Advantages and disadvantages surrounding large-scale bioenergy production; the case of Brazilian biofuel

Lamia HAMAIZIA*

University of Oum El Bouaghi
Algeria

hamaizia.lamia@univ-oeb.dz

Nasreddine AISSAOUI

University of Oum El Bouaghi
Algeria

aissaoui.nasreddine@univ-oeb.dz

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Abstract:
We aim through this paper to highlight the positive aspects of the production and consumption of renewable energies, particularly liquid biofuel. Apart from sugar as a highly prized food product and bioethanol as a green fuel, the energy from sugarcane is considered renewable because it is made from sugarcane bagasse.
We will try to show the other face of the expansion in the production of biofuel from agricultural products and its negative effects, on the medium to long term from the economic, social and environmental axes.
Apart from the difficult and inhumane conditions of the production of the first and second generation of Brazilian bioethanol, its mass production contributes to increasing the price of raw materials, in this case the price of sugar. However, the most striking, it is by adding the social and environmental cost to the economic cost; this can make the price of this bioenergy uncompetitive.
***Key Words*:** Biofuel, Brazilian bioethanol, Energy balance, Sugarcane.

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* Corresponding author: Lamia Hamaizia (*hamaizia.lamia@univ-oeb.dz*)

Introduction:

There has been a global trend since the beginning of the 21st century towards the diversification of energy sources (fossil, bioenergy, sustainable, etc.). Although this trend aims to improve the atmospheric quality and these components, which have been degraded in recent times, this choice to massively produce this kind of alternative energies in addition to the positive aspects, has several negative aspects, the latter can make this trend dangerous on humanity, especially if this kind of energy has a considerable influence on the quantity produced and the prices of these agricultural products of wide consumption. The rising prices and environmental impacts of fossil fuels; have caused the production of biofuel to reach unprecedented quantities in the last 15 years. Satisfying a need for land for the raising production of biofuel; may have a serious impact on the food supply and on the environment (Popp et al, 2014).

Our choice in this paper relates to a green energy source, which gathers the opinion of the majority of experts, which this energy source can help to diversify

the conventional energy sources, as it has only positive aspects concerning its production and consumption! The reality may be different if we bring together the different facets: economic, social and environmental those accompany the production and consumption of these alternative energies. The gradual expansion of the demand for agricultural products for mass consumption (sugar, corn, rapeseed, etc.), has led to questions about the economic impacts linked to the large quantities of these agricultural products, which are used to produce biofuel. In addition, other questions are asked about the influence of the gradual demand on prices of agricultural products, including prices for red and white meats. Some other questions was asked that concern: either social impacts of the exploitation of workers in the vast fields of third world countries, or the environmental impacts of the thousands of hectares sacrificed to meet local and global demand for agricultural products.

Biomass production and processing has the potential to positively affect bioenergy potentials, global food prices and water scarcity. Biomass is also a unique source of food and feed, in which integrated policies for energy generation, land use and water management are needed. Moreover, since biomass production is widely dispersed across all continents of the world, international conflicts related to fossil fuels could be avoided (FAO, 2011; IEA, 2009; Crutzen, 2008; Laluce, 1991). Although this green energy source encompasses several economic, social and environmental benefits, etc. However, the constraints surrounding the production of this energy in large quantities, through consumer products, are not often addressed by researchers. So, we are going to focus on this dark side of green energy production, in a country which often occupies first place in the production of bioethanol from sugar cane. (Conab, 2020).

The problem of this study can be formulated by the following question: *what are the threats that accompany the production of alternative energies based on widely consumed agricultural products; the case of Brazilian bioethanol?*

I. Historical, political and economic contexts that have accompanied Brazilian bioethanol:

The Brazilian experience in the production and use of bioethanol has gone through 7 phases.

