

International Trade and Environment: Impacts of the export-driven Soybean Production on the Biodiversity of the Brazilian Cerrado (1960-2005)

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Abstract

The complex relationship between free trade and environment is, nowadays, one of the most important issues found at the international affairs agenda. Much has been discussed, but few conclusive answers on the environmental impacts caused by free trade have been found. An accurate analysis on the issue will depend on the individual study of each case due to its peculiarities. In order to verify such assumption this paper has analyzed the impacts of the international trade of soybeans, Brazil's most important commodity, on the biodiversity of the Cerrado Savanna, one of the most notable ecosystems on Earth. From that specific study it has been possible to verify the existence of a direct relationship between export-driven soybean production and the loss of biodiversity in that biome.

Keywords: Free Trade; Soybean; Agriculture; Biodiversity; Brazilian Cerrado

I – Introduction

It is widely known that the Amazon rain forest is the central topic in most casual discussions and scientific analyses dealing with the environment in Brazil. Its importance in terms of biodiversity and other environmental-related issues makes the Amazon Rain Forest the most popular Brazilian ecosystem. Nevertheless, other biomes in South America such as the so-called Cerrado also play a role as important as that of the Amazon for the functioning of this complex ecosystem.

Covering nearly two million km² or 23 percent of the Brazilian territory, the Cerrado is the second largest Brazilian biome in terms of area, just after the Amazon. The cerrado region covers mostly the Brazilian central-western region and is found in thirteen Brazilian states as shown below (Goiás, Tocantins, Mato Grosso, Mato Grosso do Sul, Bahia, Minas Gerais, Distrito Federal, São Paulo, Maranhão, Piauí, Paraná, Pará and Rondônia).

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Fig. 1: Original Coverage of the Brazilian Cerrado.

Source: Machado *et al.*, 2004.

According to WWF (2002), the Cerrado is composed of two main ecoregions²: the cerrado *strictu sensu* and the dry *Chiquitano* forests. Besides, the Cerrado embraces a large variety of environments within the main ecological regions mentioned above, such as forestal formations (ciliary forests, gallery forests, *mata seca* and *cerradão*), fields (*campo sujo*, *campo rupestre* and *campo limpo*) as well as savannahs (cerrado *stricto sensu*, *parques de cerrado*, palm groves and *veredas*).

These environments are very different from each other, but may coexist in the same area and contain a range of species, which in certain cases are strongly dependent on the specific conditions found in these environments. For example, recent studies indicate that there could be a loss of 25 percent of bird species dependent on the gallery forest if its surroundings were destroyed (Machado *et al.*, 2004). Hence, the conservation of the Cerrado's biodiversity depends on the maintenance of its mosaic of natural environments.

The Cerrado has been considered the world's second most important savannah in terms of biodiversity, with an estimated flora and fauna composed of between 80,000 and 160,000 species. Many of these species are endemic, which means that they are only found in the Cerrado region and, therefore, may be totally extinct whether their habitats are destroyed.

Indeed, there is a controversy about the number of species and level of endemism in the Cerrado, which demonstrates the need of more accurate researches concerning this region. Depending on the source, the total percentage of species estimated for the Cerrado region ranges between 20 and 50 percent of the total of species found in Brazil (Machado *et al.*, 2004). Some data from various sources are presented in the following table (Table 1). Except for the birds, which present a relatively low level of endemism, and for the invertebrates, for which no information was available, the species of the Cerrado show a considerably high level of endemism.

² An ecoregion (ecological region) is a group of geographically-different natural communities which share most of their species and ecological dynamics and processes (IBAMA, 2002).

Table 1: Estimated Biodiversity of the Brazilian Cerrado

	Nr. OF SPECIES	% OF TOTAL FOUND IN BRAZIL	THREATENED SPECIES	ENDEMIC SPECIES	LEVEL OF ENDEMISM (%)
INVERTEBRATES	67,000	20	not available	not available	not available
PLANTS	10,000	18	not available	4,400	44
MAMMALS	199	38	21	45	22.6
BIRDS	837	52	33 (14 endemic)	45	5.3
AMPHIBIOUS	195	38	3	42	21.5
FISH	1,200	44	not available	350	29
REPTILES	180	50	15	20	11

Source: WWF, 2004a; IBAMA, 2004; EMBRAPA, 2007; Klink *et al.*, 2005.

Despite some research efforts undertaken mainly during the 1980s and 1990s, there are still many uncertainties about the Cerrado's number of species and the current state of its biodiversity. This deficiency indicates the low priority given by the Brazilian Government to the Cerrado as well as the consequent lack of sustainable management programs regarding the protection of its natural resources.

The typical vegetation of the Cerrado, composed by short-stem trees with contorted branches and thick barks, is very well adapted to adverse conditions such as droughts and fire. The soil of the Cerrado region is usually poor in terms of mineral nutrients, has a relatively high level of acidity and sometimes toxic amounts of aluminium. These characteristics associated with other factors such as latitude, fire cycles and soil declivity have determined the very particular physiognomy of the Cerrado. These exclusive characteristics of the Cerrado lead to the mistaken conclusion that it is biologically poor in terms of biomass. Yet, further research challenged this idea and advocated the preservation of the

Cerrado, which turned out to be known as the "upside-down forest". This denomination comes from the fact that most of its biomass remains underground due to its need to create deep roots for reaching water and nutrients. In addition, the Cerrado is also known for the number of water springs, which feed several effluents of important watersheds such as the Prata, the São Francisco and the Amazon basins.

This brief introduction about the Cerrado aimed at presenting its very singular characteristics as well as its importance despite its arid and hostile appearance at first sight. Due to its critical state of vulnerability nowadays, the Cerrado has been considered one of the world's 25 most threatened biomes (*hotspots*), both because of the high level of endemism of its species and reduced remaining area.³

Thus, considering this descriptive framework, the text is aimed at answering the following research problem: are environmental and free trade issues irreconcilable opposites? To accomplish the proposed task we've analysed some data concerning the anthropic occupation of the Brazilian Cerrado and their possible connections with the export-driven soybean production in that biome.

