
Environmental sustainability of sugarcane ethanol in Brazil

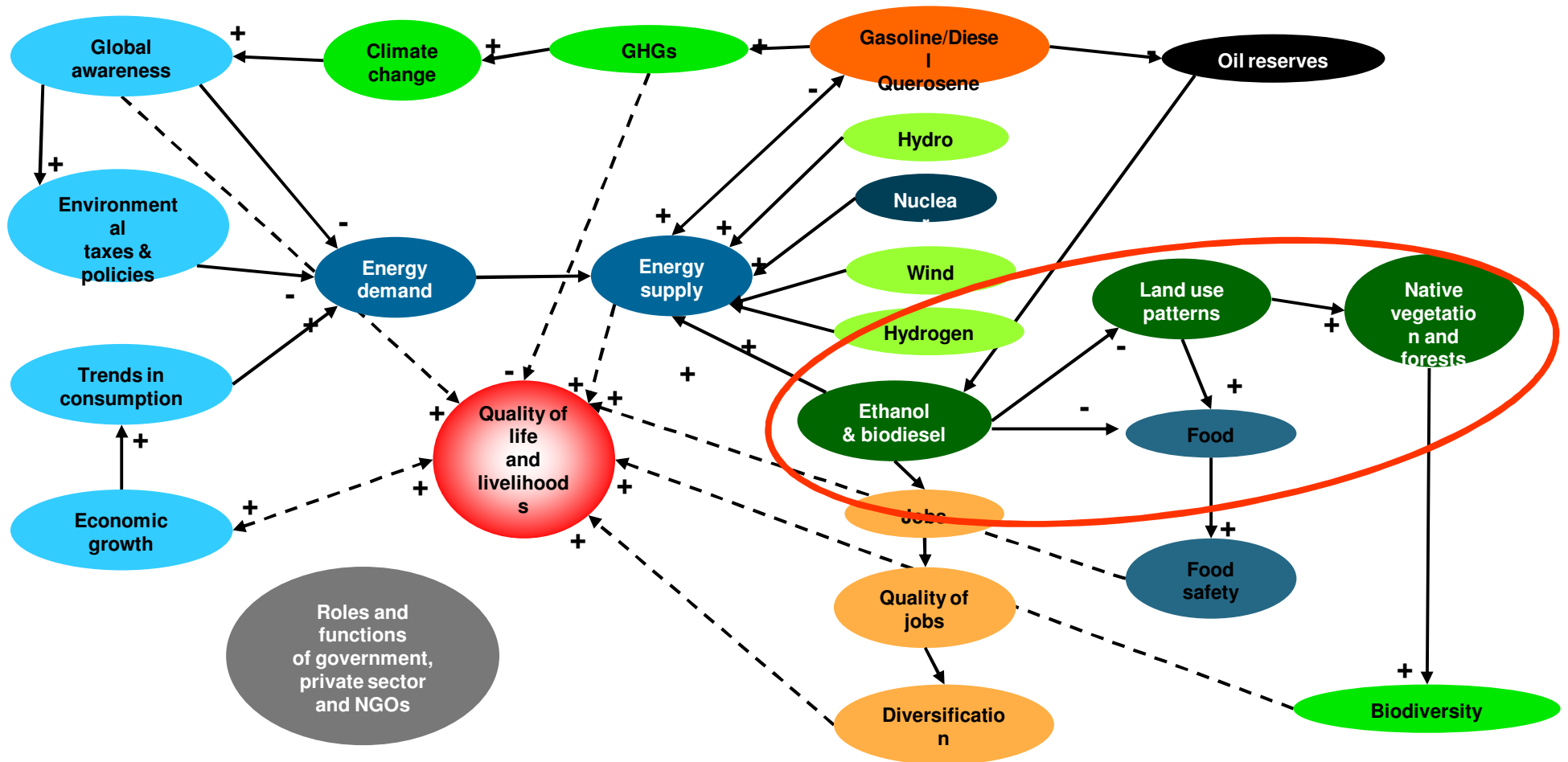
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Summary

- ❑ The Brazilian environmental legal frameworks
- ❑ Key environmental indicators: carbon, water, soil, agrochemicals, biodiversity,
- ❑ Biofuels certifications regimes and compliance
- ❑ The future steps and the role of innovation

