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AGRICULTURE IN THE NEW REGIONAL CONTEXT: FUTURE TECHNOLOGICAL CHALLENGES

Eduardo J. Trigo

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WHAT IS IICA?

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IICA was founded as an institution for agricultural research and graduate training in tropical agriculture. In response to changing needs in the hemisphere, the Institute gradually evolved into an agency for technical cooperation and institutional strengthening in the field of agriculture. These changes were officially recognized through the ratification of a new Convention on December 8, 1980. The Institute's purposes under the new Convention are to encourage, facilitate and support cooperation among its 32 Member States, so as to better promote agricultural development and rural well-being.

With its broader and more flexible mandate and a new structure to facilitate direct participation by the Member States in activities of the Inter-American Board of Agriculture (IABA) and the Executive Committee, the Institute now has a geographic reach that allows it to respond to needs for technical cooperation in all of its Member States.

The contributions provided by the Member States and the ties IICA maintains with its 13 Permanent Observer Countries and numerous international organizations provide the Institute with channels to direct its human and financial resources in support of agricultural development throughout the Americas.

The 1987-1993 Medium Term Plan, the policy document that sets IICA's priorities, stresses the reactivation of the agricultural sector as the key to economic growth. In support of this policy, the Institute is placing special emphasis on the support and promotion of actions to modernize agricultural technology and strengthen the processes of regional and subregional integration. In order to attain these goals, the Institute is concentrating its actions on the following five Programs: Agricultural Policy Analysis and Planning; Technology Generation and Transfer; Organization and Management for Rural Development; Trade and Agroindustry; and Agricultural Health.

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Eduardo J. Trigo

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INTRODUCCION

The advent of the decade of the nineties has been accompanied by momentous changes. Events in Eastern Europe and the end of the Cold War provide further evidence of the trend toward the consolidation of large trading blocs (and their accompanying "megamarkets") as the new organizational model for the world economy. This presents new opportunities for the economies of Latin America, opportunities which hitherto were either limited or reduced by prevailing protectionist practices.

In Latin America, the debt crisis has accelerated the search for alternatives to the import-substitution model; the opening and liberalization of markets and integration have been proposed as valid underpinnings for the economic reforms needed to again set the region on the path to growth and development.

The concept of economic development is being thoroughly overhauled. The issues of competitiveness, and the type and use of technology in agriculture, have become strategically important considerations. The aim of this paper is to evaluate the main technological challenges which the region will have to meet if agriculture is to play an effective role in the economic order of the region and the world.

The second section of this paper is a brief discussion of the characteristics of the "new agriculture." The third examines the issues of equity and sustainability as necessary preconditions for any development strategy, while the fourth assesses the opportunities and obstacles that exist in the international arenas where actions will have to be undertaken. Technological issues and the research and development challenges posed by the "new agriculture" are analyzed in the fifth section. Some remarks on institutional considerations which should figure in this process are presented in the sixth and final section.

I. AGRICULTURE AS A STRATEGICALLY IMPORTANT SECTOR FOR GROWTH AND DEVELOPMENT

The 1980s marked a change of course in the pattern of development previously followed by the Latin American and Caribbean countries. The confluence of several internal and external factors obliged most countries to embark upon a profound reform of their political, economic and social systems. The validity of the previous development model -based on the concept of industrialization as a means of substituting imports- was called into question, and the foundations of a new, more open and participatory economic order were laid, in which an equitable, modern and sustainable "new agriculture" could make a more germane contribution to society as a whole. In general terms, the earlier models tended to favor protectionist policies for industry and the development of domestic markets at the expense of agricultural exports, failing to capitalize fully on the farming sector's comparative advantages and capacity for economic expansion.

The application of the import-substitution model resulted in a dual and conflicting agrarian structure in which agricultural export enterprises existed side by side with an agriculture serving primarily the domestic market and on-farm consumption. A false dichotomy between the rural sector and industry led to weak, limited intersectoral relations and galvanized the exodus from the countryside to the cities. In many instances, the farming sector was viewed as a source of conflicts rather than opportunities for development and economic growth.

Exploding onto the scene in the early eighties as a result of an abrupt and unfavorable change in financial conditions and falling world prices, the debt crisis highlighted the need to create an alternative model and expedite the processes of adjustment based on the opening of the markets and competitiveness. In this new scenario, natural resources and the planned use thereof once more become strategically important factors, offering the region's economies a new alternative for growth and development.

An assessment of successful attempts at economic and social development clearly demonstrates that, in every instance, the strategies employed were based upon effective management of the factors or sectors which offered comparative advantages: natural resources in the case of the United States during the second half of the nineteenth century; highly trained human resources and industrial discipline in Europe and Japan in the recent post-war period; and low labor costs in the newly industrialized countries of Southeast Asia.

There can be no doubt that the quantity and quality of Latin America's natural resources set it apart from the rest of the world, and that they represent the main source of comparative advantages which the countries of the region can use to establish favorable competitive relations with world markets, thus enabling them to pursue development. Moreover, given the fact that a large share of these resources are located

in the agricultural sector, and in view of the significant multiplier effect which investment in agriculture and increased income can generate through forward and backward linkages and at the point of final demand, agriculture is an efficient channel for investment, both in terms of the employment it generates and its effect on the demand for imports and the balance of payments.^{3/}

The relevance and dimensions of these opportunities and the contribution this sector can make to economic reactivation become even more apparent if we bear in mind that, despite the unfavorable conditions prevailing until now, the sector represents a fifth of the GDP, employs nearly 40% of the overall labor force and brings in 32% of the total foreign exchange earnings generated by the region's exports.

It is also worth pointing out that agriculture came much closer to sustaining its potential growth rate during the crisis than did other sectors. This was particularly true of food production in rural economies, and of diversification, where a notable expansion in non-traditional exports occurred. At any rate, agriculture has played an important role as a counter-cyclical force, demonstrating much greater resistance to the effects of the crisis than other sectors. These developments also underline the possible impact of strategies intended to foster competitiveness based on effective management of comparative natural advantages.

