Ethanol and the Environment: The Political Economy of the Cost-Benefit Analysis

Luiz Niemeyer[1]
Catholic University of Sao Paulo
lniemeyer@uol.com.br

Introduction

> "The underlying assumption of the economists' models (in contrast with the limits to growth models) was that increasing resource scarcity would always generate price signals which would engender compensating economic and technological development, such as resource substitution, recycling, exploration, and increased efficiency of resource utilization. Empirical support for the models came from studies that showed little, if any, increase in real prices of basic resources. This was interpreted to mean that resources were not actually becoming scarce. It was also assumed that future scarcity of critical energy resources would be overcome as a result of technological developments such as nuclear fusion. This idea is a result of active public relations activity of the power industry" (Clark, 1991: 320).

This paper will illustrate, with a political economy lens, the relationship between cost-benefit analysis and the environment. Through an analysis of the production of ethanol in Brazil the major environmental aspects that were not taken into consideration will be pointed out.

We will study the possible modifications that can be made in the conventional CB analysis approach, with a view to evaluate development projects that have ignored important environmental preservation benefits. For this purpose, ethanol production in Brazil will be analysed. The analysis has as a starting point the Brazilian Program on Alcohol (Proalcool)—that reached its peak in 1985—and its developments.

The paper will not evaluate the theory that informed the modifications made in the CB analysis to take into account environmental aspects. Instead, using the theory behind the criticism regarding important modifications made in the CB analysis by mainstream economists, it will assess the important environmental aspects involved in ethanol production (Proalcool) in Brazil that were missed.

Being consistent with the Kyoto protocol, ethanol production (Proalcool) has been touted as a solution for environmental problems. Yet our contention is that its production poses serious environmental threats. These threats have not been properly evaluated in the traditional CB analysis as well as in its updated version that tries to assess important

[1] The author acknowledges the helpful comments of Lance Taylor, Carlos P. Bastos, Adalmir Marquetti and Zilton Macedo on early draft. All errors are my own.

environmental losses. Thus the CB analysis, in all its versions, is not the right tool to assess the environmental impact of ethanol production.

The production and consumption of ethanol is always debated in Brazil during periods of energy crisis. In spite of the intensive lobby of car manufacturers and alcohol producers, the use of hydrous or anhydrous ethanol [2] in the country as an alternative source of energy is still not very pronounced. It varies along with oil price and the international sugar price. Currently, the question of ethanol use is back in the spotlight due to the following reasons: a) in 2005**,** 95 per cent of the manufactured cars in Brazil were made with "flex" technology, i.e., the engines can run either with gasoline or ethanol; b) the year 2006 started with a serious crisis involving the price and the supply of ethanol; c) increase in oil prices since 2005; and d) the recent visit of President Bush to Brazil has rekindled the discussion of ethanol production.

A final and very important point is that, since Brazil is the biggest sugarcane producer, with the best production technology and smallest production costs, the evaluation of its experience as an ethanol producer can be of a great help to other developing countries.

There has been considerable debate among economists on the alternative ways of incorporating the environmental effects of projects in the conventional CB decision framework. On the one hand, we have the attempt to incorporate irreversibly-lost environmental preservation values as a cost induced by projects to develop a natural area. On the other hand, there is the traditional practice of ignoring the preservation alternative in the evaluation of a proposed development project in a natural area. Both approaches have their drawbacks.

Ethanol (Proalcool) production in Brazil can be used as an example of conventional CB analysis that has disregarded important considerations related to the environment. Whenever the Brazilian society discusses the energy problem due to the increase in oil price, its government turns its attention to the viability of ethanol production.

This paper will emphasize the negative impact of ethanol production on the environment. These aspects were almost completely ignored either in the debate until 1985 when Proalcool reached its peak or in the current debate involving the flex car production.

The paper is structured as follows. Section I critically reviews CB analysis as well as the alternatives presented by this technique on how to measure and deal with environmental damage. Section II presents a brief outline of ethanol production in Brazil. Section III examines some aspects of the CB analysis of Proalcool. Finally, section IV discusses important environmental aspects of ethanol production.

I. Cost-Benefit Analysis and the Environment

The whole philosophy of the CB analysis is based on the fundamental theorem of welfare economics (FTWE). This theorem intends to solve the conflicting problem of the

---

[2] Anhydrous ethanol is used for blending with a gasoline in proportion of up to 20 per cent; hydrous ethanol is used directly as fuel for passenger cars.

individual's personal interest maximization vis-à-vis the interests of other individuals. The solution of this conflict is offered by Kaldor's compensation criterion (Kaldor, 1939).

The first part of the FTWE states that any competitive equilibrium is Pareto optimum. FTWE's second part says that every Pareto optimum can be sustained by a competitive equilibrium with a suitable distribution of income, that is, a competitive market yields an optimum in itself. This is an extremely powerful ideological statement because it gives neoclassical economics a criterion for action. One can say that in so far as Pareto optimum points are desirable, it is desirable to organize society in a way that will sustain Pareto optimality. This means establishing a free market because this is the criterion for efficiency.

The calculation of the CB ratio is normally presented in text books and by some financial entities like developments banks (either national or multinational) as universal criteria for public project valuation. What is mostly debated on the subject among neoclassical economists is not related to the validity of its use vis-à-vis other alternatives, but to the improvement of auxiliary techniques.

The method generally used to determine the significance of environmental resources is the CB analysis. The application of this theory is based on the premise that natural resources yield a flow of benefits to humanity, which can be valued in monetary terms (Farber et al., 2006: 121). Examples of these techniques are: shadow pricing; contingent valuation method (CVM) and total economic value (TEV). [3]

According to Pearce and Turner (1990: 20) environmental problems are seen as an inevitable result of economic growth in advanced industrial economies. For the authors, institutionalists[4] have long accepted an approach which encompasses the notion of social costs of pollution and stresses the importance of the ecological foundations of any economic system. They have argued for the adoption of a cost-benefit framework, using monetary valuations but also incorporating explicit recognition of uncertainty (e.g., about the availability of the environment in the future), irreversibility (e.g., permanent loss of unique wilderness areas and other valuable environmental resources, wetlands, productive soils etc), and uniqueness (e.g., endangered species and unique scenic views). The TEV incorporates these three important features.

