Methane to Markets Agriculture Subcommittee

01 December, 2006

Brazil Profile for Animal Waste Management

1. General view of the agricultural sector in Brazil

Agribusiness (summing inputs, agriculture, livestock, processing industry, distribution) represents 36% of the national Gross Domestic Product (GDP), 37% of all employment, and 43% of the national exports. Grain production was estimated at 98.5 million tons in 2005. Agriculture corresponds to 4.5% of the total Brazilian PIB and livestock to 6.8%.

According to the last agricultural census (IBGE, Agricultural Census, 95/96), Brazil presented a total of 41.7 million ha as cropped area. Out of this total, 7.5 million ha corresponded to permanent crops (coffee, citrus, etc.) and 34.2 million ha to temporary crops (soybean, maize, etc.). Pasturelands occupied a total of 177.6 million ha, where 78.0 million ha corresponded to native pasturelands (rangelands) and 99.6 million ha to planted pasturelands (most part covered with *Brachiaria* sp. grass) which had its area estimated in 60 million ha in 2005.

According to the IBGE census, there were in 1995/1996 4.9 million rural establishments in Brazil. Out this total 4.1 million correspond to the family agriculture share. The proportion area categories of establishments areas, in ha, is showed in **Table 1.** According to this census, establishments with less than 100 hectares accounted to 90.8% of the total unities, although controlling only 23.5% of the total area. From 1970 to 1995, it was observed a decrease in the proportion of the number of these establishments. Establishments with 1,000 ha and more accounted for 1% of the total unities, and 41.5% of the total area of establishments.

In Brazil, the agrarian structure is composed by two components: family and entrepreneurial agriculture systems. Family agriculture accounts to 33% of the agribusiness chains GDP while entrepreneurial agriculture accounts 67% (Ministério do Desenvolvimento Agrário - MDA, 2004). Recent study carried out by Fundação Instituto de Pesquisas Econômicas - FIPE (Economic Research Institute) and Ministério de Desenvolvimento Agrário – MDA (Ministry of Agrarian Development), showed that the participation of the family agriculture in the Brazilian agribusiness GDP in 2003 was 10.1%, with an increase of 9.37% in relation to the previous year (MDA, 2004).

Table 1 – Distribution of the number and area of agricultural establishments per size categories in Brazil
Source: Censo Agropecuário 1995/1996 (IBGE, 1998)

Categories of total area (ha)	Proportion of the number of establishments in 31 Dec		Proportion of the area of the establishments in 31 Dec	
	1970	1995	1970	1995
Less than 10	51.4	49.7	3.1	2.3
10 to less than 100	30.4	39.6	20.4	17.7
100 to less than 1000	8.5	9.7	37.0	34.9
1000 to less than 10000	0.7	1.0	27.2	30.6
10000 and more	0.0	0.0	12.3	14.5
Total	100.0	100.0	100.0	100.0

The most important agricultural commodities are soybean, sugar cane, coffee, fruits, milk, meat, wood, orange juice, tobacco, among others. Brazil accounts for 25% of the global exportation of sugar cane (gross and refined), is one of main exporters of soybean, and responsible for 80% of the orange juice.

Livestock activity

Bovine cattle:
Brazil has the world's second largest cattle herd with about 165 million heads (FNP, 2005), 16.3% of the world total (1,021 million heads) (**Table 2**). The main producing states are those of Middle-West Region (Mato Grosso do Sul, Mato Grosso and Goiás), followed by Minas Gerais and São Paulo (Southeast region), Rio Grande do Sul (South region) and Bahia (Northeast) states. **Figure 1** shows the herd population since 1912, and **Figure 2** shows the situation of the finishing practices in Brazil. The use of beef finishing techniques is increasing in the country, mainly in the Southern and Middle Western regions (**Figure 3**).

Table 2- Main world bovine herds.
Source: FNP (2005).