Besides these indicators, which are convincing enough in themselves, it is also worth pointing out some other characteristics of the sector, which are particularly important in view of both the constraints and priorities of the economic structural adjustment programs now being implemented, and possible scenarios for the region's role in the world economy in the future:

First, a large percentage of agricultural output are "wage goods;" thus, raising production has a direct effect on any policy for pegging prices. Second, most countries have a favorable trade balance in agricultural products; consequently, stepping up production will have a positive impact on both exports and import substitution. Third, the reactivation of farming output will have an important catalyzing effect on economic activity as a whole, as it can enhance intra- and inter-sectoral relations. Finally, raising output will expand the demand for labor in rural areas and, therefore, will tend to counteract the exodus from the countryside to the city. All these effects will be even more notable if increased output is accompanied by more active processing of agricultural products.

For all the above reasons, it is felt that agriculture has a key role to play in any "return to growth" linked to the world economy, where its real sources of long-term competitive advantages will be accentuated. At this point, however, it behooves us to consider the kind of agricultural development that is desirable in the present circumstances, especially as we stand on the threshold of profound technological changes which, while creating new opportunities, also will diminish the role of certain strategic areas and actions that until recently, were considered to be of crucial

Importance. The issue that must be resolved is whether the region is to continue to compete on the same basis as it has up to now, capitalizing to the utmost on the comparative advantages of its natural resources, or whether future efforts should seek to enhance exploitation of those advantages to enable the region to participate in oligopolic markets where product differentiation and continual technological breakthroughs- and not prices- are the main grounds of competitiveness.4/

Latin American and Caribbean agricultural trade previously focused mainly on the commodity markets, where prices largely determine what is bought and sold, and by whom; the participants in those markets have little influence over such decisions. Competitiveness in these markets is achieved by producing at a lower cost, and in some instances, by more efficient marketing. Generally speaking, however, the possibilities of generating high profits and sustained opportunities for capital formation are very limited and, in the case of agricultural products, are often tied to climactic conditions in production areas. The long-standing problem of falling prices for most farming commodities demonstrates the weakness of any strategy designed exclusively to capitalize on the natural comparative advantages of such products. At the same time, it underlines the need for an alternative which, without minimizing the benefits (income) to be secured from the region's favored natural resource situation, makes it possible to take these agricultural raw materials and capitalize on the opportunity to create value added and develop product differentiation (thus, large profits and capital formation).

It becomes necessary, then, to abandon the limiting concept of the farming sector as merely a supplier of raw materials for export and/or cheap foodstuffs, in favor of a broader concept which includes the entire sweep of agricultural and agroindustrial activities with their forward and backward linkages; that is, the links with industries producing inputs, machinery and agricultural equipment, and with the food sector, arising from technological breakthroughs, urbanization and international trade relations.5/

With the "modernization" of agriculture, the proportion of sectoral value added created off the farm increases substantially. Indeed, it becomes the largest single component of the sector's economic contribution to GDP. Figures available for developed countries (especially the United States) point to the fact that only 10% of value added in the fibers and foods sector is generated at the farm level, while 40% is accounted for by inputs, and 50% is value added during postharvest handling -processing, packaging, storage and marketing.

The growing importance of the postharvest stages in the composition of value added and the strengthening -in terms of size and complexity- of intersectoral linkages, are key elements of the new concept of agriculture as a vehicle for investment and as an economic "growth" sector. Raw materials must no longer be treated as the principal product of agriculture; finished products, that is, products plus agroindustrial and marketing value added, must be considered as the sector's real products.

Though highly complex processing of agricultural goods does take place in some countries of the region, this is not the case with most of the output; in most cases, even when the opportunity for agroindustrial processing is not missed entirely, it is at best rudimentary, in no way reflecting the technological options available.

The benefits of agroindustrialization extend far beyond the increase in value that is generated and the competitiveness which results from diversification and expansion of markets. On the one hand, the structure of employment in rural areas is transformed (more sources and greater stability); on the other, agroindustrialization acts as a catalyst, justifying the implementation of rural infrastructure projects (communications, health, education). All these factors have important multiplier effects on final demand, far greater than the sectoral dimension we have been considering.^{6/}

Competitiveness and the ability to perform successfully in world markets will ultimately depend on whether or not a progressive, ongoing increase in the efficiency of the entire agricultural-agroindustrial complex can be achieved. In this sense, technology will have a decisive role to play in future scenarios.

Finally, it should be pointed out that the traditional role of agriculture as the cornerstone of the region's food security policy will not be abandoned or even curtailed in the new context. On the contrary, "return to growth" will inevitably have a marked impact on the demand for foodstuffs and on the sector's role in meeting that demand. Prior to the crisis, the growth in the demand for food in the region was put at 3.5% per year. If the present rate of population growth were to be sustained (2.3% per year), even a relatively modest recovery in income would produce a drastic imbalance in relation to the growth in output, currently standing at only 1.9% per year. On the other hand, the elimination of subsidies for urban consumers and of the bias against agriculture -policies implemented as part of the current structural adjustment programs- would radically alter the framework of incentives for farm products and further enhance the dynamic role of agriculture during this new phase.

II. EQUITY AND SUSTAINABILITY AS NECESSARY PRECONDITIONS FOR GROWTH AND THE NEW ROLE OF AGRICULTURE

The changes in the economic situation in the region which we have described have occurred within a broad framework of a return to democracy as the predominant political and social system in Latin American and Caribbean countries. Indeed, this move toward democratic systems has to a large degree served as a catalyst for the changes introduced (economic adjustment and stabilization, modernization of the State apparatus, liberalization of economies, subregional integration), which are regarded as the only possible solutions to a crisis unprecedented in the region's history. Sparked by the external debt problem, it has now penetrated practically every level of society. As we have already stated, agriculture in Latin America and the Caribbean has unique characteristics that suggest that it will take on an increasingly important role in bringing

the crisis to an end, as well as in the search for a new growth and development model. In part this is due to the richness and diversity of the region's natural resources, but it also stems from the fact that the modernization of agriculture gives investments in this sector high multiplier effects as a result of intersectoral linkages. Furthermore, a role as a source of growth should also help strengthen democracy. For this to take place, any new strategy should aim to fully incorporate small-scale producers into new sectoral structures.

If it is to play an effective role as a source of economic growth, a modernized rural sector should encompass all the groups involved. This will require that favorable conditions be created to ensure that the transformation process permeates not only the upper stratum of agrarian societies but also filters down to the poorest producers and regions. Specific and differentiated policies will be called for which take into account the characteristics and needs of these sectors, as will greater institutional decentralization and increased participation of their own organizations in decision-making processes.

