



# *Understanding the capacity for biofuel production in Africa and Latin America*

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**The Royal Society  
London  
Sept 25-27, 2013**



# *Presentation*

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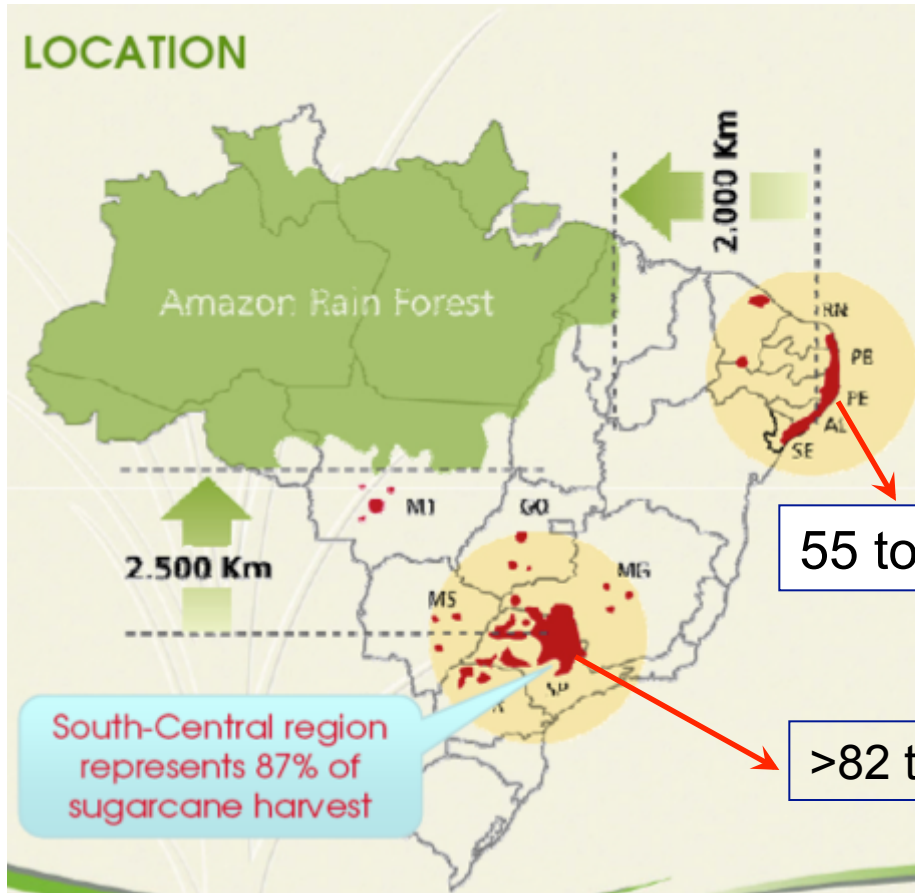
- *Present situation of Bioethanol production in Brazil*
  - *The Global Sustainable Bioenergy Project-GSB/FAPESP Collaboration*
  - *LACAf/FAPESP Project Diagnosis on Food/Energy Situation in Latin America and Africa*
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*Present situation of Bioethanol production  
in Brazil*

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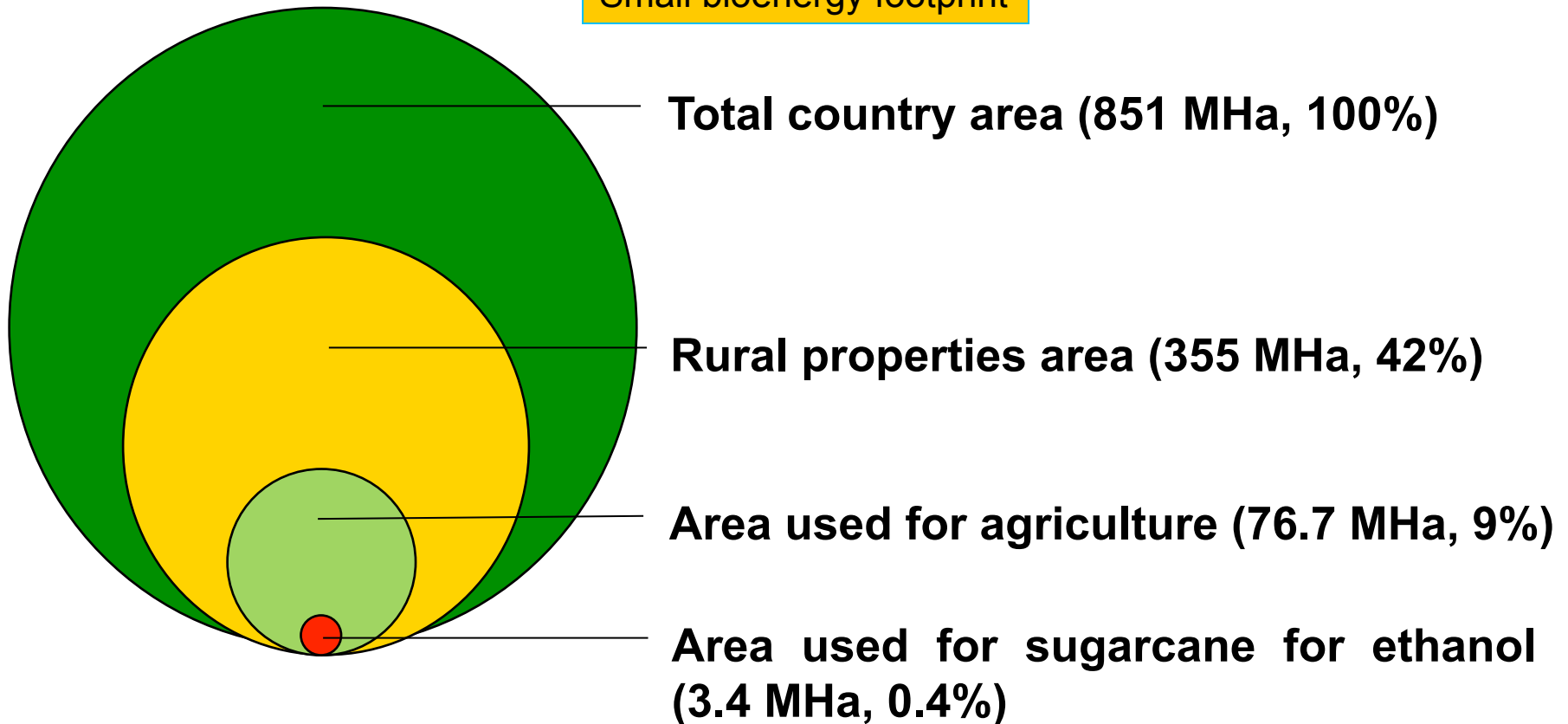
# Where does Brazil plant Sugarcane?