Country	**1996**	**2004**
	Heads (thousands)	
India	299,802	330,250
Brazil	**153,882**	**171,312**
China	110,318	138,712
U.S.A	101,656	94,725
European Union	84,526	86,305
Argentina	51,696	49,066
Australia	26,780	27,025
Rússia	35,800	20,995

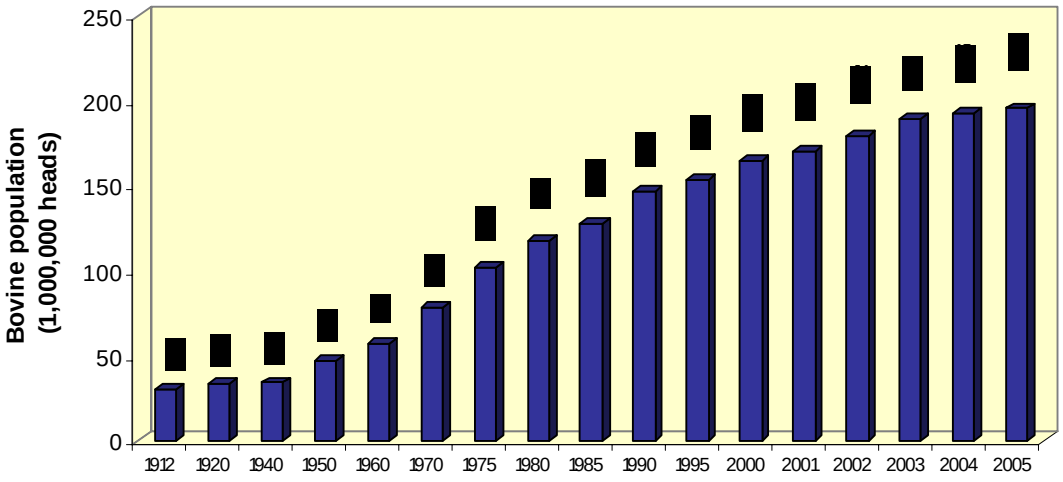

Figure 1 – Historical of the Brazilian bovine population.
Source: Anuário Brasileiro da Pecuária (2004, 2005), Anuário DBO (2005), CNA (2005), IBGE (2005), Visão Agrícola (2005).

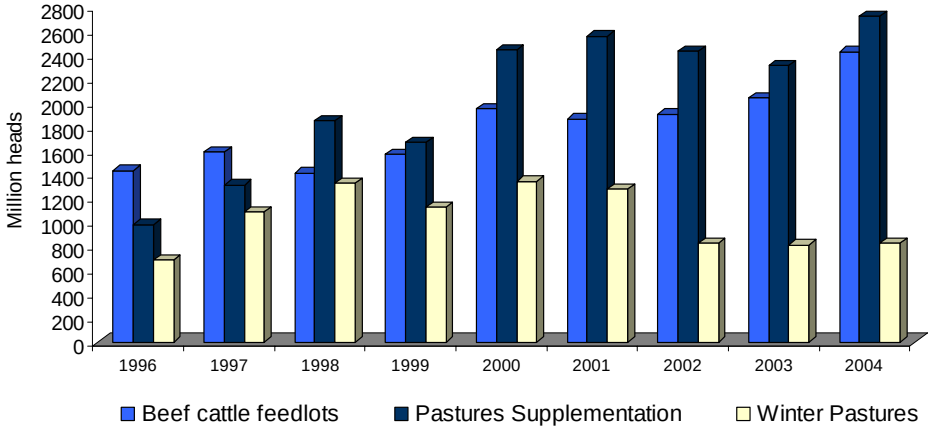

Figure 2 – Situation of the beef finishing techniques in Brazil (summing 4.4% of beef cattle population in 2004).
Source: FNP (2005).

Swine industry

The swine population was estimated at about 34.5 million heads in 2005 (FNP, 2005), being the Southern region the main producer state, accounting for 47.1% of the herd (16.5 million heads) and 80% (1.2 million tons of meat) of the national pork production. **Figures 4** and **5** show, respectively, the population of the swine herd in Brazil since 1990 and its distribution by region in 2005. In that year, around 2.6 million heads corresponded to sows.

In 1996, 95.8% of the herd corresponded to internal consumption and 4.6% to exportation while in 2005, 81.8% corresponded to internal consumption and 19.7% to exportation. Currently, it is the third swine herd in the world.

The swine industry represents an important activity with major social and economic benefits in Brazil, since it provides jobs in the rural and urban areas and generates income. Around 81.7% of swine are raised in 100 hectares farms. It is also estimated that there are around 30,000 establishments producing swine using intensive industrial production methods. Only in Santa Catarina state, this activity generates 18 thousand urban jobs and 30 thousand jobs in the farms (Gosmann, 2005).