Biofuels framework - understanding key drivers of energy supply and demand



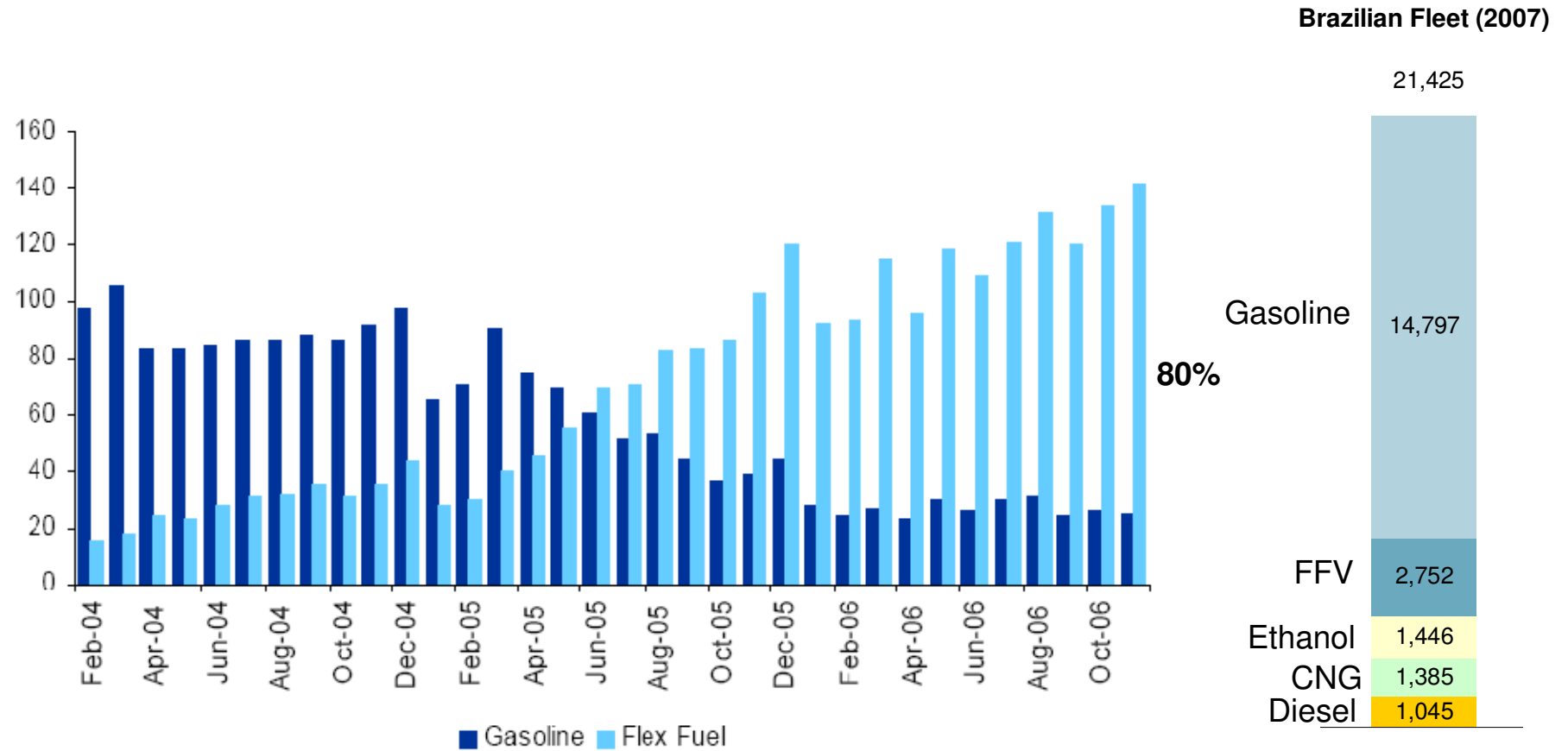
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Future projections of ethanol production in Brazil and challenges for sustainable expansion

	2007/08e	2015/16	2020/21
Sugar cane Production (M-ton)	493	829	1,038
Area (M-ha)	7.8	11.4	13.9
Sugar (M-ton)	30.8	41.3	45
Internal	12.2	11.4	12.1
Export	18.6	29.9	32.9
Ethanol (B-liters)	22.5	46.9	65.3
Internal	18.9	34.6	49.6
Export	3.6	12.3	15.7
Bioelectricity (GW average)	1.8	11.5	14.4

