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IMPROVEMENT OF THE PRODUCTIVITY IN THE SUGAR-CANE SECTOR*

Background paper for Issue II

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* The views expressed by the author in this paper do not necessarily reflect the views of the UNIDO Secretariat. This document has been translated from an unedited original.

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CONTENTS

A. INTRODUCTION

The cane sugar agro-industry as an economic sector of priority importance for those countries producing and exporting sugar has lagged behind many of the technological advances of the modern world that have been put into practice by other, more dynamic industries.

Diversification of the traditional sugar industry could be the modernizing agent and technological catalyst that would permit more intensive and efficient use of the production of sugar both in the direct application of some of the technologies and in their introduction into industry for the manufacture of derivatives; this would mean an appreciable reduction in costs when spread over the different products, better control of the sugar supply, greater availability of jobs with the establishment of new plants, savings in foreign currency by the replacement of imports, and gains in currency through the export of new products.

However, diversification of the sugar industry involves decision-making at a high national, global and sectoral level, since changing the traditional structure requires considerable investment in view of the fact that the present and future prospects for the cane sugar agro-industry are based on an essential improvement in production efficiency.

In this sense, introducing the benefits of new technologies, such as the industrial application of biotechnology, microelectronics, data processing and the use of new materials, offers options for improving the productivity and efficiency of the sector; likewise, the optimization and efficient use of energy, utilization of the linkage between the cane sugar agro-industry and the industries supplying capital goods, components and replacements, and equipment for maintenance, and, furthermore, new investments, afford ample opportunities for improving production conditions and, in general terms, the situation prevailing in this agro-industrial sector at national and regional level.

B. PRESENT TRENDS IN TECHNOLOGY IN THE CANE SUGAR PROCESSING SECTOR

Cultivation of sugar cane and the manufacture of sugar are agro-industrial activities that have been carried out in the same form for centuries, without any major change in the plant milling process or in the systems of sowing, harvesting and transporting the cane. Nevertheless, when an increase in sugar prices on the international market was recorded in the 1970s, substantial investments were made with a view to improving the production technology, the quality and the quantities of the sugar produced.

Later on, the drop in prices and the effects of the crisis were felt strongly in the sugar-growing countries, a situation which called for efforts to optimize the production processes by further improving technology, and thereby compensate for the decline in the form of an increase in agricultural and industrial productivity so that the survival of the sugar sector could be guaranteed in that way.

When it was no longer logical to hope for changes in the sector, an important technological advance was achieved in several areas of sugar production. This happened when the technological advance helped to overcome the energy crisis provoked by the rise in international oil prices. On the basis of the energy potential from renewable sources for the production of liquid fuels in certain countries, as was the case of Brazil in alcohol production, there came a technological development originating mainly in the cane-growing areas producing sugar and alcohol, which received special incentives, with the consequent reaction and subsequent development.

The greatest technological progress achieved by the sugar industry in recent time has occurred in the sectors consuming primary energy (thermal, mechanical and electrical power), i.e. steam generation and the co-production of electricity in the mills. These sectors were modernized both in terms of engineering and process technology; with regard to the other sectors, there have been some changes with regard to optimization and modernization which have also involved manpower in the form of training and instruction.

It is clear that these transformations have taken place principally in the sugar industries of the developed countries, with not very many developing countries being able to provide the financial, technological and human resources for that purpose. The great majority of countries of Latin America, the Caribbean, Asia and the Pacific possess obsolete and inefficient facilities for the production of sugar which require drastic changes if they are to survive under cost-effective and competitive conditions.

C. INTRODUCTION OF NEW TECHNOLOGIES INTO THE CANE SUGAR AGRO-INDUSTRY

The development of new technologies, the further improvement of those already existing or the technological transfer from other sectors are principally aimed at minimizing production costs, improving the productivity of the cane sugar agro-industry sector, maximizing the efficiency of the industrial units and gaining maximum profit from the agricultural areas.

As a result of this it will be possible to modernize the infrastructure, streamline the use of energy, and improve the quality of products so as to facilitate access to markets, in addition to many other advantages which will undoubtedly benefit the sector as a whole.

1. Technological prospects for the agricultural sector

The quality, quantity and cost of sugar cane as a raw material have a decisive effect on the state and overall economic viability of the sugar agro-industry, hence the future of it will be closely bound up with the progress attained in the agricultural sector.

