PN-AAD-992

AGENCY FOR INTERNATIONAL DEVELOPMENT

SPRING REVIEW
OF
THE NEW CEREAL VARIETIES

May 13 - 15, 1969

THE ROLE OF GOVERNMENT
and the
NEW AGRICULTURAL TECHNOLOGIES

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By

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*Paper prepared for the USAID Spring Review
Washington, D. C., May 13-15, 1969.

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SUMMARY AND CONCLUSION

Introduction

a. The new grain varieties clearly demonstrate the opportunity to turn from defeatist agricultural policies of price control and regulation of distribution and towards policies fostering rapid technological change in agriculture and a major contribution from agriculture towards the total development process.

b. Much investment in agricultural development, prior to the new varieties, gave low rates of return, raising legitimate question as to whether scarce resources should be invested in agriculture. The new cereal varieties demonstrate that there are situations and approaches to agricultural development for which the returns are very high. Likewise the theoretical argument against investment in agriculture as a consumer goods producing industry has been largely destroyed by the severe pressure which success in industrial development has placed on food prices and the deleterious effect that it in turn has had on further industrial growth. Thus it is now likely that the prime source of opposition to agricultural development will be from those who fear that agricultural development will so broaden the distribution of income and economic and political power as to threaten existing ruling elites.

c. The new agricultural technologies have greatly increased the

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productivity of many forms of investment in institutions and inputs for agricultural development. Thus the demands on the scarce administrative and financial resources of governments are rising rapidly, thereby presenting difficult allocational problems for governments. This gives a new economic urgency to decisions concerning what functions governments will leave to the private sector and setting of priorities for the functions to be performed in the public sector. Inventories of all the tasks useful to agricultural development are not enough. In addition, governments must avoid policies for increasing production which will conflict with policies for using increased production to solve larger problems of growth and income distribution. The precise agenda for any particular government will differ with the existing environment and the past history of institutional development in both the private and the public sectors. In any one time and place the specific requirements placed on the government may be very small and few in number or very large and many in number.

General Observations from the New Varieties

d. The contrast in success and failure of the new varieties has been greater among regions within countries than in the average among countries. This emphasizes the importance of physical conditions such as climate and soil; or past investment in infrastructure, such as irrigation and roads; and research results adapted to specific conditions.

e. The nature of specific new policies and programs accompanying success varies greatly from country to country. This emphasizes the need for flexible, pragmatic policy adapted to the specifics of time and place. Differing environments demand different actions; different

histories of past efforts call for differences in future efforts. Policy needs constantly change. Thus, emphasis in agricultural development must be on constant reanalysis of the situation and development of new programs as necessary. This is undoubtedly one reason why recent successes have been substantially associated with a major commitment to agricultural development at the upper levels of government. Such commitment breaks institutional rigidities and allows a pragmatic, dynamic process of diagnosis and meeting of needs.

Research

f. Success of the new cereal varieties in a few situations has dramatically illustrated how research in the agricultural sciences can greatly decrease unit costs of production and thereby give farmers incentive for a great increase in total production. Problems in the spread of the new varieties have sharply pointed out deficiencies in the systems of adaptive research. New varieties which met the quality standards of some areas must sell at such tremendous price discounts in other areas as to nulify the yield advantages of new varieties. Research must be done to widen the quality adaptability of new varieties. There is good evidence that this can be done. Insect and disease problems have barred the new varieties from some areas. Adaptation to water depth is still narrow. Even in successful areas yields are often well below long run potentials due to lack of adaptation to local conditions. Success in cereal production frees resources to produce other crops and raises the returns to research on other crops. A whole series of new economic and social problems are rising about which we have very little knowledge. It is likely that no country

has an adequate system for agricultural research and many have not even commenced developing one.

Education

g. Research and other institutions of agricultural development are comprised of trained manpower. The new varieties greatly increase the demand for such manpower in both the public and private sectors. The need for quality in technical knowledge is particularly acute. Thus, improved quality and quantity of higher education in the agricultural sciences has become more urgent as a result of the new varieties.

h. In some situations, the new varieties have been so dramatically profitable that lack of a technically competent extension program has not slowed acceptance. Where the returns have been more modest, acceptance is speeded by such a service. The need will become more obvious as further growth depends on less dramatic innovation and spread into marginal areas. Few countries have substantial numbers of technically competent extension workers or programs for providing them.

Price Policy

i. The new varieties (a) increase farmers vulnerability to price fluctuations, (b) increase the liklihood of sharp fluctuations in prices, (c) reduce unit costs of production, (d) increase the quantity of output to be consumed. Farmers can absorb lower output prices because of lower costs. Lower output prices help move production into consumption, shift resources to other agricultural commodities, and raise real incomes of the lowest income persons.

j. The focus of agricultural price policy for facilitating technological change needs to be more on stabilizing prices and less on raising their general level. The concern in stabilizing is to protect farmers from unexpected price declines arising from sharp shifts in supply and demand and speculative influences in the markets. This does not require setting prices before planting so much as government financial and administrative ability to move into a market at harvest time in order to buy in the face of a speculative onslaught. What is needed for such a price policy is an analytical resource for analyzing basic supply-demand relationships, predicting effectively what prices should be and can be supported, and then providing support at that or some slightly lower level. In the face of unpredictable technological change the system needs to be highly flexible.

k. New technologies increase returns to inputs and reduce the desirability of input subsidies and increase the importance of assuring adequate supplies. Assurance of adequate supplies and distribution may be greater with higher input prices and no subsidies.

Provision of Inputs and Credit

l. New technologies require a vast increase in inputs and greatly increases the returns to those inputs. Problems of supply and distribution must be met. Variation in environment allows little generalization about the specific actions needed and the division of these actions between the public and private sectors.

Marketing

m. Again little generalization is possible, although ill-founded stereotypes overstate the inadequacies of existing systems and understate their capacity to expand in response to increased production. Government emphasis should generally be on policies which facilitate competitive operation of the small scale private sector.

Employment Policy

n. Low income people spend a high proportion of added income on food. Thus increased agricultural production can be and should be accompanied by programs for expanding employment of such people. They may also facilitate agricultural development by building roads and dams. Lower prices for cereals facilitate such policy.

Income Distribution

o. Regional distribution of income may be smoothed by judicious investment in education, research, roads, irrigation and other elements of infrastructure. Low income consumers benefit from lower agricultural prices. Low income farmers benefit from research, education and marketing improvements which facilitate shifts to more labor using commodities such as vegetables, milk and poultry. Increased cereal production provides a more favorable environment for such shifts.

p. The new cereal varieties are about as easily taken up by farmers with small holdings as those with large holdings. The divisible nature of inputs makes credit not particularly limiting. The new cereal varieties greatly

expand the demand for labor. It is important that institutional policy facilitate meeting this demand with human labor rather than mechanization without following policies which prevent acceptance of the new cereal varieties.

The Role of Government and the New Agricultural Technologies*

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I. INTRODUCTION

The New Opportunities

1. The agricultural research breakthrough symbolized by the new cereal varieties offer opportunity to turn away from defeatist agricultural development policies oriented towards the food-population race and famine relief and towards a positive role for agriculture as the leading edge in the total development process. In turning from a "more food at any cost" approach and towards a development oriented approach difficult economizing decisions must be made concerning the allocation of resources between the agricultural and nonagricultural sectors as well as within the agricultural sector. In addition there will be many widely differing effects of success in agricultural development some of which will be considered undesirable. Governments must meet these problems so as to further facilitate the development of agriculture and its total contribution to overall economic development. Detailed research into the economic and social effects of alternative agricultural policies has suddenly become relevant and important.

2. Many basically undesirable government policies of the last few years, including price controls, restrictions on domestic trade and rationing have not been the causes of failure in agricultural development so much as the effects of failure, representing the desperate short term

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efforts of governments to meet scarcity situations. To swing government efforts away from failure oriented policies is desirable but complex.

Economizing in the Use of Government Resources

3. Allocation of its own limited financial and administrative resources is one of the most important allocational decisions facing development oriented governments. Achieving dynamic agricultural growth through technological change and facilitating the many adjustments in agriculture and other sectors which 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. Such demands on governments are now growing rapidly at the same time that other demands for these same resources are growing.

4. In addition, success in agricultural development may reduce the financial resources open to some governments. P.L. 480 imports have been an important source of financial resources to many governments. Either means must be found to use P.L. 480 within the context of agricultural growth, or government spending on nonagricultural development must decline or the financing of agricultural growth will increasingly have to be done by nongovernmental sectors of the economy, or ways must be found for raising additional government finances -- quite possibly by tapping the increased income arising from the agricultural successes themselves.

5. Similarly the new agricultural technologies will require a substantial expansion in institutions servicing agriculture both in the public and private sector. Governments will face problems in financing

the requisite administrative personnel and, more important, in finding sufficient administrative personnel. There will continue to be a difficult allocative problem for administrative resources between the public and private sectors.

6. In view of severe financial and administrative restraints, governments must carefully diagnose what development tasks are important and which can properly be taken care of in the private sector with resources that governments could not otherwise command. Governments must then define the key bottlenecks which other sectors will not take care of and provide adequate financial and administrative resources to remove them. These are important and difficult allocative problems. They are matters of economics much more than ideology.