According to Markandya et al. (1992), currently, in mainstream economics, one can find two main approaches with regard to the objective of protecting the environment in CB analysis. First, lowering discount rates have been advocated, so that future environmental benefits/costs and future generations are not discriminated against, since the weighting process gives lower weight to them the higher is the discount rate (ibid., p. 147). However, this procedure is defective insofar as the relationship between the discount rate

[3] Turner et al. (1993) present details about this method as well as CVM method.
[4] He classifies the institutionalists into: a) neo-Malthusians, for whom only an authoritarian regime brings about the necessary changes; and b) the ones that believes in the socialist planning system.

and the environment is not so simple. Two contradictory effects arise in this connection. On the one hand, it is true that a lower discount rate could imply less direct natural resource use because the rate of exploitation of natural resources would decrease. On the other hand, a lower discount rate implies more investment, which in turn requires more natural resources to be exploited and probably a higher level of pollution (ibid., p. 135).

The second mainstream approach (Porter, 1982: 60) consists of identifying and adjusting the relevant stream of benefits and costs, in particular the environmental costs induced by a project, and applying the usual C&B investment rules, which seems a less arbitrary way of incorporating environmental concerns in the decision framework. This modified version of the CB analysis includes two new elements: (a) the inclusion of the cost of development of the foregone environmental preservation benefits from an undisturbed area; and (b) the introduction into the analysis of the belief that development benefits decline relative to preservation benefits.

Brookshire et al. (1992) point out that, as far as the environmental costs induced by a project are concerned, the CB analysis has traditionally focused on the use values of natural environments. However, other values should be included as part of the total value of the natural resource or environment. The authors have suggested the contingent valuations method (CVM) to valuing non-marketed commodities, which can be successfully used in estimating values associated with retaining the option of future use and the existence of a natural environment (Brookshire et al., 1992: 112).

CVM basically asks people what they are willing to pay for a benefit and/or what they are willing to receive by way of compensation to tolerate a cost. Further, the contingent valuation approach enables estimates of individual discount rates to be derived for non-marketed goods. What are sought are the personal valuations of the respondent for increases or decreases in the quantity of some good contingent upon a hypothetical market. A contingent market is taken to include not just the good itself (an improved view, better water quality etc.), but also the institutional context in which it would be provided, and the way which it would be financed (ibid.: 146). For the authors, CVM can be applicable to most contexts of environmental policy and is often the only technique of benefit estimation.

Regarding the CVM approach, Sagoff (1988: 88) points out that insofar as it tries to make respondents express preferences rather than deliberate about ideas, the method denies to the respondents their status as thinking political beings. For Sagoff, ideas are different than consumer preferences and go even further. Political and ethical debates are different from CB analysis based on CVM. For him, this difference is possibly the major reason that respondents so often enter protest bids or otherwise resist this sort of experiment.

According to the author, the existence of legislation prohibiting CB analysis shows that citizens value the idea that policies should result instead from ethical deliberation and the rule of law. Examples where CB tests are not allowed are Endangered Species Act and Clean Air. These statutes have worked rather well. One may say that citizens rejected a cost-benefit or "consumer surplus" approach to trade-off between health, safety, or environment quality and economic growth.

For Sagoff (1988: 75), by and large, CB analysis assigns prices only to goods and services of the sort that are typically traded in markets and thus that can easily be priced. Certain economists generally list other values as "intangibles". The "intangible" values associated with environment, health, and safety policy may often be more important than the "tangible" ones.

Martinez-Alier (1991: 119) observes that economic values assigned in the conventional way to externalities (such as exhaustion of non-renewable resources, global warming or radioactive pollution) would be so arbitrary that they cannot serve as a basis for rational environmental policies. Externalities, defined as uncertain social costs transferred to other social groups or to future generations, must be perceived before they are valued in monetary terms.

Sagoff (1988: 91) observes that the attempt to construe moral principles and political convictions as market externalities and thus to deal with them by assigning them a market price does not end with the environment question. The beliefs and opinions of citizens should be treated separately from their consumer interests and preferences. The author observes that if we believe that the political and ethical debates are conceptually different from economic analysis, then we must infer that efforts to shadow-price "intangible" or "fragile" values must fail—not for any technical operations or empirical reason but because they rest on a logical mistake. That is, they blur the distinction between private and public interest—and therefore between the competition of preferences and the contradiction of ideas. Preferences do not always have to be specified; on the contrary, they must be understood and subject to criticism.

According to Sagoff (1988: 95), the willingness-to-pay approach to public policy used by UNIDO (UNIDO, 1972) and adopted by Rocha Filho (Rocha Filho, 1992: 373) removes the basis of legitimacy from the political process in the sense that that CB approaches deal only with values or preferences already existent in society.

Another result in public policy based on the willingness-to-pay approach like the CVM may be the most disastrous. According to Sagoff, economic analysis tends to limit conflict to those parties who have something at stake for which they are willing to pay. This approach would prevent the socialization of conflict that is crucial to the functioning of a democracy (Sagoff, 1998: 95).

Technocracy localizes the conflict so that it can be resolved by the application of some mechanical rule or decisions. One example is to present ethanol (Proalcool) production as viable alternative if the oil price is above US$50 bbl[5] as has been argued by the Brazilian Government and *The Economist*[6]. As we will see, the CB analyses of ethanol do not take into consideration serious environmental concerns. Cost-benefit approaches to public

[5] Barrel equivalent of oil.
[6] *The Economist*, 22 April 2006.

policy, if taken to their extreme, would do this, and thus they would substitute themselves for the process of democratic government. For Sagoff (1988: 97) the “ideological” genius of CB analysis is to localize conflict among affected individuals, and thereby to prevent it from breaking out into the public realm.

II. Ethanol Production (Proalcool)[7]

The use of alcohol as a fuel in Brazil and in the world precedes the creation of the Brazilian National Alcohol Program (Proalcool) announced in 1975. A mixture of gasoline and alcohol—gasohol—has previously been used in many countries. Since the early 1920s, Brazil has pursued an official alcohol policy to overcome restrictions on imports and/or to stabilize the domestic sugar sector due to a crisis of overproduction.

