CANE, SUGAR AND THE ENVIRONMENT

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Introduction

In our world today, and to an ever-increasing extent in the years to come, no product sold on the market can be developed without taking into considerations its impact on the environment. This statement is particularly valid for a food product such as sugar, given the rising interest and expansion of markets for natural and organic products obtained through procedures, both in the agricultural and industrial stages, in which the use of chemicals and damage to the local and global environment are avoided or reduced to a minimum.

Amidst the tense, controversial discussions taking place at present within the so-called Millennium Round, its agricultural negotiations and the issue of whether to include environmental matters in these talks, cane sugar producers have many advantages to offer and arguments to show the superiority of cane as a raw material for food and energy production; as opposed to other raw materials for sugar or substitute sweetener production such as corn and sugar beets.

The aim of this paper is to attempt to present a brief summary of the potential of sugar cane as regards the environment as well as to discuss the current status of environmental legislation in effect in countries in the Latin American and Caribbean Region.

Cane Agriculture

The various cane varieties cultivated for commercial purposes world-wide are species or hybrids of the Saccharum genus, which in turn belongs to the grass family. Its geographical origin remains a controversial subject, but in general it is acknowledged that it originated in the South Pacific region, Java and New Guinea, and subsequently spread out from there.

One of the outstanding features of sugar cane is, among others, its extraordinary capacity for growth. It is not unusual to find agricultural yields exceeding 100 tons per hectare annually on commercial acreages. Its genetic potential is much greater. When varieties are selected and agrotechnical handling are carried on, with the objective of maximizing biomass production, it is possible to obtain yields as high as 300 t/ha and even exceeding this volume. Theoretical potential of up to 400 t/ha is estimated. This high productivity rate is the result of a high photosynthetic efficiency, compared to other commercial crops, which permits an increased utilization of solar energy and, consequently, a higher coefficient for fixing atmospheric carbon dioxide.

Further, cane agriculture can be practised with a minimum consumption of chemical products and highly compatible with the environment and soil conservation. An issue of the utmost importance, from an ecological as well as economic standpoint, is the harvest of green cane; that is, without previous burning the foliage for harvest. Harvesting green cane is a widespread practice that has been used for many years in Cuba, and which has been gradually extended to other countries such as Australia and Brazil. The issue is not only the pollution problems generated during burning, but most important, improved soil fertility conservation, lower consumption of herbicides and the possibility of using part of the residues as fuel, animal feed or raw material.

Further, the use of fertilizers can be reduced significantly, and in some cases even eliminated, under advantageous economic conditions (4). Noteworthy examples of alternatives that contribute to reducing input of chemical fertilizers, include those recycling in the field the wastes and residues of the industry such as filter mud, and the liquid effluents as irrigation water.

In Cuba, it has been a widespread practice for many years to use residuals in cane irrigation, a practice referred to as ferti-irrigation. Likewise, irrigation of cane fields with the vinasse obtained as a waste from alcohol distilleries is a generalized practice in Brazil. These practices, handled with adequate control, not only solve the problem of how to dispose of liquid wastes but also make an important contribution of both the organic and mineral materials required by the soil. Both filter mud and agricultural crop wastes may be improved considerably with regard to their value as fertilizer through relatively simple compost processes, whereby ashes from bagasse furnaces and other elements contributing phosphorous and potassium – of great importance to the crop -- are added. The application of minimum tilling methods or localized tilling in cane acreages has been another element of significant economic importance and contribution to improved soil conservation. Several specially-designed alternatives or techniques have been used on a widespread basis in the various types of soils, with highly beneficial results.

The struggle to combat pests that attack sugar cane is carried out entirely through biological methods. Control of the sugar cane borer (Diatrea Saccharilis) is achieved through the systematic reproduction and release of a natural enemy, the Cuban fly Lixophaga Diatrea. Cane diseases are confronted through the ongoing development and inclusion of new commercial varieties, a well-established practice in most of the principal sugar cane-producing countries. Crop rotation and inter-cropping, although practised only to a limited extent at present, have shown an excellent economic possibility and positive effect for cane, basically when used with beans, peanuts and the leguminous genus in general.

