PROYECTO COOPERATIVO DE INVESTIGACION SOBRE TECNOLOGIA AGROPECUARIA EN AMERICA LATINA (PROTAAL)

Documento Nº11

"IDEAS FOR IMPROVING THE CONTENT AND PROCESS OF TECHNOLOGY DEVELOPMENT AND DIFFUSION IN LATIN AMERICA"

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"LIMITATIONS OF APPROPIATE TECNNOLOGY AS A STRATEGY FOR DEVELOPMENT OF THE SMALL — FARM SECTOR"

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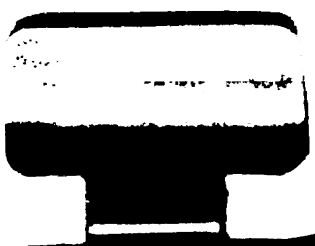

El Proyecto Cooperativo de Investigación sobre Tecnología Agropecuaria (PROTAAL) representa un esfuerzo que tiene como fin desarrollar un conjunto de investigaciones referidas a la naturaleza del proceso tecnológico agropecuario en la región. Este esfuerzo es llevado a cabo con la cooperación del Instituto Interamericano de Ciencias Agrícolas (IICA); quien actúa como agencia ejecutora, el Instituto Colombiano Agropecuario (ICA); la Fundación Ford; el Programa de las Naciones Unidas para el Desarrollo (PNUD), y el Centro Internacional de Investigaciones para el Desarrollo del Canadá (CIID).

El Proyecto plantea el análisis de dicho proceso desde una perspectiva integradora, que toma al proceso tecnológico como un fenómeno endógeno al funcionamiento de la sociedad en que el mismo se desarrolla. Este análisis intenta proveer información útil para el mejor entendimiento del problema tecnológico, y consecuentemente a la definición de políticas, modelos organizacionales y acciones que contribuyan al progreso tecnológico y al desarrollo del sector agropecuario.

Las actividades del Proyecto se iniciaron el 1° de enero de 1977 y desde el punto de vista organizativo las mismas se materializan principalmente a través de la participación de un número de equipos de investigación pertenecientes a instituciones oficiales y privadas diversos países del continente.

A fin de hacer conocer los resultados de estas investigaciones y favorecer el intercambio de información en un sentido más amplio, el Proyecto se propone editar una serie de trabajos y monografías de los siguientes tres tipos:

1. Trabajos metodológicos y resultados de investigaciones empíricas que resultan de las actividades centrales del Proyecto.

2. Trabajos que surgen de actividades vinculadas al Proyecto.

3. Trabajos preparados por los integrantes del Proyecto y eventualmente por otros autores, que estén relacionados a las actividades del Proyecto y que sean útiles al desarrollo del mismo.

Los trabajos serán publicados, en general en versiones no definitivas y por lo tanto, los comentarios críticos son solicitados.

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Proyecto Cooperativo de Investigación sobre Tecnología Agropecuaria en América Latina

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"IDEAS FOR IMPROVING THE CONTENT AND PROCESS OF TECHNOLOGY DEVELOPMENT AND DIFFUSION IN LATIN AMERICAN

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IDEAS FOR IMPROVING THE CONTENT AND PROCESS OF TECHNOLOGY DEVELOPMENT, ADAPTATION AND DIFFUSION IN LATIN AMERICA*

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I. INTRODUCTION

The subject of this Symposium and of session one in particular is the analysis and design of appropriate strategies for the improvement of food production and nutrition in Latin America. This subject is, indeed, of tremendous importance for millions of undernourished people in the continent and also for the future of Latin America and its relations to the rest of the world.

The problem of increasing food production and improving human nutrition as well as the evaluation of potential contributions that research can make in this direction has been thoroughly treated in the document "World Food and Nutrition Study, The Potential Contributions of Research" prepared by the National Research Council, which serves as the basic discussion paper for the Symposium. This study presents a number of interesting and useful recommendations regarding how the

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** The authors are coordinator and members of the coordinating team respectively, of the Proyecto Cooperativo de Investigación sobre Tecnología Agropecuaria en América Latina (PROTAAL) of the Instituto Interamericano de Ciencias Agrícolas (IICA). The Project is developed with the sponsorship and financial support of the Ford Foundation, Instituto Colombiano Agropecuario, PNUD-FAO and IDRC of Canada and the participation of a number of independent national research teams. The ideas presented in this paper are of the authors and not necessary of the sponsoring institutions.

large human research resources accumulated in the United States could be used for the improvement of food production in the rest of the world, particularly the less developed countries. Following what we interpret to be our mandate in regard to the paper we were asked to prepare (the presentation of other views in the subject matter), we would like to discuss some propositions on the nature of food production strategies taking into account the particular characteristics of the Latin American context.

The rest of the paper comprises five sections. In the second, third and fourth sections we argue, on the basis of Latinamerican food production conditions that a good part of the ideas which dominate the discussion on technological development in Latinamerica have analytical shortcomings and consequently, they are of limited use for the formulation of food production strategies. The fifth section is devoted to a brief presentation of a methodological perspective which is useful, in our judgement, for an adequate analysis and interpretation of technological change in Latin America. Such a perspective implies that technology is basicaly a social phenomenon which must be studied and interpreted as an endogenous element to the general behaviour of the social system. The last section is devoted to some tentative suggestions regarding potential research activities.

II. THE ROLE OF TECHNOLOGY IN THE DESIGN OF FOOD PRODUCTION STRATEGIES

The discussion of food production strategies in Latin America has focused on two interrelated points (a) the possibilities and desirability of increasing food

production through the incorporation of presently unused agricultural land (horizontal expantion) as opposed to the incorporation of more capital and labor per unit of land (factor deepening) and (b) the characteristics that technology should have in regard to relative factor intensity, and more recently, energy use.

Considering the first point, we would like to emphasize that although these two alternative sources of agricultural production growth are of importance, expansion of either one requires, in general, the development of new technology/1.

In addition, technological alternatives are clearly not invariant with respect to factor use. It is quite clear that different technologies will have different degrees of capital or labor intensity, and thus they will have different effects on the overall capacity of the agricultural sector to grow given the existing resources.

Variability in the growth-effects of new technology suggests the need for developing mechanisms which assure that the process of technology generation and

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1/ Horizontal expantion was an important source of agricultural growth in Latin America at the beginning of the century. However, as the development process progressed and most countries completed their territorial occupation, it became less attractive and possible to rely on the incorporation of new land for production increases. A more intensive use of marginal lands requires in most cases, not only important (public) investment in the form of economic infraestructure (roads, irrigation, etc.) but also new technology adapted to their particular ecological and productive conditions. For this reason it seems difficult to imagine that significant increases in production can be obtained in the absence of new knowledge, even in situations where the overall strategy is based in the utilization of presently unused agricultural land. In this respect it is interesting to note that, probably as a consequence of the influence of developed countries in research activities relatively little work is done in this direction as opposed to research oriented to increasing the productivity of agricultural land already in production.

adoption be as effective as possible in contributing to food production and to overall economic growth/1. In this respect, both the intensity of innovative activities --which depends basically on the development of appropiate institutions-- and the qualitative elements of the generation process, such as the relative factor intensity of new technology, must be considered as central elements of any selected strategy. The extent to which intensity and content of innovative activities must be determined by public decisions depends on the ability of non-planned activities by private and public agents to direct the innovative effort to socially desirable goals. In our view, there is currently a need to answer these three interrelated questions: must innovative activities be planned?, Is it possible to efficiently plan research activities in the context of Latin American societies? What type of research may contribute to efficient planning? We immediatly turn to the first question, leaving the treatment of the other two to following sections.

III. THE CONCEPTUAL BASIS FOR DIRECT PUBLIC INTERVENTION IN THE SELECTION OF RESEARCH PRIORITIES

The important work of Hayamin and Ruttan expanded and provided an empirical basis to the induced technological development model introduced by Hicks, Fellner and others. This models basic proposition is that market economies -- in particular those of the advanced decentralized economies -- have a whole set of institutional mechanisms, including the market, by which technological development is induced in the required direction for maximum economic growth.

1/ The importance of distributional effects of technological change in agriculture is obviously acknowledge, but not treated in this paper because of its quite specific objectives. This aspect is covered in detail by Scobie and Posada, Hewitt de Alcantara and Fiorentino, Piñeiro and Trigo).

