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# Biofuels in Brazil: Evolution, achievements and perspectives on food security

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ABSTRACT

Liquid biofuels, as ethanol and biodiesel, supply 25% of the road transport fuel consumed in Brazil. Ethanol blending has been mandatory since 1931, pure ethanol has been used since 1975, and nowadays flex-fuel cars are widely used. In 2008, ethanol production reached 28 Mm³, but recently, government efforts to reduce gasoline prices have reduced the demand for ethanol. In turn, biodiesel blending was launched in 2005, and B5 has been mandatory since 2010. In 2011, the land dedicated to production of these biofuels in Brazil was of 8.82 Mha or 11.8% of total cultivated area, a considerable fraction of the land available, considering improvements in cattle breeding and agro-ecological zoning for bioenergy. Social development associated with biofuel programs has been relevant to food security. The Brazilian biofuel programs demonstrate the relevance of adopting efficient agro-industrial routes and the possibility of sound coexistence between bioenergy and other uses of agriculture.



## 1. Introduction

The volatility of world oil prices, the security of the energy supply and global climate change concerns are the main driving forces in the search for alternatives to fossil fuels, which are responsible for 80% of the global energy supply (IEA, 2011). The transport sector is supplied mostly by fossil fuels and liquid biofuels. Ethanol produced from sugarcane, corn and other cereals and biodiesel from oilseed crops represent approximately 57.6 Mtoe or 2.4% of the fuel consumed by this sector (IEA, 2012).

Despite concerns about the impacts of bioenergy, global interest in transport biofuels is growing, and their production is expanding faster than the production of conventional oil. According to the IEA Alternative Policy Scenario, biofuel production could reach approximately 7% of the forecasted total for road transport fuels in 2030. Even with this huge increase in production, the participation of biofuels in agricultural production will continue to be relatively modest; the arable land requirement for liquid biofuel production is estimated to increase from 14 Mha in 2004, or just 1% of the world cultivated land, to 53.0 Mha in 2030, or 3.8% of the land used for agriculture, depending to a great extent on the feedstock mix to be eventually used (IEA, 2007).

In Brazil, about half of the total energy supplied comes from renewable sources, mainly hydroelectric power, sugarcane and wood (Fig. 1). Sugarcane bioenergy is important; in 2011, it accounted for 15.7% of the national energy supply (42.8 Mtoe), slightly greater than the contribution of hydroelectric power (EPE, 2012). In the road transport sector, the share of biofuels has been considerable: 25.1% in 2011 as ethanol (20.6 Mm³) and biodiesel (2.7 Mm³), as shown in Fig. 2 (EPE, 2012). Ethanol is consumed by Brazilian cars as anhydrous ethanol (less than 0.6% of water by mass) blended with gasoline (20–25% by volume) in conventional gasoline engines and as hydrous ethanol (approximately 6% water), pure or in any blend with Brazilian gasoline, in dedicated engines or flex fuel engines.

The expanding biofuels global market has raised concerns about its effective sustainability. Some recurrent issues are the potential impact of biofuels on food security and agricultural commodity prices, the effective reduction of greenhouse gas (GHG) emissions in the production chain, and the social and environmental impacts in terms of deforestation, monoculture, water resources depletion, and labor conditions. In this context, several studies have assessed the advantages of biofuels compared to fossil fuel substitutes and have shown the great influence of where and how the biofuel is produced and used (Msangi et al., 2006; Charlemann and Laurence, 2008; Escobar et al., 2009; Rosillo-Calle and Johnson, 2010).

The objective of this paper is to describe the evolution and general characteristics of the Brazilian ethanol and biodiesel programs, stressing their nexus with food security. This review and analysis can help to better understand the impacts of those programs and their potential benefits and limits.

## 2. Ethanol production and use in Brazil

### 2.1. Evolution of ethanol policies

Sugarcane has been cultivated in Brazil since the 16th century and, during the colonial period, it was extensively and successfully

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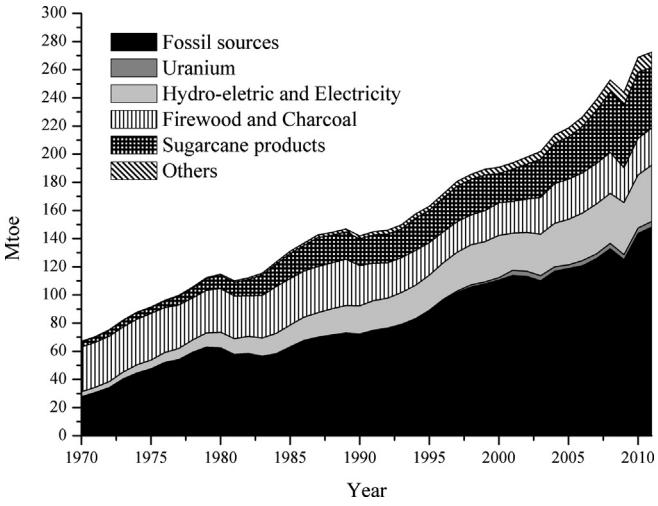


