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Expansion of Brazilian Agricultural Territory: Changes in Land Use

MERTEN, G. H.; MINELLA, J. P. G.; MORO, M.; MAIER, C
Hydraulic Research Institute, Hydraulics Department, Federal University of Rio Grande do Sul, Av. Bento Gonçcalves 9500, Porto Alegre, RS, Brasil, e-mail merten@iph.ufrgs.br

Abstract: Brazil encompasses an array of ecosystems, ranging from tropical rainforest in the north (the Amazon) to subtropical savannah in the south (the Pampas). In addition, Brazil possesses vast areas of agricultural land, located primarily in the South and Central-West regions. Favorable topography and regionally variable soil and climactic conditions enable large-scale production of grains, forage, fiber, bio-fuels, and tropical and subtropical fruit, making Brazil a potential major supplier of food and fuel for the world. However, the expansion of Brazilian agriculture, in response to international commodity prices (mostly soy and meat), is troubling because 2006 census data reveals an 80% increase in cultivated area between 1996 and 2006, occurring primarily in the ecologically fragile Amazonian and Cerrado (tropical savannah) regions. Changes in land use in these areas have contributed to increased erosion and poorer water quality. Soil management practices such as no-till, which are used in about 1/3 of Brazil's cultivated area, have been effective at reducing erosion and improving soil quality, but this technology has not been adapted for use in the humid tropics. In addition, it is important to consider that the tropical rainforest performs unique ecological functions and should not be converted to pasture or annual crops. This paper discusses the impact of the current trend in agricultural expansion in Brazil and reflects upon the probable impacts of climate change on land use in Brazil.

Keywords: Land use, No-till, Climate change.

Introduction:

Throughout human history, natural resources have been used to meet the needs of civilizations. At times this exploitation has been so intense that the civilizations engaging in it have entered into collapse (Diamond, 2007; Montgomery, 2007). In spite of these telling historical examples, humanity continues to reap nature's bounty without adequately planning for the needs of future generations. Factors such as population growth, excessive consumption on the part of those who can afford

it and widespread poverty partially explain this situation (UNEP, 2008).

One of the key indicators of inadequate use of natural resources has been the increase in soil degradation worldwide, affecting as much as 23% of the world's total cultivatable area (Oldeman et al., 1990). In Latin America and the Caribbean as a whole, about 14% of the cultivated area (243,000,000 ha) is considered to have been degraded, as has about 15% of the cultivated land in Brazil (Oldeman et al., 1991). Worldwide, the causes of degradation are related to deforestation, overgrazing, poor agricultural practices, firewood consumption, and urban and industrial growth (UNEP, 2002). In Brazil, land degradation is especially attributable to overuse and inappropriate soil management techniques (EMBRAPA, 2002). As a result of these factors, each year Brazil loses an estimated 600,000,000 t of topsoil (Bahia et al., 1992), leading to an economic loss of about 4 billion dollars per year (EMBRAPA, 2002). In addition to this important economic impact, there are more serious consequences associated with the loss of ecologic function in key biomes. This has been particularly true in the Central region of Brazil, which is currently undergoing the most rapid expansion in cultivated area. The Central savannah is the headwater for rivers that drain into the Amazon and the mammoth Pantanal wetland. Problems related to siltation of rivers and water pollution has been linked to erosion caused by cropping in the Central region (Bordas, 1996). More

recently, agriculture has begun encroaching into areas adjacent to the Amazon rainforest, a region of great ecological concern for the country and the world.

On the other hand, Brazil encompasses a vast geographic territory, much of which possesses cultivatable soils and sufficient water to make this country a major potential source of food, fiber and fuel for domestic use and export. Sustainable use of these resources, however, requires that measures be taken to insure adequate soil and water management and protection of ecologically sensitive areas. These issues become even more critical in light of anticipated changes in cultivatable area expected to occur in Brazil over the next decades as climate change sets. This paper provides a synthesis of existing documentation regarding land use in Brazil and discusses some of the challenges to be addressed so that Brazil can contribute sustainably toward meeting the needs of its people and the rest of the world.