³ The concept of *hotspot* was first suggested by Myers (1988) referring to ecosystems characterized by both high level of endemism of plants and high rates of deforestation. A hotspot is understood as a biomass with at least two main prerequisites: it should embrace at least 1,500 endemic species of plants and have less than 30 percent of its original vegetation preserved compared to its historic coverage (Mittermeier *et al.*, 2005).

Hereupon, the analysis encompasses the period from 1960 - a landmark reference regarding the occupation of the Cerrado on central-western Brazil - until 2005 - the preceding year of the so-called soy moratorium: a pledge agreed to by soybean companies not to trade soybean produced in deforested areas in the Brazilian Amazon after July 2006.⁴

2 – The Anthropoc Occupation of the Cerrado

The uncontrolled human action has led to the predatory occupation of the Cerrado and to a rapid destruction of its environment (Figure 2). Roughly 78.7 percent of the Cerrado region is under some form of human use, which means that only 21.3 percent, or 432,814 km², still remains preserved (Mittermeier, 2005).

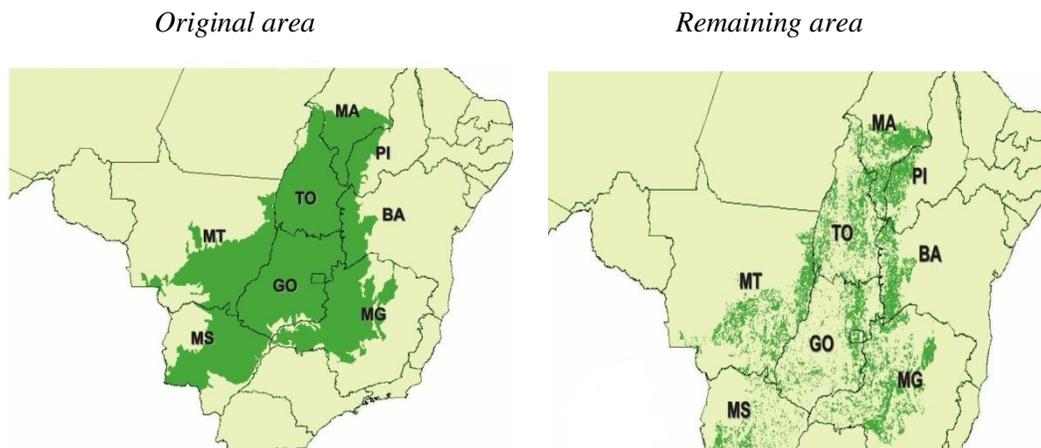


Fig. 2: Original and remaining area of the Cerrado biome in Brazil

Source: Machado et al. (2004)

The anthropic occupation of the Cerrado began around 11 thousand years ago. During the Brazilian colonization in the early 16th century, the Portuguese settlers were mainly based in the coastal areas and avoided to occupy the countryside due to territorial treaties with Spain, cultural predisposition to live near to the sea as well as others logistical reasons. Historical registers turn out that the first attempts to explore the Brazilian countryside occurred during the 18th century, motivated by the search for gold and precious stones. Hence, mining soon became an important economic activity and paved the way for cattle farming, which after the decline of mining remained the main economic activity until the 1950s (Mittermeier, 2005). Thus, the mining system shrunk progressively until becoming a subsistence activity in a regional economy dominated by low-productivity cattle farming based on the use of extense areas (Furtado, 2003).

Despite the economic decline of the mining sector in the region, its outcomes remain visible through phenomena such as soil erosion, siltation of water courses and the pollution of water resources, which were drastically affected by the uncontrolled use of mercury. The installation of a rail system during the 1930s - connecting the Brazilian central-western region to its main urban-industrial areas - associated to public policies supporting the occupation of the Brazilian countryside resulted in a significant increase of economic activities in the Cerrado region.

⁴ Despite its relevance the Soy Moratorium is an action that could be considered a "double-edged knife" because while trying to protect a specific biome, the Amazon, it has the potential to cause harm to another one by indirectly encouraging the displacement of the targeted soybean production towards the nearest agricultural frontier, in that case the Cerrado region.

This process was consolidated during the 1960s with the interiorization of the Brazilian national capital - Brasília - inaugurated in 1962, as well as the construction of new roads and the improvement of existing ones. Despite these facts, one of the main hindrances to the expansion of economic activities in the Cerrado was the lack of an efficient logistic infrastructure connecting the long distances separating the region from the major industrial centers in Brazil as well as from the country's seaports, where the agricultural and livestock production was shipped to international markets.

As a result, the progressive implementation of a more efficient logistic infrastructure and public policies boosted the expansion of the area used for export-driven agricultural production, leading to the establishment of a new productive model based on the large-scale monoculture farming. This context made possible a fast expansion of the Brazilian rural production frontier during the 1970s and 1980s, mainly propelled by the increase of two different but interrelated activities: the monoculture of grains, mostly of soybeans, and the cattle farming. Due to the pressure exerted by the monoculture of grains and the livestock industry on the fauna and flora of the Cerrado, these two activities have been considered the most important threats to the biodiversity of the Cerrado (WWF, 2000).

In order to analyze the specific case of the export-driven soybean production, this article focuses on the territory composed by the states of the Brazilian central-eastern region (Distrito Federal, Goiás, Mato Grosso and Mato Grosso do Sul) as well as by the state of Tocantins (northern region), which according to the Brazilian Institute of Geography and Statistics (IBGE) cover an area of 1,883,988 km². This territory comprises most of the original area of the Cerrado in Brazil. According to the IBGE, rural establishments occupy 67 percent of the area under analysis, i.e. 1.2 million km².