**Fig. 1.** Primary energy supply in Brazil (EPE, 2012).

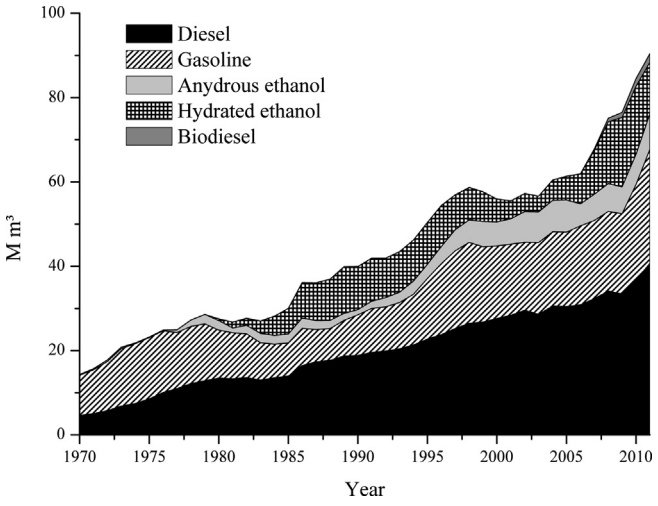


**Fig. 2.** Fuel consumption in road transport sector in Brazil (EPE, 2012).

cultivated along the Brazilian coast. In 1931, the Brazilian government implemented a compulsory blend of at least 5% anhydrous ethanol in gasoline, aimed at reducing the impact of total dependence on imported oil fuels and absorbing the excess production of the sugar industry. The creation of the Sugar and Alcohol Institute in 1933, when the use of automotive ethanol was blossoming, provided the required institutional support for this product. In addition, from that time onwards, the sugar industry began to expand in the southeast of Brazil, first in association with the decline of coffee plantations and later driven by the growth of the domestic market (Szmrecsányi, 1979).

The ethanol content in Brazilian gasoline varied over successive decades; during the period 1931–1975, an average of 7.5% of the gasoline demand was substituted by this biofuel. In 1975, the effects of the first oil crisis were responsible for the expansion of ethanol use in Brazilian cars (in blends with gasoline and pure hydrated ethanol), and the government launched the National Alcohol Program (Proálcool) (MIC, 1986). The combination of incentives adopted by Proálcool at that time included the following: (a) establishing higher minimum levels of anhydrous ethanol in gasoline (progressively increased up to 25%); (b) guaranteeing lower consumer prices for hydrated ethanol relative to gasoline (at the time, fuel prices were determined by the government); (c) guaranteeing competitive prices for the ethanol producer, even in the face of more attractive international prices for sugar than for ethanol; (d) offering financing under favorable conditions for mills to increase their production capacity; (e) reducing taxes on new cars and reducing annual registration fees for hydrated ethanol vehicles; (f) making the sale of hydrated ethanol at gas stations compulsory; and (g) maintaining strategic reserves to ensure supply outside of the production season.

Given this favorable legal framework, the production of ethanol expanded significantly. Between 1975 and 1979, ethanol production grew from 0.58 Mm³ to 3.68 Mm³, surpassing the goal established for 1979 by 15%. In 1979, with oil prices reaching new heights, the Proálcool program gained new force, stimulating the use of hydrated ethanol in engines adapted or specially made to work with it. Under this scenario, ethanol production reached 11.7 Mm³ in 1985, exceeding the intended goal by 8%.

Around 1985, the situation began to change because of the decline in oil prices and strengthening of sugar prices. In 1986, the government reviewed the incentive policies for ethanol, thereby reducing the average sugarcane agro-industry returns and further stimulating the use of available sugarcane to produce sugar for export. These events made ethanol production unattractive and created difficulties for the ethanol industry that led to the end of the expansion phase of Proálcool. The mechanisms for creating safety reserves failed, and emergency measures, such as reducing the level of ethanol in gasoline, importing ethanol and using gasoline–methanol blends as substitutes for ethanol, became necessary.

By the beginning of the 1990s, after decades of strict State control, the basic structure of the Brazilian sugarcane industry was characterized by the following elements: agricultural and industrial production under the control of the sugar mills; heterogeneous production, especially in sugarcane; underutilization of by-products; and competitiveness driven largely by low salaries and mass production (CGEE, 2007).

During the early 1990s, the Brazilian government implemented administrative reforms, reviewing its role in the economy. A move towards free-market pricing in the sugar–ethanol sector started in 1991, along with the progressive removal of subsidies and a reduction of the government's role in fixing ethanol prices, a process completed only in 1999. The result of those changes was the creation of a new set of rules to organize the relationships between sugarcane producers, ethanol producers, and fuel distributors. The only feature of the original framework of legal and tax measures—which provided the foundation for ethanol fuel consolidation in Brazil—maintained until recently was the differential tax on hydrated ethanol and gasoline, which was intended to maintain approximate parity of consumer choice between hydrated ethanol and gasoline. In this context, ethanol is traded freely between producers and distributors. Within the sphere of agro-industry, the sugarcane is also traded freely, but its price is mainly determined according to a contractual voluntary model jointly coordinated by the sugarcane planters and ethanol and sugar producers (Scandiffio, 2005).

The institutional restructuring of the ethanol industry continued in 1997 with the creation of two important institutions: the National Energy Policy Council (CNPE), and the National Oil Agency (ANP), later renamed the National Oil, Natural Gas and Biofuels Agency. The CNPE is responsible for establishing directives for specific programs for biofuels use. The ANP oversees the regulation, contracting, and inspection of biofuel-related economic activities and implements national biofuel policy, with an emphasis on ensuring supply throughout the country and protecting consumer interests with regard to product price, quality and supply.

In 2003, flex-fuel cars were launched and were well accepted by consumers. Flex-fuel cars offer owners the options of using gasoline (with 20–25% anhydrous ethanol), hydrated ethanol, or