7. In situations of scarcity, governments have been driven towards a high degree of inhibitory regulation. This type of regulation particularly in the marketing and prices area has taken considerable administrative and financial resources. The new environment of agricultural development provides scope for switching away from inhibitory regulation to facilitory regulation. In the marketing area we can exemplify this by turning away from price regulation and prohibitions on storage and movement of crops and towards more emphasis on orderly markets, a system of grades and standards and improved market information and transport. Likewise, price policy may be used as an efficient means of directing inputs and outputs in desired directions with minimum use of government financial and administrative resources.

8. For determining allocation of government's resources, it is not enough to make inventories of the various things which must be done in

order to facilitate agricultural development. The next step must also be taken of choosing those things that can properly be left to the private sector to accomplish with the minimum of facilitative regulation and what must be done in the public sector and to set priorities on those tasks to be performed in the government sector. Because of the scant knowledge of agricultural development processes and the highly varied and dynamic background in which development takes place, good decision making requires a substantial input of diagnostic services. It is unlikely that each need and opportunity for agricultural development will be seen at the beginning of the process and provided for in a set program. Required are persons who are constantly observing the progress of agricultural development, searching for problems and bottlenecks and presenting the solutions to them. It is a pragmatic opportunistic process somewhat in contrast to the rather rigid planning which has characterized many past efforts in agricultural development.

II. THE CONCERN OF GOVERNMENTS WITH AGRICULTURAL DEVELOPMENT

9. Much poor policy with respect to agricultural development results from misunderstanding the scope and complexity of agriculture's role in the total development process. A review of this role will set the stage for the substantive discussion of the means of facilitating agricultural development.

The Standard Food-Population-Famine Argument

10. For reasons of humanitarianism and political economy it is important that food production in low income countries keep pace with

population growth. This tends, however, to be a holding action not a positive force for development. It is dangerous to justify efforts at agricultural development on these grounds because with success in reaching this narrowly defined objective attention and resources may then be switched away from agriculture at just the time when agriculture might be able to play a positive overall development oriented role. In addition, the short-term urgency of the food-population race distracts attention from difficult allocative questions, and from the importance of obtaining high rates of return to resources used in agriculture, as in other sectors of the economy, and places too much emphasis on short-term palliative policies as compared to high rate of return, long-term developmental policies.

Contributions to Capital Formation and Employment

11. Rapid population growth places severe demands on the potential of low income countries to provide employment. It is important to provide the capital necessary to employment of growing labor forces not only so that they may contribute to the growth process but also to forestall the difficult political and social problems accompanying increasing unemployment. High rates of savings are difficult to achieve unless the agricultural sector itself can provide an increased rate of savings and make those savings available for employment increasing investment.

12. Since governments in low income countries are a particularly important source of investment capital, agricultural development policy must be closely concerned with the effect of agricultural development

policy on the fiscal state of the government. Thus consideration must be given to agriculture's potential to generate from within itself the capital needed for its own development particularly insofar as this can be done by tapping savings resources that would otherwise not be tapped for the development process. Further, the question must constantly be asked as to what extent the government's fiscal resources must go in the agricultural sector and to what extent the agricultural sector itself can provide those resources. And further there must be concern with the extent to which the agricultural sector can contribute to the fiscal resources of the government.

Agricultural Development and Income Distribution

13. The close relationship between agricultural development and raising the real incomes of the lower income members of society is often forgotten. It provides one of the most important reasons for vigorous pursuit of agricultural development, particularly within the context of a democratically oriented society.

14. It is difficult if not impossible to spread employment amongst the lower income people in society and thereby increase their real incomes if there is not a concurrent increase in the supply of the consumer goods upon which such low income people spend the bulk of increments to their income. Low income people in low income countries spend a high proportion of increments to their income on food. If per capita food supplies are not increased then it is not possible to follow employment increasing policies which improve the material well-being of the low income people in society.

15. Thus we see a close relationship between agricultural development and the rest of the strategy for development. If agriculture is not moving rapidly enough to provide a substantial increase in the per capita availability of food then total development policy must minimize the extent to which it increases employment more rapidly than total population growth. In these circumstances development policies which emphasize labor using techniques for expanding the infrastructure of development such as roads, irrigation dams and buildings, must be minimized. If they are not minimized, increased purchasing power will press against the limited quantity of food and similar consumer goods and an inflationary situation will follow. For example, much of India's food problem of the early 1960's rose from these problems, not from population growing faster than food supplies. Thus without agricultural growth, the development emphasis must be on heavy industry and other approaches which minimize the use of labor and in turn throw a heavy burden on foreign exchange resources for capital requirements. Rapid agricultural development can push development in the healthier direction of greater emphasis on employment creation and wider income distribution.

16. The Soviet Union has demonstrated that overall economic development can proceed moderately rapidly in substantial part on the basis of vigorous exploitation of a basically stagnant agricultural sector. This is an approach to development, however, which has a very high human cost and it is doubtful if it is consistent with development within a basically democratic framework. Thus agricultural development may not be necessary to overall development but it may be necessary to overall development within a democratic context. Although the total process is much more

sophisticated than the slogan implies, there remains a good deal of truth in the slogan that hungry people and democracy are incompatible. However, it should also be understood that agricultural development may be handled in such a way that its employment and income distribution benefits are not received. Achieving this benefit requires special attention both to the means by which agriculture is developed and to the methods used for distributing the benefits of that development.

Implications to Agricultural Development Policy

17. The following factors must be kept carefully in mind, if agricultural development is to have favorable effects on capital formation, employment and the distribution of income.

18. (1) Attention must be given to efficient use of resources and hence the question must constantly be asked as investment is made in the agricultural sector as to what the rate of return is and how that rate of return compares with alternative uses of those resources.

19. (2) Every effort must be made to finance capital investment in agriculture and to administer that investment with resources from within the agricultural sector which would not otherwise be tapped for the development effort. Through these efforts the government's scarce fiscal and administrative resources can be preserved for use in those aspects of agricultural development where other resources will not be available, thus keeping the process moving at a maximal rate.

20. (3) Closely related to the previous point, concern must constantly be given to the extent to which agriculture can contribute additional tax revenues to help finance that part of its and other sectors development which must come from the public sector.

21. (4) Concern must be given to the extent to which employment, pricing and distribution policies facilitate the spread of the benefits of agricultural development to development oriented programs for ameliorating the problems of the most disadvantaged people in society.

Why Governments May Resist Emphasizing Agricultural Development

22. Effective influence on policy requires that reasons for particular policy actions be understood. There are three primary reasons why governments have often been opposed and may in the future be opposed to efforts in agricultural development.

23. First, governments have often believed that investment of scarce resources in the agricultural sector provides low rates of return. Frequently this belief has been well based in fact. Throughout the 1950's, for example, few countries received high rates of return to their investment in the agricultural sector. This is primarily because these investments were misdirected. However the misdirection of resources was due to ignorance rather universally shared by governments of low income countries and by foreign advisors. The initial emphasis on changing farmer's attitudes (e.g. community development programs), or on inputs alone (e.g. the various "Package" programs), both provided low short-run rates of returns. Under these circumstances much of the irrigation investment also gave low returns.

24. High returns to investment in agriculture have been rare except in those few cases in which rapid technological change was provided by effective biological science research. This is now recognized. Where nations have had available the results of such research applied to their conditions, and then invested in the inputs and institutions to accompany

those innovations they have had returns to agricultural development. We must recognize in looking into the future that in particular times and situations there may not be new technologies available to justify a high investment in agriculture. In those situations we must keep our investment in agriculture concentrated in research, in all likelihood at relatively low levels. Once that research becomes successful we must then move with much heavier complementary investment. It continues to be true that low income countries must invest where the returns are high. Agricultural development can contribute significantly to the total development process if the steps are taken to see to it that investment in agriculture gives high rates of return. The problem of agricultural development is not just one of putting resources into that sector but one of doing it effectively.

25. A second reason for rejecting investment in the agricultural sector traces from theory. Economic development requires substantial savings and investment rates. Theory suggests that investment rates can be raised if resources in the economy are largely allocated to investment goods producing industries or capital goods industries and, conversely, that they not be allocated to consumer goods industries. Agriculture is of course a consumer goods industry except insofar as its product can be exported in trade for capital goods. The basic flaw in this argument against investment in agriculture is its failure to understand the extent to which increased employment in capital goods industries will raise incomes and hence demand for food. The result, if agriculture has not been progressing, will be rising food and labor costs which will eventually choke off growth in the capital goods

industries. Despite the flaws in this argument, it still contains a good deal of merit if the only way of developing the agricultural sector is in a context of static technology with growth being achieved by higher prices attracting a large quantity of scarce resources into agriculture and returning relatively low rates of return -- a situation typical of traditional agricultures. On the other hand, the argument has essentially no merit if agricultural development can be achieved through processes of technological change. The differences in these two situations should be fully understood in delineating policy.