The most significant activity in terms of extension is cattle farming, which occupies 60 percent of the total area used by rural establishments. Despite showing signs of adaptation to international standards, the livestock production in the Cerrado region is generally characterized by low technological intensity and productivity, whereas demanding large areas for pastures. The use of slash-and-fire farming represents an additional environmental threat arising from livestock production. This practice has been described as the main reason for arsons, which yearly devastate large natural areas of the Cerrado, particularly during the dry season between April and September (WWF, 1999; IBGE, 1998; Klink *et al.*, 2005).

According to WWF (2003), hundreds of thousands of hectares which have been deforested for giving space to pastures have been later abandoned due to the occupation of improper soil associated with inadequate techniques. This fact has led to the deforestation of new areas, sometimes just for the maintenance of the current herd.

The expansion of agriculture has also been considered one of the main causes of the substantial increase in the deforestation of the Cerrado. Since the late 1950s, the Brazilian rural production frontier has expanded throughout the Cerrado at a fast rate. Factors such as the vast offer of farmlands, inefficient territorial law enforcement, flat topography – favourable to mechanized agriculture and irrigation – as well as the development of technology for the correction of soil acidity and of adapted plant varieties contributed to the fast expansion of the agriculture in the Cerrado region.

According to the last Brazilian rural census, referring to the years of 1995 and 1996, agriculture occupied 6.4 percent (81,000 km²) of the total area of rural establishments in the territory under analysis. Most of this area was used by annual crops (72,000 km²), of which almost 70 percent (50,000 km²) was used for the cultivation of soybeans (IBGE, 1998). Although the area used for the cultivation of this commodity in the Cerrado region is indeed much smaller than the area used for livestock production, these two different sectors are strongly interrelated as will be explained in the section about the socioeconomic impacts of the soybean production.

In short, this section aimed at presenting the most important factors which have led to the uncontrolled occupation of the Cerrado as well as to the destruction of its biodiversity. The next sections will discuss the impacts caused by the expansion of the export-driven agriculture, in particular of soybean production, on the Brazilian economy as well as on the biodiversity of the Cerrado.

3 – Agriculture and Sustainable Development

The agricultural sector is essential for the attainment of sustainable development⁵. Efficient governmental actions in the formulation and execution of rural development policies and natural resource management can make sustainable development possible. Under these conditions the contribution provided by the agricultural sector to sustainable development is essential by providing impulse to economic growth, whereas contributing to the reduction of rural migration as well as of the pressure for the formation of large cities and conurbations. Furthermore, agricultural exports are a significant source of foreign currency to most countries, particularly in the case of those with a large share of agricultural products in their total exports (Souza, 1997; Johnston *et al.*, 1961). Concerning Brazil, the agricultural sector holds a considerable share in its total exports (Figure 3), and has positioned the country among the world's major exporters of agricultural products as shown in table 2.

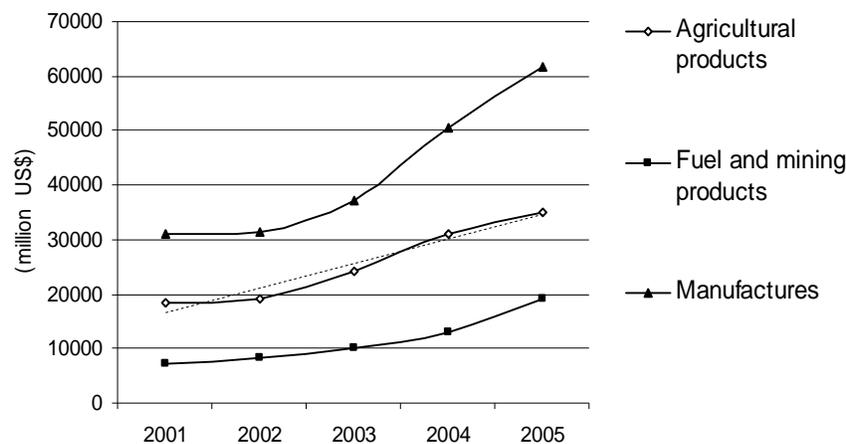


Fig. 3: Brazilian exports by product category (2001-2005)

Source: WTO, 2007

⁵ The maintenance of natural capital and biodiversity should become the main guideline for national strategies for sustainable development, not the substitution between different types of capital (natural capital by financial capital, for example), even if some flexibility is allowed. Hence, three main rules are important for the sustainable management of natural resources: (1) renewable resources should only be used according to their respective regenerative capacity; (2) non-renewable raw materials and energy sources should be consumed only to the extent that is both physically and functionally compensated by renewable resources; (3) polluting emissions should not overcome the absorption capacity of the environment and ecosystems, and emissions derived from non-renewable resources are to be minimised no matter the extent to which generation capacity is still available. Further concrete measures, such as quantified environmental targets, can be developed from these management rules (RSU, 2002: 67).

Table 2: Main Exporters of Agricultural Products -1980/2005

Countries/Year	Amount (bn. US\$) 2005	Participation in world exports (%)			
		1980	1990	2000	2005
1. European Union	369.71	-	-	41.5	43.4
2. USA	82.67	17.0	14.3	12.9	9.7
3. Canada	41.18	5.0	5.4	6.3	4.8
4. Brazil	35.04	3.4	2.4	2.8	4.1
5. China	28.71	1.5	2.4	3.0	3.4
6. Australia	21.21	3.3	2.8	3.0	3.4
7. Argentina	19.18	1.9	1.8	2.2	2.3
8. Thailand	17.82	1.2	1.9	2.2	2.1
9. Russia	14.87	-	-	1.4	1.7
10. Indonesia	14.32	1.6	1.0	1.4	1.7
11. Malaysia	13.38	2.0	1.8	1.4	1.6
12. New Zealand	13.01	1.3	1.4	1.4	1.5
13. Mexico	12.72	0.8	0.8	1.6	1.5
14. India	10.13	1.0	0.8	1.2	1.2
15. Chile	10.10	0.4	0.7	1.2	1.2
TOTAL - 15 largest	704.5	-	-	83.4	82.6

Source: WTO, 2007

Since the colonial period the agricultural sector has played a central role for the Brazilian economy. Throughout history and in response to changes in the international demand, the agriculture in Brazil has undergone successive production cycles of commodities such as sugar cane, cotton, cocoa, rubber and coffee. Since the 1960s, another commodity has become one of the major contributors to the substantial increase in the Brazilian exports of agricultural products and derivatives: soybeans, as we shall see in the next section.

