In the 1980s there is an increasing concern with the extent of human misery in both rural and urban areas of most developing countries. Traditional theories about industrial development within dual economies and the role of rural-urban migration were challenged in the 1970s. Even the principal success of the 1960s, the 'Green Revolution', has been under attack for apparent regressive income distribution effects. There is at present interest in focusing developmental efforts on the elimination of rural and urban poverty (see Bell and Duloy, 1974, and the other papers in that volume).

This paper is concerned with the potential of utilizing technological change in agriculture for income distribution objectives. In the first section, the problem of relatively large and absolutely growing rural sectors in most developing countries is set. Various rationales for not being concerned with income distribution in agriculture, when considering technological change, are revalued and some recent results of rural-urban migration research are presented. The second section considers the production of new agricultural technology and complementary strategies to improve the income distribution effect. The conclusions pull together the various policy suggestions.

**BASIC DEMOGRAPHY OF THE RURAL SECTOR IN DEVELOPING COUNTRIES**

According to the classic theory of economic development (Fei and Ranis, 1964; Lewis, 1954), there needs to be a transferral of surplus labour from the agricultural to the industrial sector. Higher levels of capital investment foster more rapid rates of industrial development, thereby absorbing more labour from agriculture and increasing the demand for food and other consumer goods.

Since World War II there have been extremely rapid increases of urban populations in most developing countries. 40 to 65 per cent of this urban increase came from rural-urban migration in the 1960s (Todaro, 1976, p. 470).
10). From 1950 to 1976 the urban population increased by 50 million in Brazil and 27 million in Mexico (Sanders and Lynam, 1981). In both those countries the geometric growth rates of the urban sectors were over 4 per cent during the 1950-80 period. In spite of high rural-urban migration rates, in most developing countries the rural sectors have continued increasing absolutely at 1 to 3 per cent growth rates in the 1970s. In 1970-80 urban growth in Africa continued at a 4.7 per cent rate with a 1.9 per cent increase in rural areas. In Asia and Latin America urban growth had decreased to 3.8 per cent growth rates in this decade but rural growth was still 0.9 per cent. Moreover, the relative size of the rural sector is very large – 30 to 90 per cent of the population in most developing countries. Only in a few of the wealthiest developing countries is this proportion below 30 per cent. With the very large sizes of the rural sectors and their continuing absolute increase over time until the later stages of economic growth, developments within these rural sectors will continue to affect overall growth patterns.

Classical growth theory posits migration as an equilibrating mechanism in sectoral labour allocations, allowing little scope for real increases in urban wages in the initial stages of accumulation of industrial capital. Moreover, technical change in agriculture is critical to classical theory since marketable food surpluses must increase as agricultural labour is released to the industrial sector and since a shift in the terms of trade against agriculture provides further incentives for development of the industrial and tertiary sectors. Technical change in agriculture was thus necessary to relieve the constraints on industrial growth and there was little concern within the theory to consider the impact of technical change on income distribution in the rural sector.

Another rationale for ignoring income distribution within agriculture stems from the consumer surplus, comparative statics analysis of the distribution of benefits from the introduction of new agricultural technology between producers and consumers. Clearly, low price elasticities for food products imply a substantial price decline resulting from increased output, assuming a closed economy with no governmental intervention to support the price. Most of the benefits of the new rice technology in Colombia were received by urban consumers (Scobie and Posada, 1978). Hayami and Herdt (1977) show that small farmers will benefit due to increased subsistence consumption, while large farmers lose money from the introduction of new rice technology. However, this is a special case, for rice in Asia as the marketed surplus varies from 20 to 80 per cent for the two farm sizes and rice comprised 70 to 90 per cent of cereal consumption in different regions of the Philippines (Hayami and Herdt, 1977, pp. 249–50).