Industrial Processing - Diversification

Cane is not only a plant that grows at a faster rate than other commercial crops and can be cultivated with sustainable techniques. The structural and chemical composition of sugar cane makes it particularly appealing for transformation into valuable products through industrial processing. For years, sugar has been the principal, and virtually only commercial product obtained from cane. Probably the only exception, and then only fairly recently, is the Brazilian alcohol fuel programme. The objective is both, to take advantage of cane for other purposes different from sugar, such as use of the by-products of the sugar industry and sugar itself as raw materials to obtain products with a high aggregate value and of interest to the market. This is what the so-called diversification consists of. The concept of diversification mentioned above and its economic and strategic importance for cane-producing countries has been the focus of attention at several international fora in the past few years. A study of the alternatives for diversification of sugar cane calls for an analysis of the different fractions that make up its vegetative structure, which are shown in Table 1.

TABLE 1: VEGETATIVE STRUCTURE OF SUGAR CANE (% OF DRY MATTER)

Part	Total Plant	Part growing above ground
Clean Stalks	50	59
Tops	10	12
Leaves	25	29
Roots	15	- -
Total	100	100

These fractions in turn have the average composition shown in Table 2 below:

TABLE 2: CANE COMPONENTS (%)

Components	Clean stalks	Tops + Leaves
Total sugars	15,43	2,18
Sucrose	14,10	- -
Lignocelullose (Fiber)	12,21	19,80
Ashes	0,54	2,31
Other	0,82	2,43
Total dry matter	29,00	26,00
Water	71,00	74,00

A study of the tables above clearly shows the importance of bearing in mind the potential use of the so-called agricultural wastes (tops + leaves), which represent nearly 40 % of the total weight.

Likewise, the clean stalks are made up mainly of soluble sugars; and bagasse constitutes the lignocellulose portion. Soluble sugars, both those taken directly from cane juice and those extracted during the intermediate currents of the sugar process (filter juice, A or B molasses) or from final molasses may be transformed into products with a high value and market interest through chemical or biotechnical processes. Table 3 below shows some of the principal products manufactured today on a commercial scale.

TABLE 3: SOME DERIVATIVES OF CANE SUGARS

Product	Process	Use
Sugar	C	Food industry, domestic consumption
Glucose / Fructose	C	Food and pharmaceutical industries
Ethyl alcohol	B	Fuel. Beverages. Chemical and pharmaceutical industries.
Yeasts	B	Fodders. Bakery products and the biotechnology industry
L – Lysine	B	Fodders. Food industry
Citric acid	B	Food and pharmaceutical industries
Lactic acid	B	Chemical and pharmaceutical industries
Acetic acid	B	Direct consumption. Several industries
Monosodium glutamate	B	Food industry
Acetone and butanol	B	Chemical industry
Oxalic acid	C	Chemical and construction industries
Dextran and/or Xantane	B	Chemical and food industries
Sorbitol and/or Manitol	C	Food and pharmaceutical industries
Tensoactive products	C	Several industries. Domestic use

The main advantage of using cane juice for these products, rather than molasses, is the possibility of having the bagasse as an energy source capable of satisfying the thermal and electrical demands of the industrial process. This is the case of the traditional sugar industry and of alcohol production as carried out in Brazil, directly from cane. As will be seen further on, with this system it is not only possible to satisfy the energy requirements of the process but to obtain significant surplus electricity as well.

For its part, cane bagasse represents a renewable source of fibrous raw material, which can replace wood in many of its applications. Various types and selections of top-quality agglomerated boards are produced from cane bagasse at present. It is estimated that world installed capacity for bagasse boards of different types totals approximately 800.000 cubic meters annually; nonetheless, this still represents only 2% of the total production volume. In Cuba, there are five bagasse board factories, which produce the so-called particle board (low density). One of them has a double production line, where the Mende, or medium density type is also manufactured.