3.1 – The Soybean Production in the Cerrado Region

This study does not aim at questioning the potential benefits of the agriculture to economic growth and welfare improvement. Instead this section will explore major national and international determinants which have incentivated the expansion of the soybean production in Brazil and the way this process has occurred.

Brazilian agricultural policies adopted between the 1960s and 1980s gave a strong priority to the expansion of the country's export-driven commodity production, considering the need to obtain foreign currency for the equilibrium of the Brazilian trade account balance. Until the end-1970s, the soybean production was restricted to the Brazilian southern and south-eastern regions, with emphasis on the states of São Paulo, Paraná and Minas Gerais. Several domestic and international factors contributed to the advance of the rural production frontier towards the Brazilian central-western and northeastern regions. This advance resulted in the incorporation of extense areas of cerrado and a large increase in the Brazilian production of grains and derivatives, particularly of soybeans.

In 1973, the US president Richard Nixon, laid a temporary embargo on the USA's exports of bran and grains to guarantee their internal supply. Countries such as Japan, for example, that had been largely dependent on agricultural exports from the US, were particularly affected (Osada, 1999).

This way, motivated by the increase in the international prices of soybeans, Brazilian state agencies drove their efforts to this sector and offered credit incentives to farmers interested in producing soybeans and derivatives. This made possible the Brazil's transition from an importer of soybeans to one of their major world exporters.

The increase in the soybean production (Figure 4) and cultivated area (Figure 5) between 1976 and 2005 in the states where the Cerrado is predominant (Goiás, Mato Grosso, Mato Grosso do Sul, Tocantins and Distrito Federal) is presented as follows. Three states, Goiás, Mato Grosso do Sul and Mato Grosso, have experienced a sharp increase in both their soybean production and cultivated area, mainly since the mid-1990s.

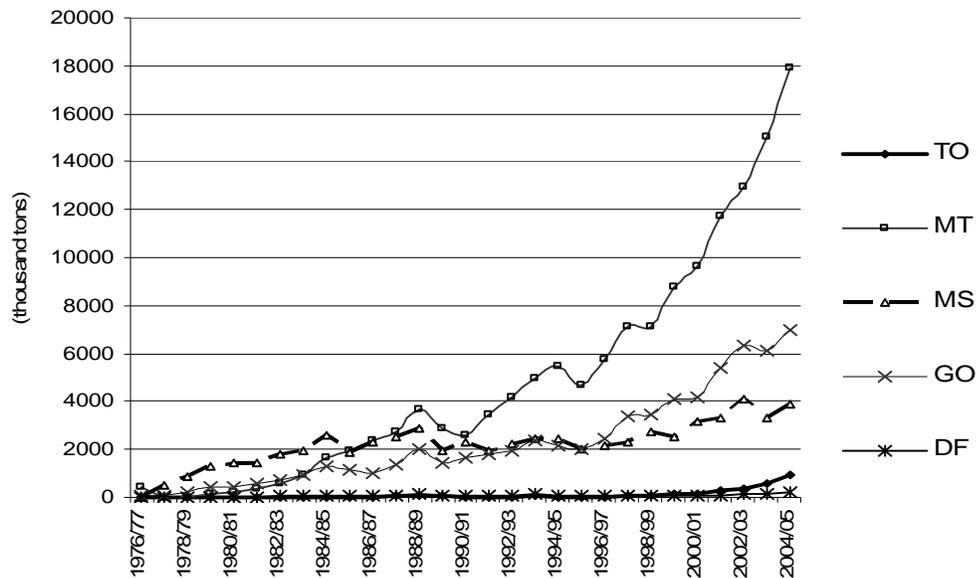


Fig. 4: Soybean production in selected states of the Cerrado region (1976 – 2005)

(Goiás: GO, Mato Grosso: MT, Mato Grosso do Sul: MS, Tocantins: TO, Distrito Federal: DF)

Source: CONAB, 2007.

The state of Mato Grosso deserves particular attention for bordering with the Amazon and covering another important Brazilian biome: the Brazilian tropical wetlands or, as it is known, the *Pantanal*. In addition to having been the state with the sharpest increase in terms of both soybean production and cultivated land, Mato Grosso has successively broken deforestation records in the last decades. The state of Mato Grosso has been the Brazilian state with the highest rate of deforestation in 2004, 2005 e 2006, according to data provided by the Brazilian National Institute for the Environment and Renewable Natural Resources (IBAMA) (IBAMA, 2007).

A range of tax and credit incentives to the Brazilian agricultural production was included in the first Brazilian National Development Plan (NDP), implemented between 1972 and 1974 during the military government of president Médici (1969-74). The first NDP comprised investments in the logistical infrastructure of the Brazilian central-western region, which were crucially important for the adequate flow of the production towards to the main seaports located in the Brazilian southern and south-eastern regions. The rural development policies adopted within the first NDP built the foundations for the extraordinarily fast occupation of the Brazilian central-eastern region by the monoculture of grains, in particular of soybeans (Figure 5).