1. First phase (1975 – 1979):

During the 1970s, Brazil was a subordinate country in the international market for energy products. Brazil was a country 80% dependent for energy on foreign countries; this dependence had a negative influence on the financial balances of this country, especially in periods of crisis like that of 1973. This situation contributed to reducing the purchasing power of households in this country. The budget allocated to the import of petroleum reached 32.2% of the budgetary envelope for the import of goods and services of Brazil in 1974; this encouraged the Brazilian government to implement a comprehensive strategy, in order to promote local biofuel as a substitute for imported fuel. The effectiveness of this strategy can be summed up in the amount produced in this period, which fell from 220million liters in 1975 to 2.8million liters in 1979 (Leite et al, 2009; Goldemberg et al, 2008). The Proalcool program is a government strategy launched from 1975, in order to reduce Brazil's dependence on imported fossil fuels, by turning to bioethanol produced from local sugar cane.

2. Second phase (1979 - 1986):

The 1979 oil shock caused by the Iran-Iraqi conflict raised the price of a barrel of oil to 30USD/ barrel in 1981, which further encouraged the Brazilian government to continue its policy of promoting locally produced biofuel. This second phase saw the birth of the second generation of bioethanol (hydrated ethanol), its specificity comes down to its use alone as fuel, without mixing it with diesel.

3. Third phase (1986 – 1990):

This period was marked by a vertiginous drop in oil prices, which came close to 10USD/barrel in 1985, the price of a barrel of oil continued below 20USD/barrel for several years. A several national and international economic facts have helped to reduce state subsidies that are allocated to biofuel producers. After a dizzying rise in oil prices in the first part of the 80s, the second part saw a considerable drop between 10USD/ barrel and 12USD/ barrel. The competitive oil prices and profitable sugar prices have shifted the course of sugarcane producers towards exporting sugar. This period was marked by a decline in confidence in bioethanol, which in turn led to a considerable drop in vehicles using bioethanol as a fuel to 9% of all vehicle sales in 1995, after its peak in 1988 with 88% of sales (Michellon et al, 2009; Nass et al, 2007; Goldemberg et al, 2008).

4. Fourth phase (1990 - 2003):

This period has undergone several changes: the first concerns the technological development of bioethanol production techniques, which has led to high production with fairly competitive prices; the second concerns the end of subsidies paid to biofuel producers; the third concerns a freeze on the functioning of the Brazilian state regulatory body named IA, which has supported the production and use of bioethanol for almost 60 years (Rosillo-Calle et Cortez, 1998; Martines-Filho et al, 2006). The beginning of the 21st century saw a rebound in oil prices, which once again revived the demand for vehicles that use bioethanol (hydrated ethanol), yet it remains incomparable with the strong demand of the eighties.

5. Fifth phase (2003 – 2014):

This period is marked by the launch of flex-fuel vehicles, the specificity of these vehicles is that it offers its owner the choice between several types of energy to use: diesel, mixture of diesel and concentrated ethanol, hydrated ethanol. The main reason that has encouraged the commercialization of this kind of hybrid vehicles is the crescendo of oil prices in the world market; even the most optimistic of experts did not predict a price per barrel of 100USD. This kind of hybrid vehicles has given confidence to Brazilian citizens, by its flexibility with the most attractive fuel prices. The quantity of flex-fuel vehicles reached 87% of all vehicles sold in Brazil in 2007, exceeding that of 1988. Since 2008, there have been almost 18 million new flex-fuel car registrations, representing 90% of overall vehicle sales in Brazil and 37% of the Brazilian vehicle fleet. It should be added that 50% of fuel consumption is ensured by bioethanol, either in a mixture or in the form of pure ethanol. Finally, all European and American car manufacturers are present on the Brazilian market and propose this type of hybrid vehicle: General Motors, Renault, Fiat, Ford, etc. (Popp et al, 2014; IEA, 2009). Since 2013, the rate of incorporation of ethanol in gasoline is 20 to 25%, and 90% of vehicle sales relate to flex-fuel models, while diesel vehicles are prohibited for individuals (Leite et al, 2009).

The initial incorporation of bioethanol into gasoline was 12%, gradually increasing to 20% and then to 25% in May 2014. If in the years 1990-2000, the discovery of new oil fields in Brazil mechanically led to stagnation in ethanol consumption, it has picked up strongly in recent years, in particular with the introduction of flex-fuel vehicles. Remember that these can run on a variable mixture of ethanol and gasoline in the same tank.