Likewise, paper and cardboard of excellent quality may be obtained from bagasse, capable of competing with equivalent products obtained from wood. The only area in which bagasse is at a disadvantage compared to wood is the type of paper used for industrial purposes, which calls for high tenacity. This is impossible to achieve with bagasse due to the features of its fiber, which is shorter than soft woods.

The ever-increasing awareness at the international level of the need to preserve the forests that still exist in tropical and subtropical regions, and the restrictions on further development the extraction of commercial areas in temperate regions, open up interesting prospects for products made from bagasse fiber, which in addition to being an annually renewable source, may be processed through less intensive, and therefore less aggressive to the environment technologies, than traditional wood sources.

Cane for Animal Feed

In countries with tropical and subtropical climates, which is where sugar is produced, animal feed availabilities are one of the most crucial economic problems. For many years, the attempts to transfer models based on the use of grains and cereals have proven not to be economically feasible.

Sugar cane and the by-products of the sugar industry can, nonetheless, represent fundamental feed support for both rumiants and swine, as shown by international experience. For cattle feed, there is a wide range of experience in the comprehensive use of cane, with good production indicators and economic results, when combined with an adequate supply of cane pieces or chopped cane. Glucogenic precursors such as those obtained from grain residues (rice for example), and small amounts of genuine protein, both vegetable and animal (a significant part of assimilable nitrogen requirements can be furnished through urea) must also be added. Bagasse or its pith have been used in cattle feed, for both dairy cattle and fattening. For many years a treatment for pith was used in Cuba to increase its digestibility, using sodium hydroxide and adding final molasses and urea. More recently, this technology has been replaced by a more economical alternative, in which the fiber is pre-digested using lime.

In Brazil, there is a wide range of experience in fattening cattle using bagasse hydrolized with steam as a base. Although this option requires a larger investment for building treatment facilities, it has the advantage that chemicals are not needed.

Compared to grains and cereals, the principal restriction of sugar cane as feed for monogastric animals is the fact that it has virtually no protein. Nonetheless, by-products of the sugar industry are perfect as a cheap source of metabolizable energy in swine feed diets. A solution must be found to contribute protein in diets, which may be achieved through protein concentrates such as soybean or fish flours. Fodder (torula) yeast has been used on a large scale in Cuba as a protein concentrate for swine feed. It is produced at industrial plants through aerobic fermentation of final molasses. Saccharomyces yeast, another sugar cane derivative, obtained as a by-product of alcohol distilleries, is another highly economically feasible alternative. Brazil is unquestionably the country with the greatest potential for this option; and in fact, yeast recovery has been on the rise over the past few years. The technical and economic feasibility of swine rations based on intermediate molasses from sugar factories, and yeast from alcohol distilleries has been proven on a commercial scale in both Cuba and Brazil.

Sugar Cane and Energy

The high photosynthetic capacity of sugar cane makes it an important source of energy. A comparison of the energy value of the cane biomass and the energy consumed in its harvest and cultivation shows a ratio of 20:1. This makes sugar cane a biomass of enormous interest at present, as alternatives are under study to reduce the rate of gas accumulation and consequent global warming, as a result of the use of fossil fuels. The cane sugar industry creates its own fuel, bagasse, which is not only capable of satisfying the energy demands of the factory but generating surplus electricity, with the consequent ecological and economic benefits.

The traditional sugar mill is highly inefficient from an energy standpoint, since it was designed to not be forced to have bagassesurpluses. On average, steam consumption for the process ranges between 450 and 550 kg of steam per tone of cane processed. Nonetheless, consumption of under 300 kg / t is possible to achieve, with schemes and equipment well-known and widely used in the beet sugar industry.

