

## THE ROLE OF GOVERNMENT AND NEW AGRICULTURAL TECHNOLOGIES BY JOHN W. MELLOR

*In the late 1960s the "green revolution" was newly under way, bringing a wave of introspection concerning its preconditions and possible future adjustments. A decade and a half later it is useful to review for the late starters, particularly for Africa, the nature of those preconditions and to see how well adjustments are going for the early participants. This paper was prepared as an overview for a review conducted in 1969 by the U.S. Agency for International Development. It reflects analysis of detailed papers on the progress and effects of the newly erupted revolution.*

The agricultural research breakthrough symbolized by the new cereal varieties offers an opportunity to turn away from defeatist agricultural development policies directed toward the race to keep food supplies in balance with population growth and famine relief and to turn toward a positive role for agriculture, which places it at the leading edge of the total development process.

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Many basically undesirable government policies, including price controls, restrictions on domestic trade, and rationing, have not been the cause of failure in agricultural development so much as the effect. These policies represent the desperate short-term efforts of governments to meet scarcity

situations. To swing government efforts away from defeatist policies is desirable but complex.

Achieving dynamic agricultural growth through technological change and facilitating the many adjustments in agriculture and other sectors that must accompany this change requires a vast number of activities, many of which must be provided by the government. Even those activities performed in the private sector often require government facilitative actions. These demands on governments are growing rapidly at the same time that other demands for resources are growing.

In situations of scarcity, governments tend toward a high degree of inhibitory regulation, particularly in the areas of marketing and prices. The new environment of agricultural development provides scope for switching away from inhibitory regulation to facilitatory regulation. In the marketing area, for example, this would mean turning away from price regulations and prohibitions on storage and movement of crops and moving toward more emphasis on orderly markets, a system of grades and standards, and improved market information and transport.

In allocating a government's resources, it is not enough to inventory the things that must be done to facilitate agricultural development: the next step of dividing the tasks between the private and the public sectors and setting priorities on those that are to be performed in the government sector must also be taken. Because of the scant knowledge of agricultural development processes and the highly varied and dynamic background in which development takes place, good decisionmaking requires a substantial input of diagnostic services. It is unlikely that every opportunity for agricultural development will be seen at the beginning of the process and provided for

in a set program. Someone must constantly observe the progress of agricultural development, searching for problems and bottlenecks and presenting the solutions to them. This is a pragmatic process, somewhat in contrast to the rigid planning that has characterized many past efforts in agricultural development.

### POLICIES FOR AGRICULTURAL DEVELOPMENT

The naive and general question of whether farmers in low-income countries respond to economic incentives has been clearly answered. They do. Two important questions remain. First, what is the relationship between the level of profitability, on the one hand, and the rate of diffusion of technological innovation, on the other hand? Second, how are increased incentives or profitability to be provided?

The rate of growth in production provided by an innovation is a function of the total increase in output it provides and the pace of its acceptance. An innovation that doubles production provides only a 3 percent rate of growth if diffusion occurs evenly over a period of 25 years. It provides a dramatic 10 percent rate of growth if it is accepted by all farmers in 8 years.

Government policies that speed the diffusion of innovation are important determinants of short-term rates of growth. When such policies are combined with policies that constantly provide new innovations, they provide rapid rates of long-term growth as well.

There is considerable variation from time to time, place to place, and innovation to innovation in the speed with which farmers take up particular innovations. All

other things being equal, the greater the profitability of a particular innovation, the more rapidly it will spread. There are, however, many qualifications to this. Some innovations may conflict with or require changes in deeply ingrained cultural and social habits. At a given level of profitability, such innovations will spread less rapidly. Policy may be concerned with changing the social and cultural habits and in modifying the innovation so that it interferes less. Some innovations will require much larger risk discounts than others. Policy may be concerned with reducing the risk by more careful field testing of innovations, giving farmers more control over their environments, or with removing the burden of risk and uncertainty from farmers.

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Farmers are concerned with the rate of return on additional inputs. However, farmers are also concerned with the total return from applying an innovation. Put another way, when the optimal amount of fertilizer to use is only 10 or 15 pounds per acre, it makes little difference to total income whether fertilizer is used or not. When the optimal amount to use is 80 pounds per acre, it makes a great difference. This is rational if one thinks of innovation as having a substantial fixed cost for overcoming inertia and making new decisions. The new grain varieties have not only increased the return at any given level of fertilizer input, thereby encouraging more investment in fertilizer, but they have greatly increased the total return by making it profitable to use much larger total quantities of fertilizer. It is the dramatic increase in *total* return that explains the revolutionary speed of diffusion of the new wheat varieties.