Comparative statics analysis has shown that, in the absence of international or interregional trade or government intervention, the principal beneficiaries from technological change in agriculture are consumers and, in most cases, producers’ incomes decline. This leads to the familiar treadmill, where the initial innovators benefit and those lagging behind are forced out of the agricultural sector (Cochrane, 1958). The problem with this analysis is the classic problem of the dynamics or time period of
adjustment of comparative statics. In the process of reaching this long-run equilibrium with a smaller labour force in the agricultural sector, some farmers will benefit. In the developed countries, particularly at present in Europe, farmers are utilizing their political power to retain larger shares of the benefits of technological change and delay reaching this long-term equilibrium by maintaining high prices, stockpiling agricultural commodities and then dumping them on world markets. In the 1960s and early 1970s PL 480 performed this dumping function for the accumulated stockpiles of American agricultural commodities resulting from the high support prices of the period. In developing countries where the rural population is still relatively large and technical change often occurs within a skewed farm size structure, the rate of adjustment as expressed in rural-urban migration may be too rapid for urban employment and infrastructure to adjust. Governments have also intervened to maintain low urban food prices, causing a further deterioration in the welfare of the rural sector and further migration.

Why should there be a concern with income distribution in the rural sector? An alternative is to ignore the subsistence agricultural sector until it can be absorbed by urban-industrial growth. However, there is evidence that large segments of the population in both rural and urban sectors in most developing countries are suffering from malnutrition (Reutlinger and Selowsky, 1976; Reutlinger and Alderman, 1980). Inadequate nutrition and health investments in the children of the rural poor implies a permanent loss of productive potential and will therefore reduce the returns to future human capital investments in education and on-the-job training (Belli, 1971; Selowsky and Taylor, 1973). If the human capital stock is allowed to deteriorate due to absolute poverty, then an equity issue becomes an efficiency problem.

The traditional solution for rural poverty in developed countries has been rural-urban migration associated with an expanding industrial sector. Most developing countries will need to decrease their birth rates to a considerable degree and in the long run their agricultural sectors will decline substantially. However, at the present time, much of the migration process appears to be a transference of rural to urban poverty with minimal net gains to society. The principal growth sector with economic development in Latin America has been the unskilled services sector, where average labour productivity was even lower than in the agricultural sector (Sanders and Lynam, 1981; for a literature review on the potential importance of the services sector in developing countries see Baer and Samuelson, 1981). Moreover, several studies have indicated a nutritional decline for the migrating urban poor as compared with the rural poor (see Ward and Sanders, 1980, and the references cited). The high costs to the public sector of the mushrooming slums in the major urban areas of the developing countries are well known (Todaro, 1976).

Developing countries, thus, often have the immediate problem of human capital deterioration in their rural sectors and a lack of policy instruments to change this situation. One immediate policy suggestion is that governments
in developing countries avoid all subsidies on labour-substituting innovations. In the absence of technological change substituting for labour, small farmers will have a comparative advantage in the production of many food crops due to the greater availability of seasonal labour on their own farms. Labour-substituting technology would include most mechanization, varieties developed specifically for mechanized production, and herbicides. Public sector subsidies on credit, production, or marketing knowledge rationed to large farmers could have a similar effect of biasing the adoption process towards large farmers. Even after eliminating public subsidies large farmers will still have advantages from being able to pay higher search costs for new information, due to greater potential benefits, from obtaining larger price discounts due to volume purchases, and from being able to take larger risks (Perrin and Winkelmann, 1976; see also Bell and Duloy, 1974, pp. 126ff) However, removing the public subsidies for large farmers (including those on research production) should help small farmers obtain more of the benefits of technological change. Binswanger and Ryan (1977, p. 226) summarized well the income distribution – technical change discussion:

Taking account of distributional implications among farm size groups in low wage countries thus reinforces the efficiency consideration of concentrating on labour-using the land-saving technical changes while at the same time calling for institutional changes to improve the efficiency of land and labour markets and the access of small farmers to modern input and credit markets.

Efforts to increase farm incomes and improve income distribution within the rural sector and thereby prevent human capital deterioration and reduce rural-urban migration rates appear to be justified. Technical change in agriculture is the key to these efforts but the principal issue remains whether agricultural technology can be designed at the experiment station to reach the low-income rural population.