Likewise, the furnaces in which the bagasse has traditionally been burned for steam production have energy efficiency rates of approximately 60-65%; whereas it is possible to achieve efficiency rates of nearly 90%, with heat-recovery designs and systems to reduce the final temperature of combustion gases. These traditional energy schemes were designed to obtain precisely the electrical power required by the factory as the steam produced by low-pressure turbogenerators passes through. In order to produce surplus electricity at the sugar factory, steam consumption must be reduced in the process, furnace efficiency must be improved; and at the same time, steam generation pressure must be increased. In this case, it is possible to obtain surpluses of up to 100 kw-hr per ton of milled cane, as proven by experiences on a large scale in Hawaii, Reunion Island and Florida. New technologies currently in the development stage, based on gasification of the biomass and use of gas turbines and combined cycles, would make it possible to increase the generation potential of the sugar industry to levels approximately twice those mentioned above.

Further, the use of agricultural residues of the cane harvest to produce energy would also make it possible to double the factory potential and use facilities during the between-crop period. In Cuba, there are experiences on a commercial scale with use of cane straw as fuel in mill furnaces; and work is currently underway on studies to perfect this and storage methods. And lastly, from an energy and environmental standpoint, it is absolutely essential to mention the strategic importance of ethyl alcohol production from cane, for use as automotive fuel. The experience of Brazil is well-known and has been discussed in depth at the international level.

Environmental Standards and Legislation

The inclusion of environmental issues in domestic legislation in countries introduces legal control as a guarantee for compliance with the standards provided for in each case.

Policies aimed at correcting failure to comply with environmental legislation may be divided basically into two general types: those using incentives (or policies based on market operation), whereby taxes or charges are collected according to the damages caused by those who pollute; and those calling for quantitative restrictions (or “official control mechanisms”), which do not have this flexibility.

The status of environmental legislation in our region presents a wide range of features and stages: some nations include it in their Constitution, and even have ministries, secretariats and/or institutions devoted to the environment. Most have general legislation at the state level (implemented or in the implementation stage). And those with the least provisions include specific standards applicable to the sugar agroindustry and others are in the process of preparing legislative bills. Our countries are also unequal insofar as drafting, implementation, demands and compliance of environmental laws and standards, in accordance with existing differences in legislation, ecological awareness and status of economic development. The existence of environmental legislation has promoted research projects as well as the search and development of ecologically compatible options in the industry.

The most comprehensive legislation and/or regulations spell out both qualitative and quantitative issues, reflecting the parameters to be evaluated, analytical methods, benchmarks, frequency of sampling, spillage standards, quality criteria and penalties, among other specifications. They also include citizens’ right to a healthy and ecologically balanced environment, and therefore provide for the legitimate power to denounce acts that violate this right and to claim redress of damages caused. Laws provide for methods of determining liability and penalties. Some legislation also covers environmental education, research and development and incentives for environmental activities.

Within the regional sphere, our countries have adopted comprehensive multilateral and bilateral instruments pertaining to the environment; at the international level, conventions on the environment and natural resources have been entered into, which are included in legal ordinances of countries. To an ever-increasing extent, ecological issues are being reflected in international treaties, such as in funding projects and international co-operation projects. The regional sugar agroindustry is adopting measures aimed in some cases at facing the demands of environmental legislation in effect; and in others, at preparing for imminent reality of implementation in the respective nations of standards and controls to prevent environmental pollution.

General and Specific Environmental Standards

National, state and federal environmental standards related to the sugar agroindustry are those dealing with conservation of water resources, pollution and emission released into the air, disposal of liquid wastes or waste waters and solid wastes, noise and odors. As follows are the general parameters used world-wide for characterization, standardization and control:

TABLE 4: MEASUREMENT UNITS FOR SOURCES OF POLLUTION

POLLUTANT	MEASUREMENT UNITS
WASTE WATERS	DBO_5, DQO, pH, ELECTRICAL CONDUCTIVITY, t^o, Q
AIR EMISSIONS	SO_2, CO, CO_2, PARTICLES, NO_2, NO
SOLID WASTES	DQO, DBO_5, t^o, QUANTITY
NOISE	DECIBELS (dBA)
ODOR	SENSORIAL TESTS

In the member countries of GEPLACEA, although implementation levels and compliance with environmental legislation are in different stages, the interest and need to search for and develop ecologically compatible technological options for the sugar agroindustry are increasingly evident.