26. A third reason for opposing agricultural development is based on its effects on the distribution of power. Agricultural development increases the economic welfare of peasant farmers and thereby influences the political and social power structure. The fact that agricultural development requires wide participation in new institutional arrangements and economic incentives makes it all the more likely that in the long run it will widen the base of political as well as economic power. Recognition of this by power elites may lead them to oppose such change. Agricultural development opposed for these reasons is unlikely to proceed without a change in the power structure.

III. GOVERNMENT POLICIES FOR FACILITATING AGRICULTURAL DEVELOPMENT

Basic Principles Concerning Farmer Incentives

27. The naive and general question of whether or not farmers in low income countries respond to economic incentives has now been clearly answered in the affirmative. They do. Further, at least within the context of basically democratic societies, increased agricultural pro-

duction depends on increased use of agricultural production inputs and that in turn requires that the profitability of the use of inputs be increased.

28. We are, however, still left with two important questions relating to incentives. First, what is the relationship between the extent of profitability or degree of incentive 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.

29. The rate of growth in output provided by an innovation is a function of the total increase in output it provides and the pace of its acceptance. It is not enough to know that an innovation or a level of input use is profitable and that therefore farmers will accept it. We must know further how long it will take all or a particular portion of farmers to take up a particular innovation. An innovation which doubles production provides an undramatic 3% rate of growth if diffusion occurs evenly over a period of 25 years. It provides a dramatic 10% rate of growth if it is accepted by all farmers in 8 years. The acceptance of inorganic fertilizers in India in the 1950's and early 1960's is somewhat analogous to the former; and the dwarf wheat varieties to the latter.

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

31. 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 change in well ingrained cultural and social habits. At a given level of profitability such innovations will spread less rapidly than those which do not so interfere. 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 careful control over their environment or by removing the burden of risk and uncertainty from farmers.

32. Even the concept of profitability itself must be carefully defined and provides a source of variation in diffusion rates. Farmers are concerned with the rate of return on additional inputs which must accompany innovation. Everything else being equal the higher that rate of return the faster will be their acceptance of innovation. However, farmers may also be concerned with the total return from applying an innovation and if an innovation has a very high rate of return to further investment but still has a very small total return, its adoption may still proceed quite slowly. This is rational if we think of innovation as having a substantial fixed cost for overcoming inertia and making new decisions. In this context it should be pointed out that the new grain varieties have not only increased the return at any given level of

fertilizer input thereby encouraging more investment in fertilizer but it has increased the total return very much by making it profitable to use much larger total quantities of fertilizer. The latter has been more dramatically improved than the former.

33. Thus when we consider the question of profitability and incentives to farmers we must be concerned not only with whether a given set of policies make a particular innovation profitable or not but the relationship between those policies, the rate of profitability and the rate of diffusion of the innovation. Where policies which speed the rate of diffusion of innovation have a cost, as they usually do, then we must compare those costs with the returns from increasing the rate of diffusion of a particular innovation. Put simply, how much is it worth to get farmers to accept an innovation in three years rather than in five years?

34. There are many ways in which policy may influence the profitability of innovation and the use of inputs.

35. Profitability of the use of inputs is a function of price relationships and physical input-output relationships. Price relationships are a function of natural supply and demand influences and policy. The relevant price relationships may be changed by manipulation of either output prices or input prices. Physical input-output relationships are basically a function of the state of technology and can be changed by research in the biological sciences. Thus in a sense higher agricultural prices and improved technology are alternative means of increasing agricultural production. Failure of technology will inevitably result in higher prices providing the incentive to increase production. Price

policy may also be used to reinforce the effects of technology and thereby accelerate the spread of new technology.

36. The new grain varieties greatly increased the profitability of the use of increased quantity of inputs by increasing the amount of output obtained per unit of input. They represent a major incentive increasing factor. In addition, the output per unit of certain inputs can be increased by investment in other inputs. For example, the profitability of use of fertilizer may be greatly increased by providing assured supplies of water through investment in irrigation.

37. Although the profitability of the use of inputs may be increased through increased incentives provided by higher prices alone, this approach is essentially anti-developmental. First of all such price policy is essentially an effect of failures in the agricultural sector rather than a cause of success. If agricultural production is not increasing apace with growth in demand from population and income growth, then agricultural prices can be expected to increase. This should in turn induce some increase in total production. However, it will be common under the conditions of low income countries for price increases without accompanying technological change to bring increases in output disproportionately small compared with the increase in prices. This is because with the existing state of technology the returns to increased use of inputs tend to be quite small and thus even if increased prices bring a substantial further increase in input use the total increase in production will tend to be small. Finally, increases in agricultural prices tend to have a strongly deleterious impact on development of other sectors.

They reduce the availability of capital for industrial development and the profitability of investing capital in the industrial sector. Such price increases have a further deleterious effect in decreasing the real incomes of the lowest income persons in society.

38. In contrast to increasing profitability through higher prices, an increase in profitability through improved input-output relationships such as the new grain varieties often has a very large effect on output because it not only tends to increase the productivity of resources already being used but greatly increases the productivity of large increments of resources. Thus while higher prices may simply induce a greater input of resources at the old level of productivity new technologies induce a greater input and provide much greater output per unit of that input. Thus seen as simple alternatives, research and technological change are preferred to higher agricultural prices as a means of increasing the incentives to agricultural production.

39. Thus the interesting question for agricultural development is how government policy can facilitate more rapid technological change in agriculture and specifically how can agricultural price policy be used to facilitate those changes.

40. Since the purpose and the effect of technological change is to decrease costs, one can presume that technological change itself provides its own positive incentives for its adoption. The role of price policy in this context is thus one of providing added profitability in order to speed the rate of diffusion and to deal with new and more serious problems of price instability accompanying technological change.

41. In the remainder of this section of the paper government policies for facilitating agricultural development will be dealt with under the four headings of (1) Institutions for Research, (2) Prices, Marketing and Transportation, (3) Purchased Inputs, (4) Extension and Education, and (5) Credit and Farm Size. In each of these parts, emphasis will be given to the role of governmentally determined price policy, particularly as it interacts with other aspects of policy. Little attention will be given to the institutional development aspects under each of the headings since these will be covered in other papers. The discussion necessarily reflects experience and hence will likely miss key requirements of the next round of development. Again one must be reminded of the importance of a pragmatic approach to government's role in agricultural development.

Institutions for Research

42. Technological change is the key to effective agricultural development. It is not enough that every once and awhile some new technology can be transferred from some other part of the world. An accelerated rate of growth of agricultural production depends upon a stream of new technologies suited to local conditions. This in return requires a set of research institutions. The rest of agricultural development is needed to facilitate the acceptance of the innovations that come from an integrated agricultural research system. Without that key there can be little gain from the rest. The importance of this question has been fully recognized in this review by the devotion of a complete paper to this subject alone. Within the context of this paper I wish only to bring to attention that development of a research system requires

(1) allocation of adequate finances; (2) allocation of trained manpower and administrators; and (3) following from the previous point flexible, pragmatic coordination of the total process, among geographic regions, across disciplines and through the range from most basic to most applied research. The biological and physical sciences provide the basis for technological change. This in turn greatly expands the need for social science research for accelerating diffusion and anticipating and meeting problems associated with dynamic change.

43. 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 manpower is crucial to this process. First priority should be given by governments to these considerations.

Prices, Marketing and Transportation

44. New agricultural technologies bring two changes which 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.

45. Thus it is suggested that the purpose of price policy facilitative of technological change should not be one of changing prices from the longer term relationships which they would otherwise hold but rather

one of providing greater stability and certainty with respect to prices and price relationships. Such a price policy should allow normal seasonal price fluctuations to occur in order to provide incentives for the private trade to carry on normal storage operations. It must provide sufficient flexibility in the relationships amongst agricultural prices to allow changes in production patterns. In particular at a time when most rapid technological changes are for 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 the desirable production shifts towards more income and price elastic commodities can occur. 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 the nonagricultural sector to the agricultural sector financed through price support processes. This is particularly true since such transfers tend to be significantly at the expense of lower income laborers and to the advantage of the higher income cultivators who sell a high proportion of what they produce. High prices do not, of course, benefit farmers with the smaller holdings who sell very little.

46. There is evidence that the private marketing agencies operate least well in situations of great uncertainty and rapid flux with respect to supply conditions. In particular if new technologies bring about sharp increases in the production of a particular commodity and particularly if that commodity is of somewhat lower grade than standard commodities then there may well be sharp speculative declines in prices at harvest time. It is these sharp speculative declines in prices which

are particularly injurious to the increasingly vulnerable farmers who are taking up technological change and it is particularly this against which one wishes to guard with a positive price policy.

47. A positive price policy accompanying and facilitating technological change might properly have the very limited objective of first determining a normal supply-demand balance price for the expected crop and then setting supports somewhat below this price. Normally the private trade would buy above the set price and the government would not be very active. If, however, there were considerable uncertainty and the trade held back from the market, then the government would do considerable buying. Presumably as the season progressed it would be able to sell its stocks. The very fact of the government participation might lend an element of certainty and stability which would keep the trade in the market in any case. Such a policy emphasizing stability rather than higher prices would not necessarily require that prices be set before planting time. The main concern of such a policy is stability and hence it does not matter when these prices are set as long as the stability is provided. The point is that the basic incentives would be provided by the technological changes. The price policy would be set so as to insulate farmers from speculative attack of short-term types.