The importance of including all rural actors in the agricultural modernization process is made even more apparent by the sheer number of small farmers and the fact that this subsector is continuing to grow in size, in part due to a contraction in the urban employment market brought about by the crisis and the subsequent decrease in migration to the cities. According to recent figures, this sector not only accounts for a very significant proportion of agricultural lands, but in many instances is a key factor in food production, its principal, though not sole, product. Around 1980, for example, over 40% of coffee production, and nearly 40% of the region's entire agricultural output were produced by small farmers. These figures were even higher for certain crops, such as beans (77%), potatoes (61%), and short-cycle crops in general (53%). In countries such as Bolivia, 80% of the gross value of agricultural output is generated by this sector. These figures outline the nature of the challenge that lies ahead. Setting aside ethical considerations in favor of cold political pragmatism, it can be affirmed that the incorporation of small-scale producers into the modernization process is an essential precondition if the farming sector is to make an effective contribution to economic reactivation.

A second consideration or precondition for the new strategic model for agriculture involves intergenerational equality of opportunity, the conservation of natural resources, and the long-term sustainability of the new production models. In comparison to other developing regions, the Latin American and Caribbean countries enjoy a privileged position as far as per capita available natural resources are concerned. Nevertheless, given the rate at which they are being used up, this situation could soon change for the worse. On the other hand, the importance of agriculture as a driving force or source of economic growth invests the subject with even greater importance than would otherwise be imagined. In Latin America and the Caribbean, it is not a question of conservation at the expense of production; on the contrary, output must rise. The challenge, therefore, is even greater.

The region's ecological riches, reflected in the enormous agricultural resources available, are inconsistent with the predicament of large numbers of poor farmers, who, in order to subsist, are forced to over-utilize highly fragile ecosystems. Under the present circumstances it is clear that current production models can only be maintained at the risk of destroying important segments of our ecological capital, threatening the future of generations to come. This makes it essential to identify production strategies which strike a balance between present and future needs. The challenge is how to achieve this at a time when the economies of the developing world in general, and Latin America and the Caribbean in particular, are striving for the growth they so desperately need.

III. OPPORTUNITIES AND OBSTACLES IN THE OVERALL ECONOMIC, POLITICAL AND INSTITUTIONAL CONTEXT

The dimensions and feasibility of the new role for agriculture in the region are magnified and become more apparent when the effects of the profound structural changes in world economic and political relations are taken into account, as well as the possible impact of new technologies (biotechnology, microelectronics and computer sciences, new materials and sources of energy), opportunities with which the region's farming sector must deal.

The outlook for Latin America and the Caribbean was very inauspicious at the start of the eighties and through the first half of that decade. First came the debt crisis, the effects of which began to be felt around 1982; later, the agricultural trade war between the United States and the European Community, which reached its height in 1986 and had a very negative impact on the international trade of less developed countries. This panorama began to change significantly, however, as the Cold War began to thaw and as plans progressed for complete integration of the European Community in 1992. Finally, the situation took an unexpected turn with the democratization of Eastern Europe. Specifically as refers to agriculture, the most outstanding event was the start of the GATT Uruguay Round in 1986. For the first time in the history of the Treaty, the subject of agriculture was placed on the negotiating table. The integration of the European Community in early 1992 will unquestionably affect the world trade of farm products; the magnitude of its impact in the short and medium term will largely depend upon the outcome of the multilateral negotiations now drawing to a close. Nevertheless, it seems clear that governments will not be able to sustain current subsidy levels and that we shall witness a progressive liberalization of agricultural trade, with flows which effectively reflect the comparative advantages of each participant rather than the strength of their financial resources, as has been the case in recent times.7/

The transition to democratic regimes and market economies in Eastern Europe also heralds important changes in consumption patterns and a greater demand for certain agricultural products, especially edible oils and tropical products. Likewise, Japan and the group of recently industrialized Far Eastern nations -the so-called Asian Tigers- make up another economic bloc which will also have a great impact on world trade as these

countries gradually open up their agricultural borders, hermetically sealed for many years on the grounds of food security. To a large degree this is the result of pressure applied by the United States in an attempt to correct the enormous trade surpluses amassed by the Asian nations over the past five years. Growing exports of meat and citrus fruits to Japan by the United States and other countries could indicate a new trend in this direction.

The situation in the People's Republic of China, though less predictable since the political events of June 1989, could be another important factor in the reactivation of world agricultural trade. With a steadily growing domestic demand, and productivity relatively stagnant, it is likely that grain imports will be stepped up during the nineties.

The consolidation of economic blocs, the greater pragmatism in policy making and the globalization of financial and commercial markets suggest that trade will emerge as the key to contemporary international relations, with competitiveness becoming a decisively important factor. These new parameters of the world order further underpin the new role for the farming sector in the strategy to reactivate the economies of Latin America and the Caribbean.

In Latin America these trends have contributed to renewing interest in regional and subregional integration projects, though the current approach differs from that employed during previous decades. It is no longer a question of promoting integration in order to "protect" regional markets. Rather, the aim is to create large economic blocs in order to enhance competitiveness in international markets. Such efforts are a relatively recent development, and while it is difficult to predict their specific impact, they will, without doubt, make an important contribution to increasing the competitive capabilities of specific sectors, since they will permit a fuller exploitation of comparative natural advantages, enhance utilization of economies of scale and foster competition in local markets.

Another trend, one which no doubt will become increasingly important over the next decade, is the growing demand by consumers, particularly in the more developed countries, for greater variety and quality in food and beverages, for fruits and vegetables that are more attractively presented and subjected to more sophisticated processing. Additionally, consumers do not want products that contain chemical residues, and when this is combined with the widespread acceptance of the importance of environmental conservation and the need to reduce pollution in all its forms, it can be expected that a top priority for developed countries -both importers and exporters- over the next decade will be an agriculture using low levels of chemical inputs.

This "return to nature," and the fact that growing budgetary limitations in industrialized countries make continued support for protectionist agricultural policies untenable (from a cost-benefit standpoint their effectiveness is questionable in any case) make it more likely that developing countries which, generally speaking, are efficient

agricultural producers -at least in terms of their use of chemical inputs- will recover the ground lost during the eighties.