6. Sixth phase (2014 – 2020):

This period was marked by the fall in oil prices by more than 60%; ie from 120USD/barrel to 40USD/barrel in 2014. This significant drop in prices once again propelled the sale of flex-fuel vehicles, demonstrating the effectiveness of the Brazilian energy mix in the face of global energy crises. Brazilian experience has shown that the diversification of energy sources (the energy mix), the technological mastery of the largest energy-consuming sector (flex-fuel vehicle) can help to cope with financial, economic and energy crises. The (table1) shows clearly the sectors

which can be considered as large consumers of energy, and which can be sensitive to cyclical crises in the world energy market.

7. Seventh phase (2021 - present):

As economic growth resumes around the world, after a major recession due to COVID-19, crude oil prices could drift more steadily, but likely above 60-70USD per barrel over the next several years (Calia, 2021). Bioethanol has significantly reduced Brazil's oil bill and greenhouse gas emissions. Nowadays, 80% of cars sold in Brazil are Flex-Fuel. Nowadays, 80% of cars sold in Brazil are Flex-Fuel, in addition bioethanol represents 50% of global fuel consumption in Brazil. In Brazil, oil companies are required to market their fuel as a blend with 20-25% ethanol. In addition, accelerate the adoption of Flex-Fuel vehicles that can run on both gasoline and ethanol, the government is providing a substantial reduction in the tax on the purchase of these vehicles. Flex-Fuel vehicles already represent 37% of the Brazilian car fleet. These vehicles exclusively use pure ethanol 80% of the time (Natura Sciences, 2021).

Table 1: «Production of sugar and bioethanol from sugarcane in Brazil »

	2007/2008	**2015/2016**	**2019/2020**
Sugarcane production (million tonnes)	493	665.6	625.17
The area planted in sugarcane (hectare)	7.8	11.4	8.59
The amount produced in sugar (million tonnes)	30.8	41.3	31.35
The amount produced in sugar (billion liters)	22.5	46.9	33.58

Source: (W.A.N Amaral et al, 2008 ; OCDE/FAO, 2020)

II. Economic, social and environmental characteristics of Brazilian bioethanol production:

The characteristics of bioethanol production are not always the same from one producer country to another, we will try to focus on the Brazilian experience for two reasons; the first is that Brazil has been the world leader in biofuel for almost 60 years, the second concerns the quality of the numerous studies available which constitute the literature in this field.

1. Economic characteristics:

There are several common economic characteristics in the experiences of the leaders of biofuel from agricultural products.

1.1 The influence of the demand for bioethanol on the quantity harvested and exporter of agricultural products and on the resources allocated:

During the seven phases of bioethanol development, the area reserved for planting sugarcane increased from 3.5 million hectares to 11.4 million hectares. In addition to the area, the productivity per hectare has also rebounded, since it went from 45 tons/hectare in 1960 to 75 tons/hectare in 2007. The quantity produced in sugarcane during the 2007-08 campaign reached the lowest levels; 493 million tonnes, half of this quantity was intended for the production of sugar, and the other half for the production of 22.5 billion liters of bioethanol (Matsuoka et al, 2009; RFA, 2008). However, a record was recorded during the 2015-16 campaign with 665.6 million tonnes (OCDE/FAO, 2020).

The agricultural area devoted to sugarcane increased by around 5% in the 2014-15 campaign. But that would not compensate for the drop in productivity to 8% on average compared to 2013-14 when it reached 79.8 tonnes of cane per hectare. Confirming the trend of recent years, the majority of the sugarcane cut in 2014-15 (over 56%) was devoted to non-sugar ethanol production. Sugar production was 32.5 Mt, down 5.23% from the 2013-14 campaign, which was 34.29 Mt. Ethanol productions reached 25.87 billion liters, up 1.2% from 25.57 billion liters in 2013-14 (IEA, 2020; Tiradoa et al, 2010).