- Not in the Amazon
- Best land for cane:
  - Northeast coast
    - Oldest (XVI century)
  - Southeast
    - highest productivity
  - Centralwest
    - main expansion area

# *Sugarcane for ethanol uses 0.4% of Brazil's total area*

Small bioenergy footprint



# Sugarcane Ethanol Learning Curve in Brazil

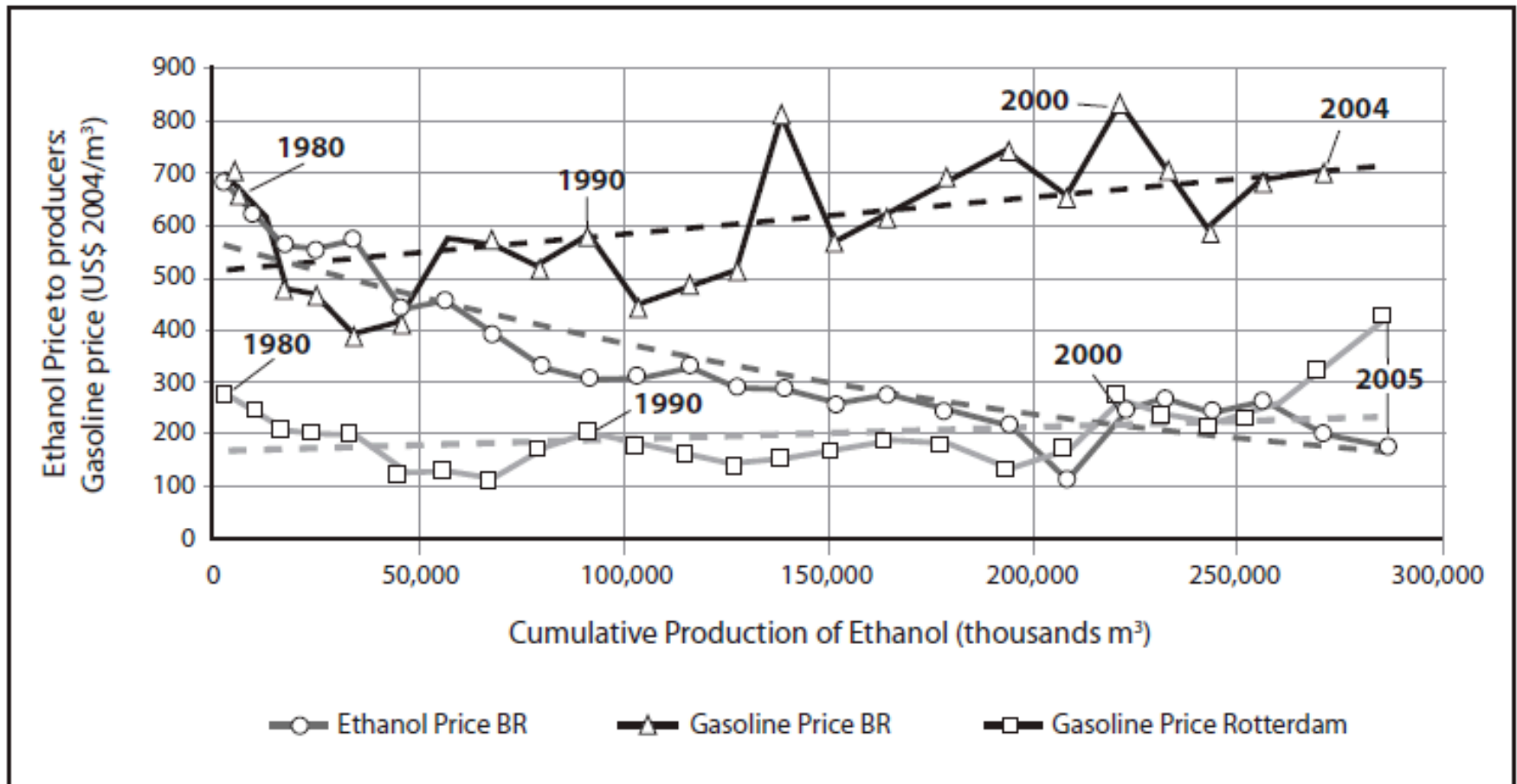
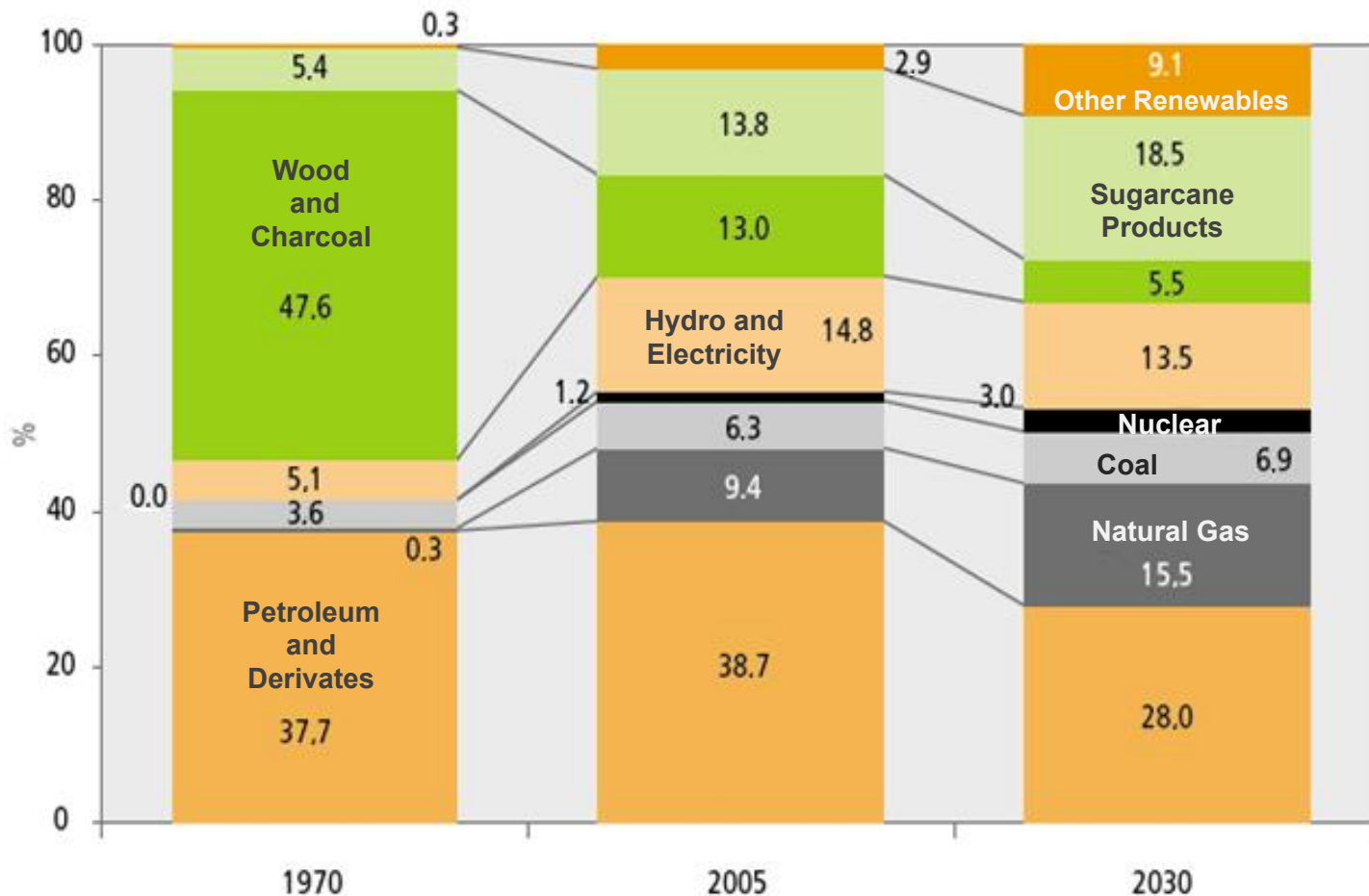