This process is well under way today and could be further accelerated by the Persian Gulf situation and the possibility of a third oil shock, which would make it even more necessary to reduce agriculture's enormous dependence on oil throughout the world, particularly in the industrialized nations.

Another important factor which can be expected to both provide opportunities for and place constraints upon the "new" agriculture are the new technologies (microelectronics, biotechnology, new materials and new energy sources). Without entering into a detailed discussion of possible developments in each case, it is safe to say that they will have a decisive, and contradictory, effect on agriculture. While biotechnology can reduce the comparative advantages of natural resources and diminish the importance of the production of raw materials in several ways, it can also have a number of positive effects, such as the possibility of producing plants and technologies better adapted to local conditions, further diversifying the use of ecological resources in general, and designing a model of ecologically sustainable long-term development. The possibility of natural resources being replaced at the primary production stage represents a genuine threat, but this can be partly compensated by possible new uses for existing products, the creation of totally new products, and more effective use of certain resources such as germ plasm, for which the region has a definite natural advantage.

Breakthroughs in microelectronics and computer technology will also have important repercussions, leading to greater efficiency in agricultural production overall and reduced commercial and climactic risks with the introduction of information networks, expert systems, training supported by telecommunications and greater access to market information and telemetry. Furthermore, the possibilities of decentralizing information and decision-making will facilitate linkages between the production and postharvest stages and, eventually, the development of new ways to integrate agriculture and agroindustry, that can involve small-scale farmers. These factors -which should be seen as positive developments- will be offset by certain negative effects: the possibility of centralized control of information, large-scale integrated processes and, in certain cases, the displacement of labor, among others.

The outlook for the new paradigm is difficult and contradictory. In some ways it will curtail agriculture's contribution to economic reactivation; in others, it will increase it. The issue of the importance of natural resources as the sole source of comparative advantages emerges again. In the agriculture of the future, as in other sectors of economy, competitiveness will be achieved by gaining access to new knowledge and then applying it. This might appear to be a threat, but it also represents another source of opportunity. Provided that needs are recognized and decisions made, new knowledge can be used effectively as a catalyst for (not a substitute) the original natural comparative advantages. Specific strategies will have to be adopted in order to guarantee access to,

and the ability to capitalize on, these new technologies. The strategies should be defined in the region itself and be shared among the social and economic forces in the countries with a view to establishing the pertinent policies, programs, and specific actions, and to promoting the institutional changes needed for the new technological paradigm. Otherwise, the technical potential we have already described will likely be concentrated in the most advanced countries and exploited by transnational corporations, putting the region at serious risk of falling victim to perverse effects of the technological revolution.

IV. THE MAIN TECHNOLOGICAL CHALLENGES FACED BY AGRICULTURE IN THE NINETIES

Technology takes on special significance in the scenario we have just described. It can no longer be viewed merely as a phenomenon of "supply," that is, as a response to existing production problems. It must now become an active ingredient in the strategy of transformation. Agriculture will only be able to fulfill its new role if there is a rapid increase in productivity, and this in turn will require a reassessment of the role technology is to play in view of the changes in demand, the national and world economic situation, and the opportunities offered by scientific breakthroughs. To achieve this, it will be necessary to develop new research and institutional approaches and to reflect on the technological challenges which will have to be met.

The Technological Consequences of Adjustment and the Move Toward Growth

Stabilization and adjustment policies have not only modified the relative price structure between products, but have also significantly altered input-output ratios and spending patterns, based on the relative weight of nationally manufactured and imported inputs. Increases in real exchange rates have contributed to boosting the cost of imported inputs, while unemployment and inflation have contributed to reducing real wages in most countries. As a result, capital-intensive technologies involving a high import factor, usually developed to counter relatively high labor costs, have become relatively inefficient in comparison with more traditional technologies that make a more intensive use of labor and natural resources.

Consequently, a large number of existing technologies are either already obsolete, or well on the way to becoming so, and new research is required that takes the new price ratios for both inputs and products into account. Research to improve efficiency in the use of inputs and to substitute imported inputs for locally produced alternatives is also urgently needed.

The growth in domestic demand which will accompany the reactivation of the region's economies underlines the urgency of such efforts, and at the same time signals other important issues. Over the past two decades, subsidies and disincentives for production have discriminated against traditional products -roots and tubers, edible legumes, etc.- and in some cases have created an over-dependence on imported

foodstuffs, particularly cereals. Reversing this trend will require not only greater emphasis on research on cereals, oilseeds, annual crops and other basic consumer products, but also on the well-adapted traditional crops for which the region enjoys a comparative advantage. The wealth and importance of genetic resources native to Latin America and the Caribbean has been widely acknowledged. Nevertheless, native species represent a smaller proportion of the region's agricultural output than in any other comparative area. This fact highlights the need to redouble the efforts to compile, evaluate and utilize these genetic resources.

It is worth pointing out, however, that it is not merely a question of improving production technologies; processing and preservation technologies are also required. Indeed, in many instances the absence of such technologies is the most serious obstacle to increased consumption of these products. The case of cassava in Colombia, Ecuador and Brazil is a good example.^{8/}

Finally, the opening of the economies and ever greater domestic dependence on free markets will make it increasingly important for all farmers (small-, medium- and large-scale) to have effective access to information and to develop the ability to process and use it in decision-making. Breakthroughs in microelectronics and information technology open up great possibilities in this regard (data bases, expert systems, decision-making models, etc.). Issues such as these do not receive enough attention at the national level, however.

The Need to be Competitive in External Markets

Regardless of the outcome of the trade negotiations currently under way, access to world markets over the medium and long term will depend upon the region's ability to capitalize on its comparative advantages -in this case the availability and diversity of its natural resources- via the incorporation of technologies which make it possible to steadily raise productivity and lower production costs, thereby making the region's products more competitive. For example, figures on the possible impact of new technologies (biotechnology, in particular) on crops in temperate zones indicate that yields will double by the beginning of the next century. This clearly demonstrates that, while natural comparative advantages will probably become more important due to the trend toward more organically-oriented farming and higher energy costs in agricultural production, they will not be sufficient in themselves to sustain competitiveness over the medium term, and the technological model applied up to now will have to be reviewed. In the case of a good many crops, output has been stepped up by expanding the agricultural frontier. Since most productive land is already in use, however, expanding the agricultural frontier no longer constitutes an effective alternative to intensification through technology in areas already under cultivation.