The importance of this idea is that it implies that Adam Smith's invisible hand is also effective in this framework since it determines the direction and intensity of the process of technology generation, it assures the best utilization of available resources and consequently the maximization of economic growth. Hayami and Ruttan show that relative intensity of labor saving technology (i.e. farm machinery) and land saving technology (i.e. fertilizers), and consequently factor productivity implicit in the technological paths followed by different countries, is highly correlated to the factor endowments of those countries. It is a corollary of this proposition, which seems to be sustained by the data presented for a world wide comparison, that policy efforts to plan research resource allocation are not necessary. Latin American empirical evidence, however, seems to suggest that quite different conclusions are attainable. We will argue, on the basis of Latin American production data that some assumptions implicit in the Hayami-Ruttan propositions are invalid, and as a consequence formal planning of research activities is a necessary component for an efficient institutional performance.

An initial evidence in this direction is given by inspection of aggregate factor production figures. In the Latin American countries included in the Hayami-Ruttan analysis (Argentina, Brazil, Chile, Colombia, México, Paraguay, Perú and Venezuela), estimates of labor productivity/1 vary -- excluding Argentina -- between 5.0 for Paraguay and 12.9 for Chile. These estimates variability is in sharp contrast with India and New Zealand estimates, which

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1/ Expressed as productivity of male workers accounted in wheat units.

vary between 2.1 and 141.8 respectively. Homogeneity in resource productivity is also apparent for land: extreme figures for the countries in the analysis are .27 for Mexico and .94 for Paraguay, whereas the relevant figure for Taiwan is 10.24 (Ruttan and Hayami, op. cit. pp.). Considerable homogenity of these figures in spite of considerable differences in factor endowments (i.e. agricultural land in Brazil and Peru) suggests that the inducement mechanism has not fully operated.

Disaggregate information, in turn, shows an extreme variability in agricultural production performance and land productivity changes which can by no means be explained by differences in resource endowments. Production increases of individual crops vary widely between different countries/1. An example of this is potatoe production in Colombia, showing a growth rate above 3% per annum, and in Peru where production increased under similar ecological conditions -- Andean hillside -- at a dim rate of less than 1% per annum. Additional remarkable examples of uneven situations are (a) wheat in Mexico and Brasil (over 3%) and in Colombia (0%); (b) beans in Argentina (over 3%) and in Brazil (0%); among many others.

However, the point we want to emphasize is the considerable variability that may be observed in land productivity (yields) growth between different crops in one country, and between different countries for each particular crop. Interesting examples of this variability are the following: Colombia had high yield

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1/ Growth rates and other figures cited throught the rest of the paper are calculated from FAO data and cover the period 1950-1975.

increases for rice and potatoes and very low for wheat and corn; Brazil had rapid increases in corn and low in rice and beans. On the other hand if we look on a product basis potatoe yields increased rapidly in Colombia and Argentina and almost nothing in Peru. Corn yields increased in Brazil and Argentina and very little in the Andean region. Rice yields increased in Colombia and Argentina but not in Brazil, etc/1 At least part of this variability is explained by the relative intensity of factor use. For example. rice in Colombia is produced with highly capital intensive technology, while corn is not. In Brazil and Mexico wheat production has expanded on the basis of capital intensive technology, while corn is still a labor intensive crop; beans are produced with capital intensive technologies in Argentina and labor intensive technology in Brazil. Other examples of this type where relative factor intensity of the technology used bears no clear relation with relative factor endowment can be brought to attention.

The considerable variability shown by the above figures strongly suggest in our view that inducement mechanisms have been relatively inefficient in guiding technological change in the direction of a socially optimal path. In general, it is clear that, with unfrequent exceptions, the nature of the technology that has prevailed in each situation has not been related to the relative scarcity of land or other factors of production.

1/ At least in some cases it would seem that mayor technological breakthroughs are adapted to restricted conditions. For example, new rice varieties developed in recent years are adapted to irrigates conditions but not to dry land farming typical of Brazil. However, this explanation cannot be generalized without raising perplexing questions. Why there have not been mayor research breakthoughs applicable to the original ecological environments of some of these crops, which have great importance in the people diets, as for example cassava in Brazil, potatoes in Peru and corn in the Andean region, while other crops of secondary importance, such as wheat in Mexico and soybeans in Brazil, have had them ?.

The precedent arguments do not necessarily imply that inducement mechanisms do not exist. They certainly do but in Latin American societies they have operated in a different context and, as it will be discussed later, have different effects. The apparent absence of adequate inducement mechanisms would imply that the definition and instrumentation of explicit actions to guide technical change in the desired direction is a socially needed activity. In this sense the previous comments would suggest that Latin American societies have been unable or unwilling, in the past, to instrument socially desirable strategies for food production. It is clear that the understanding of this failure, its consequences for food production and the design of practical solutions, are subjects of fundamental importance and should receive special attention in the definition of research priorities. This is the subject of the next sections.

IV. LATIN AMERICA: SOME PROBLEMS FOR THE IMPLEMENTATION OF SOCIALLY OPTIMUM STRATEGIES WITH SPECIAL REFERENCE TO TECHNOLOGICAL CHANGE

A. Introduction

In the previous section we have briefly discussed the role of technology in food production strategies and have expressed our views on the need of planning technological change. We have concluded that inducement mechanisms have had an inefficient performance in Latin America and as a consequence, formal planning as a means to induce technological development in the appropiate direction appears to be necessary.

However, an active and comprehensive action by the State such as it would require the planning of innovative activities in a socially desirable direction requires certain conditions of which we want to emphasize the following: (a) The existence of a State that represents the general welfare of society and that is interested and willing to implemented selected strategies and (b) The actual capability, both technical and political, of the State to instrument the selected strategies. In this respect we will argue that the diversity of socio-economic interests and the relative weakness of the State in relation to special interests have implied the global desarticulation of the technological process and the incapacity of the latter to instrument coherent and effective food production strategies.

B. Technology as a Source of Social Conflict and the Role of the State.

It is widely known that income distributional effects of technological change are heavily dependent on the factor intensity of the adopted innovations, on the price elasticity of product demand, on the relative factor endowment and on the access to new resources, including information. Technical change affects primarily the distribution of income between producers and consumers, but it also affects the welfare of laborers and other segments of society. (Pifteiro, et Al; Seckler and Schmidt; Cleaver). Consequently, different social groups and particularly those directly related to agricultural production, will have different attitudes towards technology depending on their ex-ante expectation on the effects of technology and their capacity to appropiate the potential economic benefits derived from its utilization (de Janvry, 1977). Thus, Different technologies will clearly have different degrees of acceptance by producers.

In addition, the rather high levels of investment required, the complexity of biological research, the atomistic structure of agricultural producing firms and the low possibilities of private appropiation of the benefits of the innovative process do not induce, in general, private efforts towards agricultural research activities. Most of research efforts are, as a consequence, of a public nature and the State heavily contributes to determine the intensity and direction of technological change. State actions materialize through the following two instruments: (a) through government policies (mostly economic) which determine the socioeconomic context of agricultural production and limit the private profitability of technological adoption; and (b) through research resource allocation and institutional control which determine the direction and intensity of innovative activities.

This two pronged role that the State plays with respect to the process of technology generation and adoption insures that understanding the way by which the decision process, in regards to this subject, takes place and is affected by those groups with vested interests in agricultural production is a necessary and previous step for actions directed to improve technological innovation and food production (Oliveira, pp. 120-123, Meyer et Al.). State decisions should be regarded in this context as the result of the interaction of different social groups, with different interests and political power. State actions with respect to the technological process are determined by the relative power and the specific interests of those groups participating in the political process (de Janvry, 1977).

Under certain -- and frequent -- conditions of social relations and concentration of political power in the hands of special economic interests, both inducement mechanisms (in the Hayami-Ruttan sense) and planning activities will be strongly affected. Inducement mechanisms will contribute to technology generation which is consistent with factor endowments of the strongest rural groups, which may differ from those of the majority of farmers. Technological planning will probably be oriented to innovations which are "congruent" with the private needs of power groups and research activities will be directed towards crops produced by these groups and to fit their specific resource availability. The uneven production growth of different crops under a wide variety of production techniques shown in section II is a natural consequence of this situation.