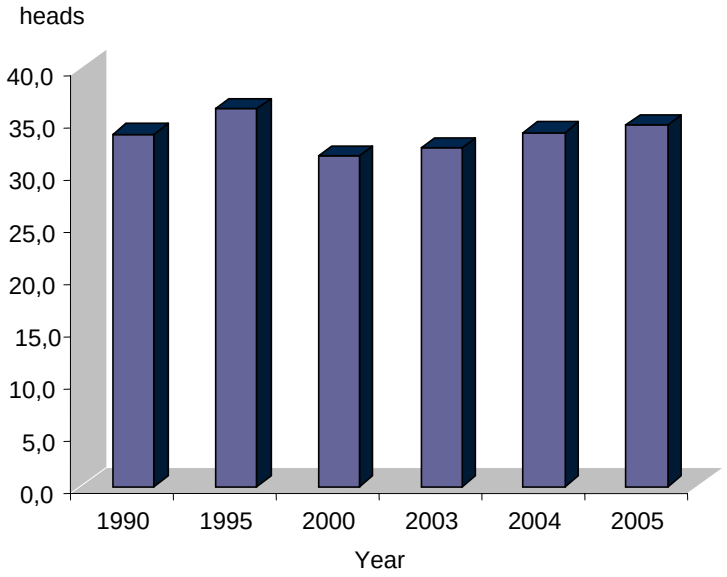

Figure 4 - Pork population in Brazil (FNP, 2005) (Note: projected number for 2005).

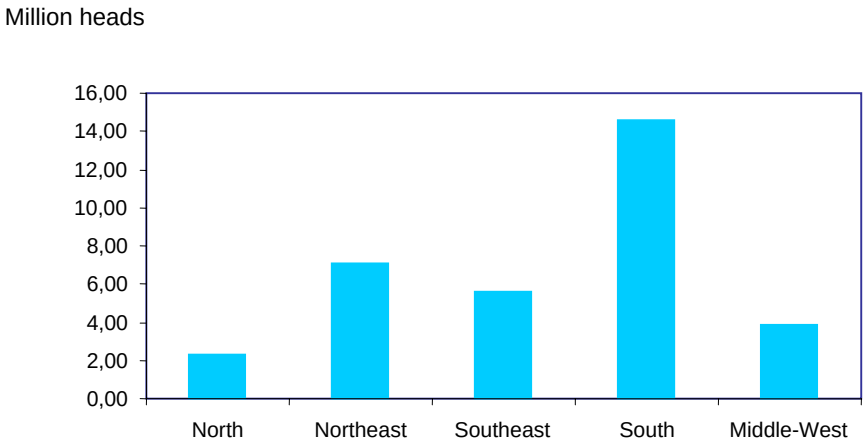

Figure 5 - Pork production by region (FNP, 2005)

According to Konzen (1983), an adult animal produces, on average, 0.27 m³ of liquid wastes per month. The increase of the swine industry, have been linked to several environmental impacts in the South Region, mainly in Santa Catarina, the main producing state in Brazil. There is no specific federal legislation dealing with swine wastes. However, it could be considered as a potent polluting activity, by affecting water resources quality in not acceptable levels, according to a federal law (Lei 9605/98 – Lei de Crimes Ambientais – *Environmental Crimes Law*).

2. Biogas production from animal waste management systems

Historical of swine wastes management systems

In the 1970's and 1980's, there was a strong interest in biogas production in the country, but the efforts undertaken were largely unsuccessfully. Incentives of federal programs with the agreement of state governments resulted in the implantation of hundreds of biodigesters in the Northeast and Southern regions. Several programs for diffusion of biodigesters were implanted in the Northeast and the expectation was very high, but the benefits of biogas and of the resultant biofertilizer were not enough stimulating to keep the continuity of those programs and the results were consequently unsatisfactory. By 1980's, in Paraíba State (NE region), around 200 digesters were installed in rural proprieties, through an agreement between EMATER (Empresa de Assistência Técnica e Extensão Rural)[1] and MME (Ministério das Minas e Energia). Currently, less than 5% are working and 96.9% of the owners do not intend to reactive their digesters. Similar programs were implemented in other regions, especially in the South region. In Santa Catarina state, e.g., around 700 digesters were installed, and mostly were not used later. The reasons for the stopping of using digester by farmers are attributed to the choice of badly dimensioned models, as well as the lack of knowledge and of technical accompanying (Kuntz, 2005). In the Indian model – the most diffused at that time – one of the problems is the cloche (*campânula*) of the gasometer, often manufactured in steel, which increases the cost and is easily oxidized, demanding constant maintenance.