The first aim of the Proalcool was to produce anhydrous ethanol for mixing with gasoline. In Brazil in 1977 terms, on an energy content basis, alcohol was five times more expensive to produce than gasoline was in the US (Rothman et al., 1983: 107). However, after the 1979 oil shock, with its dramatic price increase, and later the Iran-Iraq war that cut off one-third of the country’s oil supply, ethanol production was impressively expanded; emphasis was placed on hydrous ethanol which allows for total replacement of gasoline. The success of this programme in terms of ethanol production was beyond doubt. From a level of 600 million litres in 1974, ethanol production in Brazil reached 11.8 billion litres in 1985. Between 1975 and 1985, US$7 billion were invested in all sorts of incentives for ethanol production (Calabi, 1983: 237). Moreover, in 1985, pure alcohol-fuelled engines accounted for almost 90 per cent of new cars and 20 per cent of all passenger cars in Brazil. In 1982 alcohol fuels accounted for 10 per cent of total energy use in transportation compared to less than 1 per cent at the end of 1976.

Table 1- Ethanol Production from 1970-71 to 2005-06 (in millions of litres)

Crop	Production	Crop	Production	Crop	Production
1970/1971	637.2	1982/1983	5824.0	1994/1995	12726.0
1971/1972	613.1	1983/1984	7864.0	1995/1996	12689.0
1972/1973	681.0	1984/1985	9244.0	1996/1997	14030.0
1973/1974	566.0	1985/1986	11820.0	1997/1998	15000.0
1974/1975	625.0	1986/1987	10516.0	1998/1999	13400.0
1975/1976	555.6	1987/1988	11454.0	1999/2000	12770.0
1976/1977	664.0	1988/1989	11713.0	2000/2001	10622.0
1977/1978	14470.3	1989/1990	11881.0	2001/2002	11059.0
1978/1979	2490.9	1990/1991	11783.0	2002/2003	13000.0
1979/1980	3383.8	1991/1992	12681.0	2003/2004	15000.0
1980/1981	3742.0	1992/1993	11736.0	2004/2005	13400.0
1981/1982	4240.0	1993/1994	11278.0	2005/2006*	16000.0

[7] It is not our intention to go into a deep discussion of Proalcool’s evolution. We are just interested in the environmental impact and the CB of this programme.

Source: Until 1979/80 Magalhaes (1991: 29); from 1980/81 to 2001/2002, Marjotta-Maistro (2002: 16); remaining years Veja (2006: 92)[8].
Note: * estimate.

By the end of the 1980s, due to the substantial reduction in international oil price, Proalcool lost credibility with the Brazilian public opinion. The IAA[9] was extinguished in 1990 in the wake of World Bank's Berg Report. This marked the beginning of the process of deregulation and opening of the sugar-alcohol sector. Marjotta-Maistro (2002: 3) informs us that the sugar price was deregulated in 1990, anhydrous ethanol in 1997 and hydrous ethanol in 1999. Currently we are witnessing a new phase of euphoria regarding ethanol production due to the following reasons: a) In the first two months of 2006, 90 per cent of the new cars sold had "flex" technology; and b) President Bush lunched an extensive campaign on alternative fuel, and this has strongly affected the Brazilian market/production.

III. Ethanol (Proalcool) and the Cost-Benefit Analysis

In this section we will review the CB analysis in the peak phase of the Proalcool (1980-1985). We choose this period because much of the literature on the subject is related to this period. For instance, in 1985 ethanol production reached a record level of 11 billion litres. Bearing in mind that we have progressed 20 years on, the points that will be raised will help us evaluate the environmental aspect of ethanol production. Our comments will be based on three studies, namely, Motta (1987), Motta and Ferreira (1988) and Rocha Filho (1992). The data and conclusions of Rocha Filho extend up to 1990.

According to CB analysis, the economic viability of the Proalcool strongly depends on oil prices. Despite some years of steady prices, oil prices doubled in 1978 and reached US$35-40 per bbl (barrel equivalent of oil) in 1981. This was the major economic justification for the emphasis on the programme from 1979 onwards. However, in 1982, oil prices started to decline reaching levels below those traded in 1980. According to Motta (1987: 181), at the beginning of 1986 prices fell to US$10 per bbl, and many studies regarding the economic viability of the programme were conducted.[10]

Motta (1987: 177) used the shadow-price technique and calculated ethanol's 'social cost' evaluating specifically two items—labour and land. His estimates of the social cost ranged from US$45 per bbl (Sao Paulo state) to US$66 per bbl (Pernambuco state). He argued that ethanol production in Brazil was not economically viable when compared with the Brazilian import oil prices that in its peak reached US$37.92/bbl in 1981 (in 1983 constant price). In addition, his paper discusses the economic viability of the program in the medium and long terms; according to his estimates of ethanol's future social cost, the international gasoline prices should be at least US$37/bbl (Sao Paulo state) in December 1983 prices to make Proalcool economically viable. This will mean a

---

[8] Veja (2006) *A Dupla Conquista*, 1 February, pp. 90-101.
[9] The IAA, Instituto do Acucar e do Alcool, created in 1931 worked as a Government market Board, controlling and planning the production, consumption, price and exports.
[10] See for instance, Homen de Melo and Pelin (1984) for a good criticism of these studies.

barrel of oil of US$30/bbl in December 1983[11]. Environmental aspects were not taken into consideration.

Another study by the same author (Motta and Ferreira, 1988) a year after his strong disapproval of the programme's economic viability, presented a reappraisal of Proalcool. According to this study the social viability of ethanol production in Brazil would become positive if considerable increases in productivity were achieved and price of oil were above US$30 per bbl (in December 1983 prices); however, to the author, these factors were likely to come about only at the end of the 1990s. However, if one accepts that the investment already undertaken in the alcohol production sector could be considered as a sunk cost, then the prospect of viability would not be so remote, and would be perfectly feasible with oil prices in the US$15-20 per bbl range (in December 1983 prices). Here again the environment costs or aspects were not mentioned.

Motta and Ferreira (1988: 230) argue that if Proalcool were to be abandoned, it would result in losses on fixed assets of US$7 billion and sugarcane already planted (which is harvested over a number of years). According to them, the social question was a serious one since the production of sugarcane and alcohol were the third largest creator of jobs in the agricultural sector, employing more than 800,000 people directly. What he proposed in the name of "social justice" was the maintenance of Proalcool at the 1985 full capacity level estimated at 16 billion[12] litres of ethanol, with 30-40 per cent of the light cars fleet running with ethanol (300,000 to 400,000 alcohol cars per year). In contrast to the previous dominant justification of increasing oil prices, the CB analysis of the Proalcool was used as a tool for "social justice" in Brazil.