In this respect, the activities involved in production of “organic sugar” and “cleaner production techniques”, which characterize the technologies and processes using natural (as opposed to chemical) inputs and preventive, rather than corrective, measures are being adopted to an ever-increasing extent within the environmental policies of the agroindustry in several sugar-producing countries. This is one of fastest, more economical means of contributing to improving the environment.

Water Resources

The information available deals with laws, regulations and/or standards providing for limits for protecting water resources, depending on their use; as well as limits on waste waters, both domestic and industrial, that are released. The table below shows the ranges of maximum limits in our region of some of the parameters established for waste waters dumped into water bodies receptors.

TABLE 5: ENVIRONMENTAL STANDARDS LATIN AMERICA AND THE CARIBBEAN WASTE WATERS

PARAMETER	MEASUREMENT UNIT	RANGES
Ph	-	5 – 10
t°	° C	< 45
DBO_5	mg/l	Up to 200
Fats and oils	mg/l	Nil – 100
Sedimentary solids	mg/l	1 - 1,2
DQO	mg/l	150 – 500
Phenols	mg/l	0,02 - 0,5

(Argentina, *Tucuman*; Bolivia; Brazil, *Alagoas*; Colombia; Ecuador; El Salvador; Guatemala; Jamaica; Mexico

The following parameters are included when the waters are used to irrigate vegetables: sodium absorption ratio, NMP of coliform bacteria; and when not used to irrigate vegetables: NMP of total coliform bacteria and density of fecal coliform bacteria, among others.

Mexico is one of the countries that currently include the sugar agroindustry within specific standards (NOM-CCA-002-ECOL/1993). This standard provides for limits on discharges into water receptors where wastes from the cane sugar-producing industry are dumped.

TABLE 6: STANDARDS APPLICABLE IN MEXICO (NOM-CCA-002-ECOL/1993AND THE NATIONAL WATER ACT*)

PARAMETERS	PERMISSIBLE MAXIMUM LIMITS DAILY AVERAGE	PERMISSIBLE MAXIMUM LIMITS INSTANTANEOUS AVERAGE
MEXICO		
pH	6 – 9	6 – 9
DBO_5 (mg/l)	60.0	72.0
Sedimentary solids (ml/l)	1.0	1.2
Fats and oils (mg/l)	15.0	20.0
Phenols (mg/l)	0.5	0.75
DQO (mg/l)*	< 300	-
Total suspended solids (mg SST/l)*	< 30	-
Volume (m^3/month)	< 3000	-

*The Mexican National Water Act provides for the aforementioned limits for **SST, DQO** and a monthly volume of below 3000 m^3; if they exceed these amounts, the cost payable is calculated as follows (in which **a**, **b** and **c** are parameters depending on the area in Mexico where the company dumping the waste waters is located.):

$$\$ \text{ (Pesos)} = a V + b \text{ (DQO-300)} \times V \times 10^{-3} + C \text{ (SST-30)} \times V \times 10^{-3}$$

HOURS PER DAY IN WHICH THE PROCESS GENERATING THE WASTES IS IN OPERATION	NUMBER OF SAMPLES	INTERVAL BETWEEN SIMPLE SAMPLE-TAKING (HOURS)	
	MINIMUM		MAXIMUM
Up to 8	4	1	2
Between 8 and 12	4	2	3
Between 12 and 18	6	2	3
Between 18 and 24	6	3	4

The World Bank demands that pollutant levels in effluents from sugar mills not exceed the limits spelled out in the table below. Further, as a preventive measure, it recommends that the effluent flow be reduced to 1.3 m^3/t, with a trend toward reaching a level of 0.9 m^3/t through implementation of water recycling schemes.