48. In cases of very major technological changes which increase agricultural production very sharply the type of price policy delineated above might still bring about excessively sharp declines in prices in a short period of time. In such a situation it might be desirable to build stocks for a period of one or two years as prices were gradually allowed to decline. The declining prices would gradually shift resources

to other agricultural commodities at which time the stocks could be reduced. This kind of stock building is intended to spread major transitions over a few years rather than concentrating them in one.

49. Buffer stock policies are intended primarily to smooth the impact of major changes in weather on supplies and prices. The impact of such policies is extremely complex. In general in low income countries such policies tend to slightly stabilize incomes of the highest income farmers but to cause greater fluctuation in the real incomes of lower income farmers. It is doubtful if such policies have a significant positive effect on production. Buffer stock policies do smooth the supply of agricultural commodities to urban areas and are justified primarily on those grounds.

50. A program of higher agricultural prices may speed diffusion of innovation by increasing profitability and income. Higher prices are not likely to raise the ceiling of production significantly. That ceiling may be reached sooner as a result of higher prices. This of course gives a more rapid rate of growth in the short run which is then balanced by a slower rate of growth in the longer run.

51. This process can be advantageous from two points of view. First, in a world of positive interest rates increased production now is worth more than increased production in the future -- a bird in hand is certainly worth more than a bird in the bush. Second, the accelerated rate of growth in the short run which is provided by the more rapid rate of diffusion may be maintained if the research processes provide a stream of innovations into the future.

52. In using prices in this way it should first of all be remembered that this does have a significant cost to other parts of the economy, and we must weigh the benefits of more rapid diffusion of innovation against the higher cost to other sectors of the economy. Second, success will necessarily bring prices down in order to move production into consumption. Third, we should recognize that these higher prices may be a temporary device with the effects pointed out above. Fourth, we should recognize that in speeding diffusion there are substitute policies for prices. For example, the process of education or more careful testing of innovations to increase the certainty that they will work or research itself providing even better innovations. They may all substitute for price policy in achieving more rapid diffusion of profitable innovation.

53. The desirable effects of higher prices to farmers could be realized without the deleterious effects if major economies could be realized in the marketing channels. However, it has become increasingly evident over the past few years that traditional marketing systems, particularly with respect to grains, have performed quite well within the context of traditional agriculture. That is, they have provided the minimal services required in a low income economy with reasonable efficiency and with relatively small price spreads between the producer and the consumer. What inefficiencies there have been have arisen primarily from poor transportation facilities and some erratic seasonal fluctuations due largely to lack of information concerning crop prospects and storage stocks. The impression of highly imperfect markets arises in large part from errors of analysis in comparing price spreads between quite different varieties of commodities and in noting only years of

exceptional seasonal price increase and ignoring those of very small seasonal price increase or even decline.

54. It is also likely that the capacity of the private trade to expand in the face of large increases in crops has been underrated. Some of the indication of incapacity to expand has arisen in situations in which governments have displaced the private trade and then themselves have not been able to handle expanded production. In such situations it is difficult to know whether the private trade could have performed satisfactorily or not since it was not given the chance.

55. This position concerning the working of private marketing, particularly with respect to foodgrains, has important implications to price policy. If this analysis is correct then in view of the comments stated above about the importance of careful allocation of government's financial and administrative resources, governments should be careful not to move unnecessarily into foodgrain marketing. If government price policy sets the prices of agricultural commodities above what the private trade expects the normal supply-demand balance to be then the government is very likely to displace the private trade.

56. This is not to argue that unfettered private trade operates optimumly for development. There is considerable scope for governments to improve operation of the private trade by supervision and regulation. Likewise new varieties place new demands which government can help the private trade anticipate and meet. For example, need for dryers for earlier harvested rice may require an initial government input to demonstrate the need.

57. The one marketing aspect which may provide dramatic reduction in costs is transportation. Poor transport not only provides ordinary market imperfections, but may raise costs so much as to prevent acceptance of innovations over large areas. In such situations the returns to investment in improved farm to market roads may be very high. There are other potentials for increased efficiency in marketing, but in general the improvements are not dramatic.

Purchased Inputs

58. Almost without exception the new grain varieties bring about dramatic increases in yields by greatly increasing the profitability of using large quantities of fertilizer. Thus the success of the new varieties depends upon making large quantities of fertilizer available to farmers. Conversely, if high rates of return are to be achieved through use of large quantities of fertilizer, there must be technological change which increases the responsiveness of plant varieties to fertilizer.

59. The past record in fertilizer use in low income countries has been in large part due to the unprofitability of using large quantities of fertilizer. Once the new varieties become available it is important that fertilizer supplies be greatly enlarged and that efficient distribution channels be made available. Once new varieties are available, the first objective for a growth oriented policy with respect to fertilizer should be in planning and seeing to it that adequate supplies are available either through import policy and allocations of foreign exchange or by building domestic plants. The second objective

must be to see to it that distribution channels are available for moving these supplies to farmers.

60. In developing the optimal set of distribution channels important consideration should be given to existing systems of distribution in rural areas including both operations of the private and cooperative sectors of the economy. It is possible that past failures in the cooperative sector may be due in important part to the general unprofitability or low profitability from use of fertilizer and that cooperatives will work more effectively once farmers have 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.

61. Increased profitability to larger fertilizer input arising from new technologies may require a number of complex changes in farming practices. In such a situation the rate of acceptance of the new technologies and the rate of growth in demand for fertilizer may be accelerated by an active sales and promotional campaign carried on by the fertilizer distribution system. The extent to which such educational programs should be tied to the fertilizer distribution agencies, to credit programs or carried on within existing extension education programs or dealt with in some other way is a complex consideration which must be a function of existing institutional arrangements, political considerations and the nature of the physical and technical environment.

62. Before the new grain varieties became available the demand for fertilizer in most Asian countries had been gradually increasing as farmers found out how to use modest quantities of fertilizer moderately profitable under their specific conditions. Particularly in a situation of modest profitability under normal price relationships significant acceleration in diffusion was achieved with substantial price increases. Under these circumstances a change back to more normal price relationships has not resulted in a decline in fertilizer use since once taken up the modest profitability under normal price relationships was recognized and fertilizer use maintained.

63. The new agricultural technologies greatly increase the profitability of use of fertilizer. This occurs most dramatically because the new varieties make it profitable to use large quantities of fertilizer and these large quantities times the profit per unit of fertilizer result in very large total profits. Put another way, when the optimal amount of fertilizer to use is only ten or fifteen pounds per acre it does not make much difference to total income whether fertilizer is used or not. When the optimal amount to use is 80 pounds per acre, it makes a very large difference to total income whether it is used or not. As a result the new technologies have resulted in great acceleration in the growth in demand for fertilizer and because of the new technologies it is highly profitable to use fertilizer even at old fertilizer input-output price ratios. Under these circumstances one would expect a very rapid increase in fertilizer use even under conditions of less favorable price relationships than had been true prior to the introduction of the

new varieties. Likewise under these conditions it is most important that policy turn its concern to see to it that supplies are available and distributed conveniently for farmers.

64. If supply and distribution problems are fully solved then the diffusion of fertilizer use and perhaps to some extent the total quantity finally used may be increased by relatively higher prices for fertilizer. It should be recognized, however, that if a government is facing budgetary stringency, a common situation, and there are subsidies on fertilizer use that there may then be forces in the government which will pursue policies discouraging the use of fertilizer by discouraging expansion of supply and discouraging improvement of distribution channels. This will be particularly likely if those forces see increased fertilizer use as diverting funds from other purposes which they see as more valuable. Although this may not be sound economics, it may well be realistic politics. This may be an important general problem of subsidization and the conclusion should be drawn that wherever technological change has made increased input use profitable that we should be careful that we do not handle subsidies in such a way as to discourage solution of supply and distribution problems.

65. This generalization would apply not only to fertilizer but other inputs important to the agricultural sector including pesticides and insecticides, electricity and water. Again wherever the use of these inputs is very small in total quantity a subsidy will not use sufficient governmental funds to create a problem of this sort, but when use expands to a large volume such subsidies may be important in total quantity and create the problems indicated.

66. As fertilizer use increases substantially in low income countries it is likely that there will be increasing effort made to tax the agricultural sector through taxes on fertilizer. The reasons for these efforts and pressures should be fully understood. They arise first from the various severe budgetary pressures facing most governments in low income countries. This pressure will be increased in those countries which have previously been receiving P.L. 480 shipments and which may see discontinuation of those shipments in response to success in the agricultural sector.

67. Concurrently with these pressures on the income side, there are increasing pressures to raise government expenditure. This is particularly true for the agricultural sector where the new technologies create added need for further expenditure on research, something which is absolutely essential to continuation of the agricultural revolution, improvement in road transport which is again crucial to expanded success of the agricultural revolution in many countries, improved technical training of extension services, etc.; in addition to which there are many further pressures for expansion of activities in the nonagricultural sectors.