The evolution of the production of ethanol, these last years, from agricultural raw material remains in clear increase, especially after the new rebound of the barrel of oil at the beginning of the year 2022, which exceeded 90USD/barrel, which could reach 125USD/barrel this year, and 150USD/barrel in 2023. (Bozorgmehr, 2022). The use of cereals for the production of ethanol should grow in Europe and in the USA, since a barrel of oil at 90USD, gives a competitive value and a new life to bioethanol. However, nearly 40% of the increase in global ethanol production is expected to be due to increased production of sugarcane-based ethanol, mainly from Brazil, to meet both demand domestic and American. Second-generation ethanol from biomass: roots, tubers and molasses, etc. should only develop later in developing countries. Wheat, coarse grains and sugar beet are expected to be increasingly used in the European Union to produce ethanol (Global Ag Media, 2020; Martinell et Filoso, 2008; Hazell, 2006; Faaij et al, 2008). The quantity of sugar cane intended for the production of sugar and bioethanol is directly linked to the prices of these materials on the international market, the latter being influenced by several variables: climatic conditions in the major producing countries, fluctuations in the price of a barrel of oil, political instability in the major producing or consuming countries of these products, etc. The American government wants to reach 136 billion liters in 2022, to do this, subsidies of 8 billion dollars are granted from 2006, and tax credits have been granted to corn producers, the main source of American bioethanol. Quantity of corn dedicated to the production of bioethanol increased from 14% in 2006 to 30% in 2010, however, the United States account for 60% to 70% of world exports of this cereal. As a

result, the price of a bushel of corn on the world market doubled in 2006, to more than 6 dollars (Von Braunet al, 2009; Hazell, 2006).

1.2 The influence of fluctuations in oil prices on the price, profitability and quantity produced in Brazilian bioethanol:

Rising oil prices for long periods, and continuing pressure on industrialized countries regarding their greenhouse gas emissions, have made these countries aware of cheap, flexible and environmentally friendly fuels, among these alternative energies, bioethanol is presented as the ideal fuel on several levels (economic, technological, ecological, etc.).

1.3 The influence of international awareness for Brazilian bioethanol on the prices of agricultural products:

According to the International Food Policy Research Institute/ IFPRI, the demand for agricultural products to produce biofuel (corn in the USA, sugarcane in Brazil, rapeseed in Europe, etc.) is responsible, at 30%, of the increase in the prices of the food industry in the international market during the period 2000-2007, as it is responsible, up to 40%, of the increase in corn prices in the same period (Smeets et al, 2008; PNUE, 2009; FAO, 2008). Biofuel production will continue to absorb a significant portion of the global production of grains, sugar and vegetable oils throughout the outlook period. By 2020, 12% of global coarse grain production will be spent on bioethanol production, compared to an average of 11% during 2008-10, 16% of global vegetable oil production will be used on the production of biodiesel, compared to 11% on average during 2008-10, and 33% of global sugar production will be used, compared to 21% on average over 2008-10. Over the projection period, 21% of the increase in world production of coarse grains, 29% of the increase in world production of vegetable oils and 68% of the increase in world cane production of sugar should be used to produce biofuel (OCDE/FAO, 2020; Tirado et al, 2010; Martinell et Filoso, 2008). The Covid 19 pandemic has seriously impacted the biofuel market. Global production of biofuel for the transport sector reached 144 billion liters, down 11.6% from the record production of 2019. Global production of biofuel for the transport sector reached 144 billion liters, down 11.6% from the record production of 2019 (IEA, 2021).

2. Social characteristics:

It can be said that households with a modest income direct their budgets towards products and foods that are widely consumed to meet the basic needs of their families. The increase in demand for agricultural products to produce biofuel has pushed up the prices of these products. The rise in the prices of these foods has considerably reduced the purchasing power of these families, even though these families reduce their demand according to their purchasing power.

The production of biofuel will gobble up more and more enormous quantities of the world's production of cereals, sugar and vegetable oils. In 2019, about 13% of the world's cereal production is used to produce ethanol, 16% of the world's vegetable oil production was used to produce biodiesel, the share of sugar cane

intended for the production global ethanol consumption reached almost 35% in 2019 (Global Ag Media, 2020).