It is clear that different political conditions and social relations may prevail in each particular situation and differently affect the innovative process. This paper's major contention is that in Latin America frequent social conditions negatively affect technological change and for the same reason make difficult the implementation of socially optimal good policy strategies. These situations we think may be fruitfully analyzed with the aid of simple conceptual framework which is presented in the following section.

V. A CONCEPTUAL FRAMEWORK FOR THE ANALYSIS OF TECHNICAL CHANGE.

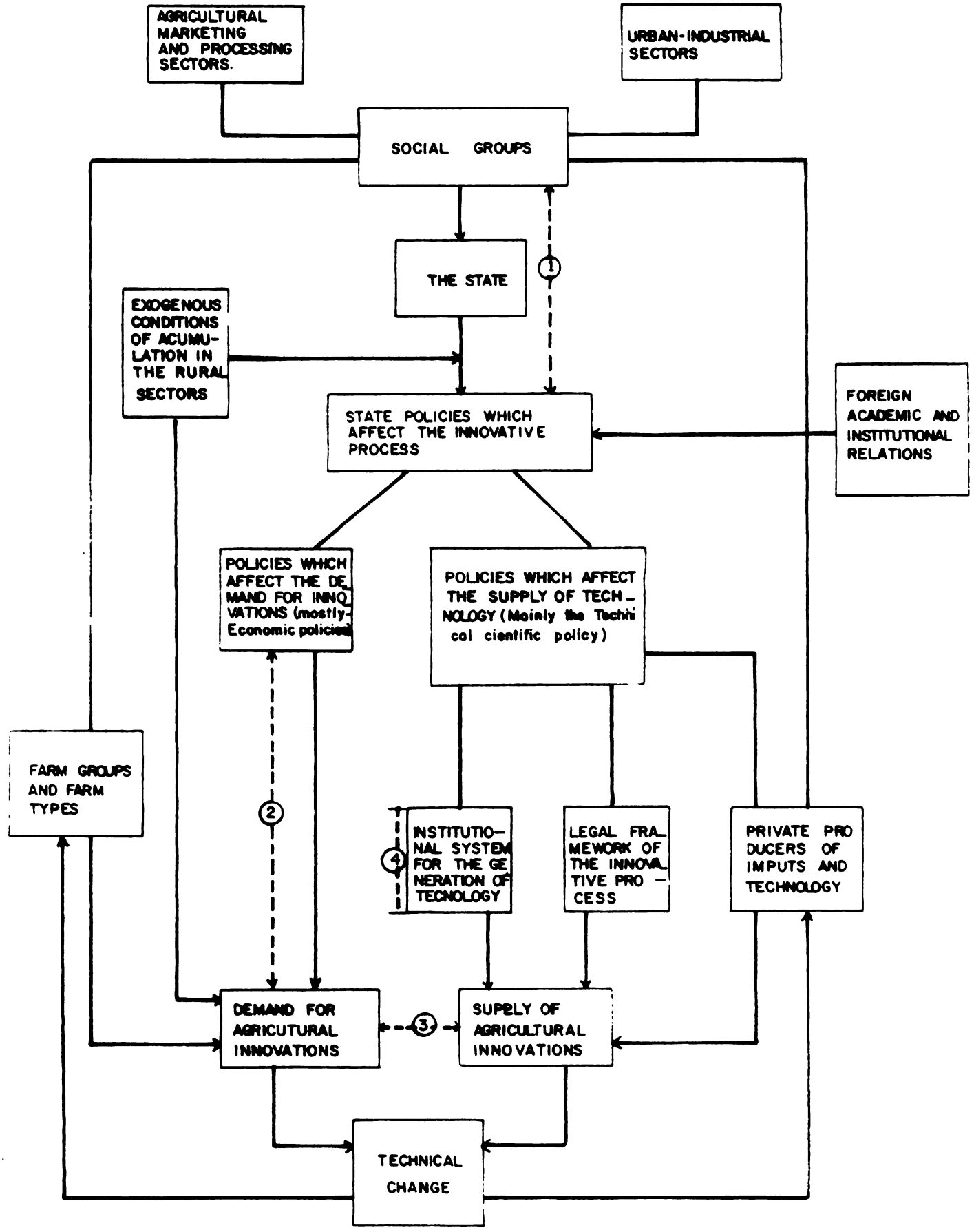
A. Basic elements of the Model

In order to present the Model's analytical categories and their interrelations, it is useful to define what we may call the socioeconomic space

where technological change takes place. The socioeconomic space (a concept which refers to one specific production location) is defined by a set of structural elements and a set of social relations which define the operational characteristics, intensity and direction, of the innovative process (see Figure 1.). The structural elements are: (a) the farm types which define the production relations, the basic characteristics of the demand for technology at farm level, and the socio-political importance of the farming group; and (b) the structural characteristics of the technology generation institutional system, in particular the size and organization of private and public activity in technology production. The social interrelations determine the attitude of the different social groups, their interplay within the State mechanisms and the nature of government policies towards the agricultural sector.

Figure 1 provides a simple graphical presentation of the Model components and relationships. The main social groups which affect the innovative process are (1) the domestic urban industrial sector, which favors low-price consumption policies; (2) the agricultural marketing-processing sector; (3) the agricultural production sector; and (4) the producers of agricultural inputs and technology. These social groups affect --through their interactions within the State, the process of policy generation and ultimately technological change. Policies which affect the innovative process are broadly divided into (1) economic policies and (2) the scientific policy for the agricultural sector.

FIGURE 1 GRAPHICAL DESCRIPTION OF THE MODEL OF THE INNOVATIVE PROCESS



The process of technical change is determined by the interaction of supply and demand for innovations. The demand for innovations heavily depends on (a) agricultural policies -- price, credit and taxation policies -- which affect the profitability of innovations; (b) the structural characteristics -- production relations and factor endowments -- and relative importance of different farm types, which determine the nature of demanded innovations; and (c) exogenous economic conditions for accumulation through agricultural production. The supply of innovations, in turn, is a direct result of (a) the structure and conduct of the institutional model of technology generation, (b) the actions of private organizations. These two items are strongly dependent on the scientific agricultural policy. A central point to note is that demand and supply are interdependent through the role the State plays in the determination of model components which affect both sides.

The basic working hypothesis we suggest is that (1) an active process of technical change will require adequate articulations between the different components which define a particular socioeconomic space and (2) this process has frequently been inactive in Latin America due to inadequate articulations between those components. Without claiming comprehensiveness, there are at least four "levels" of articulations which are of particular importance:

1. The articulation of social groups in general, and dominant groups in particular, to the overall process of technology generation. This articulation explains the extent to which technology is a recognized social issue in the sense that research is a socially accepted and valued activity (the appropriate articulation level is indicated by a circled number 1 in Fig. 1).

2. The articulation of government policies at large, and economic policies in particular, to production conditions in such a way as to promote and permit adoption of innovations. And effective innovative process requires, in addition to the existence of new technologies, a whole array of complementary services (such as marketing, transportation, etc.) and the definition of an appropriate economic context (prices, credit, etc.) to induce farmers' adoption (circled number 2 in Figure 1).

3. The articulation of technology generation to actual demand for technology. The basic characteristics of available technology must be "congruent" with what is required at the farm level in terms of resource endowments and production relations. This articulations' efficacy will depend on the effectiveness of the institutional mechanism to adequately "read" technological demands of different types of farms (circled number 3 in Figure 1).

4. The articulation among the different components of the institutional model of technology generation, which determines functional appropriateness of these components to the overall system and the efficiency of mechanisms of coordination and diffusion of information (circled number 4 in Figure 1).

B. An Interpretation of Technological Change

1. An analysis of technical change in the American agriculture, along the lines presented by Owen, suggests the ways by which articulation of the technological process took place in this country. The tremendous development

of the industrial sector during the first half of this Century gave way to a clear supremacy of industrial and consumer interests in the definition of Economic policy. Under these conditions, where a good portion of the surpluses generated from technological change in the agricultural sector were appropriate by the consumers, the interest of society as a whole (dominant interest) in technological progress was assured. Consequently both and economic policy which should induce an increase in agricultural production and the existence of efficient institutions responsible for the generation and diffusion of new technology was a natural outcome.

In addition, the agricultral sector of the United States can be characterized, by commercial enterprises with professionalized management, efficient factor markets, access to information and adequate social organizations (Owen's Western Paradigm)/1. Under these conditions, research resource allocation was geared by factor scarcities, relative factor and product prices and research institutions were induced to work in the desired direction with respect to production needs, which were coincident with those of the community. Producers, on the other hand, pressed by the need of maintaining or improving the profitability of their business quickly adopted the set of techniques generated bu public and private institutions, thus insuring an extraordinary increase in agricultural production.