68. As the agricultural revolution proceeds it will be increasingly recognized by governments that it is accompanied by sharply higher incomes in the agricultural sector. It is further being increasingly recognized in the low income countries that the agricultural sector income group by income group has been less heavily taxed than most other sectors. This situation varies considerably from country to country depending primarily on the importance of export crops. Where agricultural

export crops are important, the agricultural sector has been much more heavily taxed than in other countries where they are not important.

69. A tax on fertilizer is in many respects the economically most inefficient means of taxing the agricultural sector since it does discourage the use of a crucial output increasing input. It is, however, important to recognize that there is a very significant welfare argument for taxing agriculture through a tax on fertilizer. That is that the new technologies which greatly increase incomes are very closely associated with increased fertilizer use, thus a tax on fertilizer tends to fall most heavily on exactly those farmers whose incomes are being most benefited by the new technologies. Such a tax on newly acquired increments to income is a particularly attractive tax from the welfare point of view. If a substantial proportion of the proceeds of that tax are used to provide infrastructure for further agricultural development through investment in research facilities, improved transportation, etc. then it may be better to have that tax than not to have the facility. It should also be recognized that Taiwan which has had one of the most favorable records in agricultural development of any low income country has taxed the agricultural sector very heavily through its manipulation of the relationship between rice prices and fertilizer prices. In effect, there has been a heavy tax on fertilizer. It has not prevented agricultural development because proceeds from that tax have been used for development of the infrastructure through improving research, roads, irrigation and other investment. These points are made not to justify what are basically inefficient taxes but to indicate the complexity of tax and subsidy questions and to caution against stock answers to these questions.

70. Although fertilizer is the most dramatic input associated with technological change, one may find, particularly in the tropics, that insecticides and pesticides rapidly come to the fore. Likewise, electricity may become much more important not only because it may encourage incentives for increase in production through its association with attractive consumer goods but it may be important directly in production as well through powering of private wells. Similarly, improved irrigation facilities may be crucial to the acceptance of new technologies. It is important to recognize that the new technologies greatly increase the rate of return to these inputs, thus swinging the emphasis towards means of increasing the supply and the distribution of these inputs. Pricing policies and other policies should be pursued which would facilitate this.

The Role of Extension and Education

71. The profitability of new innovation is partly a function of how effectively it is applied. The more complex the set of complementary practices, the less likely it is that the full profitability of an innovation will be realized. In the case of extremely profitable innovations even ineffective application may result in acceptable profitability and hence farmers generally will take up the innovation quickly and will gradually learn through experience to apply it properly and eventually get the full returns. In the case of innovations which are somewhat less profitable, poor application may result in nonprofitability and the rejection of innovation and at the least, its very slow diffusion. In such situations education may play a very important role in gaining acceptance and rapid diffusion of innovation.

72. The fact that some of the recent extremely dramatic innovations have spread very rapidly should not turn our attention away from the importance of the educational process. Likewise, the failure of educational programs in situations in which there were not profitable innovations to be applied should not mislead us concerning the positive role which education can play.

73. In the decade of the fifties the importance of new technologies was not understood and it was generally believed that the role of education in traditional agricultures was one of awakening men's minds and turning them away from a tradition bound nature towards a favorable attitude towards 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 men's minds to the desirability of change and much more one of providing technical information.

74. Thus an effective extension service must be one that is well staffed with technically competent people. That is a more difficult feature to provide than the earlier defined role. 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 be instructed as to what they did wrong and thereby provide the basis for further improvement. In addition, educational facilities are necessary to provide in service training for a technically oriented extension service so that extension agents may be kept up-to-date

regarding the latest technology and the basic knowledge necessary for full understanding of that technology. This represents an important educational task that needs well trained people in staffing it.

The Role of Credit and Farm Size

75. The new agricultural technologies require a very substantial increase in the working capital resources of farmers. This arises primarily from the large increased input of fertilizers which 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 and from governmental or cooperative agencies.

76. There has been a tendency to understate the extent to which farmer's private savings could fill the need for increased working capital. This tendency to understate arises from a misconception of the extent of poverty in rural areas of low income countries. The peasant farmers who produce the bulk of agricultural production have incomes which are well above the averages of their communities and therefore include substantial potential for saving. Studies of saving habits of farmers in low income countries have in the past shown very low rates of savings. This has often been interpreted as representing low capacity to save. It is more likely, however, that low rates of savings have been due to poor investment opportunities.

77. The old misconception that farmers were not taking up improved technology because of their traditional and backward nature was consistent with the view that they were not investing because they had too few

resources. We now find that with new technologies available which provide high rates of return to increased resources, the farmers now find the higher rates of return attractive and are stimulated to increased savings. We saw this dramatically in the increased savings rates on farms in Taiwan as new technologies came in. We are also seeing this in countries more recently taking up rapid technological change in agriculture.

78. In a technologically stagnant agriculture most borrowing by farmers is done by the lowest income farmers in order to maintain consumption expenditures in the face of unusual adversity arising from bad weather or from special consumption expenditures such as weddings and other festivities. Under such circumstances, the only people well equipped to make loans and to provide the tight supervision necessary for good collection rates are the local money lenders. 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 to lenders. Under these circumstances private banks and similar lending agencies are showing much more interest in farm loans and providing a further flow of funds into rural areas.

79. Despite these potentials, there is logic for further encouragement of cooperative and other quasi governmental agencies for lending to farmers. Although such lending agencies have in general not been successful in the past, the lack of success has traced in significant part from the poor conditions for this type of lending. With the new technologies, making lending for production purposes much more profitable,

cooperatives may have a more favorable environment. Here too however, one must remember the tremendous resource requirements in economic development and the need to raise as much of these resources as possible in rural areas. Thus efforts on the credit side should recognize a substantial potential for farmers to finance technological change themselves and minimize the extent of intersectoral transfers towards the agricultural sector through the medium of credit programs.

80. One of the consequences of rapid application of the 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 which 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 not only on the impact of the new technologies on capital requirements but also on the nature of the existing financial resources and institutions.

81. A few general points should be kept in mind. First, the substantial increases in capital investment accompanying new technologies normally takes forms which are perfectly divisible. This means those with low income can apply the innovation on only part of their farm or only at low levels of input. For example, a low income farmer could try a new variety with its necessary complement of fertilizer on part of his farm. If he finds the returns high, he may then reinvest them and gradually spread use to the total farm. This may have the disadvantage of slowing the impact on both production and income, but it has the

advantage of reducing the risk to the farmer. He only makes the full investment after he has tested it to his complete satisfaction under his particular conditions. In this situation the gains from slower progress may be greater than the losses. Of course the losses to aggregate production of the country will not be particularly high since these small farmers produce only a small proportion of total agricultural production. 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.

82. It may well be that the most important role which expanded credit facilities can play in relation to the new technologies is in facilitating transfers away from basic foodgrains towards production of other crops and livestock products. Very often this will require intermediate term credit as in the case of milk production or fruit production or very large quantities of short-term credit as in the case of a shift to intensive vegetable production. In cases of this type the benefits from shifts in resources may be particularly large for those with small holdings who could particularly benefit from the increased intensification of production which these kinds of shifts allow. It is particularly these farmers who may have the greatest difficulty in obtaining the larger credit needs for these kinds of shifts.

IV. GOVERNMENT POLICY FOR DEALING WITH THE ECONOMIC EFFECTS OF SUCCESS WITH RESPECT TO THE NEW VARIETIES

83. Successfully meeting the challenges of effective government policy for bringing about rapid technological change in agriculture brings a new set of policy challenges to governments. New supply-demand relationships must be met, implications of new income relationships amongst regions and groups will arise, and new opportunities for using agriculture to speed the total development process can be grasped. The policies for meeting these challenges may conflict with policies for expanding production. This is particularly likely with respect to price policy.

Changes in Supply-Demand Balances

84. The major breakthroughs in agricultural technology of the recent past and in all likelihood in the near future as well, have been with respect to basic foodgrains. As a result, in a few areas foodgrains production has increased considerably more rapidly than population growth. If this increased agricultural production is to be used to foster more rapid overall economic development, attention must be given to ways of using the increased production. There are three logical directions for this attention to turn. First, increasing exports, second, increasing domestic demand for grain products and third, shifting the production mix away from grain products to other agricultural commodities.

85. Some countries will be successful in developing new or expanding old export markets for basic foodgrains. However, most countries will undoubtedly have to absorb increased production domestically. In judging potential for export markets the following points must be kept clearly in mind. (1) If the new technologies are generally successful

and adapted to a wider range of conditions, some old export markets may be lost and there may be many new potential competitors in the export markets. In other words, more competitors may be competing for smaller total markets. (2) Qualities, grades and handling methods for commodities used in domestic production may not be suitable for export markets and major adjustments may be necessary. (3) The problems of moving on to export markets will be particularly severe for those nations which have not been traditionally exporters.