A study carried out by the (FAO), indicates that the prices of these food industry products in the international market have a negative effect on the number of food subsidies and donations granted to regions suffering from drought, internal conflicts, etc. It should be taken into account that 80% of the world's population is concentrated in third world countries, and which may reach 85% by 2030 (Rocha et al, 2007; Nellemann et al, 2009; Ajanovic, 2010). Among the social characteristics of the production of bioethanol, which are in constant expansion, it is the exploitation of the rich countries the weak situation of the poor countries, by buying them millions of hectares under the pretext of agricultural investment, is called Land grab. In this trend: 700000 hectares has been purchased by South Korea from Sudan, 500000 hectares by Saudi Arabia in Tanzania, 350000 hectares has been purchased by India from a few African countries, China alone has more than 2.8 million hectares in the DRC (Von Braun et al, 2009; Laluce, 1991; Ajanovic, 2010).

3. Environmental characteristics:

Several environmental characteristics can be cited, among them: to produce one liter of bioethanol you have to consume 2.5 kg of corn or 13.3 kg of sugarcane; to be able to replace the traditional fuel consumed by the global fleet of means of transport, it is necessary to produce 30 million barrels of bioethanol and 23 million of biodiesel daily; to meet the needs of the global transport fleet, it is necessary to cultivate 300 million hectares of sugarcane and 590 million hectares of maize; to be able to exploit new lands to produce biofuel, it is necessary to clear large areas, cut trees, burn plants and use pesticides so that these new lands are arable. To eliminate trees and plants, it is necessary to count the projection of several gases harmful to health (CO2, O3, CH4, NOx, N2O, etc); the use of fertilizers and pesticides to increase the yield of the land will affect the waterways and the water table in the long term; repeated cultivation of a single species several times in the same year will lead to land impoverishment.

III. Economic, social and environmental impacts of large-scale Brazilian bioethanol production:

The large-scale production of Brazilian bioethanol raises several economic, social and environmental issues.

1. Economic impacts:

Currently, ethanol from sugarcane produced in Brazil is the first biofuel able to compete effectively with conventional fuels, without subsidies granted by the Brazilian government; however, some questions remain as to whether this economic profitability does not depend on practices and methods that are unsustainable for the environment and human dignity. In Brazil, the large-scale cultivation of sugarcane for the production of bioethanol does not always respect environmental and social conditions… All studies agree that if these two conditions

are met in the future, the profitability of a liter of bioethanol may be compromised. A study has succeeded in determining the cost price per liter, which will drop from 0.25 USD/liter to 0.42 USD / liter while respecting the following conditions: recycling sugarcane waste, increasing the wages of workers in the fields and workshops, the non-exploitation of children in the fields, the use of techniques that limit land impoverishment (Amaral et al, 2008; Laluce, 1991; Ajanovic, 2010). We must take into consideration a very important point which is the equation with three variables: the price of a barrel of oil, the quantity harvested in sugarcane intended for the production of bioethanol, and the price of the amount of sugar obtained from the cane sugar. There is a direct relationship between the price of fossil fuels, renewable energies and agricultural and food industry products. The probable rise in the price of a barrel of oil can considerably impact stock prices or processed basic agricultural products (rapeseed, soybeans, sugarcane, etc.), and among others all the agronomic and agro-food and animal products that use these commodities. The economic recovery in the coming years, guided by classic industrializing countries and others emerging, will call for additional demand in the fossil and alternative energy market, which may make the prices of basic agricultural products inaccessible by the majority of people of third world countries.