The transfer of technology to cane sugar production activities has been much slower despite the fact that the upgrading of the national sugar industries has been based on proper management of costs, evaluation of results and their analysis, and the ability to take decisions in agricultural activities, since it is there that we find the greatest opportunities for improving efficiency. The cost of growing sugar cane (which is a high proportion of the overall cost of producing sugar, alcohol or any other derivative) and the selling price of the final products will determine a good part of the resources available for the technical and economic back-up of future plans for the industry.

One of the most effective technological advances in the agricultural area is the introduction of mechanization into the growing and harvesting of the sugar cane, the object of which is to make up for the scarcity of manpower and reduce the cost of production. There are three basic systems for mechanizing sugar-cane growing, known as the Louisiana, Hawaiian and Australian systems, for which techniques, varieties and specialized machinery have been created. Technological innovations have gradually been introduced into these systems in order to improve and make them more efficient; and the application of them is feasible provided that studies of local conditions are made in advance as applied to preparing the ground, sowing, the age of the plantation at harvesting time, the equipment available on the market best suited to the specific conditions, and above all, the need for training and instructing the technical and administrative personnel required for such activities.

Lack of adaptation to this situation prior to mechanization has meant that many countries of Latin America have not achieved their aim of reducing costs, and even less, of filling the gap left by the agricultural labourers who take up other jobs as a result of socio-economic changes. It is therefore important to bear in mind that the application of new technologies in any country or sector at all must be planned and put into effect stage by stage in compliance with the pre-requirements at the start of each one.

Among the features of sugar cane mentioned above, the variety of it, which determines both the quality and quantity (the volume of cane per cultivated area), is the only component for which the costs for the sugar-cane grower are virtually constant since the planting of a sugar-cane plantation with the best or the worst varieties involves the same expense. Hence to cut down production costs and improve agricultural and industrial productivity there is need for high-yield varieties. Furthermore, the productivity of sugar cane results from a balanced interaction between certain basic factors, 1/ without which the genetic potential of the sugar-cane variety cannot be realized. These are:

- Agricultural process employed;
- Agricultural and industrial management;
- Proper control of diseases, pests and weeds.

In accordance with the overall agricultural planning and that of the sector, in particular, of each country, the characteristics of the varieties grown should differ according to the production goal, but in any case it is necessary to lower the cost of growing the cane in terms of the agro-industrial return. To be able to obtain suitable varieties we need to analyse the features of each area, the climatic conditions and the soil, and the objectives aimed at in the planning, and in accordance with these variables to conduct operations to improve the varieties so as to find a suitable prototype meeting future demands for sugar cane as raw material. Indeed, countries which do not have a genetic improvement programme will have difficulty in continuing as sugar-cane producers since they will not be in a position to grow it efficiently and the production of sugar, alcohol and other derivatives on a profitable basis will not be possible.

In this sense regional and interregional co-operation can play an important role through the exchange of varieties and genetic material for the improvement programmes; as a first step this calls for improvement in the quarantine services in order to look out for and diagnose diseases and reduce the entry of new pathogenic agents.

For genetic improvement of varieties there are fairly common technologies available in the countries, and other more sophisticated techniques such as tissue culture and protoplasmic fusion within the realm of genetic engineering, the potentialities of which for the future are enormous, provided there is qualified technical staff available to work with the specialists on the classical techniques of genetic improvement, since it is advisable, while applying the techniques of tissue culture and genetic engineering, to go on developing sugar-cane varieties by the traditional methods.

1/ See figure 1 in annex 1.

Sugar cane affects the economies, more specially the balance of payments, of the sugar-exporting countries in such a way that any change in land use, extension, or the outbreak of pests or diseases occurring during its cultivation will have a direct bearing on the life-style of those who grow it, process it, export it or consume it.

2. Technological prospects for the industrial sector

The productivity of the sugar-cane industry is governed by the efficiency with which the various stages of the plant process are carried out, from the time when the sugar cane reaches the mill up to when the final product is obtained, no matter what it is. It is therefore important to follow up carefully the planning and performance of the cutting, collection, transport, and processing of the raw material. With regard to the latter, special attention should be given to its quality in terms of the saccharose content. Data processing as a resource for computerized programming and control of such operations has become one of the technologies most successfully applied in a number of more developed sugar-producing countries.