Brazilian geography

The Brazilian territory is made up of 5 major ecological zones (Figure 1): the Amazon rainforest in the North (49% of territory), tropical savannah (the Cerrado) in the Central region (24% of territory), a semi-arid region called the Caatinga in the Northeast (10% of territory), a narrow strip of Atlantic Rainforest along the coast (13% of territory), sub-tropical savannah (the Pampa) in the South (2% of territory) and Weatland (Pantanal) in the Central region (2% of territory) . Climate varies from humid tropical, semi-arid, to sub-tropical at the higher latitudes. Soils vary according to the geologic, climactic and topographic conditions of each region, but are generally subjected to an intense weathering process that leads to a well-developed profile, low natural fertility, high aluminum content and good drainage. The main soil types present are FERRASOLS or Latossolos (Brazillian soil taxonomy) that represent 38.7% of the total area and PODZOLUVISOLS or Argissolos (Brazillian soil taxonomy) that represent 20% of total area. The Latossolos have excellent agricultural potential with appropriate addition of lime and phosphorus to correct fertility. The Argissolos also have good potential for agricultural use, but their higher clay content in the B horizon makes for slower movement of water through the profile. Soils in the semi-arid Caatinga region are less weathered and thus possess higher natural fertility.

Table 1 show that 65% of Brazil's 8,399,832 km^2 area is considered appropriate for tillage (Ramalho Filho & Perreira, 1992). It is important to note, however, that the methodology used in this survey evaluated only standard soil conditions and did not take into account other factors such as ecological importance or use restrictions due to indigenous reservations.

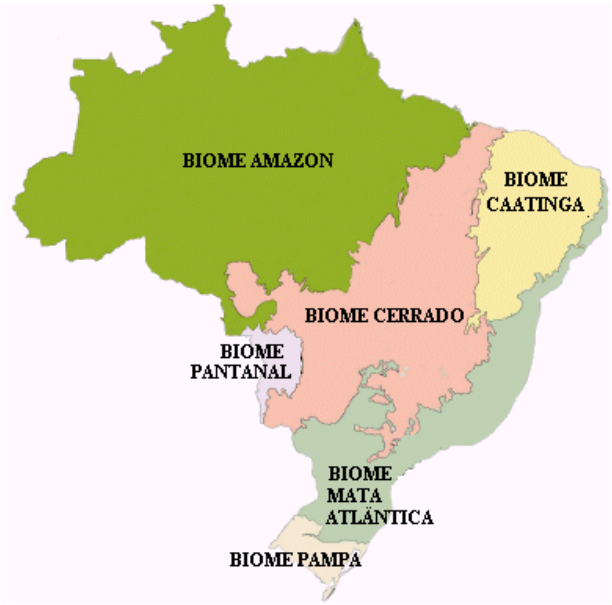

Figure 1 Brazilian biomes.
Source: (IBGE, 2004).

Table 1 Agricultural aptitude in Brazil

Territory	Crops	Improved pasture	Natural pasture/forestry	Conservation
			km^2	
North	2.792.644	288.139	13.770	457.770
Northest	793.159	112.191	462.967	168.427
Southest	565.741	140.425	136.470	80.174
Centerest	976.763	361.518	284.215	257.443
South	369.786	62.061	43.874	32.295
Total	5.498.093	964.334	941.296	996.109

Agricultural history of Brazil

The evolution of land use in Brazil has been marked by economic cycles that began shortly after the country's colonization in 1500. Initially, coastal areas were used for extraction of the pau-brasil tree (*Caesalpina achinata* Lam.), highly valued in Europe as a source for purple dye. Shortly after this period, sugar cane was introduced, using slave labor, mostly along the Northeast coast. Further exploration of the interior of the continent was motivated by the Portuguese colonizers' search for gold (18^{th} century), with introduction of livestock in the Cerrado and Caatinga regions on their heels. In the 1800's, Brazil's economy was dominated by coffee production, with most of the plantations located in the Southeast. Until this time, the biome most affected was the coastal Atlantic rainforest, which has been reduced to 7% of its original area. During the 19^{th} century, German and Italian immigrants settled in the South and began practicing subsistence agriculture. Also during the 19^{th} century, the Amazon became the focus of the rubber economy; however latex extraction occurred without significantly altering the rainforest environment.