Flex fuel cars account for more than 80% of total cars produced in Brazil

Evolution of light vehicles production and Total Brazilian Fleet – ‘000 vehicles

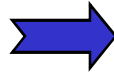


Source: ANFAVEA; VPB estimates

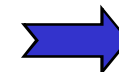
Sugarcane value chain



7,2 million ha
72 thousand growers



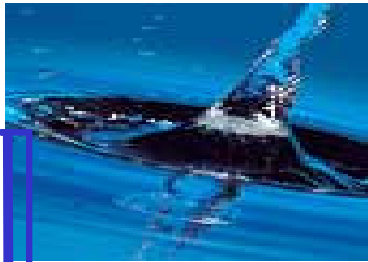
Harvest
500 M tons



ca. 400 mills & destillaries



Ethanol
22 billion liters



Ethanol

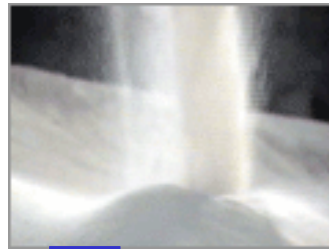


Food



Cosmetics & Pharmaceuticals

Sugar
30 million tons

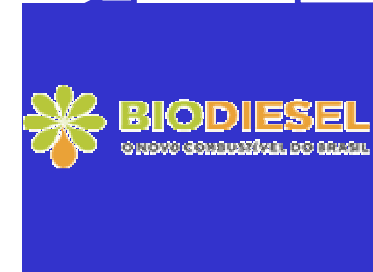
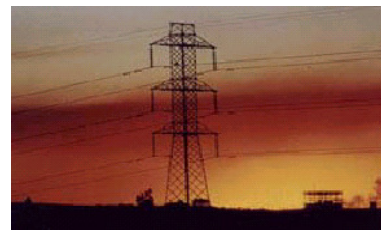