Until 1996, in Santa Catarina state - the most important swine producing state, the destination of animal wastes was basically water bodies and agricultural soils, causing drastic water pollution and other environmental implications. In that year a regional program – Expansion of Swine Industry and Waste Treatment Program, coordinated by EPAGRI (Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina - a state agricultural research institute), was introduced for control of pollution by swine wastes produced, promoting new technologies to manage the wastes. With the increase of the technological level of swine industry, mainly by confinement, systems to treat swine wastes as the "*esterqueiras*" and "*bioesterqueiras*" were developed. These systems are deposits built to stock of liquid swine wastes, and dimensioned for a stocking period of 20 days, allowing a limited stabilization of the waste. They are daily supplied, keeping the material in fermentation until its removal.

Currently, anaerobic lagoons correspond to the baseline for CDM projects based on mitigation of

[1] EMATERs are statewide institutes with the aim of technically assisting rural producers.

greenhouse gases from animal wastes management systems. Nonetheless, many regions in Santa Catarina state still face environmental problems caused by the pollution of water bodies due to swine wastes.

More recently, the potential of the biogas utilization emerged again with economical and environmental proposals related to the opportunities of Clean Development Mechanism (CDM) projects in the South, Southeast and Middle-west regions of Brazil.

Biodigesters and biogas

Digesters (or *biodigesters*) have been used to supply biogas to rural areas, replacing the use of GLP, gasoline, wood, and other sources, for heating chicken farms, transportation, drying of grains, generation of energy, and other applications.

The most common biodigester used in the South of Brazil is the *Canadian* model. It has a digester cavity of 150 m^3, made with a blanket in PVC (0.8 mm), a hydraulic retention time about 30 days, a motor of internal agitation and a gasometer of PVC (1.0 mm) with capacity of 136 m^3, enough to treat wastes produced by a swine farm of 50 sows operated in a complete cycle. Gases are driven to a heat control device, for removal of water vapors. Volatile sulfides are then removed, and compressed to supply an oven, where biogas is utilized for heating poultry farm, domestic use, internal combustion motors, grain driers, etc.

Large scale biodigesters accounts to 500 m^3, using a minimum of 250 complete cycle sows or 7,000 finished animals/year. Indian and Chinese models are also used.

The **biogas** is composed of methane (55-65%, and 60%, on average), CO_2 (30-60%) and traces of H_2S and NH_3. The calorific power of biogas is 6 kW/m^3, and 1m^3 corresponds to 0,5 L of diesel or 0.7 L of gas oil. The potential biogas production by animal category in Brazil is indicated in **Table 3.**

Table 3 - Capacity of generating biogas from wastes by animal category

Animal category	m^3 biogas/ kg manure	m^3 biogas/ animal/day
Bovines	0.038	0.36
Swine	0.079	0.24
Poultry	0.050	0.014

Source: Embrapa Suínos e Aves (2005).

Main destination of biogas has been electric energy (generators) for rural proprieties (heating of poultry farms, water supply, drying of grains, etc.). Liquid residues are often used as bio-fertilizers. A study carried out by Hardoim et al. (2000) showed that 100 fedlot dairy cattle heads were able to produce 118 m^3 biogas/day (76,8m^3 of methane), using a Indian model digester, with a capacity to generate energy for several equipments in the farm. For a daily consumption of biogas (with 65% of methane), calculated in 117.58 kWh, it was estimated an extra volume of 32.7 m^3 of biogas. In that case, it was considered an amount of methane produced with a

hydraulic retention time of 24 days, corresponding 3.125 kg/m^3.day of organic charge (volumetric), an average temperature of 25ºC e no shake.

Costs include expenses to adapt and develop equipment for using biogas, due to the presence of water vapor, CO_2 and corrosive gases (use of filters, devices for cooling, condensation and washing).

Demand of biogas requires a minimum number of animals for a median or large digester. It implies more concentrated farms, industrialized production, and high technology. Additionally, it must be considered that the most part of the swine wastes are extremely liquid, with a low concentration of volatile solids, caused by the inputs of rain water, excessive washing of the stalls, consequently resulting in low efficiency systems.