**PLANNING FOR FUTURE ‘GREEN REVOLUTIONS’**

In the late 1960s the new dwarf varieties of wheat and rice began their rapid dissemination across Asia. The pessimism about world hunger was temporarily transformed by an optimism about the potential for scientific development to overcome world food deficits if the problems were narrowly defined and the facilities located in developing countries. Eight more international centres were gradually added to IRRI and CIMMYT, thereby including most of the major food components of developing countries. However, by the mid-1970s a disillusionment with the income distribution effects of the dwarf varieties was increasingly reflected in the literature. The principal characteristic of dwarf varieties was their capacity with irrigation to respond to much higher fertilizer levels without lodging. Hence, the beneficiaries of the technology were those holding the prime lands and able to obtain the increased fertilizer (Ruttan and Binswanger, 1978).
What do the empirical studies of the income distribution effect of the ‘Green Revolution’ show? Most studies indicate that large farmers adopted faster but small farmers followed with a lag (Perrin and Winkelman, 1976; Ruttan and Binswanger, 1978). Thus, relative income distribution between farm sizes has not worsened though absolute income differences have obviously widened due to the unequal distribution of productive assets. In the Indian ‘Green Revolution’ there was an increase in both employment and wages. Land rents increased faster than wage rates in the prime production areas since the demand for wheat was fairly elastic nationally and the supply of labour was more elastic than that for land. Moreover, the increased labour demand from the introduction of new varieties encouraged intra-regional migration (Binswanger and Ryan, 1977, p. 229).

An increasingly regressive absolute income distribution between farms and regions in many developing countries has provoked a polarization of the debate on future technology production. Figure 1 is used to put the debate on design of new technologies into perspective.

A _______ B _______ C _______ D

Irrigated conditions

Farmers’ traditional system
No water control
Low or zero cash inputs
Various types of stress
Low but stable yields

FIGURE 1 Range of environmental conditions toward which the experiment station in a developing country could focus its research activities.

By breeding new varieties for A, the largest possible gains in rice yield were possible (Jennings, 1964). Moreover, much of the physiological literature on exploiting genetic yield potential under optimum conditions could be utilized. Literature development in the physiology of stress is at present increasing rapidly but suffers from a basic conceptual difficulty; how to specify appropriate levels of the stress variables studied and held constant. The relevant levels of stress will depend upon the environmental conditions for which a new variety is produced and the accompanying input levels. Biological scientists often have a very optimistic view of both. The returns to research depend not only upon the size of the absolute yield differential between farms and the experiment station but also upon the probability of adoption by farmers across the target area. Not all crops will be profitable enough, even with new technology, to move into the prime agricultural areas and to utilize high input levels. Breeding under non-stress conditions appears to be the appropriate strategy for only high value crops (Sanders and Lynam, 1981).

The other extreme of the spectrum is point D, small farmers’ input levels and environmental conditions, since most small farmers are located outside
the prime land areas. The most fervent critics of the ‘Green Revolution’ argue that the new varieties should have been selected for the most adverse conditions. These conditions could be marginal rainfall areas, low fertility soils, hillsides, or some combination of the above. Moreover, the critics often argue that the new technologies should not be accompanied by higher inputs than those already utilized by farmers. Finally, if the farmer is producing in association or any other form of multiple cropping, then the new technology should also be produced for this system. D is thus the sociologist’s position of introducing the minimum change in the most difficult environmental conditions. The extreme version of D ignores some of the basic biological information about new technology development and underrates farmers. First, one-input changes are unlikely to make much difference to farm yields or income (Sanders and Johnson, 1982). Farmers’ systems are biologically complex, hence changing one input, such as density or variety, will often result in other unexpected systems’ effects, such as an increase in disease incidence with the higher density or an inability of the new variety to perform under farmers’ stress levels or to be acceptable to consumers (Sanders and Lynam, 1982b). Most new agricultural technologies will require a series of changes including some future adaptations to new production systems after adoption. The brown leaf hopper became a problem after the introduction of the first generation of dwarf rices. The second generation rice varieties reflected much more attention to consumer requirements. The most successful innovations have required a series of changes generally involving new varieties, higher input levels, and improved agronomic management. Second, in most regions farmers have already been selecting over long periods of time for adaptation to their stress levels. Without comprehensive changes, new technology is unlikely to improve upon farmers’ selection processes.