FIGURE 1 Learning Curve – Brazilian Ethanol.

Source: GOLDEMBERG, NIGRO and COELHO (2008).

# Expected Evolution of Energy Supply in Brazil



Source: EPE-MME (2010)

# *Brazilian Ethanol: reasons for success*

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- Brazil established a dynamic relation between Research and Production particularly after 1975, involving govmt and private sectors
  - Sugarcane, an excellent energy crop
  - Creation of the “**Brazilian Model**” combining efficient sugar and ethanol production
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*The Global Sustainable Bioenergy Project-  
GSB/FAPESP Collaboration*

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# Global Sustainable Bioenergy Project

## “GSB Project” (<http://bioenfapesp.org/gsb/>)

**Objective:** Expand understanding of the possibility of beneficially producing bioenergy on a very large scale - e.g. 25% of primary energy supply in 2050, consistent with recent low low carbon scenarios (IEA, GEA, IPCC).

### Working hypotheses:

1. That it is physically possible to “make room” for bioenergy while honoring other land use priorities.
2. That a systemic approach to food and bioenergy production could positively and synergistically impact multiple urgent human needs.

### Structure

#### Stage 1. Continental Conventions (completed)

- Gather input on framing stages 2 and 3
- Continental resolutions
- Recruit participants & funds

**Stage 2. Address working hypothesis, unconstrained by current realities.**

**Stage 3. Analyze implementation paths, recommend policies**

# Global Sustainable Bioenergy (GSB) Project

(<http://bioenfapesp.org/gsb/>)



Global Sustainable Bioenergy

	Geospatial Analysis			Social		Environmental				Integrated Analyses & Scenarios	
	Livestock Production	Energy Crop	Database Development	Food security	Social Welfare & Economic Development	Soil Fertility	Water	Climate	Biodiversity	Making Room for Biofuels	Multiple benefits
<b>Global</b>											
<b>Local, "LACAF"* Countries</b>											