Although profitability of inputs may be increased through incentives provided by higher price alone, this approach is essentially antidevelopmental. First, such price policy is essentially an effect of failures in the agricultural sector rather than a cause of success. If agricultural production is not keeping pace with growth in demand from population and income growth, then agricultural prices can be expected to rise. This should in turn induce some growth in total production. However, in low-income countries it is likely that price increases without accompanying technological change will bring disproportionately small increases in output compared with the increase in prices.

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If the existing state of technology is not very advanced, the returns to increased use of inputs tend to be quite small; thus even if higher prices bring a substantial increase in input use, the total increase in production will be small. Second, increases in agricultural prices tend to have a strongly deleterious effect on the development of other sectors. Such price increases are especially harmful because they decrease the real incomes of the lowest-income persons in society.

In contrast to increasing profitability through higher prices, an increase in profitability through improved input-output relationships, such as introduction of the new grain varieties, often has a large positive effect on output, not only because it tends to increase the productivity of resources already being used but because it greatly increases the productivity of increments of resources.

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Development of a research system requires allocation of adequate finances; allocation of trained researchers and administrators; and pragmatic coordination of the total process, among geographic regions, across disciplines, and from most basic to most applied research. The biological and physical sciences provide the basis for technological change, but social science research is needed to accelerate diffusion and to anticipate and meet problems associated with dynamic change.

Development of an effective research system is probably the most important institution-building job to be performed in the development process. Provision of adequate numbers of highly trained people is crucial to this process. First priority should be given by governments to these considerations.

New agricultural technologies bring two changes that are relevant to price policy. First, because the new technologies require a much greater use of purchased inputs, they greatly increase the vulnerability of farmers to unfavorable changes in price relationships. Farmers have higher cash costs and therefore are more subject to a cash squeeze than without the new technologies. Second, because the new technologies are erratic in their effect on particular crops and areas, large short-term

supply changes may occur with consequent sharp changes in prices.

Thus the purpose of a price policy designed to assist technological change should not be one of changing prices from the longer-term relationships that they would otherwise hold but rather one of providing greater stability and certainty for prices and price relationships. A price policy should allow normal seasonal price fluctuations to occur in order to provide incentives

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for private trade to carry on normal storage operations. It must allow agricultural prices to be sufficiently flexible to allow changes in production patterns. In particular, at a time when most rapid technological changes are occurring in basic foodgrains, for which the demand is somewhat inelastic, there must be scope for the price of foodgrains to decline relative to other agricultural commodities, so that production can shift toward those commodities that are more income and price elastic. Finally, given the general demands on government's financial resources and the problems of capital formation, it is probably undesirable to have income transfers from nonagriculture to agriculture financed through price support processes.

There is evidence that the private marketing agencies operate least well in situations of great uncertainty. In particular, if new technologies bring about sharp increases in the production of a particular commodity and if that commodity is of a somewhat lower grade than standard commodities, then there may well be sharp speculative declines in prices at harvest time. It is these declines in prices that are particularly injurious to the increasingly vulnerable farmers who are taking up technological change, and it is these declines that a positive price policy should guard against.

A policy emphasizing stability rather than higher prices would not necessarily require that prices be set before planting time. It does not matter when these prices are set as long as the stability is provided. The basic incentives would be provided by the technological changes. The price policy would insulate farmers from short-term speculative attacks.

The desirable effects of higher prices to farmers could be realized without dele-

terious effects if major economies could be realized in marketing channels. A marketing improvement that may provide a dramatic reduction in costs is transportation. Poor transport may raise costs enough to prevent acceptance of innovations over large areas. In such situations the returns to investment in improved farm-to-market roads may be high.

Almost without exception the new grain varieties bring dramatic increases in yields by greatly increasing the profitability of using larger quantities of fertilizer. Once new varieties are available, it is important that fertilizer supplies be greatly enlarged and that efficient distribution channels be made available. The first objective for a growth-oriented policy on fertilizer should be in planning for adequate supplies to be available, primarily through import policy and allocations of foreign exchange. The second objective should be to see that distribution channels are available for moving these supplies to farmers.