Derived products



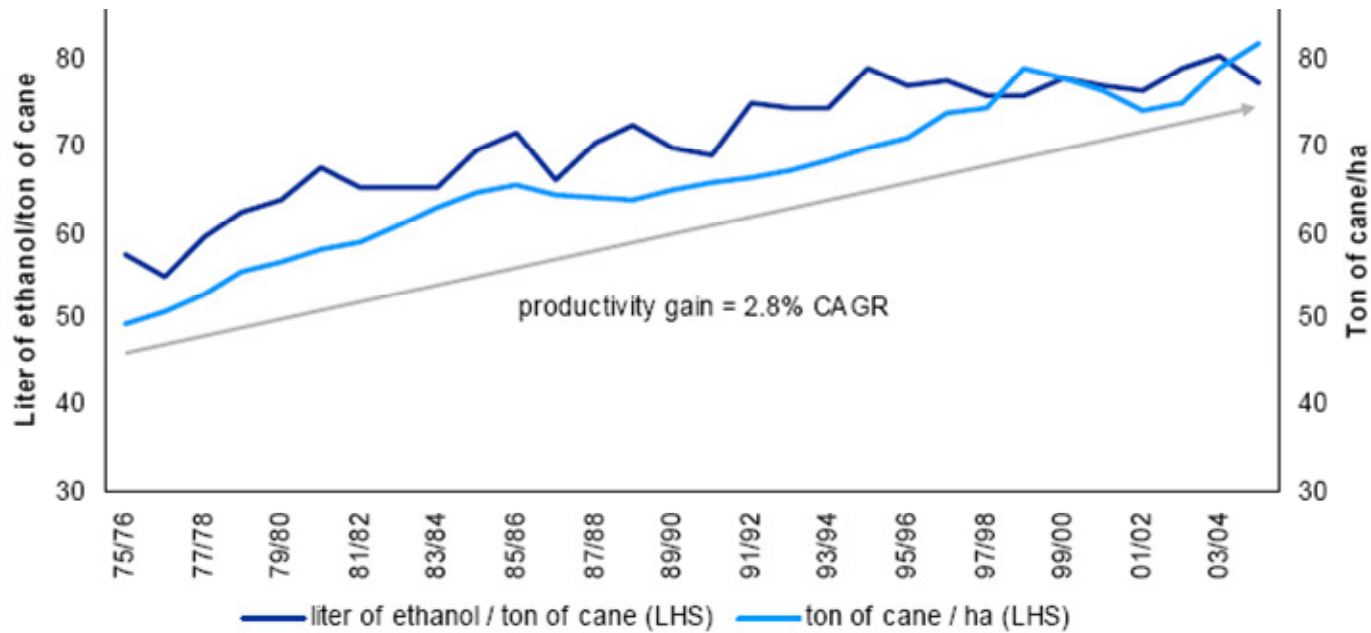
Lysine

Bagasse
125 M ton



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Evolution of productivity of Brazilian ethanol:
 continuous investment in R&D – mainly in the public domain



2. The Brazilian Environmental Legal Frameworks

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Brazilian environmental legal frameworks and zoning policies related to sugarcane

Law	Objective	P.S.
No. 4,771, September 15th, 1965	Forest Code	Permanent preservation areas
No. 997, May 31st, 1976	Environment Pollution Control	Environmental Permission
Portaria do Ministério do Interior No. 323, November 29th, 1981	It prohibits release of vinhoto in the water	
No. 6,938, August 31st, 1981	Environment National Policy	Mechanisms and instruments (environmental zoning, Environmental Impact Assessment)
CONAMA deliberation No.001/7986	General Guidelines for the Evaluation of Environmental Impact	For "industrial complex and units and agro-industrial"
No. 6,171, July 04th, 1988	The use, conservation and preservation of agricultural soil	
No. 11,241, September 19th, 2002	Gradual elimination of burning the straw of sugar cane	Elimination of the use of fire as a unstraw method and facilitator of cutting the sugar cane
No. 12183/05	Use of water charge	
No. 50,889, June 16th, 2006	Legal Reserve of landed property in the State of Sao Paulo	Obligation of reserving an area equivalent to 20% of each rural property
SMA deliberation 42, October 14th, 2006	Environmental prior license to distilleries of alcohol, sugar plants and units of production of spirits	It defines criteria and procedures
Deliberation No. 382, December 26th, 2006	It sets the maximum emission of air pollutants to sources.	Annex III: Emission limits for air pollutants from processes of heat generation from the external combustion of sugar cane's mulch
Agricultural and Environmental Protocol of sugar/ethanol industry	Prominence to anticipate the legal period to the end of the harvest of sugar cane with the previous use of fire in the areas cultivated by plants	Government of the State of São Paulo and UNICA
Elimination intentions of burning sugar cane in the ethanol/sugar sector of Minas Gerais protocol	Removal of burnt by 2014	SIAMIG/SINDAÇÚCAR-MG and Government of the State of Minas Gerais

3. Key environmental indicators

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Soil carbon stocks for different land uses

Biomass	Carbon stocks in soil (Mg/ha)	Reference
Campo Limpo – Grassland Savannah	72	Lardy et al (2001)
Sub-tropical Forest	72	Cerri (1986)
Tropical Forest	71	Trumbore (1993)
Natural pasture	56	Jantalia (2005)
Soyabean	53	Campos (2006)
Cerradão – Woody Savannah	53	Lardy et al (2001)
Managed pasture	52	Rangel & Silva (2007)
Cerrado – Typical Savannah	46	Lardy et al (2001)
Sugarcane without burn	44	Estimated - Galdos (2007)
Degraded pasture	41	d'Andréa et al. (2004)
Corn	40	d'Andréa et al. (2004)
Cotton	38	Neves et al. (2005)
Sugarcane burned	35	Estimated - Galdos (2007)

Source: In the table directly

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Above ground carbon stocks for different land uses (in the biomass)