\*Latin America, Caribbean, and Africa

## Scholar Exchange Program ([accessed from http://bioenfapesp.org/gsb/](http://bioenfapesp.org/gsb/))

Supported by the Sao Paulo Research Foundation (FAPESP) BIOEN Program

Brazilian scholars studying abroad

International scholars studying in Brazil

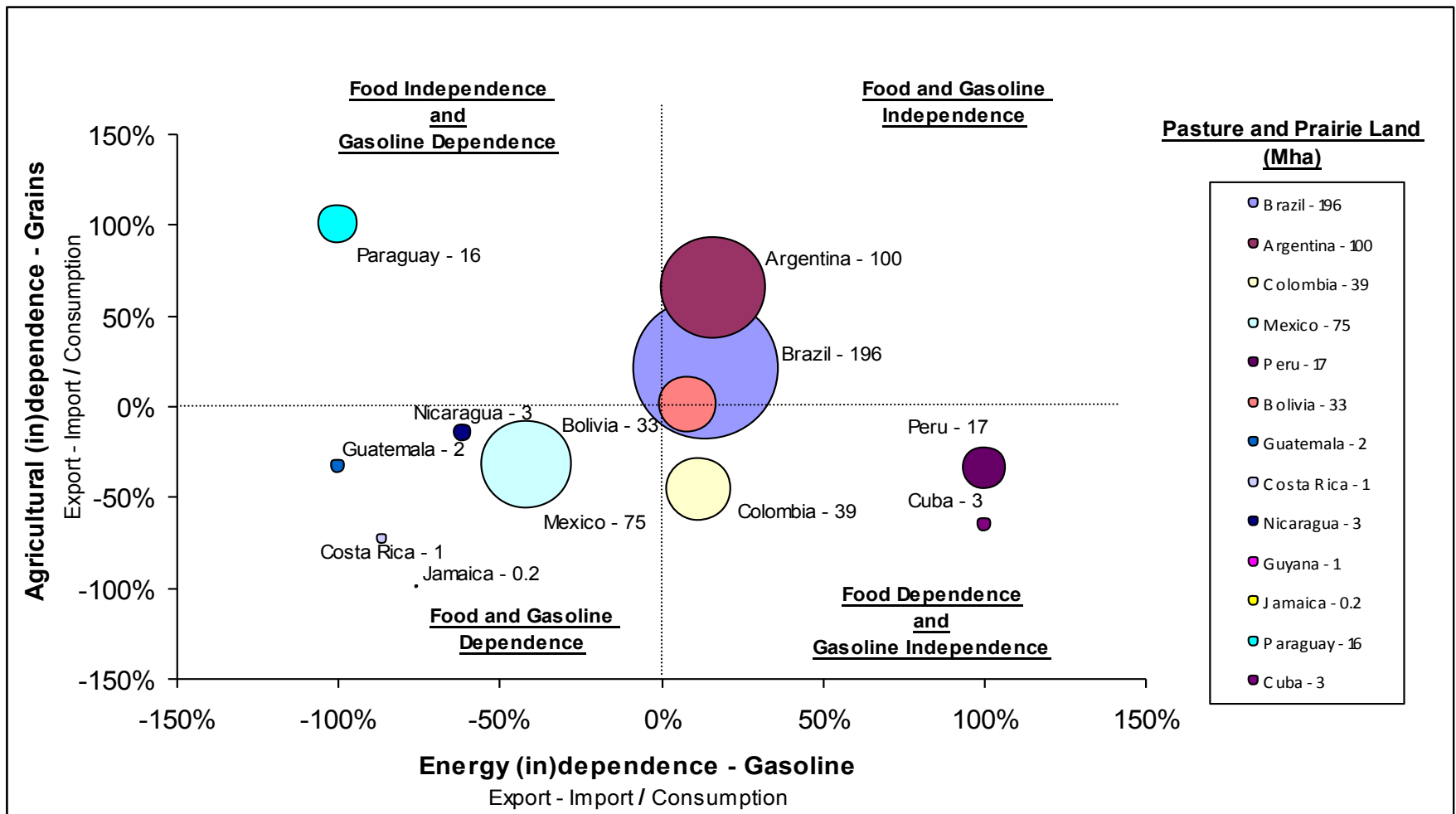
Several days to a year

**Next meeting: Nov 12-14, 2013  
Atibaia, Brazil**

***LACAf/FAPESP Project  
Diagnosis on Food/Energy Situation  
in Latin America and Africa***

***<http://bioenfapesp.org/gsb/lacaf/index.php/lacaf-cane-i>***

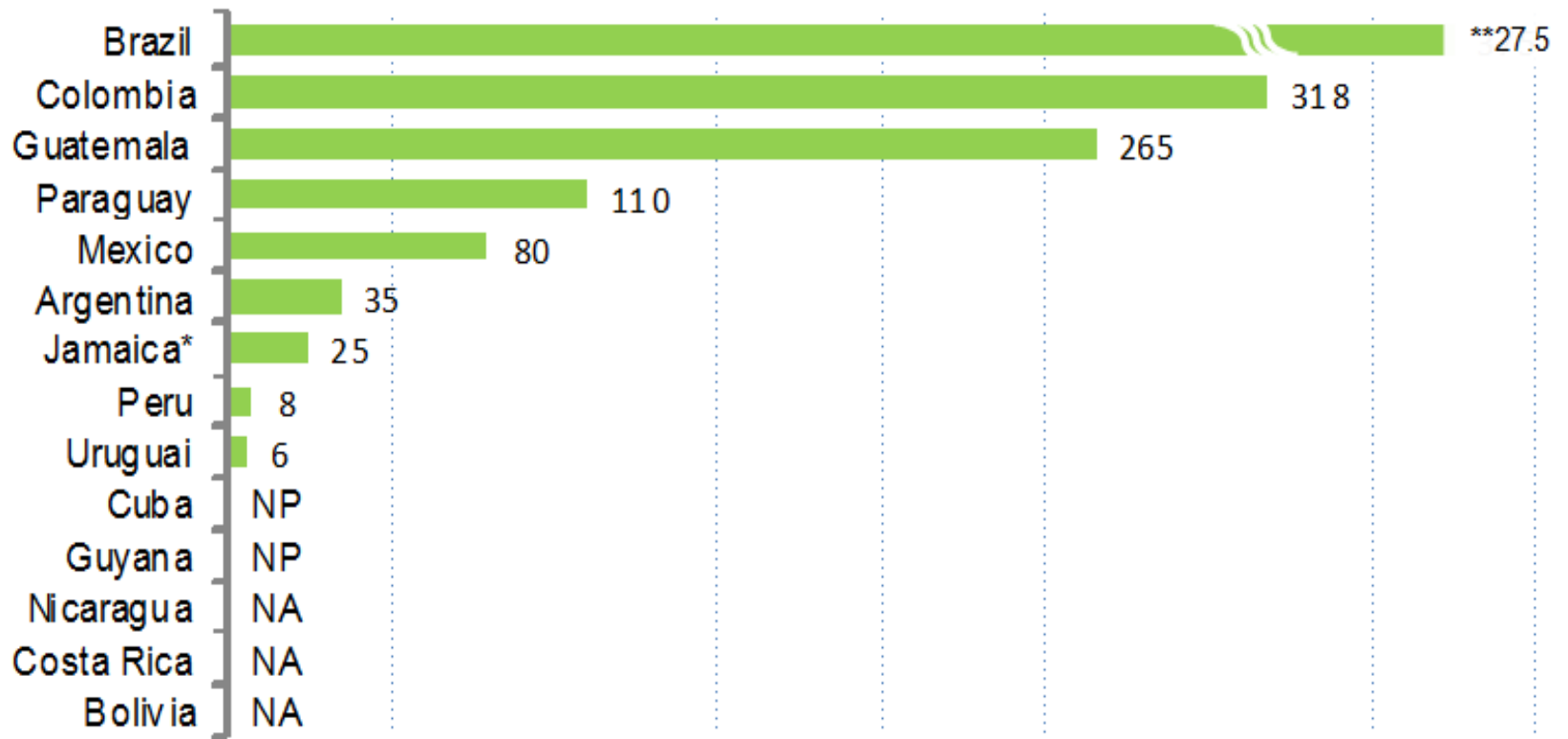
# Food (Grains) and Energy (Gasoline) Dependence in Latin America



Source: FAO (2008), IEA (2008)