1/ Owen's description of the Western Paradigm conditions is similar to the description of a capitalist economy in the neoclassic theory. Even without discussing the exaggeration of this characterization, it should be taken restrictively with respect to the U.S. agricultural sector during the period 1940-1960.

2. Desarticulation in Latin American Agriculture as a Consequence of Structural Characteristics

The material development of the Latin American Agricultural sector has generated as it has been pointed out by Amin de Janvry (1975) and others the emergence of a series of structural conditions that inhibit the replication of an articulated development process akin to the Western Paradigm.

The conceptual framework discussed in the previous section is useful to emphasize three interrelated conditions that strongly influence the process of technical change . First, in most Latin American countries, in spite of the important industrial development of recent years, rural groups preserve considerable political power. Therefore, the basic element required for a development model based in the transference of agricultural surplus through a "treadmill" strategy, as the one proposed by Owen in reference to the development of USA, is missing. Although the agricultural sector has often been squeezed it has been in the wrong direction. For example in Argentina during the decades of 1940 and 1950, agricultural production suffered because of instrumented "low price" agricultural policies. On the other hand these price policies included compensatory policies which protected the agricultural sector but where harmful to agricultural production because they inhibited the interest in technological adoption (real demand for technology) by the commercial farms/1.

1/ Herford suggests that these policies have been allowed for two reasons: (a) because they favored the industrial capitalist sector by high protective taxes and, (b) because these policies were compensated by specific measures such as subsidie credit and absence of land taxation, which have considerable effect on income distribution within the agricultural sector.

Second, the relative weakness of the State and the influence of institutional models and ideologies of the developed world has inhibited the development and growth of organizational patterns adapted to local conditions and with large participation of interested social groups. Within this context the following reasons explain why the inducement mechanism failed to provide an adequate guide to the generation of technology thus creating a desarticulation between demand and supply of technology (Third level of desarticulation, see again Figure 1)./1.

1. A great proportion of the available new technology is generated in the developed world and adapted to their economic conditions. Thus, inducement mechanisms were unable to influence the characteristics of this new technology.

2. The considerable diversity of farm-types within any one country, where large producers with relative extensive systems of production are side by side with very intensive small farms (minifundios), introduce an element of heterogeneity in the required technology and mechanisms of technology diffusion. Diversity makes the operation of inducement mechanisms considerably more difficult and the generation of new knowledge more costly. In general, research institutions have been inadequeately prepared to be responsive to all research needs and as a consequence they have concentrated their efforts to satisfy the demands of those groups which had a stronger social integration and more political power.

1/ These points also indicate some of the difficulties that efficient planning must face.

3. Inducement mechanisms require that factor prices reflect their relative scarcity at a sectoral level. In Latin American Agricultural factors of production --especially labor-- are tied to inflexible farm structures, thus, social factor scarcity differs with private factor scarcities associated with different farm structures. Consequently, there are a whole map of factor prices which hampers ther inducement process (see Mellor, p. 479). In addition economic policy tends in many cases to deliberately distort relative prices (subsidized credit).

Third, the lack of adequate recognition of technological change as an instrument for economic development and the incapacity to solve the social conflicts that technology generates, results in low levels of investment in research, inadequeate institutional development and insuficient coordination of research activities with other State actions (4th level of articulation).

The proposed levels of desarticulation that have been presented in Latin America do not imply that technical progress has been absent in all cases. We have already shown that certain crops in some countries have acheived fast increases in production. The hypothesis we want to advance is that those cases have always implied a set of conditions that assured that: (a) A substantial part of the benefits derived from production increases and technical change where appropriated by a specific social group; and (b) that this social group had sufficient political power as to impose specific economic policies that permitted high profits through production increases. In this respect for illustrative purposes

it is possible to think in a few cases where technological change has been promoted and instrumented by one of the four social groups identified in Figure 1. For example the broiler industry is one case of technical change instrumented by the processing sector; sugar in Peru by the farm sector (Flores) livestock improvement in Argentina by livestock breeders (producers of technology) and wheat and soybean in Brazil by the urban industrial sector for balance of payment purposes.

VI. SOME IDEAS REGARDING RESEARCH PRIORITIES

The previous sections attempt to show the complexity of the innovative process in Latin American Agriculture. In them we argue that the design of effective food production strategies require in addition to technical innovations a more precise and complete understanding of the social aspects of the innovative process.

Upon summarizing this paper's basic arguments, we will end our presentation with some general and tentative suggestions regarding research priorities oriented to improve the effectiveness of food production strategies in Latin America.

1. Production and productivity data for major Latin America countries suggest the absence of effective and rational (from a social point of view) strategies for food production.

2. Technology has wide effects on the economy, not only in the sense of what technological change implies in terms of increased production, but also in terms of the definition of new production relations and its effects on the distribution of income and wealth. Thus different groups will have, depending on the characteristics of their insertion in the productive process and in soci ety at large, different interests with respect to the intensity and direction of the innovative process, and will act accordingly.

3. The high risk, heavy investment characteristics of agricultural research as well as the low possibilities of private appropiation of the research benefits, determine that the State plays a central role in the innovative process. This role is played not only through the generation of new technology by public institutions but also through the creation of an appropriated economic context for technological adoption at the farme level.

4. In Latin America the diversity of agricultural production, the association of specific social groups with specific agricultural activities and the relative weakness of the State for the application of socially optimal policies imply that technology is a complex and increasingly important phenomenon, whose full understanding requires to be analyzed as a process governed by social and political factors, and largely induced by dominant groups.

5. Social sciences have stayed behind the impressive developed of other disciplines related to agricultural technology. Its relative "Underdevelopment" can be partially explained by their youth, but also and to a greater extent,

by their capacity to create resistance from those who feel that new knowledge in this area will imply undesirable social change.

With this basic ideas as a frame of reference we would like to suggest four possible lines of research that could provide useful information for the understanding of technical in Latin America.

1. Organizational Models for the generation of agricultural technology

The organizational models of the basic research institutions have been developed in Latin America in response to the experience gathered in the developed world and following a process of adjustment mainly governed by trial and error. However, little formal research has been done regarding the development of organizational models that could best adapt to the specific conditions and needs of the region.

This research could emphasize the following three aspects:

First, the ways by which national research institution relate and coordinate with: (a) Other research institutions including international research centers and the international community;(b) Other government offices that determine or influence scientific and economic policy important for technical change. Second, the development of organizational and institutional mechanisms that promote and improve the correct articulation of technology generation with the real needs at the farm level given the variability of

production conditions that may be found. Third, what organizational and administrative mechanisms can be developed to insure a most efficient use of very scarce research resources. These mechanisms may refer to planning and programming, coordination and pooling of research resources between countries with similar problems/1 and to design the more efficient ways of training, recycling and administration of the human resources in the region.

2. Classification and Analysis of Farm Production Systems

Food production in Latin America stems from a large variety of production systems. Different farm types have different technological requirements and will be affected by economic policies in a different way depending on their structural characteristics and the particular way they integrate in the productive process. Understanding their particular behavior in relation to agricultural and technological policies is a basic step to guide research and technology generation. At the same time the understanding of the economic behavior of the different farm types will permit the implementation of the required complementary actions to assure new technology adoption at farm level.

3. Social and economic effects of technological innovation. Innovations have a wide array of effects on the social body. Different economic sectors in and out of the agricultural sector have, as a consequence, differential interests respect of the qualitative elements that define alternative technological strategies. Technological policy requires, for its effective instrumentation a precise understanding of its potential effects and consequently, the expected

1/ Recently IDB and IICA have jointly promoted projects directed to this objective.

behavior of important economic and political sectors of society. Works along the lines of Scobie, Scobie and Posada and Hildebrand and Tuckman are highly useful for this purpose.

4. Social Dynamics and the functioning of the State

If efficient organizational frameworks are to be developed as a way to speed up technological change, the nature of the State and the way in which the different interest sectors affect the decision process with respect to technology generation must be clearly understood. Efficient policies to improve producers organizations -- with special reference to those segments more isolated from the social process -- could then be developed in order to improve these groups possibilities to express their technical requirements. The importance of this research line is reinforced by the fact that 40 per cent of the world's crop land is cultivated by small operators, who are frequently powerless to express their institutional and technical needs. (Dillon, p. 358).