The technology required to capitalize on the diversification in demand should also be explored, especially in the case of non-traditional exports such as vegetables, nuts,

tropical fruits and edible oils (which in some instances are very dynamic product lines), as its impact is reflected not only in more intensive use of the land but also in new sources of employment. Initially, these developments could be possible with very little research and development support. Vegetables, fruits and flowers in several Central American countries, Mexico and Colombia, among others, are good examples. Nevertheless, effective support for innovation is vital in the long term if such activities are to represent more than a mere attempt to capitalize on temporary market opportunities. Chile's experience in developing fruit exports demonstrates the interrelationship of these two factors, and how research and development activities play a decisive role in supporting such industries over the long term.

Two areas of research and development would appear to be crucial in this regard. The first is that of crop management in general and plant protection in particular. In most instances, production at start-up can get by with the use of packages of imported technology. Such a strategy has its limits, however, and local research soon becomes necessary to furnish a technological profile adapted to local ecological and economic (price ratios) conditions, and to the phytosanitary problems of each specific environment. This becomes a strategically important consideration, given the higher quality and enhanced presentation required for these products to gain access to the markets of developed countries. The second area involves the identification, collection, evaluation and development of local germ plasm resources. Research of this kind is important because of the need to introduce new varieties -maintenance research- and as new opportunities are identified.

The Modernization of Agriculture and the Type of Technological Development Required

The concept of an "expanded sector" referred to in our discussion of the new role for agriculture -in which farming output is viewed as only one part of the sectoral process and is closely linked, economically and technologically, to the postharvest phases: processing, packaging, storage, etc.- also has serious implications for technological development. On the one hand, the technologies to be promoted for the production phase should be fully integrated with the postharvest processes. On the other, the concept of productivity can no longer be defined exclusively in terms of agriculture, but should be viewed in the context of the agricultural-agroindustrial complex as a whole. Technological development, therefore, should also include innovations related to other activities in the production-processing-packaging-preservation chain. The importance of the enterprise as the key component in the technological development process therefore becomes even greater, as does innovation in the agricultural-agroindustrial sector -that is, the ability to identify market opportunities and apply the "management-technology packages" needed to capitalize on them. Therefore, policies regarding the use of technology in agriculture should take account not only of the instruments used in agriculture, but also of the mechanisms affecting the performance of the other

components of the new agro-alimentary sectors, thereby creating the positive environment which the production units of the "new" sector will require.

The Technological Needs of Small-Scale Agriculture in the Opening of the Economy

The coexistence of a wide range of production systems is one of the main characteristics of farming in the region. On the one hand we find a commercial farming sector with good access to resources, services and technology, and fully integrated into the market; on the other, a world of small-scale producers with insufficient access to resources and services. In numerical terms, these represent the vast majority of rural dwellers and in most cases a large percentage of total output. In terms of technology, each of these groups behaves quite differently, calling for separate research strategies which acknowledge the specific characteristics of each case. The research and technology transfer structures created over the past thirty years have served the commercial sector fairly well. Nevertheless, there is general agreement that they have not been successful in developing and disseminating technologies among small-scale producers. This has been reflected in falling productivity and, in many cases, by the limited participation of small-scale farmers in economic life.

Economic adjustment and opening make the predicament of small-scale producers even more dramatic, in two ways. First, the continued use of assistance-oriented policies of the past to compensate, in part, for the bias of macroeconomic and sectoral policies against traditional agriculture, becomes an increasingly impracticable proposition. Second, the growing importance of competitiveness as the key factor bringing together the different actors into the economic circuit further highlights the failure of existing technological models to generate and disseminate technologies tailored to the characteristics of the sector.

In developing a technology policy for small-scale farming within the framework of the opening of the economy it becomes necessary to draw a line between two well-defined groups: one which definitely has the potential to compete in agricultural activities, and therefore has access to development by integrating the production of raw materials with processing; and another group for whom these possibilities do not exist, and whose economic role is not really in agriculture. The technology strategy is clearly valid for the first group, but not for the second. In the case of the latter, other factors such as education and training (to enable it to compete on equal terms in the employment market, among others), would appear to be the most effective instruments for facilitating relocation within the new economic structure.

In the new economic order, the position of small-scale farmers who are potentially competitive will be reinforced to some degree by two additional factors. One is that the greater transparency of the price system tends to be to their advantage, as less capital and imported inputs are called for. At the same time, this reduction in the use of inputs

leaves them perfectly placed to capitalize on the new market opportunities created by the growing preference for products which make use of organic inputs. The second positive factor is the effect that this will have on the prices of traditional products and, as a result, on agricultural profitability. This will help eliminate the bias in macroeconomic and sectoral policies toward producing cheap foodstuffs for urban consumption.

It thus becomes a top priority to ensure access by this sector to the technologies which will enable it to develop these potential advantages and convert them into effective competitiveness. The success of any such strategy will depend upon the ability of the institutional systems to take into account the characteristics of small-scale production systems in designing new technological alternatives, the different agroecological circumstances involved, and the combinations of factors they employ.

As far as technological options are concerned, some specific factors must be taken into account. First, a large percentage of small-scale producers tend to farm in fragile environments^{9/}, with little access to other production resources. This means that farm management techniques and crop and soil conservation technologies become increasingly important, as well as those which require a minimum of investment and traditional farming expenditure (low-input agriculture, minimum soil tilling, etc.). A second aspect is diversification of output, by incorporating native species. This topic has hitherto been completely ignored where this type of agriculture is concerned, but it has a great deal of potential, not only in terms of new exports but also in regard to food security. As we have already pointed out, this will call for a restructuring of the gathering, evaluation and development of germ plasm, an important topic much underrated to date. Finally, postharvest technologies are another important issue, given the strategic nature of support for forward integration mechanisms in the new role proposed for the farming sector.

Natural Resources and the Sustainability of Output

Latin American and Caribbean countries possess an enormous reserve of natural resources: genetic, soil and water. Genetic resources, however, are either underutilized or dangerously overexploited. Cases in point are the soils and forests of some subregions, particularly Central America and certain Caribbean islands.