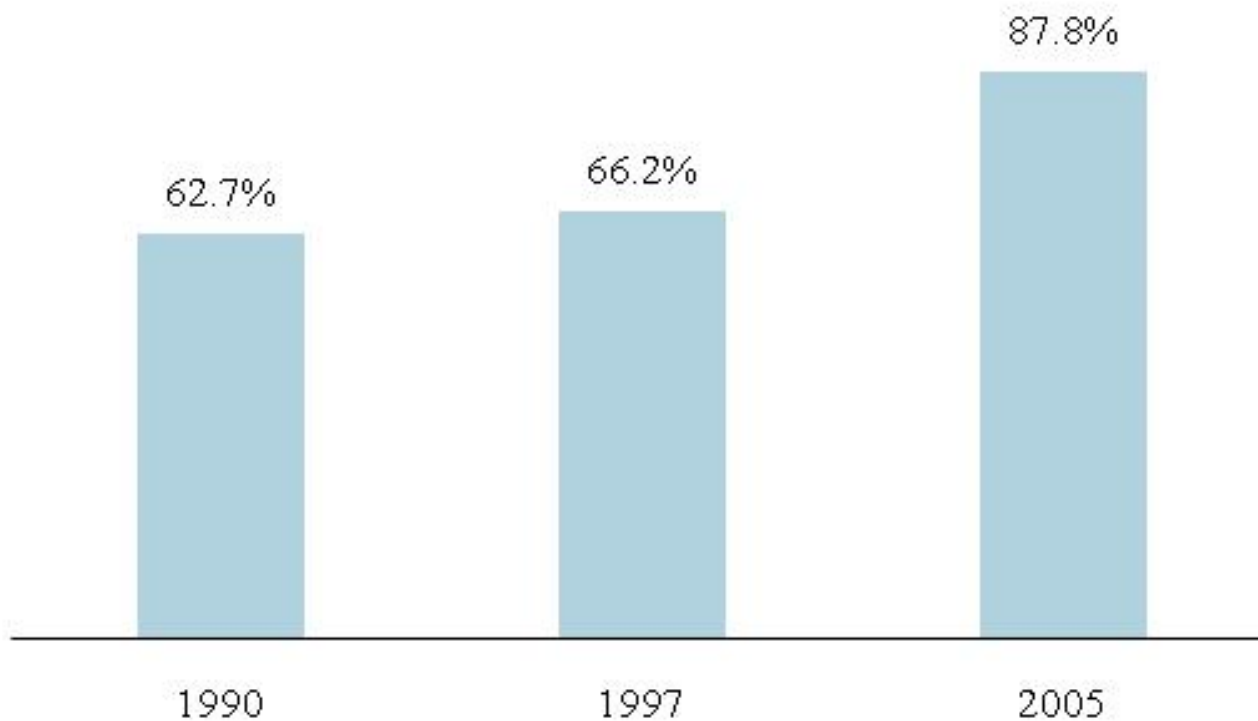
Biomass	Carbon stocks in biomass (Mg/ha)	Reference
Tropical rain forest	200.0	INPE
Cerradão – Woody Savannah	33.5	Ottmar et al. (2001)
Cerrado – Typical Savannah	25.5	Ottmar et al. (2001)
Sugarcane without burn	17.5	Estimated
Sugarcane burned	17.0	Estimated
Campo limpo – Grasland savannah	8.4	Ottmar et al. (2001)
Managed pasture	6.5	Estimated - Szakács (2003)
Corn	3.9	Estimated - Titon et al. (2003)
Cotton	2.2	Adapted - Fornasieri & Domingos (1978)
Soybean	1.8	Adapted - Campos (2006)
Degraded pasture	1.3	Estimated - Szakács (2003)