An average scale biodigester (150m^3) accounts for US$ 12,839.82 (R$ 29.018,21) for the production of 50-70m^3 of biogas (reference year: November 2004), while a big scale biodigester (300m^3) accounts for US$ 17,699.11 (R$ 40.000,00). This price is usually high for smaller scale farmers, resulting that this technology is not yet accessible to these farmers.

Impacts of CDM projects

Recent approval of methodologies of baseline of CDM projects based on the reduction of greenhouse gas emission from swine wastes management systems, by using digesters with the capture of methane and generation of electrical energy, has had a positive impact on the swine industry in Brazil, especially in the South, Southeast and Middle-West regions, bringing incomes to the farmers and improving environmental quality in the producing areas.

Digesters installed by AgCert[2], one of the companies that develop CDM projects in Brazil, involve a stock of 300,000 animals, which together allow a removal of 3 million tons of methane per year. Each ton of methane would correspond to US$ 5.63 in the international market. AgCert builds the digesters and commercialize until 90% of the carbon credits generated.

The larger biodigester was installed in the Bom Despacho farm, in Minas Gerais state. That farm produces 12,500 m^3 of biogas per day, enough to generate 100 kW-hour. In Minas Gerais state, there are 300 biodigesters installed or ongoing, and together, can generate 60,000 to 70,000 kW-hour by using the biogas.

It is estimated a total of 2.5 million of sows in Brazil (FNP, 2005), with a slight decrease of 11% since 1996, although the total swine herd have increased in 18% in this period. Also, studies indicate that the pork meat production could increase 18% until 2010, considering a maintenance scenario (Wedekin et al., 2002). Only in Santa Catarina state, with 16% of the Brazilian herd, it is estimated 5.7 million swine heads (FNP, 2005), being around 331.3 thousands, with a potential production of 79,000 thousand m^3 of biogas/day.

[2] **AgCert** is a company headquartered in Dublin, Ireland, which develops CDM greenhouse gas emissions reductions activities in Brazil, Mexico, Argentina and Chile. It is responsible for the baseline methodology AM0016 (Greenhouse gas mitigation from improved Animal Waste Management Systems in confined animal feeding operations). Other CDM projects developing companies include EcoSecurities and Sadia Institute.

Some environmental impacts related to the digesters still requires studies, e.g. those related to the residues used as fertilizer in croplands, with possible impacts in N cycle and soil pollution. Greenhouse gas flux balance in the soil-plant-atmosphere system is not adequately known in the areas where bio-fertilizers resulting from the biodigesters are applied.

Co-benefits of CDM projects: Besides mitigation of greenhouse gases by installing anaerobic digesters and capturing the methane from decomposing manure, CDM projects have generated a set of co-benefits to the regions involved, as following:

- generation of an additional source of revenue with the C credits,
- reduction of environmental contaminants by waste water run off, pathogens and diseases related to the precarious animal waste management systems,
- environmental and economical valorization of the swine industry,
- potential for electricity production,
- utilization of the resultant bio-fertilizer into agricultural lands.

From the analysis above, there is a good potential to use methane produced from the livestock sector as a renewable energy source, but this will depend on the maintenance of the private interest, e.g. through CDM projects, or stronger legal requirements, as well as on the technological improvement of digester system. In the past, the failure in keeping the use of digesters occurred partially because the rural community and industry was not prepared to this technology, which, by this turn, was not enough attractive and functional to guarantee its regular use.

3. Summary of emissions and characterization of the animal waste management sector

3.1. Annual GHG emissions inventory

Brazilian GHG Inventory refers to the years 1990 and 1994. Agriculture accounted, in 1994, for 369.311 million metric tons CO_2 equivalent ($MMTCO_2e$) in Brazil, out a total of 1,388,783 $MMTCO_2e$ from all sources, including LUCF activities (UNFCCC, 2005). Comparative values among countries of non-Annex 1 are showed in **Table 4**. The main GHGs in the agriculture source are methane and nitrous oxide. In the **Figure 6** it is showed the contribution of the sectoral activities to the methane emissions in Brazil. Methane and nitrous oxide emissions from agricultural sector in Brazil (1994 as the reference year) are showed at **Table 5**, in Gg and $MMTCO_2e$, as well as the percentage of emission by each source.