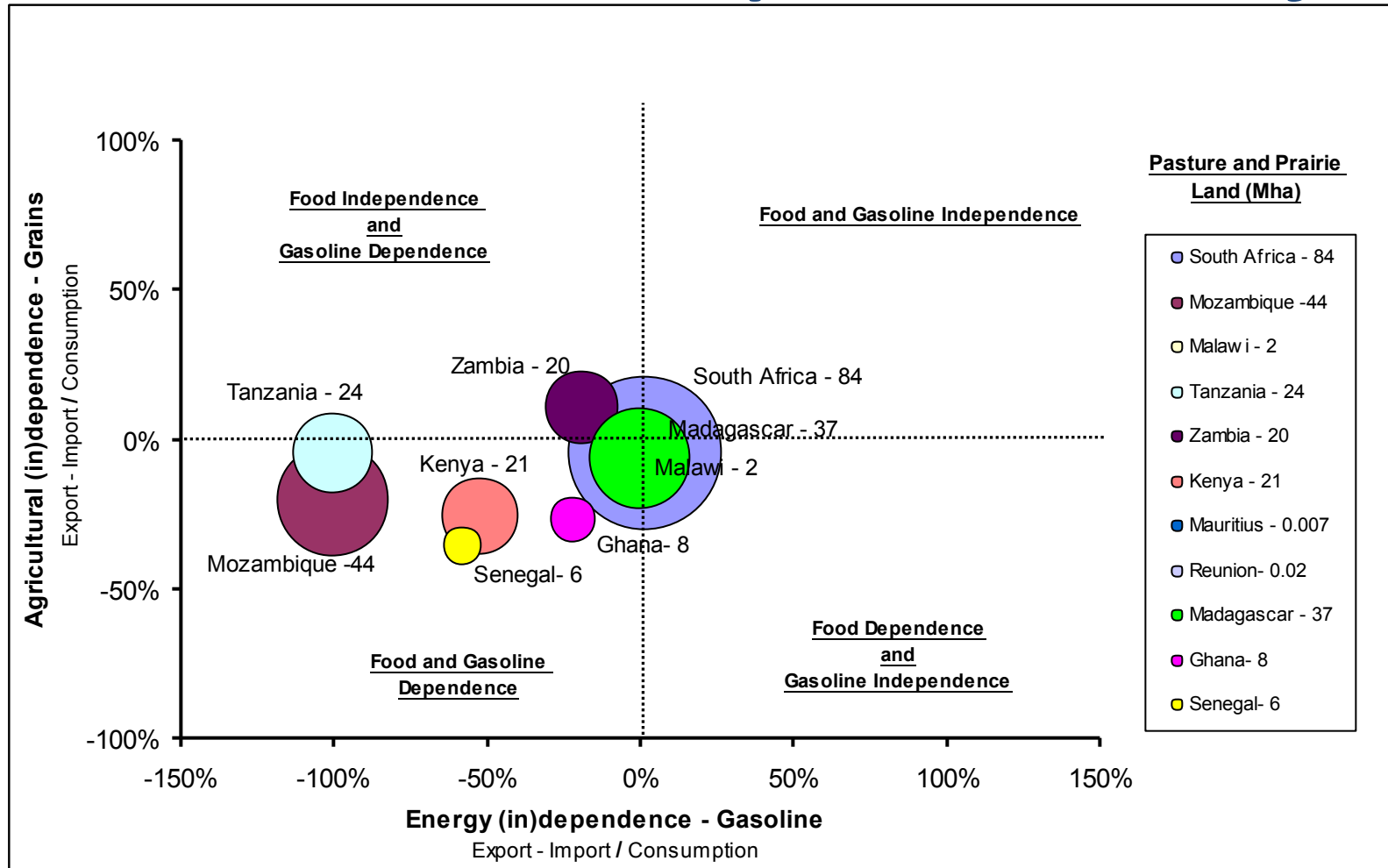
# *Ethanol production in Latin America*

## Ethanol Fuel Production - 2009 (MI)



Source: USDA (2010)

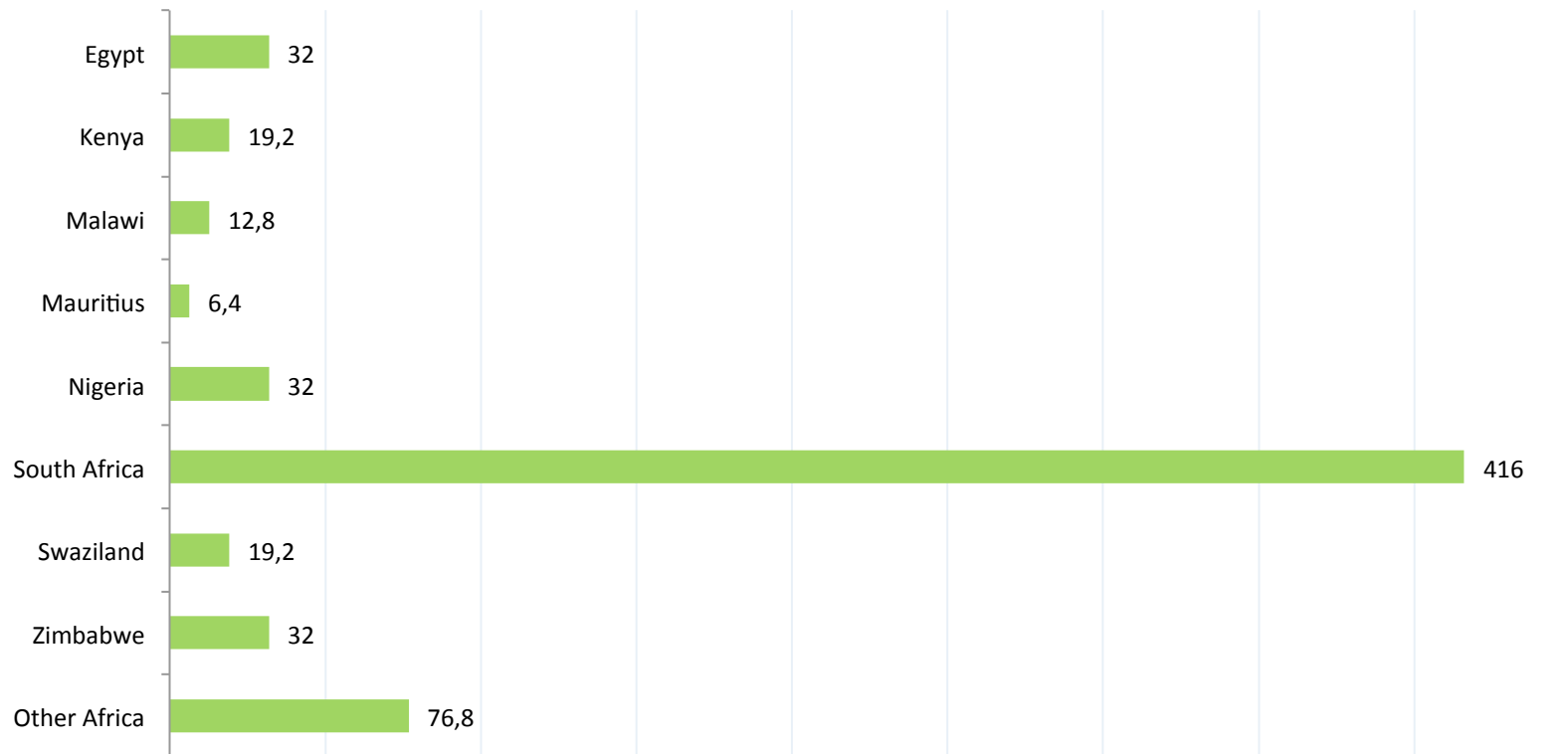
# Food (Grains) and Energy (Gasoline) Dependence in Africa