86. Not only do the traditional exporters have some advantages in terms of quality and marketing processes but they are more likely to have a price structure in line with international prices. In addition, many of the traditional exporters have been taxing agricultural exports. It is likely that they will drop those taxes before they lose major markets. Thus they have a lot of competitive room for further reduction in prices. The most obvious example in this respect is Thailand which now has a substantial export tax on rice which provides at the present time a relatively small proportion of total governmental revenues. Thailand might well choose to meet increased competition in rice markets by reducing its export tax.

Increasing Domestic Demand for Foodgrains

87. Low income countries differ from high income countries in two important respects relevant to the 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 foodgrains prices may have quite significant effects on domestic consumption. Thus in

situations in which new agricultural technologies reduce the cost of production per unit of output very substantially, some of that reduced cost may be reflected in somewhat lower prices and a substantial part of the extra production moved into domestic consumption.

88. Second, very substantial proportions of the population in low income countries have incomes so low they will spend a very high proportion of increments to their income on food. Government policy which increases employment and hence the incomes of these low income people will have a very substantial effect on the demand for food.

89. There has been a sterile debate amongst development economists as to the precise level of income and price elasticities of demand for food in low income countries. The difference of opinion that separates economists on this is very small compared to the effect on the average elasticities of major changes in income distribution. A positive way to put this whole matter is to say that with a stagnant agriculture it is not possible to have policies which increase the employment of low income people because there is no way to satisfy their extra purchasing power with the increased food supplies which they will demand. With technological change in agriculture and a substantial increase in the supplies of basic foodgrains, it becomes possible to follow employment expanding policies for low income people. Rapid increase in foodgrains supplies should be followed by governmental programs which expand employment for low income people. These could include schemes for industrialization with emphasis on small scale industries which would use a substantial amount of labor and various public works programs for building the infrastructure of development, including roads, schools, irrigation works, etc.

Shifting the Production Mix

90. With the concentration of recent technological changes in the foodgrain sector consideration should be given to shifting some of the agricultural resources away from foodgrains towards commodities for which the demand is more elastic. The more rapid pace of industrial development made possible by the agricultural successes plus the agricultural successes themselves result in accelerated increase in per capita incomes. This is translated into rapid growth in demand for milk, other livestock products, vegetables, fruits, vegetables oils, products made from fibers, etc. A number of policies can be followed which will facilitate shift of resources to these other commodities lessening the pressure of increased supplies on prices of the basic foodgrains.

91. Increased attention needs to be given in research programs to technological change in the production of nonfood grains commodities. Excessive focus on the food population race and famine has in turn given excessive focus to agriculture as a producer of calories rather than as a producer of qualitative elements of a diet and a producer of national income similar to any other consumer goods sector of the economy. Shifts to these other commodities has particular value from the point of view of income distribution since these commodities very frequently represent more intensified use of land and play particularly to the advantage of those farmers with small holdings and ample supplies of labor who in turn tend to be the lower income members of rural society.

92. There are often particularly difficult production problems with respect to these kinds of commodities. This places a special burden on extension services for helping farmers make the production adjustments. Since many of these commodities are bulky, perishable commodities for

which demand has been slight in the past, the marketing problem is likely to be complex and there has not been much experience with it in the past. Thus technological breakthroughs in the new grain varieties offer opportunities for shifting resources to other commodities, but if those opportunities are to be grasped there must be major improvements in the production and marketing of those other commodities. This is particularly true of the bulky perishables such as milk and vegetables.

93. It should be clear that if technological change brings major reductions in the costs of production for the foodgrains and if there has been less technological change for nonfood grains and, therefore, less reduction in costs of production, then resources will be shifted away from foodgrains only if the prices of foodgrains drop substantially. It is important that low income countries who can so ill afford it not drift into the kinds of price support policies which have had such unfortunate effects in freezing production patterns in high income countries such as the United States. Technological changes which have their effects primarily on a few commodities must be accompanied by flexibility in the allocation of agricultural resources.

The Effect of New Varieties on Income Distribution

94. The new grain varieties are having significant effects on relative incomes in various geographic regions within countries and on relative incomes amongst different peoples within the same region. It is important that means be found to meet the important political and economic implications arising from these shifts without inhibiting the production increasing effects of the technologies.

95. The new grain varieties have been much more successful in some geographic areas than others. Where they have worked, real incomes have risen substantially. Even if incomes stay static in the areas where they have not worked, we see regional disparities in incomes increased through this process. Where the new agricultural technologies have increased production so much that prices have declined we find that areas that could not apply them experience an absolute decline in their incomes as they absorb lower prices without the benefits of lower costs.

96. Regional disparities in the effectiveness of the new technologies will often be due to physical conditions which cannot be changed. This presents a difficult policy situation. It is most tempting to alleviate the problems of these areas through price support programs. It should be recognized, however, that a price support program can prevent a decline in real incomes in the areas in which technologies will not work but that they will have an even greater impact on incomes in the places where the new technologies do work. This is because the price support program distributes its benefits in proportion to marketings, which are more likely to have been large initially and to have increased in areas where the new technologies are most successful. Hence, price support programs are an inefficient way to rectify the problem of income disparities.

97. The more effective approach in the case of regional disparities in income which cannot be corrected through further technological change is facilitation of movements out of agriculture. Investment in education directed towards helping people adjust to other sectors of the economy and investment in creation of nonfarm jobs are likely avenues of attack

on this problem. For achieving these ends, it is quite possible that lower agricultural prices will be helpful, in that the cheaper food may be used for payments for providing increased employment in building of infrastructure. They may also facilitate increased capital investment through their effect on lower money wage rates and higher profitability of investment in industry.

98. Although some differences in regional incomes may arise from unchangeable physical conditions, it should be remembered that investment in the agricultural infrastructure may have an important impact on the returns to new technologies. Most obviously if the agricultural experiment stations which turn out the new technologies are located in certain regions, those regions are more likely to benefit than those areas where those stations are not located. Likewise past investment in irrigation facilities give certain areas major advantages over others. Similarly, for road transport and other elements of the infrastructure. Thus in facing problems of growing regional disparities in income, one should look particularly carefully at the potential for investment in the infrastructure of agricultural development in order to bring along the backward regions. Of course in following such a policy, one must be careful not to make investments where the long run rate of return is low. Separately these situations are difficult.

99. The new agricultural technologies may also widen income disparities amongst groups within a region. In particular since the new technologies increase yields per acre of land, they are likely to raise returns to the landowners widening the disparities of income between landlords or land owning peasant classes and the landless laborers. It is

this feature that is most likely to cause lesser growth in incomes of farmers with small holdings as compared with those with large holdings. The problem is not that those with small holdings cannot apply the new technologies. As indicated above, they tend to be about as progressive as the larger holders in application of innovation. However, those with very small holdings tend to draw only a small proportion of their income from the ownership of land and a large proportion from labor -- either through more intensive application of labor on their own farms or working on other people's farms. Thus a doubling of the returns to land does not increase their incomes as much as for those farmers with larger holdings who draw a much larger proportion of their income from the land source.

100. The new agricultural technologies do increase the demand for power in agriculture. Insofar as those larger power requirements are provided by human labor then the demand for human labor will increase and the incomes of the landless labor class will also increase. They may increase as a result of higher rates of return per hour, but even at old wage rates, more employment per person will raise incomes. More labor is needed to harvest increased crops, to distribute fertilizer, to do more intensive irrigation, to do a better job of seed bed preparation and a better job of weeding.

101. It is important not to take a doctrinaire position against mechanization. Mechanization may be highly complementary with other aspects of the new technologies. Nevertheless it is important to see to it that institutional arrangements regarding size of farm, taxation, import duties, etc., do not provide special subsidies to mechanization or make mechanization economic to the individual when it is not economic from the total society's point of view.

102. Efforts to encourage more intensive farming, including dairy, fruits, vegetables and poultry, may all increase employment and benefit laborers. Extension, research, marketing and other actions can all help in this regard.

103. Beyond having policies which encourage meeting the demands for additional power from new technologies with increased agricultural employment, the problem of widening income disparities, particularly with respect to landless laborers, must be met by increasing employment in other sectors of the economy. Here again it is important that the problem of low incomes amongst small farmers and landless laborers not be met by agricultural price support programs. As has been true in the United States, price support programs not only provide their benefits in proportion to sales of agricultural commodities and hence benefit the cultivators with large holdings much more than those with small holdings but they also discourage some other adjustments which would be beneficial to the lower income rural people. Lower agricultural prices do provide the basis for cheaper public works programs to provide additional employment in building the infrastructure of development and do encourage increased industrial investment and hence more jobs in the indsutrial sector. It is important not only to political stability but also to maximal rates of economic growth that these income distribution effects of the new technologies be dealt with. They have implications to many aspects of agricultural development policy including output pricing, pricing of machinery for mechanization and the extent of effort in building the agricultural infrastructure.

V. BRIEF TREATMENT OF QUESTIONS IN THE APRIL 1 PAPER ON NEW CEREAL VARIETIES

Questions with Respect to Session II, The Role of Government Policy

104. How essential is a cost price ratio favoring the farmers to success of the new varieties program? It is, of course, absolutely essential. However, it should be remembered that the new technologies reduce the cost of production and hence a cost price ratio which was favorable to a given level of input use and production before the new technologies will be favorable to a much higher level of production after the new technologies.