Similarly, establishment of a system of paying for the cane according to its quality, which is determined by devices able to measure the saccharose content (percentage polarization) with fair accuracy compels cane-growers to deliver raw material under optimal conditions, thereby bringing benefit to both producers - the farmer and the industrialist. Instruments for measuring the saccharose content in cane have been gradually improved as new technologies have been incorporated, and are now available on the market. Although many countries throughout the world are already using this system, there are still quite a few mills which abide by the traditional methods.

Another stage of the process where the introducion of new technologies is helping to improve efficiency is the extraction of saccharose; this involves better preparation of the cane, the increased milling capacity of the mills and an effective feed system. In this context, experience gained in certain countries shows that it is advisable to use cutters with oscillating blades, to introduce defibraters, to weld the surface of the grooves in the mill rollers to strengthen them, to change the imbibition system from the simple to the complex form, and to automate control of the mill feed.

More recently, excellent results have been gained from introducing sugar-cane diffusers which make for better extraction with a smaller power consumption and at a lower maintenance cost, but the need for greater investment limits the possibility of replacing mills by diffusers.

The introduction of improvements into the boiler sector, apart from increasing its efficiency, enables the boilers to act as heat economizers and preserves the equipment. In fact, the area of steam generation and distribution has undergone considerable technological development, thereby helping to improve the efficiency of the boilers and save more bagasse for other purposes.

Among the technological innovations introduced into this sector are the heat de-aeraters, bagasse driers, air pre-heaters and other economizers which act as heat recuperators for combustion gases; replacement of the horseshoe furnace by tilted racks and the installation of automatic control devices in the boilers for regulating the water level, safety and control of the extraction, and control of the heating to ensure pressure stabilization and continuity of the milling process.

The efficient use of electricity is an important factor in reducing production costs. Furthermore, given the deficient electricity supply in some countries, there is need for the mills, through co-generation, to be self-sufficient and to generate surplus amounts for the other production units or for transmission to the national grid, thereby producing in both cases a service that can be sold.

The electrical energy produced by co-generation at sugar mills using bagasse as the fuel during the harvesting, and coal or another type of fuel during the period of maintenance or standstill, is one of the "derivatives" which are being given greater priority in the diversification programmes of developing countries producing sugar cane on account of the strategic nature of it, the deficient electricity generation systems and the high cost of fossil fuel imported for this purpose.

The co-generation of electricity necessarily involves energy effiency, which is conditioned by the attainment beforehand of the plant's energy balance and subsequent optimization of the generation system; at the same time this presupposes in most cases replacement of the heaters by other high-pressure devices, more thorough water treatment and, of course, the training of operational staff. It is worth pointing out that modern boilers are designed on the basis of an integrated approach as regards the feed systems, combustion, heat recovery and so on; this means an increase in efficiency of about 30 per cent for a fuel such as bagasse. If these boilers are connected to extraction and extraction-condensation turbo-generators for the pressures (temperatures) required, it is possible to gain increases in the conversion of thermal into mechanical energy of up to 40 per cent in the overall cycle, with the consequent savings of bagasse and to attain better figures for the generation of marginal electricity.

As has been stated, optimization of the sugar-cane industry in terms of energy requires substantial investments which are highly profitable and quickly recoverable in relative terms, provided a satisfactory solution is found to the administrative and institutional problem, namely determination of the price at which the surplus electricity is sold to the national distribution grid, both in a case where the co-generation is carried out by a State-owned mill and when the ownership is private or joint. In any case, the strategy will have to be preceded by a technico-economic study to define it as a function of the characteristics and conditions of each country.

In the area of the purification and concentration of juice there have likewise been introduced new elements that have improved the process technology, making it more efficient and overcoming problems of suspended impurities due to the poor quality of the raw material. Among them we can mention the hydrocyclones for removing mineral impurities and the static, vibrating and rotating strainers for removing particles of vegetation. In the clarification process use is made of calcium saccharate instead of calcium hydroxide to produce higher-grade juice, as well as the system for automatic pH control when clarifying the mixed juice and in the refining procedure. As far as purification is concerned, we should point out the introduction of filtered juice floats which help to improve the grade of the sugar, and modification of the vaporizers or evaporators to gain a greater volume of less concentrated juice. For the purpose of reducing entrainment losses the height of the tubes as compared with conventional evaporators has been increased and the heating surface tubes have been made longer so that the surface is more fully utilized.