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Preliminary Draft - Subject to Revision

LIMITATIONS OF APPROPRIATE TECHNOLOGY AS A STRATEGY FOR DEVELOPMENT OF THE SMALL FARM SECTOR

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C O N T E N T

I. INTRODUCTION: NATURE AND OBJECTIVES OF THIS ESSAY

A fairly large proportion of land in Latin America and an even larger proportion of farm population are part of the small farm problem. Recent estimates show that about 60 percent of farm holdins have less than five hectares, and in many countries the number of small farms is steadily increasing (de Janvry, 1976).

The magnitude of this problem varies widely in the different countries of the South American continent. In many of them, even some of the largest and best endowed with agricultural land like Brazil (Hoffman, 1971) and Colombia (Kalmanovitz, 1974), the problem of land maldistribution started with the history of the countries themselves and has persisted since then as an unsolved problem. For example in Colombia, still now, more than 50% of food production is produced by small farmers (Colombia, 1975).

The small farm problem presents two interrelated issues, the first of them related to food production stagnation. Empirical studies tend to show a slow rate of adoption of technological innovations in the Latin American small farm sector, and consequently increases in agricultural production and factor productivity have been poor on the average. (Contador, 1975; Paiva, 1971; Fiorentino, 1973 and 1976). The second issue relates to rural poverty and its effects in low living standards and malnutrition.

Although it is analytically important to separate both issues, they are

interrelated in a complex cross causal relationship. The form of this causal relationship has been a source of argument for many years and has provided the basis for alternative policy propositions. Many social science-researchers have argued that farmers are poor because they do not adopt technology and have proposed alternative measures to increase the rate of technology adoption as appropriate solutions. Others have argued that farmers do not adopt technological innovations because they are small and, consequently, solving their smallness (agrarian reform) is the first step for a possible solution to the problem.

This paper argues that there is no unique explanation to the small farmer problem and that, in most cases, it is part of a larger problem that trascends the agricultural sector. Consequently, the small farm problem must be analyzed within a broader perspective, in order to understand the basic causal relationships and the most appropriate solutions to each particular case. Our basic argument is that the principal element in these interrelations is the functional role that the peasant economy plays in the overall process of capital accumulation.

This paper includes 5 sections. In the second section the small farm problem is briefly presented both in regard to its importance in Latin American agriculture and to its nature and social effects. The third section briefly provides the alternative interpretations that have historically prevailed regarding this problem and the different policy recommendations that accompanied them. Subsequently, the concept of appropriate technology

is introduced in order to indicate its meaning and conceptual basis. Section four presents our views regarding the correct setting for the analysis of the small farm economy and the limitations of appropriate technology as a relevant instrument for improving small farmers' living conditions. Section five summarizes this paper's major contentions and provides tentative suggestions for further work.

II. THE SMALL FARM PROBLEM

The importance of small farming has been stressed by Dillon (1978) who estimates that forty percent of world agricultural output is provided by small farms. Tentative evidence suggests similar estimates for Latin America, as explained below. Additional empirical work also shows the growing numbers of small farms as well as the increasing intensity of their poverty problems. Seventy percent of Latin America's rural population is confined to subsistence agriculture or to landless agricultural activities, and the large majority of the poorest households are located in the rural sector (de Janvry, 1976, p. 17-18).

In most Latin American countries, as oppossed to the prevailing situation in central countries, the largest farm estates tend to subdivide and subsistence agriculture explodes in farm numbers while average farm size tends to decline. Estimates by the Janvry (1976) indicate the persistence of this phenomenon in such countries as Dominican Republic, El Salvador, Honduras, Nicaragua, Brazil, Colombia, Ecuador and Chile (Table 1). Regional examples, such as North East

TABLE 1

Share of Farmholdings and of Land Area in Subsistence Agriculture, Selected Years

Country and census year	Definition of subfamily farms	Farmholdings	Land area
	hectares	percent	
Dominican Republic			
1950	0-1	33.5	2.1
1960		44.3	3.7
Mexico			
1950	0-5	86.6	40.4
1960		84.2	28.2
Guatemala			
1950	0-5	76.2	9.0
1964		74.9	11.6
El Salvador			
1950		40.4	2.3
1961	0-1	47.2	3.9
1971		48.8	4.8
Honduras			
1952	0-1	9.9	0.4
1966		15.0	0.8
Nicaragua			
1952	1-5	19.8	0.8
1963		33.2	1.5
Costa Rica			
1950	0-5	62.4	1.4
1973		43.2	1.9
Panama			
1950		52.0	8.3
1961	0-5	45.8	5.4
1971		45.4	3.6
Venezuela			
1950	0-5	53.7	1.2
1961		49.4	0.1

(Continued on next page)

TABLE 1 - continued

Country and census year	Definition of subfamily farms	Farmholdings	Land area
	hectares	percent	
Brazil			
1940		21.8	0.5
1950	0-5	22.2	0.5
1960		30.8	1.0
1970		36.6	1.4
Ecuador			
1954	0-1	26.8	0.8
1968		32.6	1.3
Colombia			
1954		54.9	3.3
1960	0-5	62.6	4.5
1970		59.5	3.7
Paraguay			
1956	0-5	45.9	0.9
1961		46.4	a/
Chile			
1955		36.9	0.2
1964		48.7	0.7
Argentina			
1937		30.4	
1952	0-20	41.8	1.1
1960		39.7	1.0
Uruguay			
1937		37.6	1.2
1951	0-20	42.0	1.7
1961		45.8	1.8
1970		45.7	1.7
United States			
1940		69.7	21.0
1950	0-50	66.7	15.9
1959		56.8	10.4
1969		50.4	7.6

a/ Blanks indicate no data available.

Sources: A. de Janvry, Rural Development in Latin America, Three Projects Observed, unpublished paper, University of California, 1976.

Brazil, suggest a similar evidence. In this latter region the number of small farms (0 to 10 hectares range) has outgrown the increase in the total number of farms (Fiorentino, 1977), whereas farm size at large has been substantially reduced in the 1950-1970 period (Table 2).

Small farm sizes and low income levels have been correlated features of subsistence farming in Latin America. We draw again on the Janvry's work to indicate the magnitude of indirect indicators of rural income levels and poverty. The net rural-urban migration between 1950 and 1960 has been as high as 16 percent of the total rural population in Colombia, 17 percent in Ecuador, 19 percent in Brazil and 29 percent in Chile and Argentina. A 45 percent increase in industrial employment between 1950 and 1965 has kept the industrial employment level, however, at a constant 16 percent of the total labor force between those two years. If the sizes of the rural and urban sectors are compared, the net result indicates that in spite of rural outmigration the number of landless peasants and rural unemployed has grown (de Janvry, 1976, pp. 23-24).

Malnutrition and illiteracy are also a widespread phenomenon in the Latin American small farm sector. Lacerda de Melo (1975) reports undernourishment of rural sugar cane workers of North East Brazil in the 70's, while the Janvry (1976) reports food intake problems for 90 percent of children in the Honduras rural sector. In addition, a work by Consultores Técnicos (1971) reports on poor protein content in small farm families' diets of the Argentine North East. According to the Janvry's estimates, 80 percent of the rural population in

TABLE 2

Number of Farms and Total Area by Farm Size Strata in the Brazilian North East, Selected Years (Also, Percentage Figures)

1 - Number

Farm Size (Hectares)	Numbers (Thousands)				Total Area (Thousands of Hectares)			
	1940	1950	1960	1970	1940	1950	1960	1970
Less than 10	369	450	873	1504	1441	1644	2082	4090
10 to less than 100	289	230	421	562	9443	10031	13744	17894
100 to less than 1,000	74	90	105	130	19093	23647	27544	32059
1,000 to less than 10,000	5	8	7	8	12909	16896	15364	17260
10,000 and more		0.3	0.2	0.1	-	6103	3592	2508
Total	737	847	1407	2201	42816	58321	62326	73811

2 - Percentage

Farm Size (Hectares)	Percentage of Farms over Total (%)				Percentage of Farm Area over Total (%)			
	1940	1950	1960	1970	1940	1950	1960	1970
Less than 10	50.6	53.1	62.0	68.4	3.4	2.8	3.3	5.5
10 to less than 100	39.3	35.4	30.0	25.5	22.1	17.2	22.0	24.4
100 to less than 1,000	10.0	10.6	7.5	5.7	44.5	40.5	44.2	43.5
1,000 to less than 10,000	0.01	0.9	0.5	0.4	30.0	29.0	24.7	23.4
10,000 and more	0.0	0.0	0.0	0.0	-	10.5	5.8	3.4
Total	100	100	100	100	100	100	100	100

Source: R. Fiorentino, 1977, pp. 11

Honduras is illiterate. UNESCO's estimates show similar illiteracy levels for rural Haiti. These estimates are not but a small sample of a large set, as it is not difficult to anticipate. In spite of scarce availability of accurate estimates of rural income figures, World Bank income estimates for North East Brazil (de Janvry, 1976, pp. 22) indicate that 70 percent of the rural active population was earning less of the minimum wage (50 US$ per month.)