There is no reason that small farmers will not use higher inputs or even change their systems of production once new technology becomes available. Also, from the perspective of technology development, it is inefficient and will probably be unsuccessful to produce technology for the most adverse conditions (Ruthenberg, 1981). If one objective of agricultural policy is to raise the incomes of small farmers and small farmers are concentrated on hillsides, new technology development can be accompanied by land reform to first get the small farmers down into less inclined and more fertile soils (Sanders and Johnson, 1982). Utilizing agricultural technology as the only instrument to help the rural poor puts an unreasonable burden on both the international and national research centres in developing countries. To the extent that the larger farmers have both most of the better land and greater access to the services necessary for technology adoption to be profitable, it would be almost impossible to prevent larger farmers from being major recipients of the benefits of most new agricultural technologies. Clearly, technology development has to be combined with other instruments to focus its benefits on the rural poor.

If breeding for point D offers little probability of a return on research investment, whereas high returns are assured on the limited prime land
areas, one alternative is to increase public and private investment in irrigation and fertilizers, thereby expanding the area of A type environments. In the Punjab, the adoption rate doubled from 30 to 60 per cent when irrigation facilities were extended and improved in the early 1970s (Perrin and Winkelman, 1976, p. 889). Estimates, however, suggest that irrigation investment costs would average $640 (1975 dollars) for each additional ton of food produced per year (Oram, et al., 1979, p. 47). Most countries must weigh these high costs against the potential for increasing rain fed production. For countries outside North Africa and certain Asian countries it appears to be necessary to produce new technology for environments such as B and C.

Developing new technology for intermediate points between A and D will be more difficult than producing for A because yield differentials will be smaller, stress factors will be more important, and returns on input use will be smaller. Characterizing the variability in the target area will be critical to defining an effective research strategy for rain fed crops (Sanders and Lynam, 1982a). Although there will be a wide range of technologies, each particular technology will be more narrowly adapted. Choice between research alternatives will influence the extent to which technology can be directed towards the rural poor. Examples include floury maize for the highlands versus mechanized dent maize for the coast of Ecuador; drought and high temperature tolerant cassava for the Northeast versus long-season cold-tolerant cassava for the South of Brazil; and mechanizable erect-type bush beans versus climbing beans or indeterminate bush beans. Thus, although technology is a blunt instrument for raising the incomes of the rural poor, appropriate technology design can be a component in raising small farmer income as the ‘Green Revolution’ is extended into rain fed areas.

CONCLUSIONS

Concern about income distribution within the relatively large and growing rural sectors of most developing countries appears to be a necessary component of development planning due to the efficiency loss resulting from malnutrition and poor health conditions often prevailing there. Stable growth may well depend upon improvements in rural income distributions. Rural-urban migration will undoubtedly play a future role in reducing rural poverty. However, the migration process does not at present appear to be substantially increasing either productivity or welfare of the migrant. Hence, there is increasing interest in improving the conditions of the rural poor before they become the urban poor.

The income distribution effects of new technology can be improved with the following three strategies: removing all public subsidies for research on labour-substituting technological change; eliminating factor subsidies if they are being rationed for large farmers; developing new technology for regions outside the prime areas to be accompanied by low or moderate input levels.

For some regions resource distribution will first have to be modified.
Without land reform, technological change is expected to have only a minimal effect on income distribution in the Andes, where small farmers are concentrated on the hillsides, or in the Brazilian Northeast where small farmers are predominantly in the more marginal rainfall areas. Technological change is not a panacea. Hard choices will be necessary, especially in Latin America, and there will be losers from the development process (Bell and Duloy, 1974, p. 119ff). Moreover, the initial effect from land reform in cultivated areas is expected to be a sharp production decline; hence a comprehensive development policy including new technology, extension, credit, and marketing services will be necessary. This is not a low cost solution.