The flotation process likewise applies to purification of the molasses, and to the removal of impurities from it; use is made of a sedimentation tank by means of which the quantity of insoluble substances can be reduced.

To improve the quality of the saccharose crystal during the final stage of concentration, plans have been made for straight vertical pans with a "calandria" of the same diameter and consistency to reduce the stagnation zones and thereby improve circulation. The quality of the seed used for crystallization has been improved by making it less pure so as to obtain higher-grade sugar. Regarding the final manufacturing operations, since the introduction of the faster automatic centrifuges (1,500 rpm) there have been few technological innovations in the centrifuging operation except for replacement of washing with water and steam by washing with superheated water (110°C), which reduces the cycle and the temperature differential between the sugar left in the centrifuges for bagging and the temperature of the air.

The installation of magnetic equipment to remove magnetic particles from the sugar has helped to improve its quality. Furthermore, packaging, storage and dispatch have made progress with the implementation of bulk sugar handling systems, these operations having been considerably simplified as compared with the traditional methods.

Chemical control of the mills has been considerably improved by introducing sampling and analysis; this enables us to observe the operational conditions prevailing in different areas, to check the level within the parameters conditioned by the capacity of existing equipment and by the process employed, and to detect in this manner the bottlenecks and areas where there is reduced efficiency. This calls for duly standardized methodologies and, more particularly, technical and management staff who are qualified.

Finally, as far as quality control of the final product is concerned, more efficient systems have been introduced that make specific allowance for the consumers by eliminating certain measurements of little significance such as the polarization and ash content, and including others such as insoluble residues, black point and grain size. Quality control of sugar for export is based on the techniques established by ICUMSA (International Commission for Uniform Methods of Sugar Analysis).

Although technological developments in most of the areas operational in the sugar production process are feasible, just as in the production of derivatives, where practically all the technology has been tranferred from other industries, adapted or developed for specific purposes in the derivatives industry, the incorporation of new technologies makes for considerable improvements in process engineering, as well as for the introduction of equipment ensuring continuity and stability in this respect and the attainment of goals in terms of cost, quantity and quality of the final products. Hence the need arises to modernize and streamline the systems used for maintenance and repair so as to ensure the uniformity of the process, to reduce production expenditure and to improve productivity through the availability of high-performance equipment.

3. Plant maintenance

Techniques and process equipment used in other industries have been transferred to the system of maintenance and repair used in the cane sugar industry and by means of these it is possible to perform within a short time operations which would be, using traditional techniques, much more time-consuming and would require frequent dismantling of bulky equipment in order to diagnose and set right

mechanical faults. The new techniques make it possible to manufacture precision instruments which on the basis of ultrasonics, X-rays and other systems used in modern technology for maintaining more complex industrial equipment enable us to detect different types of faults in any kind of plant machinery or equipment without need to dismantle it; the result is a saving in time and other resources as well as minimization of the possibility of unforeseen failure or breakdown, which are frequent in such activities. It is also possible to recover components and spare parts worn out by continual use, or to protect them before initial installation by coating them, using special equipment and materials, with metal on plastic powders similar to the material originally used to manufacture the units in question.

Such instruments are normally portable, which makes it easier to carry out maintenance in different plants with the same equipment and also to have a service at national, regional (within the same country) level or even an international service.

Nevertheless, a modern maintenance system requires a strict and detailed programme to improve the efficiency of the service as well as the existence or preparation in advance of records of the equipment to facilitate preventive maintenance and guarantee continuity and uniformity of the production processes.

4. Improving the quality of human resources

Transferring new technologies or, as is the same thing, introducing, adapting and putting into practice more modern and effective systems and methods to improve efficiency in the sugar-cane agro-industry processes is one of the most difficult tasks to perform, compared with other production sectors, because of the traditional nature of that activity in the developing countries and the relative scarcity of professionals, technical experts and skilled labour as a whole.

For this reason it is essential, apart from undertaking a programme of instruction and training for the different classes of workers so as to ensure the smooth operation of the enterprise as a whole and optimum utilization of equipment and facilities, to see that when acquiring new technologies they should include as far as possible the installation, start-up and operation for a set period by specialized staff from the suppliers and, at the same time, to train local personnel in these areas and provide the technical assistance needed for the whole unit to function efficiently once the modified older structures have been integrated with the modern, newly installed ones.