In developing distribution channels important consideration should be given to existing systems in rural areas including distribution operations of both private and cooperative sectors of the economy. Past failures of fertilizer cooperatives may have resulted largely from the unprofitability of fertilizer use itself; hence cooperatives may work more effectively once there is a strong demand for fertilizer. Under such circumstances farmers themselves may participate more actively in the operation of cooperatives and see to it that they perform more effectively.

The profitability of new innovation is partly a function of how effectively it is applied. The more complex the set of complementary practices that must accompany an innovation, the less likely it is that the full profitability of an innovation will be realized.

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In the 1950s the importance of new technologies was not understood, and it was generally believed that the role of education in traditional agriculture was one of awakening people's minds and developing a favorable attitude toward innovation. It should be clear now that farmers the world over are interested in improving their incomes through technological change and hence the role of extension is much less one of awakening their minds to the

desirability of change and much more one of providing technical information.

Most important in fulfilling this function are higher educational institutions such as agricultural universities, which can provide a large number of technically trained technicians who can understand the new technologies; explain them to farmers; and, most important of all, diagnose failures so that farmers may learn what they did wrong and improve.

The new agricultural technologies require a substantial increase in the working capital resources of farmers, primarily because of the large increase in the amount of fertilizer that must accompany the new technologies. A number of additional complementary investments may also be needed. The added capital may come from private savings of farmers themselves, private lending agencies, or from governmental or cooperative agencies.

Under the new conditions of improved technologies, returns to production investment have gone up substantially, thereby making lending to more prosperous farmers for production purposes much less risky and potentially more profitable. Under these circumstances private banks and similar lending agencies are showing much more interest in farm loans, and they are

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**A rapid increase in foodgrain supplies should be followed by governmental policies that expand employment for low-income people.**

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providing a further flow of funds into rural areas.

Nevertheless, there is a need to encourage the development of cooperatives and other quasi-governmental agencies to lend to farmers. With new technologies making lending for production much more profitable, cooperatives may have a more favorable environment for successful lending. Here too, however, the tremendous resource requirements in economic development and the need to raise as many of these resources as possible in rural areas must be considered. Thus efforts on the credit side should recognize a substantial potential for farmers to finance technological change themselves and should minimize intersectoral transfers toward agriculture through credit programs.

One of the consequences of rapid application of new technologies is an increase in income disparities. There is concern that operators of very small farms will have neither the knowledge nor the financial

resources to apply the new technologies and hence will neither be able to make their full contribution to growth in agricultural production nor receive the benefits to income that come from the new technologies. The financial problem can be met by credit programs. The extent to which it is a problem will vary considerably depending on the impact of the new technologies on capital requirements and also on the nature of the existing financial resources and institutions. In any case, it is by no means clear that small farmers have been inhibited from taking up new technologies. Recent evidence shows them progressing about as quickly as farmers with larger holdings in applying the new technologies.

## **POLICIES TO CONFRONT ECONOMIC EFFECTS**

Once the challenges of setting effective government policy for bringing about rapid technological change in agriculture have been met, governments must face a new set of policy challenges. New supply-demand relationships must be established, implications of new income relationships among regions and groups must be determined, and new opportunities for using agriculture to speed the total development process must be grasped.

The major breakthroughs in agricultural technology of the recent past, and probably those of the near future as well, have been in basic foodgrains. There are three logical possibilities for using the increased production: increasing exports, increasing domestic demand for grain products, and shifting the production mix away from grain products to other agricultural commodities.

Some countries will be successful in developing new or expanding old export markets for basic foodgrains. However, most countries will undoubtedly absorb increased production domestically.

Low-income countries differ from high-income countries in two important respects relevant to domestic demand for basic foodgrains. First, the demand for foodgrains is much less inelastic in low-income countries than in high-income countries: as a result, modest declines in foodgrain prices may have quite significant effects on domestic consumption. Thus in situations in which new agricultural technologies greatly reduce the cost of production per unit of output, some of that reduced cost may be reflected in lower prices, and a large part of the extra production may go to domestic consumption.

Second, a large share of the population in low-income countries will have incomes so low they will spend a high proportion of increments to their income on food. Government policy that increases employment

rural employment, infrastructure investment offers immense potential for effective use of food aid, particularly in the low-income countries. It is puzzling that hunger, lack of labor and food resources for building infrastructure, and huge food surpluses can coexist.