Table 4– GHG emissions from agricultural sector in non Annex 1 countries, in 1994.
Source: UNFCCC (2005)

Non Annex 1 Country	Sector		
	Agriculture	LUCF	Total

	Million metric tonnes CO_2 equivalent ($MMTCO_2$ e)		
Brazil	369.311	818.080	1,477.056
Mexico	39.463	141.538	524.615
Argentina	115.450	-34.179	229.700
Chile	13.156	-27.133	27.527
China	604.776	-407.479	3.649.827
South Africa	35.456	-18.616	361.221
India	344.485	14.292	1,228.540

* reference year: 1990

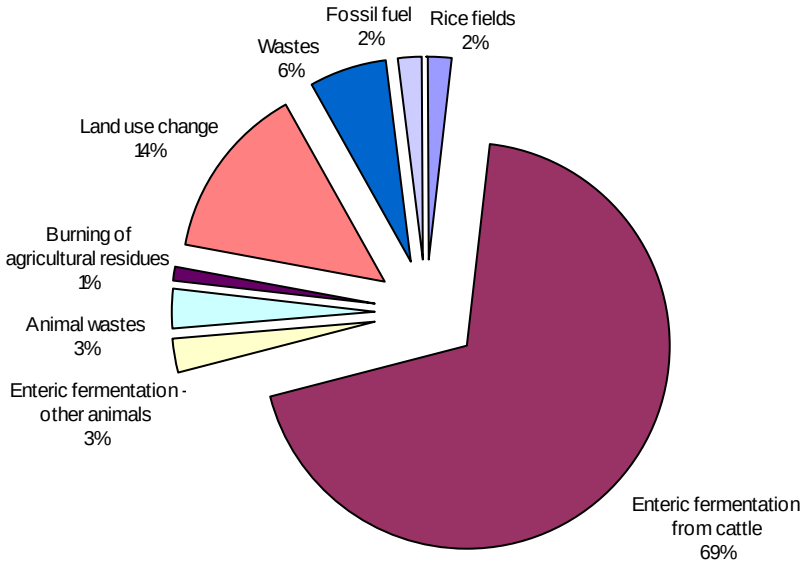

Figure 6 - Methane emissions from economic sectors in Brazil in 1994
Source: Brasil-MCT (2004)

Table 6 - GHG emissions from agricultural activities in Brazil, 1994
Source: Brasil-MCT (2004)

Anthropogenic sources	**CH_4**		**N_2O**	
	Tg	$MMTCO_2e$	Tg	$MMTCO_2e$
Flooded rice crops	0.283 (2.1%)	5,943	-	-
Livestock				
Enteric fermentation	9.377 (71.2%)	196.917	-	-
Animal wastes	0.368 (2.8%)	7.728	0.020 (3.7%)	
Burning of agricultural residues	0.133 (1.0%)	2.793	0.007 (1.2%)	2.17
Agricultural soils	-	-		
Grazing animals	-	-	0.219 (39.7%)	67.890
Synthetic fertilizers	-	-	0.021 (3.8%)	6.510
Aplication of animal wastes in soils	-	-	0.013 (2.4%)	4.040
N biologic fixation	-	-	0.026 (4.8%)	8.060
Agricultural residues	-	-	0.043 (7.8%)	13.330
Organic soils	-	-	0.023 (4.1%)	7.130
Indirect emissions	-	-	0.132 (24.0%)	40.940
Total of agricultural sources	**10.161 (77.1%)**	**213.381**	**0.503 (91.5%)**	**155.93**
Total in the country	**13.173 (100%)**	**276.633**	**550 (100%)**	**170.500**

3.2. National and regional methane emissions for animal waste management systems by type of system and animal type

As indicated in **Table 5**, enteric fermentation is the main methane source in Brazil. For that reason we have focused our analysis on methane from livestock and animals wastes.

96% of the total methane emission is assigned to the livestock (enteric fermentation and animals wastes), mainly bovine (**Figure 7**). Other 3% corresponds to the flooded rice cultivation and 1% to the burning of agricultural residues. In the **Figures 8** and **9** are showed the proportion of methane emissions from enteric fermentation and animal wastes by animal category, respectively.