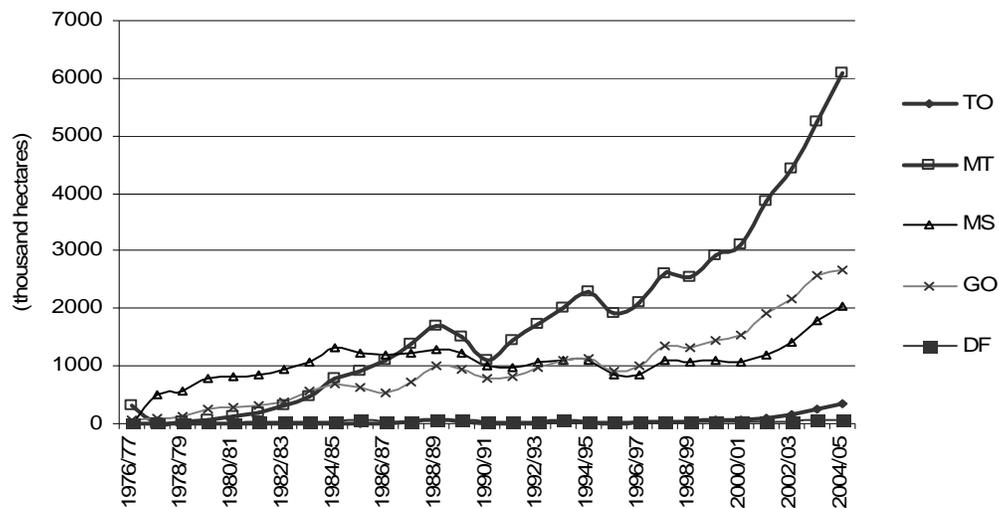


Fig. 5: Area with soybeans in selected states of the Cerrado region (1976 – 2005)

(Goías: GO, Mato Grosso: MT, Mato Grosso do Sul: MS, Tocantins: TO, Distrito Federal: DF)

Source: CONAB, 2007

In addition, the process of occupation and use of the Cerrado was intensified by state-sponsored technological research, undertaken by the Brazilian Public Enterprise of Agricultural and Livestock Research (EMBRAPA), mostly due to new techniques for balancing soil acidity as well as for the development of new plant varieties genetically modified.

Moreover, the Brazilian development policies between 1960s and 1970s were strongly based on external loans, which were indeed attractive due to the temporary abundance made possible by the so-called petrodollars. In the dollar crises of 1971 and 1973, as well as in the first oil crisis of 1973, the international credit offer was considerably modified. Consequently, the Brazilian external debt increased drastically since it had to be adjusted according to high interest rates due to the instability of the international economy at that time. In the second oil crisis, motivated by the war between Iran and Iraq (1979), the world economy went through a period of general recession and high-inflation rates, which affected the economic growth of many countries during the 1980s (Queiroz, 2012).

The worldwide economic depression during that time destabilized the international trade, mainly of agricultural products, which suffered successive price depreciations due to drastic decreases in the demand. Thus, countries which had large shares of agricultural exports such as Brazil experienced severe problems to equilibrate their trade account balances whereas struggling to control their increasing external debts, which reached unprecedented high levels. As a result, many developing countries had to review their agricultural credit incentives to equilibrate their balance of payments.

In spite of that scenario, the Brazilian government maintained its incentives to the expansion of agriculture, considering the need to increase exports, stabilize its trade account balance and sustain imports from the industrial sector. Considering these conditions the second NDP, implemented between 1975 and 1979 during the military government of President Gen.

Ernesto Geisel, was driven towards consolidating the already existing agricultural production as well as towards incorporating new areas⁶. The diversification of the Brazilian exports and modernization of its agricultural production were central issues in the second NDP, which contained several measures for supporting the increase in the agricultural production.

One important measure strengthened by the second NDP, which was adopted by the Brazilian government in the mid-1940s, was a minimum-price policy for agricultural products, known as PGPM (Policy of Minimum Price). The PGPM has been a powerful incentive to the expansion of the agricultural production and has guaranteed that the state would buy any exceeding production at a pre-established base price.

Besides neutralizing the effects of the international volatility in the short term, the PGMP – jointly with other measures of agricultural policy such as regulating stocks – managed to maintain the soybean production growth at rates similar to those before the international crises mentioned above. The PGMP has gone through several reformulations since its creation and was shortly interrupted during the process of economic liberalization in Brazil during the 1990s (CRUZ, 2007).

As a result, the Cerrado remains the most important region for the expansion of the rural production frontier in Brazil and several programs have been adopted in support of the agricultural expansion in that biome, two of them deserving special attention: the POLOCENTRO (Program for the Development of the Cerrado) and the PRODECER (Japanese-Brazilian Cooperation Program for the Development of the Cerrado).⁷

3.2 – Polocentro And Prodecerc Programs

The POLOCENTRO program, implemented between 1974 and 1980, intended to increase and modernize the agricultural production in the Brazilian central-eastern region. By means of this program the Brazilian government attempted to improve the infrastructure of the region for the expansion of the agricultural production in the Cerrado (Alencar, 1975; Osada, 1999).

According to Alencar (1975), two specific criteria were used in the selection of rural establishments that would benefit from the POLOCENTRO. The potential beneficiaries were selected according to both the existence of available infrastructure such as roads and to their distance in relation to limestone mines, since this mineral was essential for the balancing of the soil acidity. Considering these factors the program divided the region into areas of priority and secondary importance. Between 1977 and 1979, around 3.7 million hectares benefited directly and indirectly from the POLOCENTRO through investments in roads, storage facilities, electrification, tax incentives, agricultural research and technical assistance.

Most of the credit offered through the POLOCENTRO was destined to large agricultural producers, fact that boosted the criticism that the program incentivated income concentration instead of addressing the core problem of social exclusion in rural areas. Indeed, almost 90 percent of the total amount of credits was destined to rural establishments larger than 200 hectares. Around 50 percent of the credits were destined to agricultural producers owning establishments larger than 2,000 hectares. So, the POLOCENTRO made possible the occupation of approximately 2.5 million hectares of the Cerrado by agricultural and livestock production (Warnken, 1999).

⁶ Since most of the Brazilian central-western region has already been occupied by the rural production territory, its expansion has occurred more recently towards the Brazilian northern and north-eastern regions.

⁷ Although these programs were not specifically designed to provide incentives to the soybean production, they had a crucial role in the process, which made possible a large rise of the soybean production in the Cerrado region.