The scope of these genetic riches is clearly reflected in the fact that this is the region where such important crops as corn, beans, cassava, potatoes, sweet potatoes, tomatoes, peanuts, cocoa, tobacco and rubber, among others, originated. According to some estimates, the region has provided approximately 36% and 34% of the genetic base for the twenty most important food and industrial crops, respectively. This percentage is significantly higher than for any other region of the world. These resources have an enormous potential, especially in view of the breakthroughs being achieved in the field of biotechnology and genetic engineering which transform germ plasm resources into production resources with a clearly identifiable economic value. Nevertheless, only a very small proportion of such resources have been explored and identified, especially in the

tropical areas. For example, less than 50% of the genetic base of important species such as cassava and beans has been collected, and only 5%-10% of wild species have been catalogued, clearly a grave situation, considering the rate at which forests and other ecosystems are disappearing.

At the same time, a lack of clear policies combined with prevailing production practices lead to rapid deforestation, soil degradation and sedimentation of watersheds. Taken in conjunction, these factors represent a significant loss of the comparative advantages which the region originally enjoyed and which were referred to in previous sections. This is especially true of tropical areas¹⁰/, though it is already a growing problem in temperate zones, where the trend toward permanent farming is beginning to threaten sustained production use over the medium and long terms.

These problems are also exacerbated by the intensive use of agrochemicals for some crops (cotton and vegetables, for example). Such practices are beginning to have a detrimental effect on health in rural areas, causing the destruction of wildlife and polluting drinking water supplies. In addition, they also thwart efforts to break into new markets, especially with products such as fruit and vegetables, which have a high added value, but are subject to very strict quality controls and analyzed for chemical residues.

It is clear from all the above that factors such as the sustainability of output and environmental conservation should now play a key role in the definition of technological strategies for the development of the "new agriculture." As a first step, priority should be given to collecting information on the nature and functioning of different ecosystems, and to obtaining indicators and data which will make it possible to arrive at a more accurate assessment of the potential impact of different alternatives. Follow-up should be included once the latter have been implemented. Developments in the fields of microelectronics and computer technology (simulation models, remote sensing, expert systems, database management, etc.) open up a wide range of opportunities for the development of more realistic and efficient resource management models.

As far as the application of specific technology is concerned, we have already mentioned the importance of consistent policies and efforts for the management and use of the region's genetic resources. These would serve to underpin attempts to diversify exports and also as a long-term strategic factor for stabilizing production and food security. Other important research topics include soil management and fertility and the development of pest and disease control systems using a minimum of chemical products (integrated pest management).

A final aspect of the subject of natural resources and sustainability concerns technology transfer. Over the past two decades, this has largely taken place through technical assistance -mostly from private institutions- geared toward the transfer of information either about, or directly associated with, the use of inputs, usually involving individual products. There has been a noticeable decline in the fortunes of traditional

extension systems -designed to provide the producer with greater expertise in crop management and to foster social and production development in the community in general- though they have not disappeared entirely. This problem will have to be addressed and is of particular importance in the search for a sustainable agriculture based on enhanced natural resource management. As already stated, developing an agricultural system with these characteristics calls for greater emphasis on disembodied technologies designed to enhance resource management and utilization as a whole (agricultural technologies, farm-management models, integrated pest management), and on group behavior, where all the producers in a given area or watershed -and not individual farmers- adopt new methods. With technologies such as integrated pest or watershed management, nothing is achieved by one farmer adopting new strategies; if the true potential of such efforts is to be realized, changes must be adopted by all the farmers in a given region or watershed. Technologies of this kind require transfer mechanisms including group education, training and public work, as opposed to the technical assistance models involving work with individuals, which tends to be the case at present. Developing mechanisms of this kind calls for a reassessment of the traditional agricultural extension systems, not an easy task in view of the current tendency to reduce the role of the public sector in this type of activity.

V. CLOSING REMARKS: SOME INSTITUTIONAL CONSIDERATIONS

Overcoming the crisis affecting most of the region's economies and fully capitalizing on the opportunities presented by the changes in the world situation will require large-scale production efforts which make optimum use of available resources and of the region's comparative advantages. As we have argued in this paper, technology has a critical role to play in this process. Only a renewed technological effort that adequately responds to present and future economic conditions and to the opportunities generated by further developments in the scientific field, will make it possible to mobilize the reactivating capability of the farming sector. However, for this to be possible, a series of institutional factors will have to be taken into account; these will determine the potential contribution science and technology can make to agricultural development and economic growth.

A first topic concerns research and development priorities. At present, the allocation of resources to technology transfer reflects a long period of adjustment to the needs of the import-substitution model for development. As the opening of the economy and the adjustment of the price system gather momentum -these do, after all, depend on the availability of resources and the real comparative advantages of the economies involved- this strategy will quickly become obsolete. Agreeing upon new priorities, however, will require the ability to predict the direction in which economic development will evolve under the new economic model. Very little information is available on this subject, so priority will have to be given to designing models and conducting studies dealing with the future trends of these factors. It is on these that decisions about priorities

and the future allocation of resources between products, regions, and types of activity, will have to be based.

In the case of institutions themselves, important adjustments are also required. The region possesses a sophisticated research and technology transfer infrastructure - especially in the public sector- based on the national research institutes introduced into the region in late 1950s, and subsequently complemented by other regional and subregional developments such as the CGIAR international centers, regional organizations such as CATIE and CARDI, and cooperative networks and programs. This system has proved quite successful in providing support for the region's agricultural development, and without doubt its original conception was an effective response to the conditions and needs prevailing in Latin American and Caribbean countries at the time. Nevertheless, it is no longer clear whether these structures continue to be functional today, given the new political, economic and scientific conditions and challenges which must be faced.

The process of economic adjustment and the modernization of the State, on the one hand, and changes in the nature (public/private) of the technologies involved on the other, -leading to the ever growing importance of the private sector in research and development activities- call for a redefinition of the scope of technological policies for the agricultural sector and of the structure and role which public sector institutions should play in the technological process.

The modernization of agriculture and greater agricultural-agroindustrial linkages make it necessary to undertake research in new fields not previously covered by agricultural research institutions. Aspects such as the range of products, regions, types of technology, producers to be catered to, funding models and relations between the public and private sectors, should be reassessed in the light of the changes which have taken place, and the results then reflected in new institutional proposals.