TABLE 7: POLLUTANT LEVELS IN EFFLUENTS OF SUGAR MILLS (WORLD BANK)

Parameter	Maximum value
pH	6-9
DBO_5	50 mg/l
DQO	250 mg/l
Total suspended solids	50 mg/l
Oils and fats	10 mg/l
Total nitrogen	10 mg/l
Total phosphorous	2 mg/l

Air Emission and Air Quality

As opposed to the regulations and standards issued for wastes, regulations issued by member countries in the region for atmospheric emissions are of a much more general nature at present. The most specific standards are based on established types of stationary sources, or on mobile units, rather than on a standard issued by type of industry.

The international standards governing atmospheric emissions are established according to the social and environmental impacts generated by their continuous discharges. It has been established that particles below 50 micras, released during long periods of exposure, have an accumulative effect that alters people's breathing capacity. Sulfur anhydride (SO_2) at certain concentration levels also has an effect on breathing, but what has been most seriously questioned is its role in the cause of acid rain, which affects large extensions of forests and vegetation. Nitrogen oxide (NO_x) has an impact because it is a photochemical precursor of ozone, which affects the breathing capacity of both humans and plants. And finally, CO_2 emissions are important, as the number one cause of the greenhouse or global warming effect.

Within this context, standards in the region are as follows:

TABLE 8: AIR QUALITY PARAMETERS (Latin American and Caribbean Countries)

AIR QUALITY PARAMETER	LIMITS (■g/m^3)
-Unspecified particles (Jamaica) -Total suspended particles (Ecuador)	60 – max. (annual geometric average) 150 – max. 24 hr. (arithmetic average) 80 – max. 24 hr.
-Sulfur dioxide (Jamaica) -Sulfur dioxide, SO_2 (Ecuador)	50 – annual average 260 – max. 24 hr. 300 – max. 3 hr. 80 – annual arithmetic average 400 – max. 24 h. 1500 – max. 3 h.
-Nitrogen dioxide (Jamaica) -Nitrogen dioxide, NO_2 (Ecuador)	100 – max. Annual average 100 – max. Annual average
-Carbon monoxide (Jamaica) -Carbon monoxide (Ecuador)	10 mg/m^3 (9 ppm) - 8 hr. Average 40 mg/m^3 (35 ppm) - 1 hr. Average 10 µg/m^3 - 8 hr. Arithmetic average 40 µg/m^3 - 1 hr.
-Sedimentary particles (Ecuador)	1 mg/cm^2 x 30 d.
-Photochemical oxidants expressed as O_3 (Ecuador)	200 – max. 1 hr.
-Lead (Ecuador)	1,5 µg/m^3

The following table show emission standards for particles from bagasse furnaces established by credit institutions (World Bank) and those in effect in various countries.

TABLE 9: EMISSION STANDARDS FOR PARTICLES FROM BAGASSE FURNACES (WORLD BANK)

Country or Institution	**Emission standard for particles, mg/Nm^3**	**Observations**
South Africa	120	-
India	250 850	Grill-type furnace Spreader stocker furnace
Mauritius Islands	400	-
Malaysia	400	-
Brazil	70 100 120	Preserved and metropolitan areas New furnaces Existing furnaces
World Bank	100 150	In general Small furnaces

Climate Change and the Kyoto Protocol

In the mid 1990's, the international scientific community reached a broad consensus regarding the existence of a phenomenon known as Climate Change, caused by the increase in concentrations of certain gases in the air, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_X) and chloride fluorocarbons (CFCs), all referred to as greenhouse effect gases (GEG).

The increase in their concentrations produce greater retention of the radiation emitted by the earth's surface, with consequences on the earth's thermal system.