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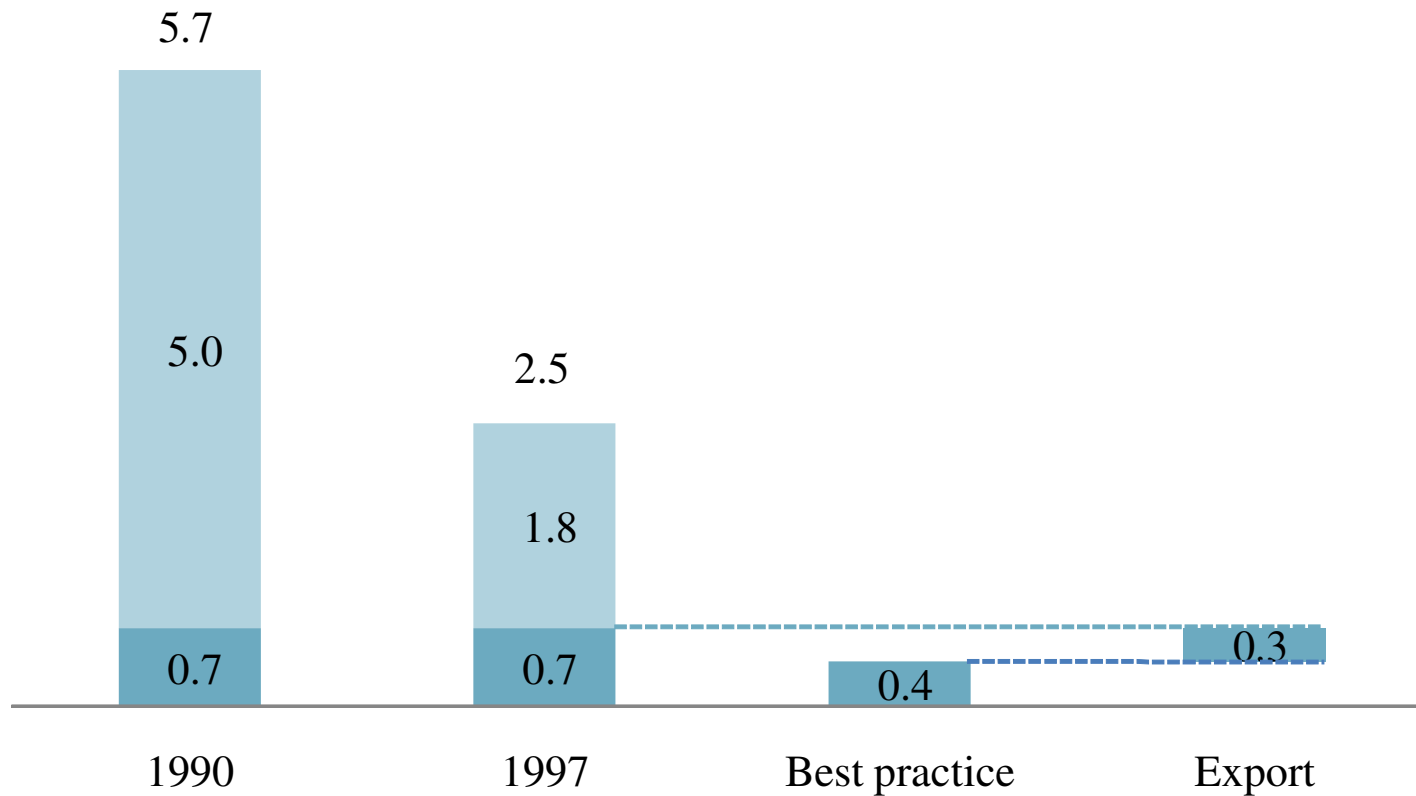
Carbon balance under different land uses replaced by unburned sugar cane – 61,8 MgC/ha

Biomass	Total carbon stocks (Mg/ha)	Carbon balance due to sugarcane replacement (Mg/ha) *
Cotton	40.1	21.8
Degraded pasture	42.0	19.8
Corn	44.1	17.7
Sugarcane burned	52.1	9.7
Soya	54.9	6.9
Managed pasture	58.5	3.3
Cerrado – Typical Savannah	71.5	-9.7
Campo Limpo – Grassland Savannah	80.4	-18.6
Cerrado – Woody Savannah	86.5	-24.7
Tropical forest	271.0	-209.2

Evolution of water recycling in percentage



Evolution of water consumption in the industry (m3 water/ton of sugarcane processed)



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Losses of soil and water for selected crops

Annual Crop	Losses	
	Soil (t/ha-year)	Water (%rain)
Castor	41.5	12.0
Beans	38.1	11.2
Manioc	33.9	11.4
Peanut	26.7	9.2
Rice	25.1	11.2
Cotton	24.8	9.7
Soybean	20.1	6.9
English Potato	18.4	6.6
Sugar Cane	12.4	4.2
Corn	12.0	5.2
Corn + Beans	10.1	4.6
Sweet Potato	6.6	4.2

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Agrochemical inputs consumption/ha and per ethanol production (M3)