For Marjotta-Maistro (2002: 11) the period between 1971 and 1987 which forms the economic context of both of Motta's analyses is very different from the current period. During this period the concern was the preponderance of hydrous ethanol over gasoline. In the 1990s the concern was with permanence of ethanol as a fuel. Thus Motta's analysis follows the conventional CB methodology, and the CVM or TEV techniques discussed in section I were not incorporated.

Rocha Filho (1992) also specifically discusses the CB of ethanol production. His major concern was the permanence of hydrous ethanol as a fuel. The data of the study go up to the 1986-87 crop; however, some data go up to 1990.

The CB analysis used is the conventional one. It is based on the willingness-to-pay approach—its limitation regarding the environment was discussed in section I. For the author, the social cost of the land is the value of its rent; the social cost of labour is its social price, in this case below the market value; and the social rate of discount is the marginal productivity of capital or the marginal return of investment. By converting private prices into social prices the author established the social cost of ethanol: a)

---

[11] To come up with number you deduct US$7, US$5 being related to refining and US$2 to insurance and freight (Motta, 1987: 182).

[12] The authors assume substantial increase in 1985's level of productivity.

including the depreciation—US$36.70 per barrel of gasoline equivalent or US$29.70 per barrel of oil equivalent; and b) excluding the depreciation—US$34.91 per barrel of gasoline equivalent or US$27.91 per barrel of oil equivalent (Rocha Filho, 1992: 377).

The author concludes that ethanol is a feasible long-term alternative, and advocated that the program should be maintained and expanded through incentives. His conclusion is different from that of Motta and Ferreira (1988) who argue in favour of the programme in order to maintain jobs.

In both studies we have the barrel of oil equivalent (bbl) or barrel of gasoline equivalent (bgl) as the benchmark for the decisions related to Proalcool. Hence, we recollect Sagoff's comments about the "ideological" genius of CB analysis. It localizes conflict among affected individuals by the use of some mechanical rule (i.e., ethanol is feasible if the oil price is above US$45 per bbl), and thereby prevents conflicts or discussions about the impact of ethanol production on the environment from breaking out into the public realm.

We present below several environmental aspects related to the programme. If these aspects were taken into consideration in the CB analyses of the programme they would cast doubts on its feasibility. Some of the points raised were already disputed by the programme defenders (see Magalhaes et al., 2001).

IV. Ethanol and the Missing Aspects relating to the Environment

We will divide the evaluation of the environmental impact into parts: Proalcool and Ethanol. In this section, Proalcool refers to the Brazilian government's programme of ethanol that achieved its peak in 1985 and has a rich literature. Ethanol is circumscribed here to more current aspects of ethanol production. The goal here is to double-check the validity of the criticisms. Following the reasoning discussed in section II we describe below several "intangibles" aspects that were missed in the CB analysis either in the conventional or a future one that would try to account for the environment.

The Production of Ethanol and Water

Proalcool

> "Brazilian water quality has already suffered greatly from the rapid expansion of Proalcool, as 12 to 17 gallons of slops are produced for each gallon of sugarcane alcohol. The 1980 Brazilian production level of 4.1 billion gallons of fuel is a gargantuan pollution problem. Even worse, the slops are usually discharged into rivers and streams during the six dry months of the year in which sugar cane is harvested. At this time, shrunken streams and rivers are least able to assimilate the discharges. Carl Duisberg reported in his doctoral dissertation on the Proalcool program that several large river systems in the state of Säo Paulo, including the Piracicaba, the Mogi-Guassu, and Pardo have been virtually poisoned to death by stillage" (Bernton et al., 1982: 182).

Berton et al. (1982) report that among the worst threats to water quality posed by the development of the alcohol fuel industry lies in the enormous volume of stillage that is generated. Stillage, also called slops or vinasse, is the leftover liquid of the fermented mash after the alcohol has been distilled off and the solids separated for livestock feed. Slops have, from 1 to 10 per cent, dissolved minerals and organic materials. The compounds rapidly decompose when dumped into waterways, robbing the water of oxygen required for the survival of fish and other aquatic life. Even after all the oxygen in a waterway has been dissolved, a second-stage anaerobic (oxygen-free) decomposition process is set in motion, producing the noxious-smelling hydrogen sulfide gas.

Rotham et al. (1983: 137) stress the importance of the State of Säo Paulo as the most important sugarcane producer. At that time with seventy-six sugar and alcohol distillers, it accounted for two-thirds of the production of ethanol. This represents a pollution potential equivalent to 2.02 million kg BOD[13] (biochemical oxygen demand) per day, of which 1.79 million kg BOD per day (88%) are produced by the different systems of production of the various ethanol industries. The rest (12%) or 0.24 million BOD per day represent a pollution equivalent to that produced by 4.4 million people.

During the 1990s, the problem of vinasse disposal was worked out by “congestion”—i.e., using slops to irrigate the soil instead of discharging it into rivers. According to Silva and Simoes (1999), Brazil solved the problem of vinasse disposal by using this byproduct of the ethanol production as a fertilizer and for irrigating the soil. This technique is known as “fertirrigação” (fertirrigation).

Corazza (2001) assessed the environmental impact of an alternative technique, i.e., the anaerobic treatment of sugarcane stillage vis-à-vis “fertirrigação”. She recognized the positive aspects of the latter. However, remembering that until 2001 no substantial progress was made in the reduction of litres of ethanol/litres of stillage, she also pointed out its negatives aspects. Some of these are: a) increasing saltiness of the soil; and b) risk (vulnerability) of soil and ground water pollution (Corazza, 2001: 217).

Regarding ground water pollution, she reports that in 1986, 40 per cent of the slops produced were not reused in the process of “fertirrigação”. Ethanol producers could dispose it in areas known as “sacrifice areas” (using impermeable wrap to protect the ground water basin). Apart from the fact that this can affect the surface springs, no study was made whatsoever to evaluate the impact of the residue on the ground water springs and some researchers are worried about this risk (ibid.: 215).