The need to improve the quality of human resources is one of the fields in which South-South and North-South co-operation could be useful through exchange of knowledge, experience and technical assistance; this would be a valuable aid in the industrial development and growth of the economy of developing countries which are seeking to improve their socio-economic conditions.

D. FINANCIAL REQUIREMENTS AND TECHNOLOGICAL INNOVATIONS

The availability of financial resources to purchase new technologies able to help improve productivity in the sugar-cane processing sector with all that is needed for their transfer and application is one of the principal obstacles facing the developing countries in planning the balanced growth of their economies, since the normal credit systems, both domestic and foreign, often assign greater priority to the traditionally more cost-effective sectors. Hence it is the responsibility of governments and international organizations to bring in changes in the selection criteria for sectors entitled to credit and to include the cane sugar agro-industry in the order of priorities to be considered as soon as possible with a view to supporting its development needs to an adequate extent.

Another important source of resources is the private enterprise sector which by means of investments, either independently or in conjunction with the State sector or with foreign companies, can encourage sugar agro-industry activities in the sense required; this calls for State incentives to guarantee the effectiveness of the investments as well as their profitability. Of particular value is the system of domestic and foreign co-investment with firms in the same line that could promote and facilitate the transfer and application of new technologies able to optimize processes, diversify production, reduce costs and improve the quality and presentation of products, thereby improving opportunities for access to new markets and gaining more remunerative prices.

For their part, the international organizations could assist governments in the task of promoting interregional investment among the sugar-growing developing countries as well, perhaps, as multinational investments in them, at the same time as exploring the possibilities of funds from international institutions for specific projects which they themselves could help to prepare or evaluate in those countries, guiding them and facilitating their access to such sources.

A determining factor in any of the alternatives planned for obtaining financial resources is the political will of the governments of the countries involved in worldwide problems, both in the northern and southern hemispheres, since it is vital to join forces to ensure complementarity and to achieve the objectives of economic development, social peace and stability.

E. INTERNATIONAL CO-OPERATION

Within the above-described context, international co-operation could play an important part by encouraging and supporting activities and programmes on an international, interregional, regional and national scale as well as by the negotiation of specific agreements on co-operation and technological exchange both vertically and horizontally, by means of which the developing countries would receive technical assistance and financial aid for the introduction of new technologies and be given specialized advice on strengthening the local technical and administrative personnel for the selection of the most suitable of the given alternatives as well as for more effective implementation of them on the basis of experience gained by other countries.

Co-operation should be carried out at different levels: at the intraregional and interregional, between developing sugar-producing countries in which the evolution of the cane sugar agro-industry has been different enough to allow complementarity between them and the combination of forces and resources for common aims of regional interest. At international level the developed countries could, either through the international and regional specialized organizations or in direct form lend specific support for the technological development of the cane sugar industry in the less favoured countries, more especially the companies in those countries manufacturing machinery, equipment and instruments to which we have referred, with due regard for the fact that this would mean expansion of their markets, which would be to their own benefit.

Nevertheless, the emphasis should be placed on the importance of an exchange of technology, knowledge and experience between developing countries in the same region and with other similar regions, for example between the countries of Latin America, the Caribbean, Asia, the Pacific and Africa, which have for different reasons reached differing degrees of development in their economies, industries and technological advancement.

F. FINAL CONSIDERATIONS

Given the importance of the sugar-cane processing sector in many of the developing countries of the world, there is an absolute need to improve its productivity by the introduction of new technologies so as to be able to improve the efficiency of the production processes all through the different stages, starting with the plantation in terms of growing, harvesting, transport and processing of the raw material, passing through the different stages of manufacture, process control, maintenance and so forth, and ending with the production of one or more final products that can meet local demand and possibly be exported under competitive conditions.

All the technologies described under the previous headings have been tried out and are being utilized in several sugar-growing countries to a greater or lesser extent depending on the socio-economic conditions. Similarly, the result of their application has certainly been effective in improving the efficiency of the process, stepping up the quality of the products, by-products and derivatives, reducing production costs and, in general terms, increasing the sector's productivity.

But although it is true that the developing countries will have to make full use of the benefits to be gained from technological advances in favour of an improvement in the state of their obsolete plants and in the precarious state of their economies, it is none the less true that they may be prevented from doing so in face of the various constraints that they are compelled to overcome in order to have access to them.