Small farms are frequently specialized in food crops for the domestic market, whereas large commercial Latin American farms tend to specialize, by contrast, in higher-income export crops (Fiorentino, 1977, pp. 11-19). Growth of food supply has frequently taken place on the basis of replication of prevailing production patterns, without substantial increases in factor productivity. In face of inelastic supply of land in some regions or lack of access to it due to unequal land distribution in others, absence of technical change and factor productivity increases has led to low food growth trends, and in some cases to production stagnation (Table 3). For subsistence crops, often associated with small holdings, performance was also very poor. Table 4 indicates that 11 countries have had negative production growth rates between 1960 and 1974. The net result of this trend was that countries such as Bolivia, Chile and Perú, not long ago traditional grain producers, become heavily dependent on grain imports (de Janvry, 1976, pp. 5).

Progressive specialization of small farms in food crops for subsistence and for the domestic urban-industrial sector sets the food stagnation problem

TABLE 3

Growth Rates of Total Food Production by Country (1960-1974)

Country	5	5 to 4	4 to 3	3 to 2	2 to 1	1 to 0	0
	percent						
Guatemala	5.2						
Panama		4.5					
Costa Rica		4.5					
Venezuela		4.3					
Brazil		4.2					
Nicaragua		4.2					
Mexico			3.8				
El Salvador			3.7				
Ecuador			3.7				
Colombia			3.4				
(Latin America)			3.3				
Honduras			3.2				
Dominican Republic				2.3			
(United States)				2.3			
(Canada)				2.1			
Argentina				2.0			
Peru					1.7		
Bolivia					1.6		
Paraguay					1.2		
Haiti						.7	
Uruguay						.1	
Guyana							- .2
Trinidad							- .9
Jamaica							-1.3

Source: A. de Janvry, "Rural Development in Latin America, Three Projects Observed", manuscript, University of California at Berkeley, 1976.

TABLE 4

Growth Rates of Per Capita Production of Subsistence Crops by Country, 1960-1974 a/

Country	2	2 to 1	1 to 0	0 to -1	-1 to -2
	percent				
El Salvador	2.2				
Nicaragua		1.3			
Guatemala			1.0		
Dominican Republic			.9		
Ecuador			.9		
Venezuela			.6		
Brazil			.5		
Bolivia			.5		
Peru				-.1	
Mexico				-.5	
Haiti				-.6	
Jamaica				-.6	
Costa Rica				-.9	
Colombia				-.9	
Trinidad					-1.3
Panama					-1.3
Paraguay					-1.7
Chile					-1.7
Honduras					-1.7

a/ Corn, rice (except Colombia), potatoes, sweet potatoes, cassava, and pulses.

Source: A. de Janvry, "Rural Development in Latin America, Three Projects Observed", manuscript, University of California at Berkeley, 1976.

out of the boundaries of the agricultural sector. Indeed, small farm food production relates -- through their effect on the price of the wage-goods basket -- to urban industrial capital accumulation.

The preceding paragraphs attempt to show the growing importance of the small farm problem and to characterize its two major dimensions; the growth of the food supply aspect and the rural poverty aspect. Aside of valorative qualifications, which may rank the poverty problem considerably higher from the social welfare viewpoint, the quantitative impact of these problems varies through countries and locations. Nevertheless, it can be said that "poverty" effects are far more general and widespread than "food-shortage" effects. This proposition is clearly true in those areas where availability of unused agricultural land and of farm labor is so considerable that food production can easily grow on the basis of replication of existing farming patterns through occupation of unused - or underused - land. The remarkable growth of Brazil's agricultural output in the sixties and early seventies can easily be attributed to the expansion of agricultural land use under highly concentrated land tenure conditions and on the basis of family farm labor provided by small-plot tenants and sharecroppers (see Johnston, 1971; Sampaio, 1976; Fiorentino 1977). Likewise, Argentina's agricultural output growth outside the Pampas during 1940-1970 is also the result of horizontal expansion of small and medium scale family-owned farms (Reca, 1976; Giberti, 1061). In both cases aggregate farm production grew under conditions of occasional poverty - North East Argentine - and extreme poverty - North East Brazil, and light modifications in production and technological patterns.

Poverty and Production aspects of the small farm problem are equally stressed by Latin American policy documents and Government Officials. Nevertheless, in spite of the acute welfare effects of the poverty problem, it is fair to say that major government efforts towards small farming systems have been, in general, initiated whenever small farms have been identified as a major restriction to food production. On the contrary, farm poverty conditions have been tolerated when the rural sector at large was able to sustain urban consumption needs. This evidence suggests the need to study the institutional aspects of the small farm problem with a broad perspective which includes the behavior of urban interests and their reflection on government actions. An attempt to develop such a perspective is made in the following sections.

III. THE CONCEPT OF APPROPRIATE TECHNOLOGY IN THE CONTEXT OF THE CURRENT "RURAL DEVELOPMENT" APPROACH TO THE SMALL FARM PROBLEM

Appropriate technology is a concept of recent diffusion. It is often used in relation to the small farm problem, and its popularity entails recognition of the importance of technical change as a major policy instrument to raise food production as well as farm income. It also conveys the idea that the diffusion of new technology has occasionally bypassed the small farm stratum, and consequently it implicitly suggests that research efforts should be directed to the generation of innovations which are congruent with peasant agriculture. It is clearly a concept mostly related to agricultural policy analysis and, as a consequence, it is coined as an answer to rural development

problems. In order to set the concept of appropriate technology in a historical perspective, it is useful to briefly review four major interpretations of rural poverty which have emerged in recent years. This review provides the basis for a simple definition of appropriate technology, which is presented at the end of this section.

A. Alternative Interpretations of the Small Farm Problem and their Implicit Policy Recommendations in Historical Perspective

The major features of the small farm problem were identified years ago and have received considerable attention from social scientists (particularly sociologists, agricultural economists and anthropologists) and policy makers.

Empirical evidence provided by research on social problems related to the agricultural sector which took place after the end of second world war gave place to successive lines of interpretative efforts which provided the necessary intelectual backing for alternative programs and public action.

Four main interpretative lines of thought may be mentioned which have had considerable influence both in academics and government thinking. They will be termed for short the Educational, the Land Reform, the Technological and the Rural-Development approaches to rural poverty. The first of them in a historical sense, the educational approach, was based in sociological work specially in the Asian continent and in Latin America, by Rogers and others, that emphasized cultural "backwardness as the main determinant of inadequate

behavior for adoption of technical innovations and overall production and income growth. Traditionalism, lack of education, cultural biases, were to be solved through education and the incorporation by peasants of "adequate values" so that technical adoption could become possible.

Partial failure of this strategy and the increasing awareness of the unequal distribution of land and its socio-political implications generated towards the 1960's a widely influential school of thought which emphasized land tenure aspects as basic "structural" limitations to agricultural development. Policy recommendations were based on improvement of the pattern of land distribution through land reform which was the predominant theme during the early part of the 1960's. The series of works developed by CIDA (1963-1968) were relevant to this development, as it was the work by the Land Tenure Center of the University of Wisconsin and that by Latin American "structuralists" -- Ferrer (1962) and Chonchol (1966) among others).