Source: FAO (2008), IEA (2008)

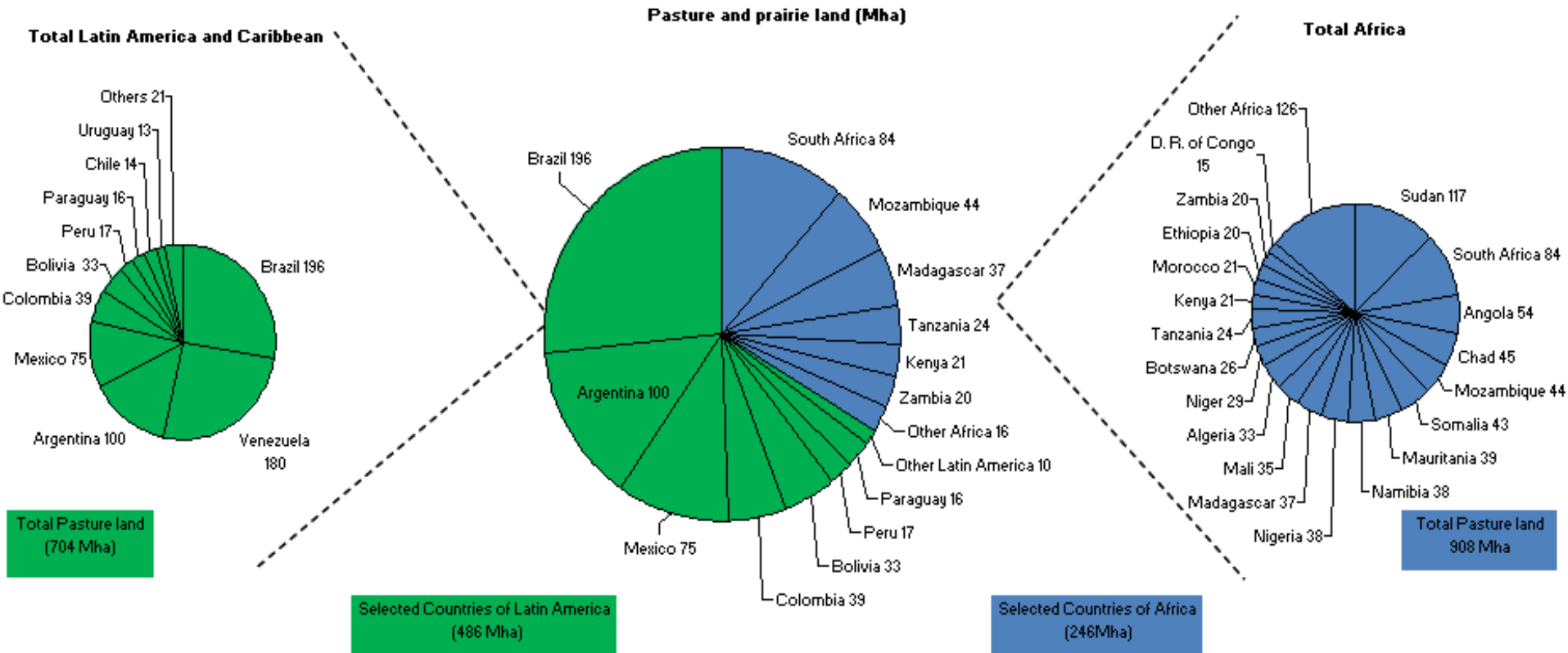
# *Ethanol production in Africa*

## Ethanol Fuel Production - 2007 (MI)



Source: DFiD (2007)

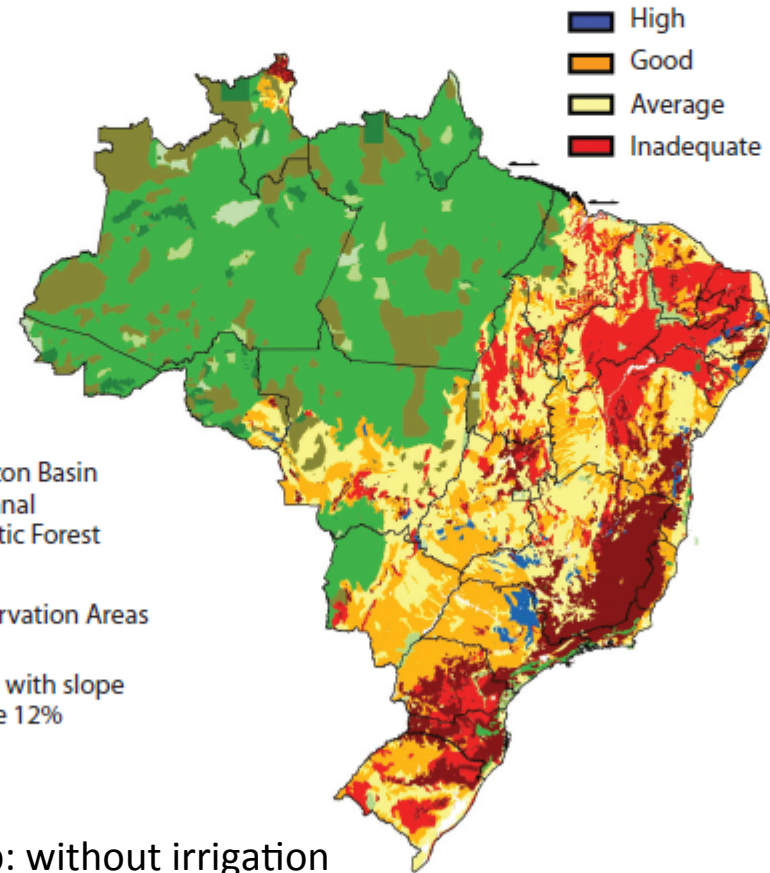
# Land Availability for bioenergy in LA and AF