Attempts to focus technological change and associated agricultural policy to obtain income increases for small farmers will also contribute to an increased understanding of other barriers to achieving this objective. Mechanization research orientated specifically for small farmers could reduce the drudgery of traditional farming systems and help eliminate seasonal labour constraints (Hardin, personal communication, 1982). Developing countries will probably need to increase investment in the human capital formation process in rural areas, especially to provide minimal public health and education services. However, most improvements in nutrition and health result from individual consumer decisions and therefore require increases in the incomes of the rural poor.

In the 1980s, income distribution is increasingly one of the principal goals of development so that the rural and urban poor in developing countries can become effective participants in these societies. The 'trickle-down' approach to income distribution of earlier years, when industrialization and import substitution were primary goals, has been challenged by the stresses arising from the population and urban explosions in developing countries since World War II. It appears to be possible to do more in the rural sectors of developing countries about income distribution by means of technological change in association with other agricultural policies (see Lynam, et al., 1981).

NOTES

1 We are indebted to various scientists at CIAT, especially Peter Jennings, for numerous discussions and critical comments on earlier papers over a five-year period since 1976. We are also indebted to Lowell Hardin for extremely detailed comments on an earlier draft. The authors are responsible for any remaining errors. These views do not necessarily reflect those of CIAT (Centro Internacional de Agricultura Tropical).

2 A recent review of the migration process summarizing many empirical studies argues that rural migrants take the low wage urban jobs but that their unemployment rates and time periods of job search are lower than those of the urban poor. Hence, there appears to be a churning process with the more marginal urban jobs continually being filled by the new migrants (FAO, 1978, and studies cited). If policy-makers in the developing countries are also concerned with the urban poor, the basic argument here to reduce the rates of rural-urban migration is not affected.
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DISCUSSION – RAPPORTEUR: RAMESH SHARMA

Due to the absence of Sanders and Lynam, this paper was presented by Professor J.B. Hardaker. Dr Seiji Sakiur opened the discussion and said that by and large he shared the views expressed in the paper but he had three points to add. First, he noted that the authors had limited their coverage to the rural sector and thus missed completely rural to urban migration which plays an important role in the issues and strategies given in the paper. Secondly, he asked what sort of theoretical assumption underlies their strategy on removal of poverty. Thirdly, he was of the opinion that instead of generalizing a strategy, the authors should have used a separate area focus, for example Asia, Africa and Latin America.

Seven speakers from the floor expressed their comments broadly in four areas; coverage of the paper, labour scarcity, income distribution, and agricultural research. The view was expressed that the paper contained no new evidence or analysis, especially in the area of rural-urban migration, human capital investment and agricultural research. In Brazil the agricultural labour force is going to decline drastically in the future and so labour-productivity, mechanization, power and efficient use of inputs have to be increased. Three points were made on income distribution. The speakers disagreed with the authors that distribution effects of the new modern varieties are ignored by governments. The validity of two of the authors assertions was also questioned: that the new varieties are regressive in income distribution, and that consumer surplus comparative static analysis is a rationale for ignoring distribution effects. On agricultural research, we should try to develop low-fertilizer requiring HYVs. Also raised was the point that one cannot dismiss research for adverse areas purely on grounds of inefficiency and likely lack of success.

Professor Hardaker briefly responded to the queries raised. He agreed with most of the views expressed. But he was not sure that Governments in LDCs had taken serious measures towards equity following the ‘green revolution’. For balancing growth and equity considerations, he was of the opinion that it depended upon the social welfare function of a country.

Participants in the discussion included V. Palmer, D. S. Tyagi, D. Hedley, G.O. Hughes, J.P. Hrabovszky, M.G. Chandrakanth and V. Steigerwald.