105. Are generalizations possible as to the minimum rate of return required for innovation? No generalization is possible on this. Farmers are generally economically oriented and will use inputs up to the point at which the marginal cost of the inputs is equal to the marginal revenue. Many different factors influence how quickly various proportions of farmers reach these optimums. A further complicating factor is the extent to which farmers discount for uncertainty. They will feel uncertainty with respect not only to prices and weather, but also with respect to whether the innovation itself will work. This latter risk or uncertainty can be reduced by proper field testing. The more certain farmers are that something will work as recommended, the less risk premium they will require.

106. Are other policy elements critical or are price incentives sufficient? A whole range of policies are necessary to bring about new technologies which reduce cost of production. These are more important than price incentives in themselves.

107. Did farmers need such (price) encouragement to accept the new seeds? In the case of seeds which were dramatically more profitable,

higher agricultural prices were not necessary to acceptance. In the case of some of the rice varieties in certain areas, it may well be that the additional profits from these varieties were so small that some additional price incentive may have been necessary to speed the rate of diffusion.

108. Can differences in policies pursued by "success" countries and "control" countries be identified? The basic difference between the success and the control countries with respect to the radical new technologies we are here discussing is the extent to which they had underlying physical conditions including water control through irrigation and transportation suitable to radical cost reduction from the specific new varieties now available. In this situation all other policy variables seem small in their importance. A careful look at less radical technological changes or situations of marginal adaptability may provide evidence of impact from differing policies.

109. What have been the causes of policy changes with respect to agricultural development and what is the relative importance of internal and external influences? The most important factor is the dramatic demonstration to governments that the new varieties greatly increased returns to use of scarce resources. The increase in agricultural prices in recent years, due largely to a series of very bad weather years in much of South Asia and to successes in industrial development, also helped bring added attention to the need for agricultural development.

110. Is a generalized agency position on such matters as price ceilings, price supports, subsidization of input prices, free markets for inputs and outputs, etc., either possible or desirable? A generalized

position on these matters is not desirable because the physical, economic and institutional framework for these policies differs greatly from one country to another and from one time to another within a country. In general, a price stabilization program will be effective in fostering faster technological change, but not always. In general, a free market for both inputs and outputs is desirable so that these functions can be handled by the abundant resources in the private sector leaving the government's scarce administrative and financial resources for problems which cannot be handled by the private sector. However, there may be special situations in which the government should go into fertilizer distribution, expand storage for agricultural commodities, provide rice dryers, or displace the private trade in other respects.

General Policy Questions Raised

111. How important to the new varieties have been AID's programs and institution building? One of the most unfortunate features which has come out of some of the recent radical technological changes in agriculture is the belief that all that is needed to bring about agricultural development is a little research somewhere in the world which may then be applied indiscriminately in all other countries and without much support from other elements. In fact, most agricultural growth is based on rather modest technological changes, one piled upon another and each requiring a substantial developmental infrastructure. The infrastructure is primarily a matter of institutions which are manned by trained manpower. Many of the institutions which AID was helping to build, such as land grant universities, credit programs, soil conservation

organizations, extension service, etc. could not provide a positive return in the form of increased production as long as there was not a set of research produced innovations. It is the development of these innovations which is now making AID's past investment in infrastructure highly profitable.

112. Is an accelerated research program indicated for noncereal crops? Clearly yes. With rapid technological change in the cereal crops, production resources will need to be shifted away towards commodities which have more elastic demand. The country report on Turkey for wheat illustrated the need and the potential for this very well. Technological change in production of the noncereal crops will help the necessary shift of resources.

113. Does the farmer's cash return appear to be the decisive factor in any successful production campaign with traditional extension and credit institutions ineffective in the absence of an adequate return and irrelevant when it is present? This is a common misconception. The question is based on the implicit assumption that a particular technology is either highly profitable or not profitable at all. In the case of a highly profitable innovation like the dwarf wheats in well irrigated, high sunlight areas, farmers may see to it that the crop is adopted without any other help by the public sector. Many innovations, however, provide much more modest returns and in those situations production can be increased significantly over a period of time, with that process greatly accelerated by extension, credit and other programs. It is this latter kind of innovation which makes investment in infrastructure so important.

114. Do AID programs pay enough attention to storage, distribution, processing and the other factors involved in transforming production into consumption? There is no general answer to this complex question. However, it is probably correct that AID programs have put excessive emphasis on shifting these functions from the small scale private sector to the large scale public sector, placing an additional burden on the government's scarce administrative and financial resources. This is probably the economic effect of recommendations based on narrowly technical considerations.

115. Is private enterprise making its full potential contribution? Here again I would add that it has been common for technically based efforts to press for larger scale operation which falls more easily into the public sector than the private sector. Much of the marketing job in low income countries can be quite effectively carried out by a small scale private sector. Large scale foreign firms will in general also find it difficult to compete in this type of business.

116. Should AID use its influence and leverage with host governments to persuade them to adopt integrated crop production programs? In principle it is highly desirable for AID to help host governments in formulating integrated approaches which will solve production problems and bring about increased efficiency in achieving increased production. There is a great danger in this approach, however, in building it on the assumption that nothing that is necessary for a systems approach is now being done and in feeling that a total new system must be introduced. It is far preferable to recognize the existing elements of a complete system and make use of them in building a system and in delineating the

holes in that system. In practice, systems approaches often do not follow this type of elementary principle. Optimal programs can only be built by those with a detailed knowledge of existing structures, approaches and limitations.

117. Should greater emphasis be placed on agriculture now that it is moving or should the balance swing to other sectors? When technological change makes the rate of return to resources in agriculture much higher than it has been in the past, that is a reason to give greater emphasis to the agricultural sector, not less. There are, however, complex adjustments which must be made if the greater production of agriculture is to be effectively used in a total development process. Part of this adjustment will involve switching resources away from cereal production and towards other agricultural commodities. Part of it will require lower agricultural prices to allow increased domestic consumption or exports.

VI. PROPOSITIONS AND SUPPORT FROM THE COUNTRY CROP REPORTS

118. The preceding analysis is based on a large volume of information including a careful reading of all the country crop reports submitted for the review. A number of propositions can be drawn from the analysis which lend themselves to illustration from the country crop reports. The emphasis in this section is on presenting a few relevant illustrations of each of several propositions. It is too early in experience with short strawed wheats and rices to conclusively demonstrate the theses here advanced as to the role of government policies in all respects. Some, however, come through and other proofs should be watched for.

> 119. The new cereal varieties, by providing high rates of return to new inputs, serve as an important catalyst to government action on the many fronts which relate to widespread application of the new varieties.

120. In Turkey the new varieties brought quick, vigorous and effective government action in several areas which had been previously marked by delay and inaction. In particular, the Minister of Agriculture observed the spectacular results from a small planting of the new wheats and thereupon provided vigorous leadership in solving problems related to rapid introduction of the new wheat varieties. In India significant change in policy with respect to fertilizer imports and domestic production came as soon as the members of the upper level of the government recognized the possibilities presented by the new varieties. Change in a number of other policies favorable to agricultural development also seem to be associated with recognition of the implications of the new cereal varieties.

121. Lack of adaptive research programs has slowed the spread of the new grain varieties.

122. The new rice varieties have not spread widely in Thailand. The quality requirements for the Thai export market, the problems of water depth and other factors require additional adaptive breeding to suit the conditions of Thailand. The new rice varieties seem extremely well suited to the conditions of West Pakistan but not to those of East Pakistan. A very spotty pattern of acceptance of new rice varieties is found in India. To some extent this is simply related to water control but other factors such as quality, disease and insect resistance and temperature all seem to enter the picture. The role of local adaptive research is indicated by the apparent success of the Padma and Jaya varieties recently developed in India to suit certain specific conditions in India. The development of amber colored wheats for India and Pakistan have moved back the margins of the areas suited to the new wheat varieties. A major attack of disease or insects on the new varieties, where they have been widely accepted, has not yet brought a major disaster of the type which domestic adaptive research should protect against. However, special concern with the new strains of rust are mentioned for Turkey, Pakistan and India.

123. Location of research has probably accentuated problems of interregional income disparities.

124. The country papers are too aggregated to show very much on this question. However, it appears that the direction of research in Mexico has been with particular reference to the irrigated condition

of the north where it happens that farms are large and income high. A different orientation of research, perhaps towards more intensive crops such as vegetables, might have had a greater impact on the smaller farms of the central plateau. The new rice and wheat varieties are providing large increases in incomes in West Pakistan but very little impact in the much lower income areas of East Pakistan. As in these examples there is a tendency for the problem to be not just one of location of research, although that certainly enters in, but also one of the tendency for new research results to be particularly productive under conditions of irrigation where incomes already tend to be higher.

> 125. The new cereal varieties have greatly increased the total returns from using fertilizer by making it profitable to use large quantities of fertilizer whereas previously it was profitable to use only very small quantities. This provides a much greater incentive to take up the new varieties and to use fertilizer.

126. This point is well substantiated with data from India with respect to rice and wheat and from the Philippines with respect to rice. Many of the other reports draw attention to this fact.