Land use intensified in Brazil during the Green Revolution in the 70`s. Soybean production, stimulated by public policies in the form of subsidies and research grants, gained importance in the national economy. Soybean cultivation began in the South and expanded

northward toward the Cerrado. This period was marked by a process of rapid land degradation due to inadequate soil management based in practices introduced by European immigrants like intensively tillage the soil. Soil tillage and the use of burning to manage crop residues, combined with high tropical rainfall during the period of soil preparation favored the erosive process and consequent land degradation. By the end of the 1980s, changes in management began to be introduced, involving the use of crop rotation, cover crops, and minimum tillage systems. The widespread implementation of no-till agriculture was fundamental for stabilizing the intense soil degradation process in the South and Cerrado regions.

Evolution of land use in Brazil

Rural activities are practiced on 6 million farms in Brazil, representing 26% of the Gross Domestic Product and 37% of all employment. In addition, in 2007, agribusiness generated US$49.7 billion in exports, equivalent to 36% of external trade. Soybeans were responsible for US$11.4 billion, with meat (beef, pork and chicken) the second most important export (US$11.3 billion). Sugar cane also plays an important role in the economy, supplying 16% of the country's energy needs – more even than hydropower (14.7%). In addition to export agriculture, family farms that represent 30% of total farm land in Brazil produce 70% of domestic foodstuffs (Brasil, 2000).

Tables 2 show the areas under permanent and annual crops in Brazil. Soybeans and corn occupy the greatest area, with sugarcane and coffee being grown on 7 and 2 million ha of land, respectively.

Table 2 Cultivated area under different crops in Brazil

Cultures	Area (ha)
Soybean	20,581,334
Corn	13,817,340
Beans	3,833,552
Rice	2,895,122
Wheat	1,849,911
Sugarcane	7,052,466
Coffee	2,262,787
Cassava	1,912,925
Total	54,205,437

Given the economic importance of agriculture, Brazil has been undergoing a rapid expansion in agricultural area. Table 3 presents the changes in area under crops and pasture between 1970 and 2006. Over the past 10 years, there has been an 80% increase in crop area, especially affecting the Northeast region in areas considered viable for soybean production (Figure 2). Since the 1980s, the area under pasture has stabilized at around 170 million ha. However, when this data is examined by region (Figure 3), it becomes clear that there has actually been a 34% increase in pasture area in the North, with a corresponding decrease in the other regions. This leads to a troubling issue which has drawn considerable media attention: the expansion of agriculture into the Amazon. The trees are initially removed for lumber, followed by the introduction of livestock, after which the areas are abandoned for a while until finally planted with soybeans.

The Amazon is the largest remaining tropical rainforest in the world and thus its environmental value is incalculable. Under no hypotheses should it be considered as an option

for large-scale agro-pastoral production. Impacts such as loss of biodiversity (Brazil ranks 6th in loss of biodiversity), water resource degradation, carbon emissions due to deforestation (Brazil ranks second in deforestation), and negative climactic repercussions preclude any land use changes in the Amazon region.

Table 3 Evolution of land use in Brazil from 1970 to 2006

Land use	1970	1975	1980	1985	1995	2006
			(ha)			
Crops	33,983,796	40,001,358	49,104,263	52,147,708	41,794,455	76,697,324
Pasture	154,138,529	165,652,250	174,499,641	179,188,431	177,700,472	172,333,073
Total	188,122,325	205,653,608	223,603,904	231,336,139	219,494,927	249,030,397

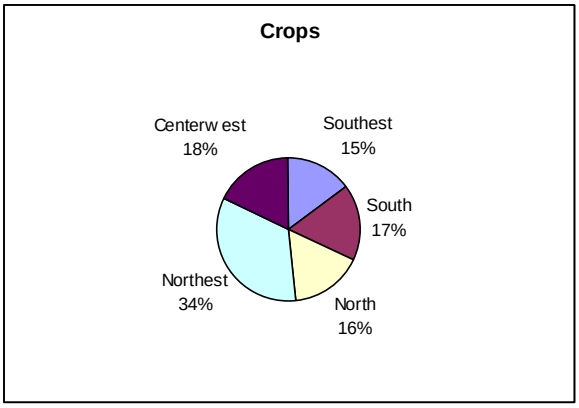

Figure 2 Changes in area under crops by region, over the past 10 years (1996-2006).