The use of new technologies, particularly, but not limited to, biotechnologies, also requires important adjustments, both in terms of human resources and the regulatory, legal and institutional provisions governing their development and use. The present cadres of highly qualified personnel are also becoming obsolete due to the changes in the scientific basis of research procedures and the growing importance of expertise in new disciplines such as molecular biology, biochemistry, microbiology, virology, and enzyme engineering, among others, not normally found in traditional agricultural research institutions. The change occurring in the relationship between basic and applied science at the institutional level should also be recognized, especially since it has a bearing on access to sources of knowledge, and on the way in which research and development are organized. The very nature of the methodologies involved calls for control mechanisms and biosecurity regulations to protect human health and the environment. The importance of this issue will probably diminish as further experience is acquired and more information on these technologies becomes available. Finally, the fact that access to much of this knowledge may be protected by property rights' law will require a review of patenting and

other types of legal ownership systems. Regulation of the use of innovations, including not only technologies as such but also related issues such as germ plasm resources, will also have to be studied.

Much has been made of the danger of the region's being denied access to the latest technological breakthroughs by multinational companies (which will, without doubt, play a key role in their development). The fact is that high investment and development costs pose a serious obstacle to technological development at the national level and, to a large degree, much of what is eventually accomplished will have to depend on imported technology and capital. For this reason, establishing clear rules of the game and regulations for striking a proper balance between the sometimes conflicting need to stimulate investment and simultaneously safeguarding national interests is an issue of great importance. Proposals of this nature should be developed within the framework of the new models of economic opening and integration into world markets, in order to encourage businesses to participate in regional markets.

A final point concerns the role of technology in the process of integration. The current emphasis on competitiveness makes technological developments particularly important. Integration efforts will be successful to the degree that all the participants are economic actors within a given country, or that groups of countries can ably capitalize on their shared comparative advantages. This will be achieved only if every level is guaranteed equal access to the key component of competitiveness - technology. In "common markets," only equal access of this kind will make it possible to transform the comparative advantages of each actor, sector or country into real competitive advantages, and into a mechanism for improving the well-being of society as a whole, whether it be by optimizing the use of common resources or through external competitiveness. In non-farming sectors, the existence of fairly well-developed technological markets leads us to believe that achieving equal access can be a relatively simple matter given the opening of economies and the accompanying reductions in tariffs and non-tariff barriers. In the farming sector, the public nature of many of the main technologies and the critical role played by public sector institutions in their development make it essential that cooperative models be created and consolidated to promote harmonious and integrated development of these capabilities, including aspects such as the harmonization of human resource training programs, legal safeguards and measures to protect new technologies, and the relationship between the public and private sectors, among others.

NOTES

1. *This document is based on the work carried out by IICA from 1987 to the present as part of the preparations for the Plan of Joint Action for Agricultural Reactivation in Latin America and the Caribbean (PLANALC). Some ideas and arguments presented are contained in the following documents and publications: Plan of Joint Action for Agricultural Reactivation in Latin America and the Caribbean (Principal Document); Trigo E. J. and Runsten, D., "Hacia una Estrategia Tecnológica para la Reactivación de la Agricultura de América Latina y el Caribe"; Piñeiro, M. E., "Los Desafíos Tecnológicos para la Reactivación de la Agricultura en la Decada de 1990"; proceedings of the seminar "Retos para la Investigación y la Extensión Agropecuarias en América Latina y el Caribe", Ascochinga, Cordoba, Argentina, 1989; Trigo, E. J., "Los Sistemas Nacionales de Investigación y Transferencia de Tecnología Agropecuaria en la Decada de 1990". The contents were presented by the author at the International Seminar entitled "Nuevo Contexto de las Políticas de Desarrollo Científico y Tecnológico," sponsored by Uruguay's Ministry of Education and Culture and Ministry of Foreign Affairs, the Organization of American States (OAS) and Canada's International Development Research Centre (IDRC).*
2. *Director of Program II: Technology Generation and Transfer, IICA.*
3. *In 1980 the percentage of the region's economically active population in agriculture was estimated to be 31.7% of total EAP, while in the case of countries like Paraguay and Guatemala, this percentage was put as high as 45% and 50% respectively. On the other hand, agriculture's contribution to GDP in non-petroleum producing countries averages around 15%, though it exceeds 25% in certain cases, such as in Honduras, Guayana and Haiti. The sector's importance becomes even more apparent if the figures for agriculture's share in the region's foreign trade are used. In most countries, agricultural exports are the main foreign exchange earner and in many cases represent over 50% of total exports (data take from the Inter-American Development Bank, Annual Report, 1989).*
4. *A more detailed analysis of these alternatives is to be found in the document "América Latina: El Desafío del Crecimiento Económico en el Fin de Siglo", presented at the "Seminario Internacional sobre el Nuevo Contexto de las Políticas de Desarrollo Científico y Tecnológico", in Montevideo, Uruguay, by Jaime Villanueva.*
5. *The following table gives an idea of the sector's importance and the possible impact of a strategy based on this position:*

**STRUCTURE OF THE MANUFACTURING INDUSTRY:
SOME LATIN AMERICAN COUNTRIES
(% W/O TOTAL VALUE ADDED)**

	Foods and Agriculture		Textiles and Garments		Machinery and Transp. Equipment		Chemical Products		Other Manufactured Articles	
	1970	1985	1970	1985	1970	1985	1970	1985	1970	1985
Argentina	24	24	14	10	18	16	9	13	35	37
Bolivia	33	37	34	16	0	2	3	4	29	41
Brazil	16	15	13	12	22	24	10	9	39	40
Chile	17	28	12	7	11	4	5	9	55	53
Colombia	31	33	20	14	8	9	11	13	29	32
Costa Rica	48	47	12	10	6	6	7	10	28	27
Dominican Republic	74	63	5	7	1	1	6	5	14	24
Ecuador	43	35	14	13	3	7	8	9	32	37
Honduras	58	56	10	10	1	1	4	4	28	29
Jamaica	46	50	7	6	0	0	10	13	36	31
Mexico	28	24	15	12	13	14	11	12	34	39
Nicaragua	53	54	14	12	2	2	8	10	23	22
Peru	25	25	14	12	7	12	7	11	47	39
Uruguay	34	32	21	20	7	6	6	10	32	32
Venezuela	30	20	13	8	9	7	8	10	39	54

Source: World Bank, World Development Report, 1988.