	Sugarcane		Corn	
	Cons. /ha	Cons./M3	Cons. /ha	Cons./M3
Ethanol production (M3)	8.06	-	4.15	-
Quantity of N (kg)	25.00	3.10	140.00	33.73
Quantity of P (kg)	37.00	4.59	100.00	24.09
Quantity of K (kg)	60.00	7.45	110.00	26.50
Correction (kg)	600.00	74.49	500.00	120.45
Herbicide (liters)	2.58	0.32	13.00	3.13
Drying hormone (liters)	0.40	0.05	-	-
Insecticides (liters)	0.05	0.01	2.17	0.52
Formicide (kg)	-	-	0.50	0.12
Nematicide (liters)	1.20	0.15	-	-
Total	726.23	90.16	865.67	208.54

2,4 times less inputs than corn

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Sugarcane production and forest cover in Sao Paulo State

Year	Sugar Cane					Vegetation			% SP State	
	New lands (Kha)	Land in use (Kha)	Total area (Kha)	Production (KTon)	Productivity (ton/ha)	Woody - Cerradao (Kha)	Schrruby - Cerrado/savana (Kha)	Native forests (Kha)	Sugar Cane Area	Native Forests Area
1983	345	1.421	1.765	107.987	76,0	196	489	1.139	7%	5%
1985	326	1.626	1.952	121.335	74,6	221	438	1.545	8%	6%
1987	311	1.753	2.064	132.322	75,5	211	348	1.870	8%	8%
1989	322	1.757	2.078	130.795	74,5	198	325	1.487	8%	6%
1991	301	1.864	2.165	144.581	77,6	198	301	1.601	9%	6%
1993	371	1.989	2.360	156.623	78,7	238	259	2.120	10%	9%
1995	449	2.260	2.709	175.073	77,5	189	220	2.434	11%	10%
1997	422	2.451	2.872	194.801	79,5	215	244	2.478	12%	10%
1999	281	2.475	2.756	193.374	78,1	218	244	2.468	11%	10%
2001	440	2.569	3.009	201.683	78,5	223	262	2.622	12%	11%
2003	495	2.818	3.313	227.981	80,9	225	264	2.720	13%	11%
2005	553	3.121	3.673	254.810	81,7	217	254	2.648	15%	11%
2007	935	3.897	4.832	327.684	84,1	233	277	2.716	19%	11%

5. The role of S&T and innovation

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New technologies and innovation

- Improving the productivity at agricultural and industry levels
- Optimizing the use of feedstock: second generation - ligno-cellulosic materials
- Reducing waste
- Adding value to ethanol co-products
- Moving towards the full deployment of ethanol chemistry and biorefineries

Brazilian frameworks supporting S&T&I in bioethanol

- Long history of investments in the public domain in ethanol research - ca. US\$ 2 billion – 30 years
- **Agencies**
- Federal level -
- Ministry of Science & Technology - Agencies – CNPq and FINEP
- Ministry of Education - CAPES
- State level – SP - the case of FAPESP
- **Frameworks for innovation**
- Innovation law in BR – being implemented – facilitate interactions between academia and private sector

Players and investments in sugarcane & ethanol R&D in Brazil.

Crops and biofuels R&D initiatives and experience

- More than 15 universities, 14 research centers and 150 researchers focus on biofuels in only one initiative (Bioetanol project) – Federal level
- The sugarcane technology centre - CTC - more than 300 people work in R&D activities
- Efforts are made to share knowledge between universities and research centers (ex: Bioetanol project, The Bioenergy Public Policy Project - FAPESP)
- International participation in R&D initiatives (Bioethanol Project, Oxiteno, Votorantim)
- Country is a world leader in the production of sugarcane plants capital goods (ex: Dedini)