In 1980, the POLOCENTRO was substituted by the PRODECER program, which was implemented in three phases and aimed at providing incentives to the development of a model of cooperative agroindustrial production in the Cerrado. The program PRODECER was jointly designed in 1974 by public and private Brazilian and Japanese institutions, and was financed by the Brazilian government, Japanese private banks, the *Overseas Economic Cooperation Fund of Japan* (OECF) and the *Japanese International Cooperation Agency* (JICA). The eventual growth of the Brazilian agricultural export production was in line with the interests of Japan, which was a major importer of agricultural products, in particular of soybeans (Table 3). A significant increase in the Brazilian production led to lower international prices as well as to a lower vulnerability of Japan regarding unilateral decisions taken by the major exporter of soybeans: the United States (Osada, 1999).

Table 3: Main exporters and importers of soybeans in grains – 2004

MAJOR EXPORTERS OF SOYBEANS	thousand US\$ 2004	Share of the world's total (%)	MAJOR IMPORTERS OF SOYBEANS	thousand US\$ 2004	Share of the world's total (%)
1. USA	6,692,044	42.9	1. CHINA	7,695,178	39.2
2. BRAZIL	5,394,907	34.6	2. JAPAN	1,774,624	9.0
3. ARGENTINA	1,740,114	11.1	3. NETHERLANDS	1,504,202	7.7
4. PARAGUAY	578,705	3.7	4. GERMANY	1,129,566	5.7
5. NETHERLANDS	489,140	3.1	5. MEXICO	1,107,989	5.6
6. CANADA	295,300	1.8	6. SPAIN	780,739	3.9
7. CHINA	150,034	0.9	7. ITALY	481,238	2.4
8. URUGUAY	82,662	0.5	8. SOUTH KOREA	480,300	2.4
9. BELGIUM	24,333	0.1	9. THAILAND	471,439	2.4
10. BOLIVIA	23,083	0.1	10. INDONESIA	418,000	2.1
11. ITALY	12,626	0.08	11. IRAN	296,688	1.5
12. AUSTRIA	9,949	0.06	12. PORTUGAL	273,184	1.3
13. GERMANY	9,710	0.06	13. BELGIUM	266,374	1.3
14. UKRAINE	9,544	0.06	14. UK	238,180	1.2
15. FRANCE	8,746	0.05	15. MALAYSIA	237,690	1.2
TOTAL - 15 major	15,520,897	99%	TOTAL - 15 major	17,155,391	87%

Source: FAO, 2006

The PRODECER I (1979), mainly implemented in the western region of the state of Minas Gerais, incorporated around 70,000 hectares of Cerrado to the Brazilian agricultural territory by means of credit incentives focused on cooperatives. The PRODECER II (1985) was implemented throughout the states of Mato Grosso, Mato Grosso do Sul, Goiás and Bahia, and incorporated more than 200,000 hectares to the Brazilian agricultural territory. The PRODECER III, established in 1993, aimed at covering the Brazilian northern and north-eastern regions, more specifically the states of Maranhão and Tocantins, contributing to the occupation of approximately 40,000 hectares (Osada, 1999; Warnken, 1999).

Although the PRODECER delivered modest results compared to the impact generated by the POLOCENTRO, its supporting programs stimulated the migration of thousands of agricultural workers and producers to the Cerrado region, which led to the occupation of more than 300,000 hectares and contributed to the sharp increase in the number of inhabitants in the region (Figure 6).

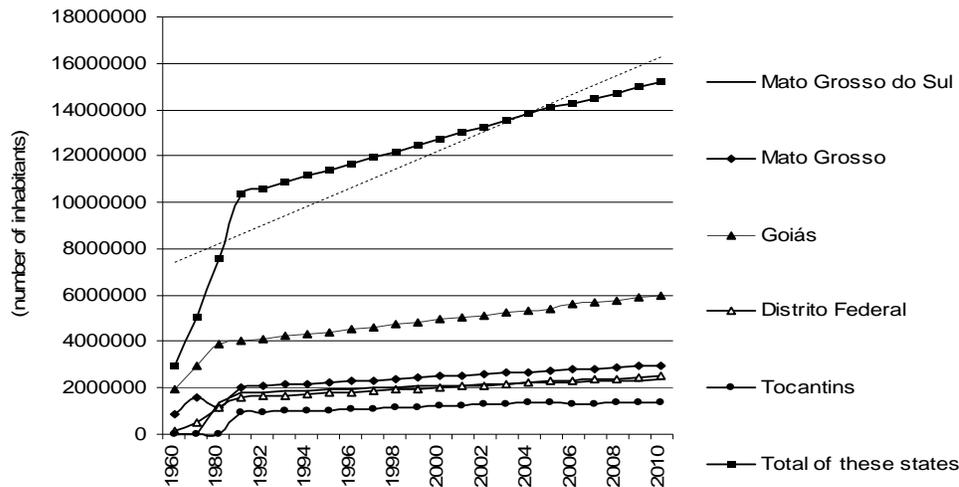


Fig. 6: Estimated population in selected states of the Cerrado region (1960-2010)

Source: IBGE 2007

The total amount spent by this program during its three phases reached approximately US\$ 570 million. The PROCEDER made possible the occupation of around 350,000 hectares of Cerrado in the states of Minas Gerais, Goiás, Bahia, Mato Grosso, Mato Grosso do Sul, Maranhão and Tocantins for the agricultural and livestock production (Osada, 1999).

3.3 – The Outcomes of the Soybean Production for the Brazilian Economy

The soybean is currently the main source of protein for the animal food industry worldwide. In addition, as seen, the soybean sector is one of the most important exporting sectors in Brazil and has become a major source of foreign currency for the country. Most of the Brazilian production of soybeans (71.3 percent of the total production of soybean in grains and bran, considering the average between 1990 and 2006) is meant for export (Pinazza, 2007: 13-15). In 2006, the soybean production chain represented nearly 20 percent of the total production of the agribusiness in Brazil (Filho, 2007: 5).