The last point becomes noteworthy if we bear in mind that the biggest ethanol producer region of the State of Sao Paulo—i.e., between Campinas and Ribeirao Preto—is the recharge region of the Guarani aquifer, one of the major aquifers of South America (ibid.: 216).

Ethanol

[13] BOD is a chemical procedure for determining how fast biological organisms use up oxygen in a body of water.

There is a natural conflict between agricultural and human needs regarding the use of water. Sadeq (1999: 19) reminds us of the increasing competition among the different types of water consumers and considers the urban environment, where necessities are immense, as being in the worst situation. According to the author, worldwide the agriculture sector captures 69 per cent of the water while industry's share is 23 per cent and household consumption is 8 per cent.

In the case of Brazil, Hespanhol (2003: 38) estimates the consumption for agriculture at 70 per cent, and for industries and household at 15 per cent each. He forecasts that the agricultural share will reach 80 per cent in the first decade of the twenty-first century. The author (ibid.: 37) observes that this activity is totally dependent on water supply to the point that it treats food production on a sustainable level. Irrigation became a key component of increasing the Brazilian agricultural productivity. Therefore, on the main Brazilian hydrographic basin that serves regions with an intense urban and agricultural development, we will see an increasing conflict of use.

In another study, Hespanhol (2001: 150) reports frequent water rationing in the cities of Recife and São Paulo. Furthermore, the author together with 5 Elementos (2005: 21) reveals that the Sao Paulo Metropolitan Region needs to import 50 per cent of its water consumption through the Cantareira Production System.

Using the 2001/2002 crop, the state of São Paulo produced 65 per cent of ethanol and sugar in Brazil (Marjotta-Maistro, 2002: 18). Sugarcane plantation takes up 8.2 per cent of the entire area of the State (Arbex, 2001: 72). We have a clear case of conflict of use and this has repercussions on the water supply for the Metropolitan Region of São Paulo.[14] This Metropolitan region has water disputes with the Piracicaba basin region. The latter, apart from being a major producer of sugar cane, is also surrounded by other great cane and ethanol producing regions.

Galvão (2000: 29) observes that this Metropolitan Region, served by the Alto Tiête basin, shelters 47 per cent of São Paulo State's population. This region imports water from the basin of Piracicaba, Capivari and Jundiai rivers. Thus the Great São Paulo with its 16 million inhabitants and responsible for 20 per cent of the country's GDP has water disputes with the Piracicaba valley. The latter region (Campinas, Jundiai and Piracicaba), is also highly industrialized with a diversified agricultural sector. It shelters 4.5 million inhabitants and is responsible for 9 per cent of the country's GDP; it is also not in a comfortable position in terms of water supply.

One can argue that the need to import water by São Paulo Metropolitan Region could be avoided by the adoption of strict regulation regarding the pollution of the fountainhead (wellspring). However, there are two points to be considered: a) the costs involving the treatment of highly polluted water are very high and would thus make the costs for the existing industry very high (Galvão, 2000: 29); and b) this strict regulation may be very

[14] According to SABESP (2002), São Paulo State's share in the distribution of water in Brazil is 1.6 per cent. From this total, São Paulo Metropolitan Region receives 4 per cent. As previously stated this region shelters 47 per cent of the entire population of the State.

important but it is biased towards the agriculture, and we have to bear in mind that this activity in Brazil already uses 70 per cent of the water!

Ethanol production is water intensive. Based on the 1999 influential work "O Estado das Aguas no Brasil", Galvão (ibid.: 31) reports that each kilogramme of sugar produced demands 100 litres of water. Another study from the IDEC (2000) stressed that the sugar distillers require 75 litres of water to produce one kilogramme of sugar. Sugar and ethanol are substitutes in the production process. Given that the distillation of the alcohol comes after sugar production we can assume that the production of one litre of ethanol requires more than 100 litres of water.[15]

According to Rebouças (1997: 76) the average water potential of the Southeast Region rivers (the biggest ethanol producer in the country where São Paulo State is located) is 334.2 cubic kilometres per year (km^3/year) accounting for 6 per cent of the country's overall potential. The social disposal of water (5333 cubic meters per inhabitant per year) is slightly superior to that of the Northeast Region (average water potential of 186.3 km^3/year), the lowest ranked region and quite well-known for its droughts. The Southeast Region was responsible for 83 per cent of the sugar production and 77 per cent of the ethanol production in 2001/2002 (Marjotta-Maistro, 2002: 16).

The Production of Ethanol (and Proalcool) and Air Pollution

> In Brazil the use of anhydrous ethanol as fuel for passenger cars or the mixture of 22 per cent of hydrous ethanol with gasoline brought gains for the environment and the health of the population, mainly to those living in big urban centres. A major benefit was the reduction of the emission of lead in the atmosphere due the replacement of lead in anti-detonating by a combination of hydrous ethanol and gasoline.
>
> However, the large-scale use of ethanol as fuel for passenger car has resulted in a substantial increase of the land used for sugarcane predominantly in the State of São Paulo. In the regions where the sugarcane is produced and industrialized the quality of the air suffered due to the increasing amount of cane and straw burned resulting in increased pollution of the atmosphere (Arbex, 2001: 126).

Arbex (Doctoral dissertation, 2001: 85) reports that the dust resulting from the sugarcane and straw burned, which falls on the cities around the plantation, affects the health of its inhabitants. During the period of the burning of cane and straw he found an increase in the incidence of asthma and emphysema as well as an increase in the number of deaths due to respiratory diseases among the exposed population.

The author points out that in 1998 sugarcane production was the agricultural sector's major employer in the State of São Paulo, employing roughly 90 thousand workers. The

---

[15] The household consumption of water in Europe averages 165 litres per inhabitant per day (Sadeq, 1999: 20). In Brazil SABESP estimates household consumption of water at 120 litres per inhabitant per day (5 Elementos, 2005: 15). For more information on water consumption during the different stages of sugar and ethanol production, see Silva and Simoes (1999: 359).

trade union was very much against the State Law (42056 of 08/06/1997), which established that the burning of the dust and cane should be eliminated gradually in 8 to 15 years' time.