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Third is increasing food security nationally and internationally. That is needed because a strategy relying on food and employment growth is terribly vulnerable to the effects of normal fluctuation in food production.

Behind all these processes is rapid expansion of trained people—a high employment strategy of growth is accompanied by extraordinarily rapid growth in demand for educated people at all levels. Foreign assistance has its greatest comparative advantage in helping meet that demand.

## **AGRICULTURAL RESEARCH POLICY**

The new environment of apparent global abundance of food brings somewhat differing requirements for food production research.

First, there must be an even greater emphasis than in the past on reducing costs of production. In Asia, that reduction occurs by raising yields per acre. In Africa, the problem is more complex. Labor productivity is the greatest limitation to production increases in Africa. We can already substantiate that, in general, the appropriate way to raise labor productivity in Africa is through yield-increasing technology but with a particular concern for the effect of such technology on labor productivity.

The national and international agricultural research systems have done yeoman work in recent years to broaden the range of conditions suitable to high-yielding varieties. This work has gone sufficiently far that one can truly talk about saturation of large areas with high-yielding varieties. How then will growth rates of the recent past be maintained into the next decades? That will soon be a serious problem in Asia. All impressions of food abundance will dis-

appear within a decade or two without further breakthroughs in yield potential.

Second, with a more bountiful food supply in the world, we have the opportunity to take more meaningful steps toward sustaining growth in agriculture. On the one hand, we must increasingly shift higher-yielding, more productive farming systems into environments whose ecosystems can sustain such increased intensity. That should allow gradual increase in the proportion of population in more sustainable areas, while concurrently reducing population pressures in areas that cannot sustain arable agriculture. We must ask ourselves what are the implications of this to two related research questions. One is: under what circumstances and by what mechanisms can we use the increased abundance of food in the world to reduce population pressures more rapidly in the areas that cannot support arable agriculture? The other is: should that then push our research resources more toward the perennial grasses and tree crops that can be sustained in such areas?

Third, when the abundance of food is increasing, we must increase the emphasis on maximizing the linkages between agricultural growth and employment growth in nonagricultural sectors. That too requires research. Increasingly, lack of effective demand for food is proving to be a constraint for developing countries with per capita incomes under \$500, in spite of progress in agricultural production. We have done a good job of documenting the existence of linkages between agricultural growth and employment in other sectors, but we have not gone far in diagnosing the policy pre-

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scriptions for maximizing the size of those linkages.

Fourth, where food is more abundant, we can turn more vigorously to increasing employment by developing smallholder livestock production. Here we face elastic demand for the product and hence a substantial increase in demand from a small decline in prices. There are, however, clear technical problems, not only in production but also in marketing. Because of the in-

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elasticity of waste and by-product feed supplies, research must have a twofold emphasis on increasing the productivity of grasslands and improving our knowledge about the productive use of concentrate feeds. Any enhancement of livestock production will also help to solve the difficult problem of inferior grains, such as millets and sorghums, and even maize. These cereals are well-suited to large areas and have good possibilities for increasing yields, and yet the demand for them is highly inelastic except as livestock feed.

Fifth, with an increasing abundance of food, we need to focus our attention more on the problems of the poorest countries and the poorest people within those countries. However, these two sets of problems call for somewhat different treatment. With respect to the poorest countries, there undoubtedly needs to be an emphasis on the better areas within those countries in order to increase the returns to investment in agriculture and to generate the funds for tackling the much more difficult problems of the more backward areas.

With respect to the poorest people in the poorest regions, we need to be much more innovative in developing research approaches. We must differentiate clearly between short-term needs to mitigate the problems of the very poor and longer-term adjustments that can be made as population densities are gradually reduced through more intensive and sustainable development in other areas.

## **CONCLUSION**

Let us hope that the present abundance of food is not an illusion or a quickly passing aberration. Let us recognize abundance for the blessing it is: by raising incomes in developing countries with new, cost-effective food production technology; by using food surpluses to support labor-intensive investment in the infrastructure that broadens participation in growth; by providing food security measures that reduce the risks to governments of caring about poverty and acting on those concerns; and by learning now how to bring the lower-income countries to the stage of development where effective demand for food outruns effective agricultural development policies.