Sources: Doornbosch and Steenblik (2007) , FAOSTAT (2008), IICA (2009), www.eclac.org. 2009 - organized by the authors

# A similar estimate for Brazil

Area classification					
	Prodvty	No irrigation		W. irrigation	
Potential	(ton/ha)	MHa	%	MHa	%
High	> 80	7,9	2,2	37,9	10,5
Medium	>73	113,9	31,5	98,0	27,1
Low	> 65	149,2	41,3	167,7	46,4
Inadequate	< 65	90,6	25,1	58,0	16
<b>Total</b>	-	<b>361,6</b>	<b>100</b>	<b>361,6</b>	<b>100</b>

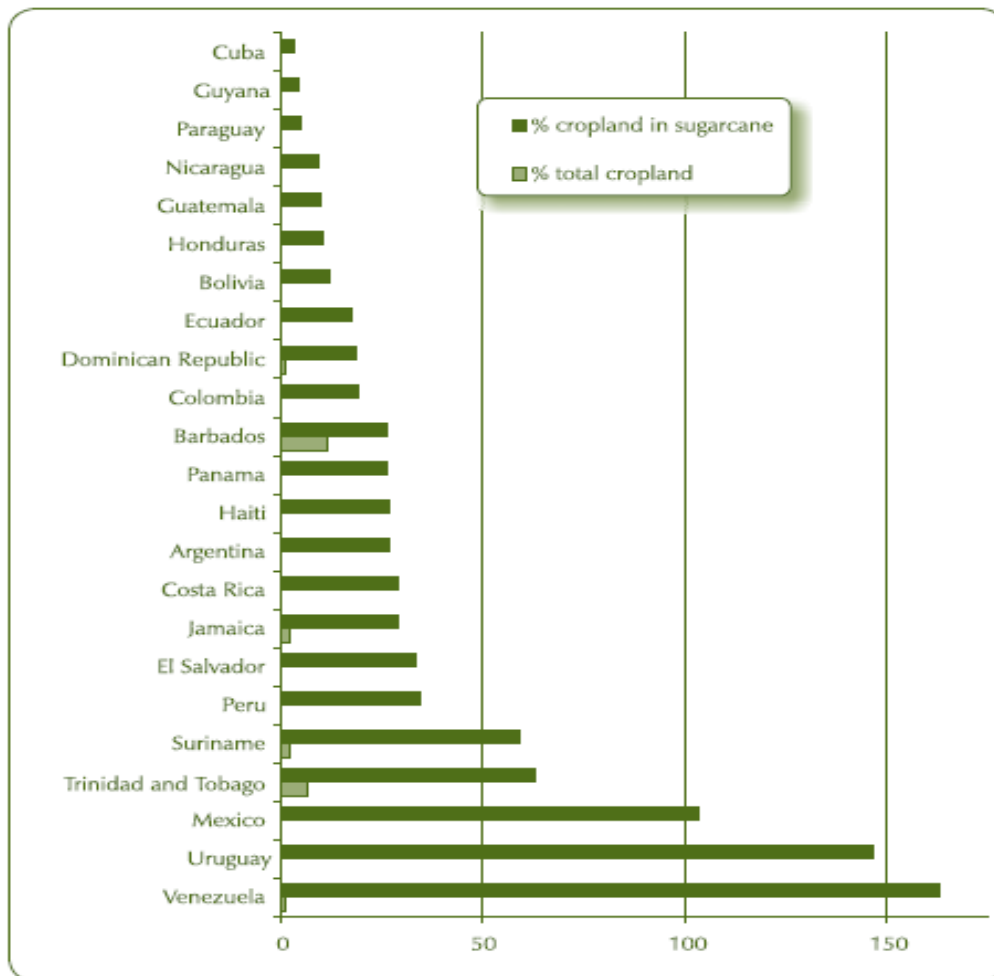


Source: Leite et al. (2009)

# *Pasture/Cattle integration with Sugarcane Expansion in Brazil*

- Pasture land in Brazil 150-200 Mha (extensive 1 head/ha)
- IBGE (2006) 159 Mha with 151 kg (live weight)/ha (54% yield), results 24,000 Mkg live weight beef/year
- CTBE-CGEE (2010): if same beef production with integrated production beef/sugarcane: needs 53 Mha of pasture instead of 159 Mha (estimated beef productivity 452 kg/ha instead of 151 kg/ha)
- Integration pasture/sugarcane: 1:1. Therefore 52 Mha of integrated sugarcane could be necessary to produce ethanol and supply enough balanced feed for the 53 Mha of integrated pasture land.
- **The integrated 159 Mha can yield: 53 Mha of integrated intensified pasture land + 52 Mha of sugarcane (300 billion liters of ethanol), and leaving extra 54 Mha for other crops**

# CEPAL estimate for area requirement in LA countries for E90



Source: Sugarcane-based  
bioethanol : energy for sustainable  
development / coordination  
BNDES and CGEE – Rio de  
Janeiro :  
BNDES, 2008

<http://www.bioetanoldencana.org/en/download/bioetanol.pdf>

***LACAf/FAPESP Project  
Analyzing ethanol production in  
case study countries (Colombia,  
Guatemala, South Africa and  
Mozambique)***

# *Sugarcane Ethanol in Latin America*

## **Colombia:**

- The world's second-largest sugarcane ethanol producer
- Governmental regulations established a mandatory blend (E10)
- Current ethanol production covers 85% of the local needs
- Colombia has a great potential for sugarcane ethanol production in the East part of the country (expected lower yield than Cauca Valley)

## **Guatemala:**

- Number one producer of sugarcane in Central America
- In 2009, Guatemala produced 2.38 million tons of raw sugar, of which 1.3 million tons were exported
- 5 out of the 14 sugar mills are also producing ethanol, whose production reached 265 million liters in 2008
- All of the ethanol is exported, mainly to Europe and the U.S.
- The domestic market for biofuels consumption has not been developed yet

# *Sugarcane Ethanol in Africa*

## **South Africa:**

- Is the largest producer of sugarcane in the continent
- The Industrial Development Corporation and the Central Energy Fund announced plans to invest US\$ 437 million in 5 biofuels projects
- Ethanol Africa, South African commercial maize farmers, invested in 8 ethanol new plants. Has investments in Angola, Zambia, Tanzania and Mozambique to produce biofuels from corn and sugarcane