Within the context of technological progress and the constraints mentioned the Consultation Meeting should focus its efforts on discussing the most relevant points mentioned, which bring out the need to strengthen the economies of the developing countries, support the attempts by those countries to set up a technological development process supported by their cane sugar agro-industries and seek to improve productivity in that sector. Similarly, there is need to study the alternatives by which mechanisms for attracting domestic and foreign capital that could help to attain the aims outlined in the overall and sectoral development plans could be put into practice, with full awareness of the requirements which, in terms of human resources and materials, involve the transfer of technology from developed countries to developing countries and from other production sectors to the agro-industrial sector concerned with sugar cane.

Furthermore, national, regional and international institutions should renew their efforts to encourage investment in the sector and seek alternative funding under suitable conditions, as well as promoting the most effective forms of co-operation based on complete understanding of the differences in development, the peculiarities of the countries and regions involved and, more especially, the degree of technical progress attained in them.

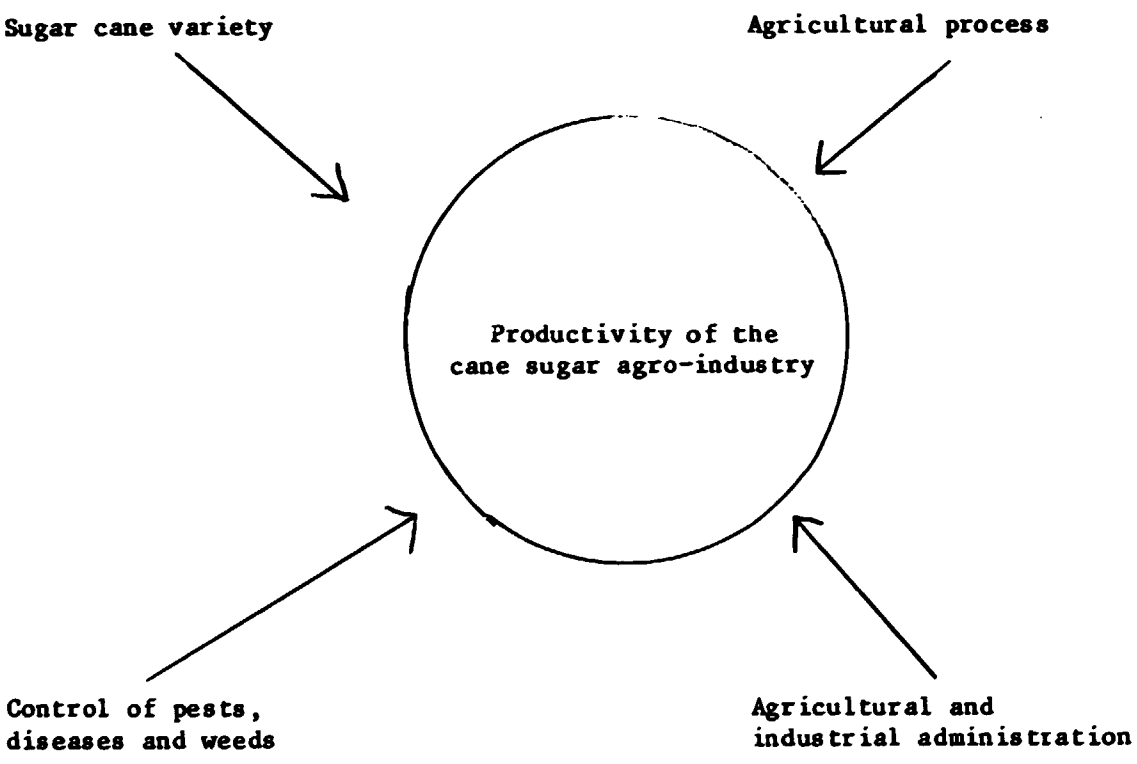
Participation by the government sector and private companies in imparting a dynamic approach to the sector should receive the additional backing of fuller and more intensive international co-operation through such organizations as UNIDO, FAO, UNDP, IBRD, ITC, ISO, GEPLACEA, international development banks and so on. When properly co-ordinated such co-operation could assist largely in overcoming the obstacles in the way of technical progress and greater productivity in the cane sugar agro-industry in the developing countries of Latin America, the Caribbean, Asia, the Pacific and other parts of the world.

IMPROVEMENT OF THE PRODUCTIVITY IN THE SECTOR

Annexes

Annex 1

Productivity factors relating to sugar cane



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Annex 2

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