Arbex (ibid.: 70) notes that in São Paulo during the harvest of 1997/1998, 81.8 per cent of the cropland was harvested manually with the cane leftovers and straw burned. In a more recent research Tolmasquim (2003: 76) noticed that 75 per cent of the entire cane harvest in Brazil is manual. This type of harvest is followed by burning of straw.
Arbex (ibid.: 76) brings to light some alarming data regarding the estimate of air pollution levels from sugarcane plantation burning: a) the amount per year of dried material burned in the sugarcane plantation per unit of area is 15 times greater than the amount burned in the Amazon region (0.5 square km against 0.03 square km); and b) the State of São Paulo, during the harvest period, burns 82 million tonnes/day of cane straw. This burning is responsible for 285 tonnes/day of particular matter and 33,342 tonnes/day of carbon monoxide (the total State area used for sugar cane production is 8.22 per cent). In contrast, the vehicles emission of particulate matter and carbon monoxide in the metropolitan region of São Paulo (2.82 per cent of the area of the state) is 62 tonnes/day and 4,293 tonnes/day respectively!

Energy Crops and Food Crops

Proalcool

Brown[16] (1980: 28) noted that the decision to turn to energy crops, more strongly in 1979, to fuel Brazil's rapidly growing fleet of automobiles is certain to drive food prices upward, thus leading to more severe malnutrition among the poor. In effect, the more affluent one-fifth of the population who own most of the automobiles will dramatically increase their individual claims on cropland from roughly one to at least three acres, further squeezing the millions who are at the low end of the Brazilian economic ladder. As the author pointed out, Brazil is a chronically grain-deficient country. For instance, in 1979, imports of grains soared to a record 5.7 million tonnes.

Calabi (1983) showed concern over the production goal of 11 billion litres of ethanol in 1985. His concern stemmed from the country's record with respect to food security in the past. Since the late 1960s, Brazil placed a lot of effort in promoting agricultural exports like soybeans. As a result of this, food import rose to US$2 billion in 1979 vis-à-vis US$1.2 billion in 1978. The emphasis on ethanol production could increase the country's food imports further.

> "The possibility of large-scale biomass alcohol production has posed the question of whether, and to what extent, such a development is likely to compete for land and other agricultural resources that could otherwise be allocated for producing food... The issue is complex and can sometimes be emotional. Basic considerations in assessing the extent of future competition for agricultural resources are the relative price movements for energy and food. As noted, on a global basis a sharper increase in energy prices than in food prices or most other

[16] This author's major concern is the impact of ethanol on corn and the production of food.

> agricultural products is plausible, at least over the next decade. Assuming this occurs, the potential land use conflict between food, export, and energy crops will increase as economic forces increasingly draw resources into energy production (World Bank, 1980: 53).

To illustrate the lack of concern of economic authorities regarding the question of "energy cropping" and its trade-off with food production, we refer to the Government's contention that the social cost of an ethanol industry based solely on sugarcane would ultimately prove to be unacceptable. They were hoping to develop second generation feed stocks. The most important of these second-generation crops was thought to be manioc[17], one of the world's five staple crops (together with sorgo, rice, wheat and corn).

According to Seroa da Motta (1987: 178), in 1983, São Paulo State accounted for 50 per cent of ethanol production and, as opposed to other states 'energy crops' replaced other crops such as rice, beans and corn. Hence the State suffered reduction in food production. São Paulo State is, by far, the most economically vibrant and also has the largest urban population.

> Town dwellers (the towns are the seat of political power) are therefore relatively well protected against famine, at least in peace-time and its for this reason that, when supplies are scarce, there is a mass exodus of country dwellers towards the towns to which they are lured by the hope of finding cheap food or some way of earning money, no matter how little. For, although in rural areas food shortages and high food prices are generally accompanied by a reduction in the number of jobs available, such is not the case in towns, which are less affected by seasonal variations. This migration towards the towns may be organized to a greater or lesser degree by the population itself (Spitz, 1978: 868).

According to Spitz (1978), the urban areas have more power to buy food and this aspect is an important one in urban migration in developing countries. The power that São Paulo State, and other powerful and urbanized States, had in the food market also contributed to the massive migration[18] of the rural and poor states' population to big cities like Säo Paulo, Rio de Janeiro, Belo Horizonte etc. Hence these cities have all sorts of urban environment problems, from squatting around the areas of water and the consequent pollution of the water supply, to an astonishing increase in the number of the slums population with a severe degradation in sanitation and the urban environment. Of course this 'social injustice` is not due to Proalcool alone, but one can say that it did contribute to it.

Ethanol

[17] During the decade of Brazil's 'economic miracle", as the living standards of the rural poor began to drop, many people turned to manioc for survival. By the end of 1977, small manioc plots took up some 2.1 million hectares of land—more than the total sugarcane acreage at the time (Berton et al., 1982: 157).

[18] Obviously, structural factors such as rapid industrialization and great disparity between rural and urban incomes and lack of land reform are some of the major aspects that "promoted" the massive migration. What we are saying is that Proalcool is partly responsible for this situation.

A recent report from OECD-FAO (2007) notes that debate on energy cropping versus food cropping is very current. The increasing demand for bio-fuel, like ethanol, is leading to fundamental changes in the agricultural markets which are currently witnessing price increase in various products. For instance, the report notes that the world costs of food imports in 2007 increased 5 per cent due to this increasing demand. It also stresses that this increase in cost will affect developing countries mainly.

Silva (2007) draws attention to the influential IEA's (Sao Paulo State Agricultural Institute) report that in the 2006-2007 period there was reduction in the agricultural area of 32 products in the state; among them were rice (10 per cent), beans (13 per cent), manioc (3 per cent) and tomato (12 per cent). They also report a reduction of more than a million cattle.

Ethanol Production as a Substitute of Energy

Proalcool

> Sometimes it is said that agriculture might become a source of energy, by which it is meant that biomass might be used as fuel, not merely in the form of wood or dung. It is difficult to understand the physics (as distinct from the sociology) of simultaneously excluding sugar production from the "energy sector" and including ethanol from sugarcane. It is only an "urban bias" (or an "upper class bias") of the most potent sort, which allows people who are perhaps worried about an excess of calories in their diet, to exclude food production from the "energy sector" of the economy (Martinez-Alier, 1987: 20).

Martinez-Alier (1987: 15) in his book calls our attention to the fact that economics is unable to convincingly deal with ecological critique. Therefore, it was paradoxical that the renewed faith in the market coincided with the energy crisis of 1973 and its aftermath.