Almost simultaneously with the Land reform theme, the work of Schultz (1959, 1964), followed by the main stream of academics in agricultural economics, provided the intelectual stimulus for the development of a school of thought that emphasized technical change as the basis for agricultural development. The basic well-known argument of this school of thought is that small farmers are interested and culturally prepared to adopt adequate technology and increase production. The adoption process is slow because price policy, capital markets or available technology reduce profitability of tech-

nical change for the small farm sector. There is consequently a need to develop appropriate price and credit policies and to accomplish sound research efforts to provide farmers with "high pay off" inputs and stimulate adoption. This line of thought, which has been considerably influential, gave way to the very large effort in the development of native research capabilities during the 1960's and more recently to the creation of the International Research Centers.

The large body of empirical economic research developed recently has shown that this research oriented strategy has had quite unequal effects on different strata. "Green revolution technology" was largely incorporated by large and medium-size farms, whereas small peasants were frequently unable to take advantage of new inputs and production techniques. Since in many cases small farmers integrated the dominant stratum, massive effects of research efforts were even lacking (Cleaver, 1962; Fiorentino, 1977; Darlymple, 1977).

The rural development approach was born in the 70's partly as consequence of these results and undoubtedly it dominates present thinking on the subject. This approach is based in the recognition of the fact that small farmers face a whole set of restrictions that inhibit and condition their possible response to modernization efforts. Besides the more obvious aspects, related to the explicit recognition of the need of roads, information, markets capital inputs, and an adequate capital supply from external sources, this approach incorporates more sophisticated interpretative arguments.

B. A Definition of Appropriate Technology

Three of these arguments are the most cogent; the production-scale economies, the inelastic supply of limiting productive factors and the small farmers' risk aversion.

The modern version of the economies of scale argument, which is highly linked with the so-called 'green revolution effects', indicates that, for the most important grain crops, high yield varieties require sophisticated production techniques associated with high cost, often indivisible capital inputs (expensive farm machinery and irrigation facilities), which are economically inefficient in small holdings. (Frederick, 1970; Cleaver, 1970; Darlimple, 1977). Rejection of profitable technologies due to limiting productive factors has been empirically documented. Zulberti et al found low application of capital inputs - in spite of their economic efficiency in small farms in Ecuador. However, once institutional and economic constraints to capital use were removed through government intervention, high yield technologies were adopted (Zulberti et al, 1977, pp. 327-335). Similar results were provided by Contador (1975) for Brazil.

The aversion of small farmers to risk, widely documented in several empirical studies in Latin American and Asian Agriculture (Sanders and Hollanda, 1976; Sampaio, 1976; Lin et al, 1974) induces small farmers to avoid or reduce production of high yield crops, frequently associated with high price and income variances. Small farmers, due to limited resources and a

lexicographic preference ordering - in which the need to secure food self-sufficiency is a primary objective - tend to favor low yield subsistence crops in their production mixes (Sanders and Hollanda, 1976).

Awareness of the hampering effects of these well-known obstacles to small farm growth emphasized the need for adequate supplies of restrictive inputs through public help (marketing facilities, credit, education) and for developing production techniques which are congruent with small farms' structural restrictions.

The three interpretative elements previously mentioned, which are the most generalized small farmers' restrictions to technological adoption, are, in our judgement, also the basic intelectual support for the concept of appropriate technology.

In this sense, appropriate technology may be defined as one which, by overcoming the mentioned restrictions, becomes available, profitable and technically feasible for small farmers. This proposition implies that appropriate technology has to be: a) neutral to scale, b) biased, in the Hicks sense, towards factors of production (labor) and inputs readily available to small producers, and c) have consistent and fairly invariable effects on yields irrespective of climatic conditions.

It is conceptually clear that this type of technology can be developed if an adequate research strategy is implemented, and that it would enhance

adoption possibilities. However and in spite of this assertion, our main contention is that the overall effects of a development strategy based on the concept of appropriate technology will basically depend on the existing interrelations between the farm sector and the rest of the economy, and the functional roles small farmers play in the overall process of capital accumulation. In most cases, a strategy based solely in the development of appropriate technology will not effectively contribute to the solution of the small farm problem.

IV. THE FUNCTIONAL ROLE OF THE SMALL FARM (PEASANT) ECONOMY AND ITS EFFECTS ON THE INNOVATIVE PROCESS IN LATIN AMERICAN AGRICULTURE

In order to present our views regarding the limited usefulness of appropriate technology as a strategy for solution of the small farm problem, this section will present the basic relationships between the peasant economy and the rest of the economic system. The ability of Latin America's small farm sectors to incorporate technological change and the very nature of induced and adopted technological innovations depend on the nature of these relationships.

Recent hypothesis on stagnation of the peasant economy, which have not been incorporated to current "accepted knowledge" make use of the proposition that the small farm sector is, in general, politically 'dominated" or "passive", and as a consequence the determinants of technical backwardness or output stagnation should be sought outside this sector. (Stavenhaguen, 1969; Gunder

Frank, 1970; de Janvry, 1975). Being the small farm sector partially dominated by other sectors of the economy, small farm growth results from particular forms of social and economic "linkages" with the dominant sectors. There is stagnation whenever the dominat social forces either take advantage of backwardness or they are indifferent towards the small farm development; and this sector, in turn, cannot internally generate growth forces. Conversely, there is growth-oriented technical change wherever there exist social and economic articulations between small farms and the leading social sectors by which these sectors take full advantage of small farm growth.

In the following section it will be argued that the principal forms of social dominance will, in general, result in slow technical change, poor increase in food supply and maintenance of poverty conditions in the peasant economy, and that these relations will be based on social articulations which, by emphasizing the need to secure high labor supplies at low labor prices, will promote development of subsistence farms which provide a "captive" labor supply to large land owners. However, it will also be argued that additional forms of social dominance can exist where these social groups derive economic gains from technology induced output expansion in the small farm sector and, as a consequence, will promote farming systems and an "economic environment" which is adequate for adoption of technology.

A. The process of Generation of Rural Poverty in Latin America and the Technological Issue

The principal forms of social dominance that, in general, will result in

slow technical change in the small farm sector, can be summarized to a few major types that comprise the major part of small farm situations. Of these, the following four seem to be the most important: a) sharecropping; b) semi proletarian subsistence farms, internal to large holdings, that sell labor to it; c) semiproletarian subsistence farms, external to the large land holdings, who sell labor in the labor market and d) the independent small farm producer that produces for self-consumption and the market.

Understanding these situations of social dominance requires the development of a consistent body of theory which analyses the logic of the economic relationships between central and peripheric countries in order to derive propositions about the rural social relations of productions in peripheral economies and their effect on rural development. An interpretation of these relations have been presented by several authors (de Janvry, Gunder Frank), and can be summarized as follows:

The process of capital accumulation and overall economic growth in central economies requires development of a massive market for industrial goods since only through massive circulation of goods can capital accumulation take place. Wage levels in central economies which must thus keep pace with needed growth of aggregate demand are both a need and a threat for capital accumulation in the central economies. Maintenance of accumulation rates in the center, in face of high wage levels, requires that the burden of needed accumulation be transferred to the peripheral economies through sistematic reduction of the price of imported raw materials and foodstuff. However, for supplies of these

exportable goods to grow, overall accumulation rates need also be maintained in the periphery's economic system. This situation can only take place, given the low and declining export prices, through exploitation of rural labor. Agricultural export goods are thus cheaply produced by the periphery's commercial farms which in turn employ cheap domestic rural labor. Low wages in the periphery are in turn consistent with the periphery's economic development pattern, since aggregate demand needed for the circulation of goods (and subsequent capital accumulation in the periphery) originates in profits, rent, and the upper income strata of wage earners. These inner differences in the logic of the functioning of central and peripheral economies have been aptly described by de Janvry (1975) by suggesting that in the central economies labor is a cost and a benefit to capital, whereas in the periphery it is only a cost. Consequently, labor costs may be reduced to subsistence levels which are congruent with the reproduction of the labor force.

Historically, the main instrument to lower the cost of rural labor has been the provision of land to peasants in order that they may produce subsistence crops with the available family labor. This mechanism allows for a reduction of currency payments to employed labor provided by peasant families. The form through which this mechanism was institutionalized has varied historically depending on overall labor availability and the degree of development of the commercial, export oriented agricultural economy. In de Janvry's view (1975, pp. 12-16), different land and labor relations were the result of historical modifications of relative labor availability and land rent. The first part of this century is characterized by a situation of scarce labor, which

implies that the establishment of "precapitalist" labor relations are needed. Minifundia labor is "tied" to the land in order to alienate it from "external" employment sources. In mid century, labor becomes more abundant and occasionally due to the development of highly commercialized agriculture, the opportunity cost of land for commercial farms becomes increasingly high. As a consequence, commercial farms have both the need (increasing land rent) and the possibilities (increasing rural labor supply) of driving small peasants away of large holdings. "Internal" minifundia are thus transformed into "external" small plots, where additional changes in labor relations accompany the locational transference. External minifundia operations become the labor source for large commercial farms, at a monetary cost below reproduction levels, since part of subsistence is covered by the non-tradeable output of peasant agriculture. Labor relations become capitalist, and the small peasant provides proletarian work (de Oliveira, 1973).