The soybean production can spur regional and local economies by stimulating complementary activities which range from the supply of machinery, inputs and technical assistance to trading logistics and transportation. Moreover, the need to rotate cultures also stimulates other products, which end up contributing to many other sectors. This is the case with the maize production, which also motivates sectors within the livestock production dependent on fodder such as swine and poultry farming. Subsequently, these latter sectors create incentives to the meat industry, often through integrated facilities which industrialize the meat, produce fodder and fertilizers and work with fattening (WWF, 1999).

Generally, the soybean production has been considered an activity for large producers, since most part of the production is negotiated in international markets where information access, production scale, intensive technology, productivity gains and financial support to face demand fluctuations are key prerequisites (WWF, 1999). The participation of four multinational enterprises (ADM, Bunge, Cargill and Louis Dreyfus) in the soybean production chain and trade in Brazil has been particularly important. Since most of the world's soybean comes from North and South America, which have different harvesting seasons, it is important for these companies to be present in both regions in order to guarantee the stability of the international supply of soybeans and derivatives (Pinazza, 2007).

Due to the intense mechanization, the large-scale soybean production has been criticized for not contributing significantly to direct employment creation. In Brazil, according to studies developed by WWF, on average one worker is necessary for each 170 - 200 hectares of soybeans crops and it is usually a seasonal job based on low remuneration (WWF, 2000; WWF, 2004b).

More recently, since the mid-1990s we have witnessed the Brazilian soybean processing industry shrink due to a mixture of national and international variables such as side-effects of tax incentives to exports implemented by the Brazilian government as well as tariff restrictions against imports of processed products by industrialized countries. Currently, the Brazilian soybean production can essentially be characterized as a supplier of soybeans in grains to industries based abroad (Pinazza, 2007: 99).

The fast growth of the production of grains in the Cerrado region, particularly of soybeans, has led the governmental agencies and private sector organizations to jointly plan the implementation of the so-called export corridors, which are supposed to restructure the regional logistic system with the aim of improving the agricultural production flow and reducing transportation costs.

These investments will generate more incentives not only to the already existing crops, but also to the establishment of new ones as well as of interrelated activities, which includes the expansion of the livestock production. This way, undoubtedly, the soybean production has contributed to confirm Brazil among the world's major producers of this commodity and its derivatives, as well as among the world's major exporters of agricultural products.

4 – Impacts on the Biodiversity of the Cerrado

The previous section demonstrated the importance of agriculture, in particular of the soybean production, for the Brazilian economy. The rural development policies adopted in Brazil since the 1960s have been addressed to foster the expansion of the agricultural production frontier, whereas paving the way for the growth of an export-driven rural productive model. In line with this, the soybean production has essentially been an export-driven sector and, therefore, has played an important role in terms of foreign currency generation for Brazil.

Despite its good financial results, the agroexporter model adopted in the Cerrado region has so far caused considerable environmental impacts. One of the most usual charges is that the Brazilian soybean production, pushed by the growing demand from China and the European Union, may lead to the deforestation of an area of 220,000 km² (equivalent to the area of the United Kingdom) within the next 15 years (Coelho, 2004).

Based on imagery data from 2002, Machado *et al.* (2004) argue that an area of 880,000 km² of Cerrado has already been cleared out or transformed for human use, what represents three fold the deforested area at the Brazilian Amazon. According to Klink *et al.* (2005), annual deforestation in the Cerrado has been considerably higher than in the Amazon. Between 1970 and 1975, the average deforested area in the Cerrado was 40,000 km² per year, which is 1.8 times the deforestation rate for the Amazon between 1978 and 1988. Current deforestation rates range from 22,000 to 30,000 km² per year, which is also higher than in the Amazon region (Klink *et al.*, 2005: 708).

By transforming extense natural areas in agricultural systems, the monoculture of grains on the one side and the extensive cattle farming, on the other side, have imposed considerable direct and indirect environmental impacts on the Cerrado. This also represents a real threat to other biomes which border the Cerrado region such as the Brazilian tropical wetlands (Pantanal), the Caatinga and the Rain Forest (Amazon).

Furthermore, associated to the increasing international demand for the traditional use of soybeans and its derivatives, the prevalent political support in Brazil for the dissemination of the so-called biofuels (biodiesel and ethanol, mainly) make the perspectives for the conservation of the Cerrado biome unclear. The rising demand for biodiesel and ethanol stimulates the advance of the Brazilian rural production frontier and places more emphasis on export-driven monocultures for the production of the necessary raw materials (oilseeds and sugar-cane, for example). Considering the current deforestation of the Cerrado and the international prospects of the “biofuels”, it seems reasonable to assume that it shall be a potential threat for the biodiversity of that biome.

Thus, significant environmental externalities directly generated by the soybean production such as soil erosion and degradation, intensive use and pollution of water courses and edaphic resources, deforestation, destruction of natural habitats, intensive use of toxic chemical inputs in large areas of cultivation, and alteration of natural systems have motivated several analyses to criticize the agroexporting soybean-production model in the Cerrado region. Additional environmental externalities generated by the expansion of interrelated sectors such as the livestock production and complementary activities led to the conclusion that the soybean production has been one of the main factors for the loss of the Cerrado’s biodiversity.

Therefore, the insufficient consideration of environmental costs and risks involved in the expansion of the export-driven soybean is an indication of the inadequacy of the rural development model that has prevailed in the Cerrado. These aspects are aggravated by the apparent insufficient capacity of environmental law enforcement (minimal areas for environmental conservation in rural plots, territorial planning, preservation of water courses and ciliary forests, for instance) by the Brazilian state institutions.