> 127. Farmers are economically motivated and the pace of diffusion of the new varieties is influenced by relative profitability. Increases in profitability are the key to change -- whether by change in technology or price relationships.

128. Although the evidence from the country crop reports is not fully consistent on this point, the decrease in cost of production per unit of output is more dramatic for the new wheat varieties than for the new rice varieties. This cost reducing effect of new technology has

more than balanced the fact that international rice prices have risen more than wheat prices in the last few years. Thus, in rational economic response, the rapidity of spread of the wheat varieties has been greater than that of the rice varieties. The new rice varieties have spread more rapidly in West Pakistan than they have in East Pakistan, the conditions in West Pakistan providing a higher rate of return than in East Pakistan. The report on rice in the Philippines shows a new variety not displacing an old variety in a situation in which the yield advantage of the new variety was more than overbalanced by a price advantage related to quality of the old variety. Farmers made the sensible economic decision of staying with the more profitable although lower yielding variety.

> 129. The effects of the new varieties on cost per unit of production have been more dramatic in their effect upon incentives than the substantial price increases for agricultural commodities which have occurred over the past few years.

130. The higher agricultural prices of the middle 1960's accelerated growth in agricultural production in India but a much more dramatic increase in production occurred when the new varieties were released. Substantially lower wheat prices in India in the last year or two do not seem to have slowed the spread of the new wheat varieties.

> 131. The vulnerability of farmers to uncertainty increases with new varieties.

132. Without exception the new varieties involve substantially higher cash costs -- often by two or more times.

133. Price instability may increase as new varieties provide sharp changes in production. These sharp changes in production may be associated with particular grades, quite often the lowest grades.

134. Problems with low quality rice in the Philippines, low quality rice in West Pakistan, and low quality wheat in both West Pakistan and India all indicate a potential for sharp price declines in connection with the new varieties.

135. Forward pricing has proven a liability whereas pragmatic stabilization of prices announced just prior to harvest has proved useful.

136. Pakistan announced wheat prices three years ahead, finding later that the level was set unnecessarily high in view of the low cost of production of the new varieties. As a result problems in stimulating domestic demand and exports arose. The Philippines experienced similar problems with respect to rice support prices. India set its government buying prices shortly before harvest when the totality of supply and demand factors could be better known. This action prevented what would otherwise have been a sharp speculative decline in the prices of the inferior quality new varieties but left scope for flexible response to rapidly changing conditions.

137. High support prices for crops experiencing large cost reductions may contribute to uneconomic allocation of land and other resources to these crops.

138. Although the evidence is not clear on this, both Pakistan and Turkey may be experiencing this with respect to allocations between wheat and cotton.

139. Where technological change greatly increases profitability in input use, subsidizing inputs is not necessary and may prevent solution of difficult problems of supply and distribution.

140. India did not subsidize fertilizer in the Punjab while Pakistan did, but growth and use has been more rapid in the Indian Punjab than in the Pakistan Punjab. Now that the new wheat varieties are resulting in rapid expansion in fertilizer use, Pakistan is gradually reducing its subsidy on fertilizer. Prior to the new varieties, the Philippines subsidized fertilizer use but has now ceased doing so. It is stated in the Philippine report that the manner of operation of fertilizer subsidies was discouraging to active private distribution of fertilizer and hence the elimination of the subsidy provided encouragement to distribution. In contrast, the Brazil report on corn states a sharp increase in consumption of fertilizer in response to a substantial subsidy. The report on Turkey reports a subsidy on fertilizer but in that case it simply means that fertilizer was sold to farmers at the import price which is below the cost of production in the plants in Turkey. It is quite possible that the presence of high cost domestic plants and efforts to protect them may result in a level of fertilizer prices to farmers which is discouraging to consumption. This is, of course, a subsidization of domestic production of fertilizer paid by farmers. A good example of this is provided in the report on Thailand where an import ban has been placed on certain types of nitrogen fertilizers which are now produced domestically in limited quantities. The removal of subsidies on pesticides in India has apparently stimulated a much greater effort by the private sector in marketing. It is likely that one of

the factors discouraging the expansion of rural electrification in India is the large subsidy element involved in this. Farmers would like to have electrification but those who provide the subsidy are concerned by the fiscal and financial implications. In Brazil, subsidization of government-produced hybrid corn seed seems to have been associated with low quality. It is not clear whether this has discouraged the private sector or not.

141. A high level of support prices will tend to displace the private trade and move grain into the hands of the government.

142. In India the 1968 wheat harvest prices were placed higher than the private trade thought consistent with supply-demand balances. As a result over 90% of production moved into government hands. This probably resulted in underutilization of private storage facilities and underutilization of private road transport for moving the crop out.

143. Small scale private marketing systems have a substantial capacity to expand to meet greatly increased production.

144. Thai merchants expanded rapidly to move a large corn crop into international channels. In several countries heavy movement of the government into purchasing cereal crops in order to maintain prices has not provided opportunity to test the private sector's ability to do this job.

145. New cereal varieties bring new needs which are difficult to predict. Marketing provides several examples.

146. The new rice varieties are often harvested earlier during a wet period of the year providing a special demand for dryers and storage facilties. This problem is notable in the Philippines report and the Indian report and also arises in the Pakistan report.

147. Lack of agricultural credit does not seem to have been an important limiting factor to the spread of the new varieties.

148. In some countries, credit agencies have played a key role in the spread of the new varieties. Turkey is a good example as is Brazil in the case of corn and the Philippines for rice. In these cases, credit and credit agencies were used as important devices for transmitting the technology and the full package of resources used along with it. It is not clear how necessary the credit action was in these countries. In a number of other countries no special credit action was taken and does not seem to be limiting to acceptance of the new varieties. In India and Pakistan the great increases in income from the new varieties seems to have stimulated a substantial increase in savings and investment on the part of farmers. In both India and the Philippines private lenders seem to have moved heavily into agriculture as the new varieties have increased incomes. In India, the success of cooperative credit has increased as it has accompanied the new cereal varieties.

149. The new varieties with the greatly increased demand for inputs seem to have increased the effectiveness of cooperatives for distributing inputs and serving other purposes.

150. In India the cooperatives handled much larger volumes of fertilizer when the new varieties became available. This shows very strongly in the Punjab and Madras.

151. The new varieties have increased the effectiveness of and the demand for extension services.

152. A good extension program in Madras in India seems to have speeded dhe spread of the new varieties. Lack of technically competent extension service seems to be slowing the spread of profitable research results in West Africa.

153. The new cereal varieties greatly increase the demand for labor and thereby increase incomes of landless laborers.

154. Almost every country reported greater labor requirements in association with the new cereal varieties. In some countries this seems to have led to increased mechanization. Most emphasis on mechanization appeared in the report for West Pakistan where the tenure system seems to run heaviest to large farms. In india considerable mechanization of thrashing was indicated. In Turkey considerable mechanization of harvesting and the use of combines was noted. Nevertheless there is a general indication of somewhat increased incomes for landless laborers as a result of the new cereal varieties.

155. There is mixed record with respect to the acceptance of the new technologies by farmers with small holdings as compared with those with large holdings.

156. Those with small holdings seem to have come quite rapidly to the new innovation with respect to rice in both India and Pakistan. Mexico appears to be a striking exception to this. However, the problems may be more one of association of larger farms with the areas with irrigation and other physical situations well suited to the new varieties while the small farms are in areas to which the new research results are much less well adapted. In Turkey the smaller farms apparently had less complete use of improved practices and thus a lesser response from the new technologies.

157. The availability of collaborative or complementary inputs is very important to the new cereal varieties.

158. To a very large extent the new varieties are restricted to areas with good water control. The new wheats are grown on irrigated or assured rainfall areas in India, Pakistan, Turkey, Morocco and Mexico. The degree of success of the new wheat is largely a function of the proportion of the wheat acreage irrigated. Maize has had a very limited success in India because such a very small proportion of the maize acreage is subject to good water control. The success of the new varieties of rice has been largely in the areas with good water control. Similarly, the availability of transport has played an important role in the spread of new varieties in some countries. The most dramatic case is that of corn in Thailand. Fertilizer is just as important as water with respect to the new varieties but it is usually more easily provided and hence turns out not to be a limiting factor in practice.

159. There is tremendous variety from one country to another in the specifics of the new program which were taken up in connection with the new cereal varieties.

160. In some countries successful fertilizer distribution programs are in the private sector and in others they are in the public sector. Some countries had elaborate price support programs, others did not. Some insulated their domestic markets from international prices and others did not. In some countries the new varieties came after a long period of development of extension services and in others, they did not. Relatively few generalizations are possible concerning the specifics of what institutions must be developed and the extent to which they should be in the private or public sector. This probably does not mean that it does not matter what is done in these respects but rather that what is most important varies from country to country and time to time. It underlines the importance of pragmatic decentralized determination and execution of policy. The new varieties have provided a return to past investment in institutions and trained manpower. The Philippines report, in particular, emphasizes this. In each country a few things were found to be still missing and the new varieties provided the stimulus to meet these specific needs.