Different forms of social dominance, such as those outlined above, will lead to general and specific obstacles to adoption of new technology. In general, the nature of the functional relation between peasant agriculture and the rest of the economy is such that the dominant groups' needs to maintain an abundant and cheap supply of rural labor would tend to induce development of labor substituting -- instead of labor intensive -- technology. More precisely, labor intensive yield increasing technologies which may raise small farm incomes will be seen by large farmer as a threat to needed cheap labor supply provided by the rural peasants (Scandizzo, 1975).

In addition to these general obstacles there are other specific ones which are particularly relevant in the case of the sharecropper. In sharecropping one of the major elements which secure the peasant's ties to this particular mode of production are peasant's financial debts to the land owner, caused by preharvest anticipated payments and food supplies by the latter. Yield increasing techniques which, in face of constant family labor supply, can raise the peasant family's income, are often not fostered by landowners, since larger peasant incomes may break financial ties and give peasants the possibilities to aspire to improved labor relations. Sharecroppers, on the other hand, have additional reasons to avoid labor intensive yield increasing technologies. Since a substantial part of production increases are to be shared with landowners, growth of labor productivity brought by new techniques must be sufficiently high to attract sharecroppers' fairly inelastic labor supply to additional efforts in farm production. This outcome is most likely when external employment sources for family labor are available at comparatively high wage rates. On the other hand, new labor intensive techniques were part of the efforts materialize in overhead facilities - such as the "hand-and-hoe" construction of small dams and irrigation networks - will not be pursued by sharecroppers since benefits will largely materialize in capital gains (land price increase) for land owners.

External minifundia, for which social linkages with the rest of the economy relate mainly to employment sources in commercial farms, agricultural processing activities and the like, face frequent restrictions to adopt new technology related to the labor market. There has been a great deal of govern-

ment actions for generation and diffusion of technical knowledge for this particular farm group, However, in-farm labor employment related to suggested new techniques competes with outside employment sources in such a way that only labor intensive or neutral techniques that considerably increase labor productivity will be able to attract labor to in-farm activities.[1/] Although empirical evidence is scanty, previous work provides some evidence in this direction. Benito's (1976) findings for the Puebla project reveal, after analysis of output data of a mathematical programming model, that modern activities - strongly recommended by extension workers - cannot compete for the small peasants labor time in external activities. Similar findings are provided by Sampaio (1976) and Lacerda de Melo (1975), for Brazil.

B. Functional Relations which Induce Technological Change in the Small Farm Sector

"Positive" functional relations between the small farm sector and the rest of the economy prevail when needed growth in food supply takes place in face of inelastic land availability. Dominant social groups linked with the circulation process tend in such cases to induce yield increasing technical change which can occasionally reach small farmers. Alternatively, dominant social groups related to the process of circulation of agricultural inputs

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1/ In general, evidence with respect to small farm labor use tends to indicate that this factor is intensively utilized and its productivity at the margin is considerably low. It is indeed surprising to learn that similar results have been reported for such different countries as the United States (Paris and Lianos, 1974), Argentina (Piñeiro et al, 1978), Brazil (Sampaio, 1976, and Fiorentino, 1977).

will be interested in capital intensive technical change even by small farmers. This line of reasoning could be enlarged by incorporating situations in which induced farm sector behavior is due to social or organizational-type linkages. A path breaking attempt to discuss this type of social articulation has been made by Hirchman (1977). Economic growth for a particular social group will take place whenever there are social and economic forces - often generated outside the group's decision framework - which induce the social group to "invest", modify production patterns, and growth (Hirchman, op cit, pp. 2-19). Examples of these forces or "linkages" are this group's appropriation of innovations or services produced for alternative groups - like managerial innovations developed for industrial production but readily adaptable to agriculture -- or the use of tax revenues generated in other economic activities for the development of agricultural services (for example research).

Even if the nature of social articulations is such that technical change can be easily induced, technical restraints may still exist, which relate to factor availability, economies of scales, etc., and force adoption of technical change away of the smallest farm strata. In this respect, it is interesting to mention the regressive distribution results of green revolution technology which are widely known to deserve additional comments (Darlymple, 1977; Scobie and Posada, 1976, etc.). It can be argued, as Darlymple (1977) does, that from an initial high assimetry in factor endowments, such as the one which prevails in Latin America, only regressive income distribution results of technical change can be expected (1977, pp 4-9). Interesting enough, such

an argument clearly indicates that technical change is an inadequate instrument to deal with income-distributional problems and that structural reform is previously needed.

The discussion in this section has centered until now on the ways in which the predominant social relations will condition the feasibility of having technical change in the small farm sector. In this respect we have emphasized that only under a few and quite restrictive conditions the overall social system will permit technical change to take place. This process will improve the efficiency of labor and land utilization in the small farm sector which in this way will improve its contribution to the overall food production problem.

This discussion has said nothing about the relationship between technical change as an instrument to the solution to the second problem associated with the small farm sector, rural poverty. In this respect empirical evidence suggests that small farmers will benefit from economic gains generated by technical change only under special conditions related to its insertion in the circulation process and the institutional setting in which they operate.

It is quite clear that in order that small farmers may benefit from technical change several conditions must be met. The most important of them are an elastic farm product demand, a market structure with an atomistic demand and a favorable price policy, perfect competition in input markets (particularly in those associated to technical change), and property of the

land or, on the contrary, a highly elastic supply of land.

If these conditions are inexistent, the market mechanism, including its institutional components, will adjust in the form of extracting the additional economic benefits gained from technical change in order to maintain the small farmer at near subsistence levels.

V. SUMMARY AND TENTATIVE RECOMMENDATIONS

The preceding sections attempt to assess the relevance of appropriate technology as one of the main instruments to solve food shortage and rural poverty problems, They explore the nature of the social articulations between the peasant agriculture and the rest of the economy to propose that, in frequent situations, the nature of these articulations is such that the interest of dominant groups in appropriate technology is very limited, and as a consequence research efforts to cope with food production and poverty problems have few possibilities of success.

Additional propositions are presented, however, to describe the nature of alternative and not occasional forms of social articulations which are favorable to induce technical change of the land saving-labor using type in the small farm sector. Even in these cases, empirical evidence suggests that, although the adoption of land saving innovations contributes to the increase of agricultural supply, poverty problems remain often unsolved.

Different types of social forces induce this outcome. First, adoption possibilities are occasionally restricted for the smallest stratum of the farm sector. This outcome is frequently due to the impossibility of adoption of capital intensive input packages and to inadequacy of labor returns associated with new technology in comparison with out-of-farm employment possibilities. Second, and perhaps more important, social dominance of small farmers by other groups tends to determine the nature of product and input market structures which, by effective "treadmill" type mechanisms, allow dominant groups to appropriate the economic surplus generated by technology adoption. Consequently, it seems that appropriate technology may be an adequate instrument for the solution of food and poverty problems only in a limited number of situations.

Adequacy of appropriate technology to specific situations suggests the need to avoid general policy recommendations. To deal with the small farm problem, empirical work addressed specifically to the situations under study is needed. Efforts should be made to describe and understand the nature of the social articulation between small farms and dominant social groups in the economy, in order to evaluate society's interest in small farm technical change for the specific situation under study and, consequently, the real possibilities for it to take place. The preceding analysis will provide information for development of analytical models for microeconomic evaluation of proposed innovations. Since farm production situations are highly heterogeneous, there may be a need to classify small farms into different types on the basis of analytical criteria which allow

to appropriately describe the nature of social and economic articulations. As recent studies indicate (Colmenares et al, 1977; Piñeiro and Trigo, 1977), social relations of production -- with emphasis in the nature of farm and out-of-farm employment, the land tenure system, and the nature of the small farm relation to product and input markets may be appropriate criteria.

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176
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