A range of environmental issues corroborate the assertion above and one of which refers to the sustainable use of water resources. Important river basins flowing through the Cerrado region have been endangered by changes in natural regimes of water. The deforestation, inefficient irrigation systems and inefficient use of agricultural inputs have altered the water dispersion and accumulation leading to siltation and pollution of water courses (WWF, 2000). Costa *et al.* (2003) argue that until 1998, 49 percent of the Tocantins river basin, located in the state of Tocantins, had been converted to cropland and pastures, which increased river discharge by 24 percent (Klink *et al.*, 2005: 710). According to the Food and Agriculture Organization of the United Nations (FAO, 2007), the Brazilian agricultural sector uses around 61 percent of the water consumed in the country, surpassing by far the industrial sector (18 percent) and the domestic use (21 percent).

The environmental externalities generated by the export-driven soybean production have exerted a strong pressure on the biological diversity of the Cerrado region. This process has endangered several species of its flora and fauna, since a large part of the Cerrado biodiversity is endemic and, thus, strongly dependent on specific environments and regular natural regimes. Thus, taking into account the growing importance of the soybean production coming from the Cerrado region in relation to the Brazilian total soybean production (Figure 7), it is expected that Brazil’s efforts towards financing and maximizing the production of this commodity will be kept. Hence, attention is required regarding the potential impacts on the biodiversity caused by this likely expansion.

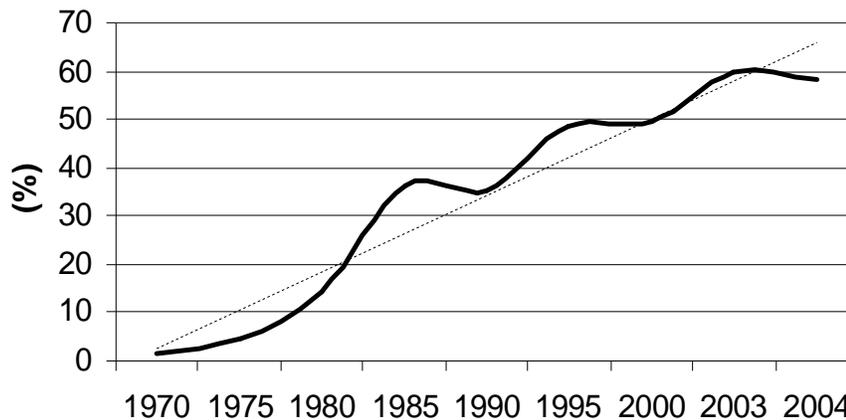


Fig. 7: Share of the Cerrado in the Brazilian total soybean production

Source: CNA, 2007

In sum, considering a) the sharp increase in the soybean cultivated area in the Cerrado region as well as its direct and indirect environmental impacts, b) the successive deforestation records of the major Brazilian soybean-producer states in the region c) the maintenance of public policies aimed at increasing the production of soybean and d) the high level of endemism of the Cerrado's flora and fauna; an expressive relationship between the expansion of the soybean production in that biome and the loss of its biodiversity becomes evident.

The occupation of the Brazilian central-eastern region and the rise of the soybean production have indeed contributed to economic growth and were mainly possible due to governmental supporting programs such as the NDPs, POLOCENTRO and PRODECER. Nevertheless, it seems that these programs have not taken into consideration neither environmental externalities nor the preservation of the Cerrado's biodiversity. Therefore, considering the current context both in Brazil and internationally, which seems conducive for increasing incentives to the export-driven agricultural production, the perspectives of preserving the remaining areas of Cerrado are not promising.

The Brazilian rural development model has been largely influenced by the growing international demand for agricultural products, mainly in the case of soybeans. Corrective measures concerning rural development policies in the Cerrado, on a solid environmentally-sustainable foundation, are urgently needed. Such measures should be systematically incorporated in rural development and trade policies so as to properly account for environmental externalities and conserve not only the Cerrado biome, but the wider natural ecosystem (Queiroz, 2012).

5 – Conclusions

This case study aimed at verifying the existence of a relationship between the expansion of the Brazilian rural frontier intended for export-driven commodities, among which the soybean production stands out, and the degradation of the Cerrado, one of the most important savanna biomes on the planet, from 1960 to 2005.

The main factors pointed out as determinants for the expansion of the soybean production at that time frame are: governmental policies to incentivate the export-driven rural production; the Brazilian need to obtain foreign currency for the equilibrium of its trade account balance; the increasing international demand for soybeans and its derivatives; the conducive topographic characteristics of the Cerrado region; the lack of awareness concerning possible environmental externalities as well as of measures for prevention and mitigation; and the predominant perception, even among the local communities, that the Cerrado is a biome of minor importance, biologically poor and, therefore, intended for agricultural and livestock production.

Due to these factors the Cerrado has been strongly affected by the soybean production and interrelated activities. Together, the factors described above and the environmental externalities generated by the current model of production prevailing in the Cerrado have considerably threatened this unique biodiversity.

It has been also possible to observe that considering the analyzed trends and the importance of the soybean production to the Brazilian economy, the state incentives to increase the production of this commodity and its derivatives will be maintained. This may promote the expansion of the rural production frontier over the remaining areas of the Cerrado. A clear indication of this trend is the absence of the Cerrado among the protected biomes in the Brazilian Constitution, which in its article 225 only guarantees protection to the Amazon, the Atlantic Forest, the *Serra do Mar*, the Pantanal and Coastal Areas.

Actually, as it has been discussed in this article, there has been an intensive agricultural use of the Cerrado supported by governmental programs. The public pressure concerning the protection of the Amazon forest seems to have stimulated Brazilian policymakers and decisionmakers along all these years to drive more efforts to protect one biome, the Amazon, at the expense of another one, the Cerrado, generally considered less important.

Finally, a possible measure for its conservation is the strengthening of the government agencies' capacity in the enforcement of environmental laws regarding natural resource management. Furthermore, it is important to establish new conservation units and ecological corridors for the conservation of the remaining areas of Cerrado once it has been considered one of the most vulnerable Brazilian biomes in terms of conservation units, since only 2.2% of its area is under legal protection.

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