A total of approximately 6.000 million tons of carbon are released annually (one ton of carbon equals 3,66 t of CO_2); and on the order of 3.000 million tons remain and build up in the air. The effects produced by the presence of gases with a greenhouse effect, carbon dioxide in particular, on the weather system have been studied and are contained in the conclusions of the Second Report of the Intergovernmental Panel on Climate Change (IPCC), made up of an important scientific research group established to define the scope of the phenomenon and draft possible strategies to combat it. As follows are some highlights of these conclusions:

- The average temperature of the Earth could increase by between 1 to 3.5º C by the year 2100, unless policies are implemented to curb the growth of greenhouse gas emissions.
- The level of oceans is estimated to increase by between 15 and 95 cm. by the year 2100.
- The long life-span of many greenhouse gases, coupled with the thermal inertia of the oceans, will produce long-lasting effect on temperatures.
- Potential hazardous effects are forecast that will have impact on the economics and quality of life of present and future generations (health problems, water and food shortages, loss of housing, deterioration of ecosystems).
- The success of adaptation will depend on technological advancements, institutional arrangements, availability of funding, technology transfer, exchange of information and the inclusion of issues related to climate change in economic decisions. Many developing countries have very limited adaptation options, in view of the scant availability of funding and technology.
- The cost of mitigating and adapting to change can be reduced by implementing flexible, cost-effective policies based on economic incentives as well as instruments coordinated at the international level.

From 1995, when this report was drafted, to date, scientific evidence of the impact of global warming continues to grow.

The United Nations Framework Convention on Climate Change was designed as an unprecedented response to this global phenomenon. It was adopted during the United Nations Conference on the Environment and Development (also known as the Earth Summit) in June 1992 in Brazil. It received 155 signatures, including all Latin American countries; since then many countries have ratified it. The last objective of the Convention and of any related legal instrument adopted by its Conference of Parties, is stipulated in its Article Two. It is *“to achieve stabilization of concentrations of greenhouse gases in the atmosphere at a level to impede dangerous anthropogenic interference with the climate system. This level must be reached within a period of time to permit ecosystems to adapt naturally to the climate change, guarantee that food production is not threatened and to allow economic development to continue in a sustainable manner”.*

In addition to the commitments with regard to national emissions inventories, domestic programmes and technology transfer, among others, the Convention provided for the obligation of the nations listed in Annex 1 (industrialized nations) to reduce their greenhouse effect gas emissions to 1990 levels by the year 2000

Nonetheless, in 1997, with only slightly less than three years left, very few countries were in a position to fulfill this commitment.

Following the meeting of the Conference of Parties, the highest body of the Convention in charge of periodically reviewing its implementation, held in Berlin in 1997, finally, at the third Meeting held in Kyoto in 1997 (COP_3), the Convention Parties approved a protocol with legal commitments and flexible mechanisms to facilitate its compliance. In the KYOTO Protocol, industrialized countries (Annex I of the Framework Convention of Climate Change and Annex B of the Protocol) assume the commitment to reduce their emissions by 5,2% on average, compared to 1990 levels, between 2008 and 2012 years.

The European Union, United States and Japan will reduce their emissions by 8%, 7% and 6% respectively. It is important to underline that the Protocol provides the so-called flexibility mechanisms to facilitate this process, known as the KYOTO mechanisms. They are as follows:

- Establishment of an international market of emission reduction certificates, to serve as a base for funding projects to reduce emissions and capture carbon.
- Clean development mechanism, which allows for implementation of projects to reduce emissions among the developed countries listed in Annex B and developing nations (non-Annex B). Developing countries can receive investments from Annex B nations aimed at curbing emissions or increasing the capture capacity (this point is still under discussion); and obtain reduction certificates that may be accredited to the latter, provided they are measurable and in addition to the efforts made in the territory of the Annex B country involved. Part of the financial resources involved would be used to cover administrative expenses and to support the developing countries that are particularly vulnerable to the effects of climate change.

The Kyoto Protocol, its definitions and mechanisms proposed to reduce the greenhouse effect open interesting prospects for the use of energy biomass and the biofuel and alcohol fuel (ethanol) markets to recover CO_2 from the atmosphere.

Within this context, sugar cane, for all the reasons outlined above, has excellent opportunities and competitive advantages compared to other crops for production of biomass or as raw material for sugar and alcohol fuel production. The use of corn, sugar beets or other tubercles such as sweet potatoes and manioc does not seem to be interesting from the energy, and therefore ecological, standpoint.