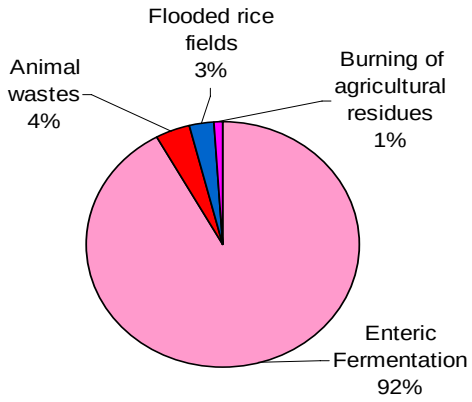

Figure 7 - Methane emission from agricultural sources in Brazil, in 1994.
Source: Embrapa (1999).

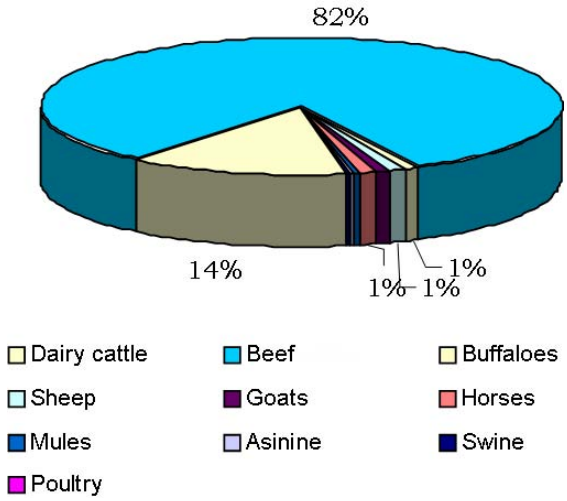

Figure 8 - CH_4 emission from enteric fermentation (% per animal category)
Source: Embrapa (1999).

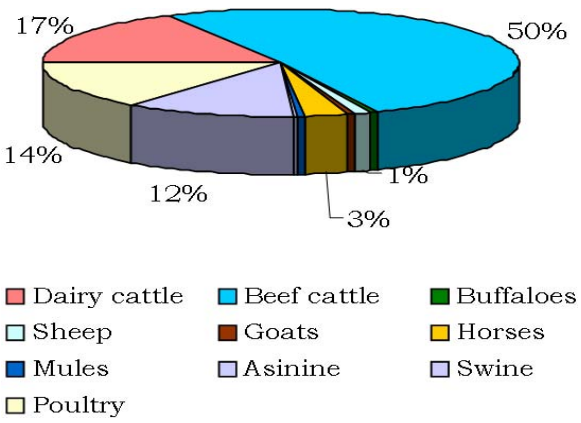

Figure 9 - CH_4 emission from animal wastes (% per animal category).
Source: Embrapa (1999).

Animal waste management practices

The percentages of animal waste management practices are presented in Table (Brasil, 2004).

Table 4 - Waste management systems according to type of animal, in 1994
Source: Brasil, 2004

Management System	Region	Category of animal					
		Dairy Cattle	Non – Dairy Cattle	Swine	Sheep	Poultry	Others
		Fraction (AWMS)					
Pasture	Brazil	0,45	0,97	0	1,00	0	0,99
Solid Storage	Brazil	0,20	0,03	0	0	0,20	0
Liquid system	South	0,05	0	0	0	0	0
	Brazil	0,03	0	0	0	0	0
Anaerobic lagoon	South	0	0	0	0	0	0
	Brazil	0,01	0	0	0	0	0
"Daily spread"	Brazil	0,20	0	0,20	0	0,80	0
Other systems	South	0,10	0	0,80	0	0	0,01
	Brazil	0,11	0	0,80	0	0	0,01

Key stakeholders in the animal waste management sector

The stakeholders in the animal waste management sector in Brazil are composed by farmers, farming organizations (mainly in the Southeast and Southern regions) or cooperatives, local environmental and sanitary organizations, environmental lawyers, researchers/academics (e.g. from Embrapa Swine and Poultry, UNESP-Jaboticabal, Epagri), and consultants, agencies involved in development of CDM projects (e.g. Agcert, Ecosecurities)

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Information on methane recovery potential

Currently, there are not available statistics on the technical and economic potential for methane recovery and use from animal waste management systems in Brazil. According to an agricultural survey performed in 1995/1996 (LUPA, 1997), the use of digesters was registered only in less than 1% in São Paulo state, one of the most developed states in Brazil. A new national agricultural census, to be carried out by IBGE (Brazilian Geography and Statistics Institute), has just started and will generate information on the use of animal wastes at farm level. This census will be probably published in the end of 2008.