Unlike Pearce and Turner (1990: 120)[19], Martinez-Allier (1987: 21) states that because ethanol is used as a fuel for cars, one relevant comparison is between the energy efficiency of ethanol production and other types of agriculture. Another relevant comparison would be between the energy cost of ethanol and the energy cost of other sources such as coal, oil, and hydroelectricity; in this sense, ethanol from sugarcane appears to be quite expensive.

Considering the ethanol industry as one branch of the so-called "energy sector" of the economy, the energy cost of ethanol could then be compared with other sources of energy (coal and oil extraction, hydroelectricity etc.). In coal or oil extraction, transport and refining, an expenditure of one calorie would be needed to produce five to ten calories; in ethanol production, with the appropriate corrections, an optimistic estimation would be two or three calories produced per calorie spent (ibid.: 27).

[19] They are in favour only of money terms of unit of account.

For Martinez-Alier[20] (1987: 27) the energy requirements of ethanol production are additional reasons why it is misleading to present ethanol programme as an oil-saving programme, which at the same time allows motorization. The production of ethanol is very energy intensive, compared with oil or coal.

According to Da Silva et al. (1978)—quoted by Martinez-Alier (1987: 26)—the breakdown of about 50 per cent of the energy input of 4.2 million kilocalories/hectare/year is as follows: 50 per cent for fuel for machinery, 30 per cent for fertilizer, 10 per cent for machinery and equipment annual depreciation and the rest to seed, pesticides and human labour. The ratio between energy produced from ethanol and energy consumed in the agricultural stage of sugarcane is 4.53. For Martinez-Alier (1987) the data of Da Silva et al. (1978) is regarded generally, as optimistic since it might depend not only on the use of crop-residues but also on the low fossil-fuel energy costs of agriculture in Brazil. They neglect, for instance, the energy cost of the work force.

As far as the energy balance is concerned, existing differences of opinion derive primarily from variations in energy assumptions and their interpretations. Part of the controversy appears to have begun when Chambers et al. (1979) calculated that the energy content of ethanol produced from farm crops was less than the fossil-fuel energy consumed in the process. It should be noted that excluding the positive energy balance given by Da Silva et al. (1978) most studies show little real net energy gain, if any (Rothman et al., 1983: 124).

For Martinez-Alier (1987: 22), Proalcool as an agricultural programme, was extremely impressive. The production of 10 billion litres (11 billion in 1985) requires nearly 3 million hectares of cane—more than the area of cane in Cuba, and it also represents 10 per cent of Brazil's cropland. This area converted for food production would add about 900 kilocalories per head per day, for a population of 150 million. The essence of the ethanol programme, however, is not that it will provide energy as food (or drink), but that energy will be provided specifically as fuel for cars**.**

Ethanol

Regarding the energy cost of the work force, we refer to the study by Pereira (2007: 16) and published in the weekly magazine *Carta Capital*. This study discusses the reports of two experts on the work time of sugarcane workers: Dr. Maria Aparecida de Moraes e Silva from Sao Paulo State University (UNESP) and Dr. Jose Novaes from the Federal University of Rio de Janeiro (UFRJ). Both inform that the work-life of these workers was 15 years. From 2000 onwards, it dropped to around 12 years. Dr. Moraes e Silva, who has been researching migrant workers for more than 30 years, recalls that up to 1850, the work-life of the slave was 10 to 12 years! Novaes reports that the productivity of these workers has been increasing substantially over the years; it increased from five to eight tonnes in the 1980s, to eight to nine tonnes in the 1990s and to 12 to 15 tonnes in 2004. There is no improvement in the technology used and they are paid based on production.

[20] He is extremely critical of "farming with petroleum" and his book reveals his concern regarding the technical progress in modern agriculture.

Since 2004, the Catholic Church has been keeping an account of the suspicious deaths among these migrant workers; the number of dead under investigation since the beginning of this year is above 20.

Conclusions

Ethanol production in Brazil can be used as a good example to show the imperfections of CB analysis discussed in section I. Ethanol is a project that affects the life of the top 20 per cent of the Brazilians—that is the cars' owners—in terms of personal income distribution. As stressed in section III, the ethanol programme can be shown as an example of conventional CB analysis where the environmental question is neglected. Further, even if you acknowledge the current updates in the CB analysis intended to account for the environmental loss in terms of "tangible" values, the serious aspects discussed in section IV would be ignored since they represent "intangible" values associated with the environment

The use of CB analysis as a mechanical rule or decision-making procedure to justify ethanol production in Brazil only serves to deflect public opinion. It seeks to prevent the breaking out into the public realm of serious negative aspects associated with its production that involve, among others, water quality and distribution and air quality.

References

Arbex, M. A. (2001) *Avaliação dos efeitos do material particulado proveniente da queima da plantação da cana de açúcar sobre a morbidade respiratória na população de Araraquara-SP*, Unpublished doctoral dissertation, São Paulo: University of São Paulo (USP) Medical School.

Berton, H., Bill Kovarik and Scott Sklar (1982) *The Forbidden Fuel: Power Alcohol in the Twentieth Century,* New York: Boyd Griffin.

Brookshire, D. S., Larry S. Eubanks, and Alan Randal (1992) "Estimating Option Prices and Existence Values for Wildlife Resources", in Markandia, A. and J. Richardson (eds.) *Environmental Economics: A Reader,* New York: St. Martin's Press, pp. 112-128.

Brown, L. R., (1980) "Food or Fuel: New Competition for the World's Cropland", World Watch Papers, No.35.

Calabi, A. (1983) *A Energia e a Economia Brasileira,* São Paulo: Pioneira-Fipe.

Chambers, R. S., et al. (1979) "Gasohol: Does It or Doesn't it Produce Positive Net Energy?" *Science*, 206, pp. 89-95.

5 Elementos, Instituto de Educação e Pesquisa Ambiental, 2005, *Águas no Oeste do Alto Tiête: uma radiografia da sub-bacia Pinheiros-Pirapora,* São Paulo: 5 Elementos.

Clark, C. W. (1991) "Economic Biases against Sustainable Development", in Costanza, R., (ed.) *Ecological Economics,* New York: Columbia University Press, pp. 319-330.

