agriculture where returns on investment have risen. However, this also makes food imports relatively more attractive and these imports (especially if subsidized in the country of origin) may prevent increased agricultural production. Growth in the nonagricultural sector could be inhibited by scarcity of foreign exchange if food imports are high.

Compare this to a vibrant agricultural sector with continuous technical change, including increases in irrigation effectiveness, which permits some expansion in demand for commodities to be met without higher

relative agricultural prices. In this event, net transfers of resources from agriculture can take place to increase employment in nonagricultural sectors and there are no incentives to reverse the domestic terms of trade towards agriculture.

What is the scope for capital transfer from the agricultural sector to the rest of the economy, given that there has been some degree of capital formation in the agricultural sector?

According to Johnson (1991) there must be an increase in factor productivity if agriculture is to contribute to economic growth. Given that land and increasingly labor are the abundant factors in the early stages of the development process, Johnston and Kilby (1975) concluded that intersectoral productivity differentials are greatest at the beginning of the development process and narrow as income per capita increases. In addition, they noted that labor productivity is lowest in agriculture but grows at a faster rate than in other sectors. Today, 5 percent of the world's farmers produce half of the world's food. These farmers reside in the North.

In the early stages of development, it is unlikely that the nonagricultural sector can expand to absorb all population growth and, therefore, the size of the agricultural labor force will increase (Mellor 1973). Mellor cites Doving (1966), who argued that the farm labor force does not decrease in absolute numbers until fairly late in the development process. If labor fails to move out of agriculture in an optimal fashion then what are the implications for economic growth?

In the absence of a sustained increase in agricultural output, agricultural labor productivity will fall. If agriculture is to contribute to overall increased economic productivity, there has to be a marked rise in factor productivity, and land-saving and labor-absorbing techniques such as irrigation have an important part to play. This is particularly so given the rapidly rising populations of working

age and the unfavorable capital-labor ratios in manufacturing.

Research in the North shows that technical change does not necessarily mean more investment. Less than half the growth in the North can be explained by additional capital investment. Most economic growth comes from existing capital stock being used better through improved resource management. Emulating this experience and finding new and more productive ways to use existing facilities is the great challenge facing irrigation managers, farmers and all those involved in the production process today.

Getting higher productivity from the existing capital stock through improved ways of working, better management, enhanced education and training for all the workforce are ways in which irrigation will realize its potential contribution—a potential that increases daily as advances in complementary areas such as agronomy and engineering come forward. We do not need 2020 vision to recognize that new resources are clearly going to be extremely scarce for many years to come.

Conclusions

It is likely that as income rises structural changes in the economies of the South will lead to increases in and changes to the pattern of food consumption demand. It has also been shown that consumption is likely to outstrip production in the South whether the economies grow or stagnate, necessitating food imports from the North. It is thus conceivable that in the next decades we will see increasing incentives for the North's food producers to increase production (perhaps with less subsidy), given that an increasingly urbanized and industrialized South will be in a position to pay for these imports.

However, it is recognized that not all countries of the South, in particular those in Sub-Saharan Africa, will see substantial rises in per capita incomes.

This is partly because of a high rate of population growth but also because growth in GDP will be slow. A primary reason for this is that agriculture in these countries has not played a productive role—irrigation is relatively unimportant, the topography presents problems and new schemes are costly. Water problems are central to agriculture's difficulties. Rainfall is inadequate and highly variable. Yet a vibrant agriculture is essential, and, under the assumption of a favorable macroeconomic policy, as land becomes scarcer, technological change in favor of some forms of land and water saving, labor using technology appears to be a key. In Sub-Saharan Africa, if this option is not widely available, then food production on concessionary or commercial terms is inevitable.

At present, irrigated agriculture provides one third of the world's food production. Perhaps two thirds of the future incremental production will come from irrigated land (Carruthers 1994). However, we do not anticipate or call for an increased rate of capital-intensive investment in irrigation infrastructure but we do need to see more achieved with what is presently developed. What we conclude with our 2020 vision is that in 25 years' time, the North will supply much of the urban food needs of a more developed South which will, in turn, provide the North with much of its requirements for industrial goods and services. There will still be a need for capital flows from North to South and perhaps some increased agricultural investment in the poorer countries if livelihoods are to be protected and other broader poverty-reducing developments are to be stimulated.

References

- Abbott, P.C. and R.L. Thompson. 1987. Changing agricultural comparative advantage. *Agricultural Economics* (1), pp. 97–112.
- Brown M, and I. Goldin. 1992. The future of agriculture: Developing country implications. OECD, Paris.
- Carruthers, Ian. 1993. Going, going, gone: Tropical agriculture as we knew it. Purseglove memorial lecture, London 1993. (Available free from Wye College Press, Wye College, Ashford, Kent. TN 25 5 AH, UK.)
- Carruthers, Ian. 1994. The economic case for sustainable irrigation development. In L.S. Pereira et al. (eds.), *Sustainability of water resource utilization in agriculture*. Dordrecht: Kluwer. (in press).
- Chenery, H. and Syrquin, M. 1975. *Patterns of development 1950–1970*. Published for the World Bank by Oxford University Press.
- Chenery, H. 1979. *Structural change and development policy*. Published for the World Bank by Oxford University Press.
- Ethier, W.J. 1988. *Modern international economics*. Second Edition, Norton International, New York.
- Johnston, B.F. and Kilby, P. 1975. *Agriculture and structural transformation*. Oxford University Press, New York.
- Mellor, J.W. 1973. Accelerated growth in agricultural production and the intersectoral transfer of resources. In *Economics Development and Cultural Change*, Vol. 22 No. 1, pp. 1–16.
- Mellor, J.W. and Johnston, B.F. 1984. The world food equation: Interrelations among development, employment and food consumption. *Journal of Economic Literature*, Vol. XXII pp. 531–574.
- Trotter, B.W. 1992. *Urbanization in Sub-Saharan Africa: Much ado about nothing?* Natural Resource Institute, Chatham.
- World Bank. 1989. *Sub-Saharan Africa: From crisis to sustainable growth*. Washington, D.C: World Bank.
- World Bank. 1992. *World development report 1992*. Washington D.C: World Bank.