Challlenges and/or priorities to greater methane recovery and use

Some challenges have already been discussed in former topics, like the improvement of equipments to combat corrosion, reducing the amount of water in the wastes, among others.

International Energy Agency (IEA) indicates that 35,9% of the energy generated in Brazil is based in renewable sources, while in the world this value would be 13,5%. With the increase of internal and external interest in substituting fossil fuels by biomass-energy, some recent initiatives have been delivered by the government, with emphasis in the alcohol and biodiesel production. Also, it was recently launched the National Plan of Agroenergy, from the Ministry of Agriculture and Food Supply (MAPA), which indicated a number of strategic actions for this sector (Embrapa, 2006). Beyond the improvement of the technology and expansion of ethanol production as well as of biodiesel, are also included strategies related to biogas production and animal waste management systems.

Strategies for biogas production:

- to develop systems to compress and stocking biogas,
- to evaluate the use of biofertilizer (digestate) as organic manure
- to develop equipments for the use of biogas as source of heat
- to develop equipments to the transport and distribution of biofertilizer
- to improve equipments moved by biogas for the generation of electric energy
- to develop processes of biogas purification

Also, research is being encouraged for the improvement of the efficiency of biogas generation, e.g. for:

- offering new models of digesters with thermic isolation, shaking, and heating of biomass, in order to increase the biogas production and to improve the efficiency of the remotion of organic matter

- evaluation of the use of biodigesters as unit of treatment of residues from swine and poultry farms, eliminating sanitary problems
- development and evaluation of complementary systems for the final treatment of liquid residues from biodigester
- evaluation off quantitative and qualitative characteristics of the biogas considering the effect of the climatic seasonality and animal production systems
- evaluation of the use of the fertilizers, as organic manure.
- development of equipments related to the generation, stocking and distribution of biogas

In relation to the "vinhaça", residue resultant from the production of alcohol, it is known that its energetic use is possible by the anaerobic digestion and of the production of biogas. Currently, its main destination is the ferti-irrigation of the surrounding sugarcane crops. The calorific power of that biogas was estimated in 21,32 J/m^3, which explain the interest in the production of biogas by the digestion of "vinhaça". Some problems are indicated, e.g., the corrosive effects of biogas in the equipments, stability of digestion due to the oscillation of the amount and quality of material processed.

List of existing or planned methane capture and/or use projects
See the topic Financing options.

Market assessment and reform issues
Survey not performed.

Financing options (characterize):
There are some federal (sectoral funds - FINEP) and state (e.g., FAPESC-Santa Catarina) funds addressed to projects which involve the development of technologies related to the reduction of greenhouse gas emission and generation of clean energy.
In terms of CDM projects in a national level, the projects involving the capture of methane (from agriculture and landfills specially) still represent a minor part (around 5%). The majority of the project activities developed in the country is in the energy sector, with CO_2 being preponderant in the Brazilian emissions reduction. According to MCT (2006), the scopes that will reduce more tons of CO_2e are landfill and reduction of N2O, with a total of 111 million tCO_2e to be reduced during the first crediting period, representing 61% of the total emission reduction of Brazilian project activities. The projects involving methane (17) recovery under Validation/Approval Process represent 5% of the total, being responsible for only 2% (553,111 tCO_2e) of the annual emission reduction provided by all the projects (24,9 million tCO_2e).

Current cooperation among countries or non-governmental organizations
CDM projects involving the use of animal wastes for reducing methane emissions, especially from swine industry, have been developed with partnerships with Agcert and Ecosecurities.

Other issues related to animal waste management
Analysis on costs and benefits of methane recovery and use from animal waste management are

scarce. There are, however, some specific papers indicating comparative costs of different waste management systems oriented to the biogas production (Hardoim et al., 2000; Silva et al., 2005).

Conclusions and Observations

State legislation and national programs could create opportunities of accessibility to biodigester technology by smaller scale farmers. In that sense, a program has been introduced recently by the Secretaria de Meio Ambiente e Recursos Hídricos do Estado de Santa Catarina (Environment and Water Resources Secretary of Santa Catarina State), through the PNMA II – Programa Nacional de Meio Ambiente II (Environment National Program), involving 34 small swine farmers (productions until 300 animals), with a total of 11,000 animals. The pilot-project of this program proposes the management of animal wastes and its conversion to biogas, aiming the control of water contamination and incomes to the farmers by selling of carbon credits.

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