6. Agroindustries can be classified according to the degree to which the raw materials are processed. The following Table gives some examples of raw materials, the level of processing, and representative products, according to Austin (1984).

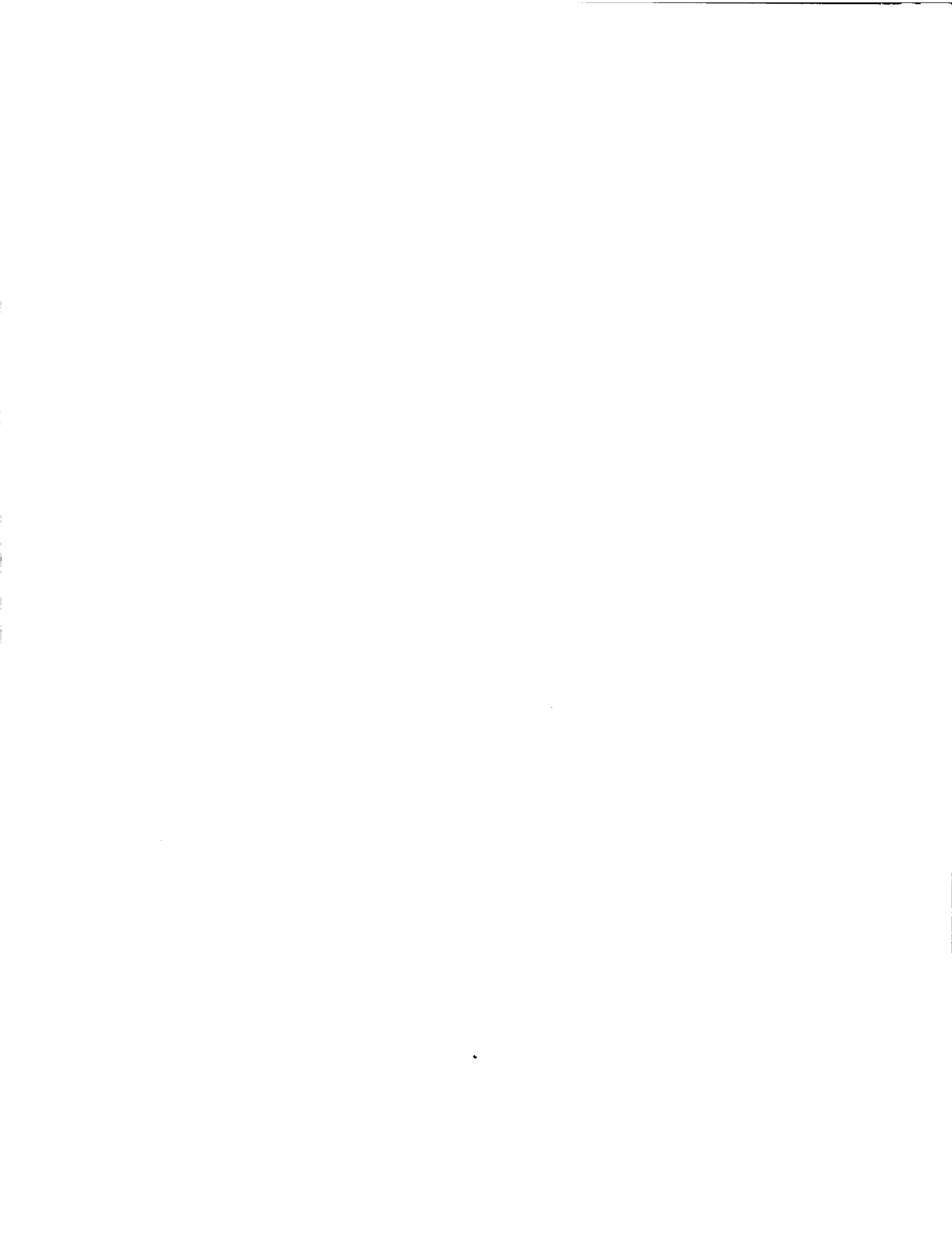
CATEGORIES OF AGROINDUSTRIES ACCORDING TO THE LEVEL OF PROCESSING

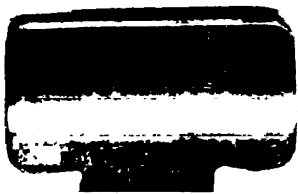
I	II	III	IV
Type of Processing			
Cleaning Sorting	Ginning Milling Cutting Mixing	Cooking Pasteurization Canning Dehydration Freezing Weaving Extraction Assembly	Texturizing Chemical change
Representative Products			
Fresh fruits Fresh vegetables Eggs	Cereals Meats Spices Animal feed Jute Cotton Wood Rubber	Fruit and vegetable products Meats Sauces Textiles and garments Oils Furniture Sugar Beverages	Foodstuffs Texturized vegetable products Tires

Source: Austin J. E., 1984. Analysis of Agroindustrial Products, World Bank

7. Regardless of the final outcome of the GATT negotiations, the fact is that energy costs for agricultural production in countries in the North will eventually become a decisive factor in the structuring of a less interventionist model than the one presently in place.
8. The International Center for Tropical Agriculture (CIAT) recently developed a technology for preserving cassava which is rapidly transforming the potential of this crop by significantly extending its useful life in the distribution chain, a factor which has always been one of the main obstacles to greater use of the product as a fresh food in cities and for export.
9. The stability of ecosystems basically depends upon the interrelations between the factors of climate, soil and biotics. Their level of fragility depends upon which factor is modified, and how critical it turns out to be. For example, ecological systems with steep slopes will become more fragile if plant cover is removed and there is high precipitation. Likewise, an ecosystem with high winds and sandy soils -even if there is zero gradient- will be quickly and severely modified if the natural barriers protecting the ecosystem from the erosive action of the wind are removed.

10. Many species of flora and fauna have not been catalogued in tropical ecosystems. Both general and specific information on the range of plant and animal species making up these ecosystems is scanty; as a result, their potential benefit for humanity is not known. Upsetting the ecological balance and altering these ecosystems without proper controls has a far more drastic effect than in other habitats where the flora and fauna are not so rich and varied and where they are well documented.





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