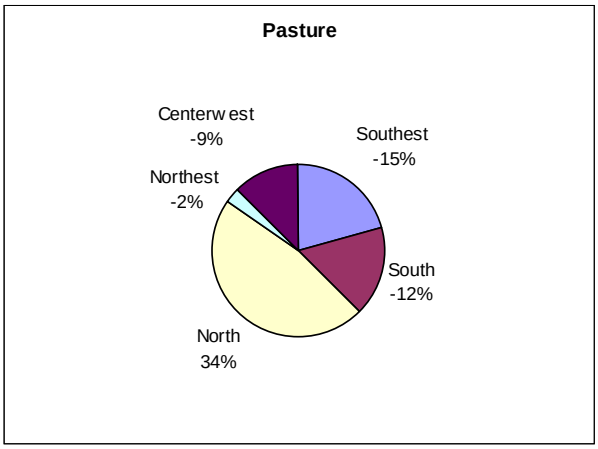

Figure 3 Changes in area under pasture by region, over the past 10 years (1996-2006).

Climate change and land use in Brazil

The anticipated impact on land use caused by climate change in Brazil was recently presented in a paper published by the Brazilian national agricultural research foundation (EMBRAPA) in conjunction with researchers at UNICAMP (EMBRAPA, 2008). This document uses climactic simulations carried out by CPTEC (the Brazilian Center for Forecasting and Climate Studies), based on two different scenarios proposed by the 4th IPCC

report, to present potential new geographical distributions of agriculture. The first scenario assumes an increase in 2-5.4 ^{o}C (scenario A) by 2100, while the second, more optimistic, anticipates an increase of 1.4-3.8 ^{o}C (scenario B) over the same period.

One of the main conclusions of this paper is that areas that currently produce grains, such as the South, will no longer be apt for this use due to drought. At the same time, it may become possible to produce tropical crops such as coffee and sugarcane in the South – crops currently not possible in this region due to frosts. Table 4 presents the key changes in dedicated crop area in Brazil based on the two climactic scenarios. For both scenarios, an overall reduction in area is expected for all crops except sugarcane. The area apt for soybean production may shrink by as much as 20%.

Table 4 Reduction in crop area considering scenarios A and B

Crops	Reduction in area considering scenario A	Reduction in area considering scenario B
	%	
Cotton	-11.0	-11.1
Rice	-8.6	-9.7
Coffee	-6.,7	-9.5
Sugarcane	170.9	159.8
Beans	-3.9	-4.4
Sunflower	-14.1	-14.2
Cassava	-2.5	-3.1
Corn	-12.2	-12.0
Soybean	-21.6	-23.6

Challenges and opportunities

Considering the current worldwide crisis in food production, the energetic possibilities represented by biofuels, the importance of the biodiversity present in Brazil's different biomes, Brazil's abundant water resources, and expected climate change, it is crucial that Brazil adopt policies that promote sustainable use of its natural resources. This requires land use planning on a national level. The post-dictatorship Brazilian constitution of 1985 stipulates that the federal government should designate agro-ecologic zones to determine appropriate land use. However, to date, this zoning process has only been completed in the case of sugarcane, due to intense domestic and international pressure related to concern over whether the expansion of sugarcane to meet demand for alcohol production was at the expense of area dedicated to food crops. Enforcement of zoning should theoretically be carried out by environmental protection entities; however this process is typically subject to intense political pressure from agro industries.

For areas that are already under cultivation, it is vitally important that Brazil adopt a nationwide program to expand positive experiences in soil management, such as no-till, which is currently used in 25 million ha. Brazil has 80 million ha of degraded pasture land which is in need of restoration, and which could potentially be used for grain, fuel and fiber production, rather than expanding into the virgin rainforest. Further study of the Amazon is necessary before this environment can be appropriately exploited for the good of the people who live there, for Brazilian society, and for humanity as a whole.

Conclusions:

Brazil is a country that possesses immense biodiversity and natural resources capable of producing tremendous amounts of food, fiber and energy. However, for this to be done sustainably, the government must be prepared to implement land use zoning on a national scale and other measures to preserve and restore agricultural land. This is necessary to conserve Brazil's environmental heritage and to minimize the negative impacts of anticipated climate change.

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