Corazza, R.I. (2001) *Políticas públicas para tecnologias mais limpas: uma análise das contribuições da economia do meio ambiente,* Unpublished doctoral dissertation, Campinas: Instituto de Geociencias - Universidade Estadual de Campinas - Unicamp.

Da Silva, J. G. et al. (1978) "Energy Balance for Ethyl Alcohol Production from Crops", *Science,* 201, pp. 903-6.

Dasgupta, Partha, S. Marglin and A.K. Sen (1972), *Guidelines for Project Evaluation, UNIDO,* New York: United Nations.
Farber, S. et al. (2006) "Linking Ecology and Economics for Ecosystem Management", *BioScience*, Vol. 56 (2), pp. 117-129.
Galvão, L. E. (2000) "As Águas não Vão Mais Rolar", in *Rumos: Economia e Desenvolvimento para Novos Tempos,* Ano. 24, No. 168, pp. 26-33.
Hespanhol, I. (2001) "Gestão de Água no Brasil", accessed in July 2007, http://www.crmariocovas.sp.gov.br/pdf/pol/gestao_agua.pdf.
Hespanhol, I. (2003) "Potencial de reuso de água no Brasil: agricultura, industria, município e recarga de aqüíferos", in Mancuso, P. C. S. and H.F. Santos (eds.) *Reúso de Água*, Barueri, São Paulo: Manole, pp. 38-50.
Homem de Melo, F. and E.R. Pelin (1984) *As Soluções Energéticas e a Economia Brasileira,* São Paulo: Hucitec.
IDEC (2000) "Água, Disponível", accessed in July 2007, http://www.idec.Ed.br/biblioteca/mcs_agua.pdf.
Kaldor, N. (1939) "Welfare Propositions of Economics and Interpersonal Comparisons of Utility", *Economic Journal,* 49, pp. 549-52.
Magalhães, J. P. A., N. Kuperman and R.C. Machado (1991) *Proálcol, uma avaliação global,* Rio de Janeiro: Astel, Assessores Técnicos.
Marjotta-Maistro, M.C. (2002) *Ajustes nos Mercados de Álcool e Gasolina no Processo de Desregulamentação*, Unpublished Doctoral Dissertation, Escola Superior de Agronomia "Luiz de Queiroz", University of São Paulo (USP).
Markandya, A, David Pearce and Edward Barbier (1994) *Blueprint for a green economy*, London: Earthscan.
Markandaya, A. and Richardson (1992) *Environmental Economics: A Reader,* New York: St. Martin's Press.
Martinez-Alier, J. (1991) "Ecological perception, environmental policy and distribution conflicts: some lessons from history", in Costanza, R. (1991) *Ecological Economics: The Science and Management of Sustainability,* New York: Columbia University Press, pp. 118-136.
Martinez-Alier, J. (1987) *Ecological Economics: energy, environment and society,* Cambridge MA: Basil Blackwell.
Motta, R. (1987) "The social viability of ethanol production in Brazil", *Energy Economics*, July, pp. 176-182.
Motta, R. and L.R. Ferreira (1987) "Reavaliação econômica e novos ajustamentos do Proálcool", *Revista Brasileira de Economia*, Vol. 41 (1), pp. 117-133.
Motta, R. and L.R. Ferreira (1988) "The Brazilian National Alcohol Programme: An Economic Reappraisal and Adjustment", *Energy Economics*, July, pp. 229-234.
Pearce, D. and R.K. Turner (1990) *Economics of Natural Resources and the Environment,* Baltimore: Johns Hopkins University Press.
OCDE-FAU (2007) "Agricultural Outlook 2007-2016", accessed in July 2007, http://www.oecd.org/dataoecd/6/10/38893266.pdf
Pereira, R. R. (ed.) (2007) "O Colossal Brasil. In Retratos do Brasil no.1", *Carta Capital,* August, 22, pp. 1-20.
Porter, R., (1982) "The new approach to wilderness preservation through benefit-cost analysis", *Journal of Environmental Economics and Management*, 9(1), pp. 59-80.

Rebouças, A. C. (1997) "Panorama da Agua Doce no Brasil", in Rebouças, A. C. (ed.) *Panoramas da Degradação do Ar, da Água Doce e da Terra no Brasil,* Rio de Janeiro: Academia Brasileira de Ciências e CNPQ, pp. 59-107.
Rebouças, A. C., (ed.) (2004) *Uso Inteligente da Água*, São Paulo: Escrituras.
Rocha Filho, J. P. (1993) "A Alcool como Alternativa Energética para o Brasil", *Encontros Nacional de Economia*, Belo Horizonte, Anais, pp. 361-381.
Rothman, H., R. Greenchild and F.C. Rosillo (1983) *Energy from Alcohol: The Brazilian Experience,* Lexington: University Press of Kentucky.
Sadeq, H.T. (1999) "A Demanda Aumenta, Oferta Diminui", in *Correio da UNESCO*, April, pp. 19-26.
Sagoff, M. (1988) *The Economy of the Earth*, New York: Cambridge University Press.
Shikida, P. F. A. and C.J.C Bacha (1999) "Evolução da Agroindústria Canavieira Brasileira de 1975 a 1995", *Revista Brasileira de Economia,* 53 (1), pp. 69-89.
Silva, G. A. and R.A.G Simoes (1999) "Água na Industria", in Rebouças, A. C., B. Braga and J.G. Tundisi (eds.) *Águas Doces no Brasil*, São Paulo: Escrituras, pp. 339-368.
Silva, M. A. M. (2007) "Atrás das cortinas no teatro do etanol", *Folha de São Paulo*, 2 October, accessed in October 2007, http://www1folha.uol.com.br/fsp/opiniao/fz0210200709.htm.
Spitz, P. (1978) "Silent violence: Famine and inequality", *International Social Science Journal,* Volume XXX (4), pp. 867-892.
Tolmasquim, M. T. (2003) *Fontes Renováveis de Energia no Brasil*, Rio de Janeiro, Interciência.
Turner, R. K., David Pearce and Ian Bateman (1993) *Environmental Economics: An Elementary Introduction,* Baltimore: The Johns Hopkins University Press.
World Bank (1980) *Alcohol Production from Biomass in Developing Countries,* Washington, D.C.: World Bank, September.