2. Social impacts:

The collection of sugarcane in Brazil is characterized by a strong involvement of cheap local labour for 8 months of the year. The working conditions in the sugarcane fields are almost the same conditions of their slave ancestors before 200 years old (SCDB, 2010; Walter et al, 2008; Rocha et al, 2007). Among these conditions: workload of a sugarcane cutter; can reach on average between 2 and 3 tons per day; temperature in the fields is generally between 26 ° and 36 °; a cane cutter can give up to 70000 machete blows/day; a cane cutter can cover a distance of 4500 meters/day. Sugarcane cutters are not immune to health problems because of the specificity of working in tropical areas, Among them: respiratory problems, due to the almost permanent presence of dust and residues in the fields during collection; sunburn and humidity can cause cane cutters to pass out; high risk of developing cancer of the respiratory system: due to the smoke from sugarcane waste in the fields; high risk of food poisoning: due to the presence of chemicals in food and waterways at rather high rates.

For example, in 1998, there were 700 cases of poisoning and 17 cases led to death; sudden death: between 2004 and 2007 there were up to 18 sudden deaths due to the unbreathable air in the fields; fairly high risk of having serious pathologies: cardiovascular diseases, respiratory diseases, insect bites and animal bites, etc. (SCDB, 2010; Ajanovic, 2010).

3. Environmental impacts:

When cultivated areas are mechanically harvested, it is possible to harvest both the stem and a large part of the leaves. The rest of the leaves are left on the ground and serve as a protective mat to reduce soil erosion. With the rhizome remaining in

the ground, the sugarcane will be able to grow back again. On average, there are 5 successive harvests without loss of yield from the same plant. These residues, once harvested, will be burned in boilers to produce heat and steam from which turbines are driven to generate electricity to operate the sugar factory. The factory produces more electricity than it needs and can sell its surplus. Thus in 2008, these factories contributed to the production of green electricity covering just over 1% of the country's electricity consumption. However, the picture is not all white and only 47% of cultivated areas are harvested mechanically. For manual harvests, the leaves are burned on-site; energy recovery is zero and atmospheric pollution is too significant. But many improvements are underway. Thus, the Brazilian food industry sector has signed a protocol aimed to eliminate burning by 2014 on all farms where mechanization is possible. The legislature, on the other hand, requires that burning be eliminated by 2021. The second approach to increasing electricity production is through the installation of high pressure and high-temperature boilers (IEA, 2020; Zuurbier, 2008). During the sugar cane harvest, the country's 360 factories become energy self-sufficient. Of these, 194 produce excess amounts of electricity which contributes to supplying the national grid. Thus more than 22,600 GWh of electricity was produced in this way in 2020; enough to power 775,000 homes in the United States for a year (Wilson Center, 2021). Large-scale sugarcane cultivation for bioethanol production involves ecological risks that can doom Brazil's ecosystem, including that of the entire planet. Between 2007 and 2009 almost 57,000 km2 of Amazon rainforest was cleared, to increase the areas for pasture and crops for human and animal food (Wilson Center, 2021). Among the risks involved: burning of forests and plants, so that these lands are arable, increased the temperature of these areas, and amplified the projection of greenhouse gases; deforestation has caused water to rise in wetlands, which can threaten hundreds of animal and plant species; decrease in the area of forests, can affect the role that the Amazon plays as the lung of the planet; massive use of fertilizers and pesticides, to increase the productivity of the land, can affect the flora and fauna that live in and around waterways; massive use of water for irrigation has caused a drop in groundwater; deforestation has caused a considerable drop in rainfall.

Conclusion:

The production and use of biofuel has several positive characteristics, which significantly limit greenhouse gases compared to fossil fuels. Because of greenhouse gases are responsible for climate change, which threatens the ecosystem and the life of thousands of species of fauna and flora.

All of the studies that have addressed the subject of agricultural products used to produce biofuel have claimed that the growing demand for biofuel is among the main causes of rising food prices. The growing interest in green energies places bioethanol as the best candidate that can replace fossil fuels, in return, the production of this energy on a large scale can lead to negative impacts, especially

on the producing country and on several plans (economic, social and environmental).

Through this study, we arrived at a truth, which may change the opinion of many conservationists. Indeed, by adding the social and environmental cost to the cost price resulting from the traditional accounting information system, we can have the overall cost price, which can make this energy unprofitable economically, socially and environmentally.

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