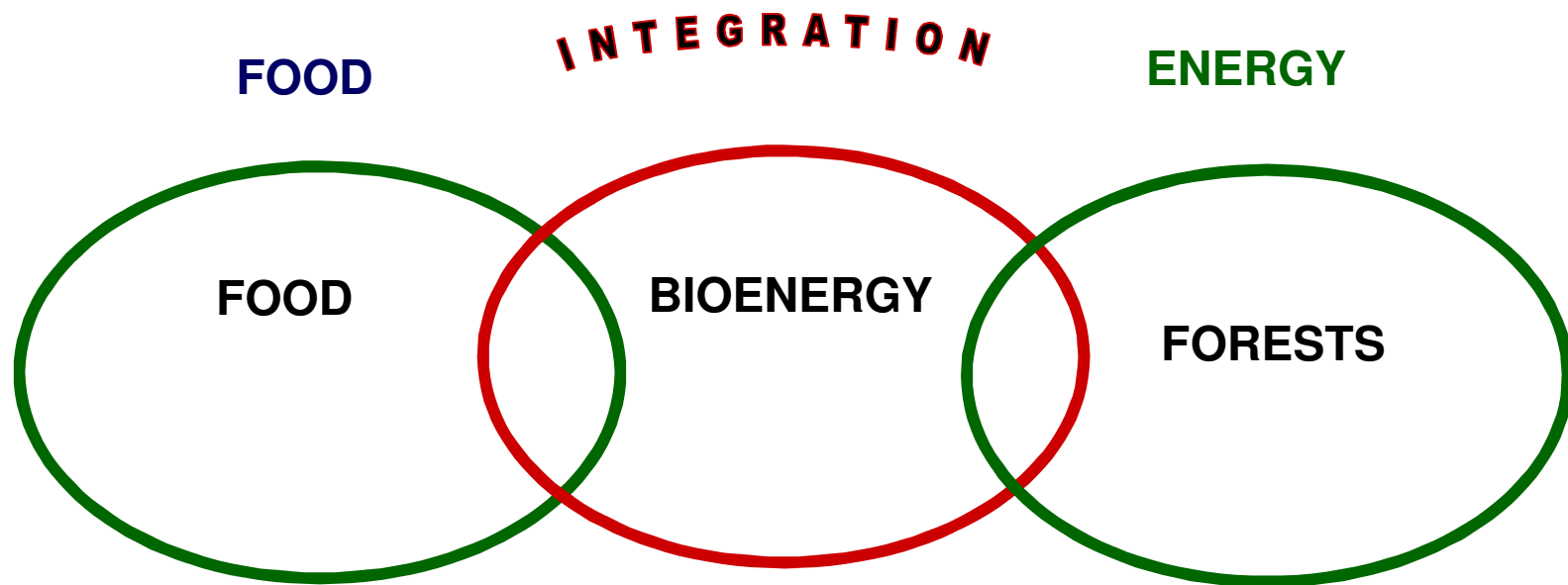
Innovation and scientific achievement on biofuels feedstocks

- Productivity improvements through sugarcane classical breeding, from 55 tons/ha in 1970 to 75 tons/ha in 2006 with associated best management practices
- Almost 300 sugarcane varieties were developed by CTC, other 80 varieties by RIDESA and approximately 45 varieties from IAC (São Paulo State Agriculture Research Institute)

Investments in R&D

- Almost 80% of investments in biofuels in Brazil come from the private sector
- In 2005 MCT (Science and Technology Ministry) invested US\$840 MM in R&D, 21% of which went to agriculture-related research (US\$176MM)
- US\$105 MM to be invested between 2003 and 2008 in agroenergy by MCT
- Votorantim invested US\$ 40 MM in biotechnology in the last 4 years developing 15 transgenic sugarcane varieties

A land use approach:



- Sustainable use of complex landscapes
- Income generation and diversification of farmers portfolio
- Diversifying farmer's options
- Deployment of best practices and new technologies
- Capacity building

Subsídios técnicos para a agenda brasileira de bioetanol

Etanol - sustentabilidade - Relatório parcial

Unicamp - 7 de fevereiro de 2009



Research on LCA and iLUC

- Coleta e análise de informações
- Consolidação do banco de dados
- Regiões de expansão da cana – linhas de base
- Uso atual do solo versus potencial de crescimento e produtividade da cana
- Gargalos de informação
- Principais desafios metodológicos
- Grupos de pesquisa

Within the possible next steps – can't afford not to have the five Cs...

- Concentration and concerted efforts: focus and scale
- **Continuity**: 30 years of investments worthwhile – the Brazil case
- **Complementarity**: need for a transdisciplinary approach
- **Commitment**: to make a change
- **Coordination** of efforts

Thanks to:

Organizers of the Workshop – Thais Coser
University of São Paulo - FEA
Students and graduate students from my lab
Prof. Isaias Macedo

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