## **Mozambique:**

- Is set to become one of a major biofuels producer in Africa
- ProCana will process its cane in a Brazilian-built sugar-ethanol factory
- Last year Central African Mining & Exploration has invested U\$ 150 million in a plant of ethanol, and Petromoc spends U\$ 550 million to develop biofuels
- The potential for sugarcane ethanol production is great, both for domestic use or exports. It enjoys tax exemption to export to Europe

# ***LACAf FAPESP Project: a contribution to the GSB Project***

## **1. Diagnosis of Energy and Food Situation in LA and AF & Integrated analysis**

**Coordinator: Luiz Augusto Horta Nogueira (UNIFEI/UNICAMP)**

- Why should Latin American and African countries get involved in a global effort to increase biofuels production? (Horta, Regis, Furtado, Emile, Rincon)
- How can countries in LA and AF implement the necessary actions: the cases of Colombia, Guatemala, South Africa and Mozambique? (Horta, Emile, Rincon)
- What is the present and expected future situation of energy and food security in Latin America and Africa? (Horta, Regis, Emile, Rincon)
- Integrating analysis for AL and AF (Horta, Regis, Emile, Rincon)

# ***LACAf-FAPESP Project: a contribution to the GSB Project***

## **2. Determining the Physical Potential for Sugarcane Ethanol Production in Latin America and Africa**

**Coordinator: Edgar Beauclair (Esalq/USP)**

- Identify potential areas to sugarcane production in African and Latin American countries; (Fernando-CTC team)
- Quantify the different production potential of sugarcane crops in these countries; (Fernando-CTC team)
- Assess the land use impacts of biofuels production in Latin America and Africa: the cases of Colombia, South Africa and Mozambique (André Nassar-AGROICONE team)
- Use a Sugarcane Crop Model and Estimate Total Sugarcane Ethanol Production in LA and AF (Edgar Beauclair)

# ***LACAf-FAPESP Project: a contribution to the GSB Project***

## **3. Production Models & Innovation**

**Coordinator: Manoel Regis Lima Verde Leal (CTBE)**

- Defining Possible Production Models for LA and AF (Regis, Emile, Rincon)
- Analyzing the Possible Impact of Advanced Technologies in Conversion: Celulosic ethanol, energy cane (Regis, Bonomi)

# LACAf-I FAPESP Project:

## milestones

Diagnosis (Horta)	Methodology Indicators diagnosis	Database Food & energy security	Integrated analysis		Full analysis	Papers
Survey CTC (Beauclair)	Evaluations of areas and obtain data Basic maps	Field trips	Creation of production near-term potential maps	Final Report		
Survey Agrolcone (Beauclair)	Methodology	Land Use Basic Maps	Land Use Maps			
Determining Land Use and Physical Near-Term Potential (Beauclair)	Identify the potential area to plant sugarcane based on climate and soil conditions	To establish the constrains - preservation areas	To development yield model to estimate the potential biomass production			Papers
Productive Model (Regis)	ossible models will be visualized based on variations of the preliminarily assumed as the optimum model	Information on agricultural production model, field trips, visits and discussions with the government, private sector, agricultural workers and NGO's.	Analysis of the alternatives and suggestion of the models to be presented to the stakeholders in each country	Final analysis and recommendations based of the results of the workshops	papers	

**Kick-off Meeting November 14-16, 2013**  
Atibaia, SP, Brazil

**Meeting March 2014**  
Durban and Mozambique

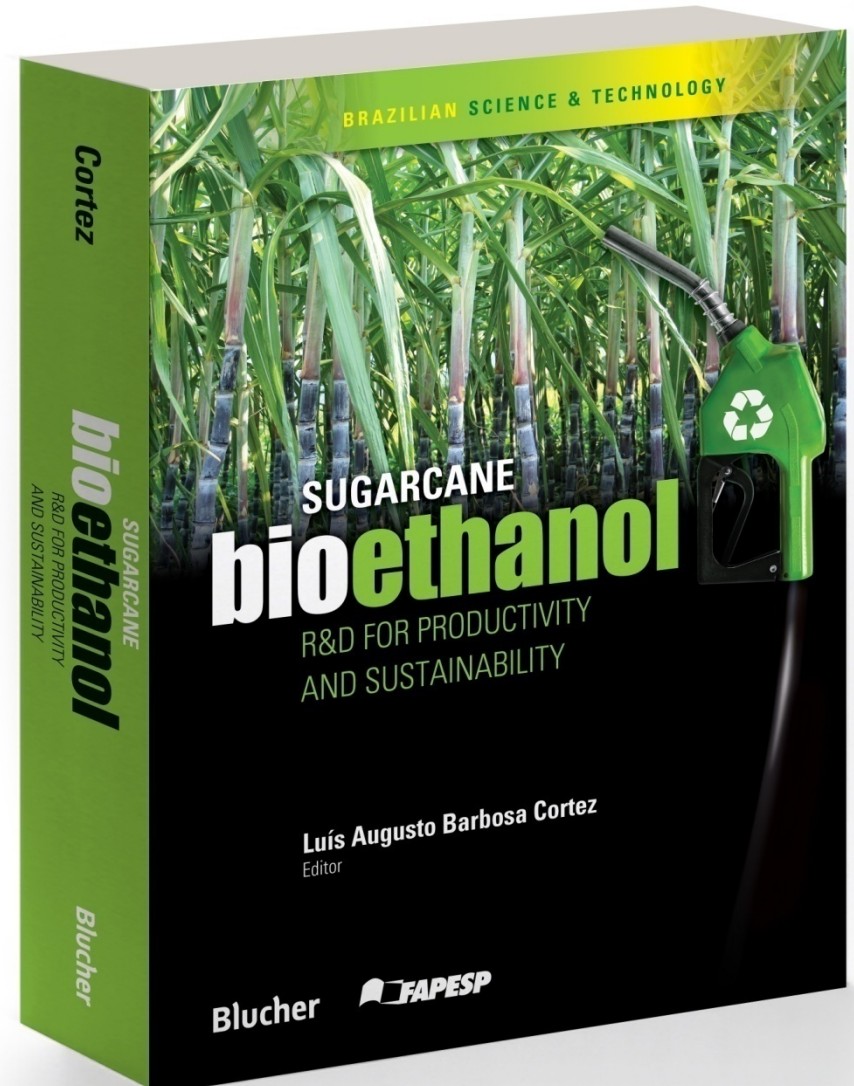
**Meeting 2nd semester 2014**  
Colombia and Guatemala

# *Sugarcane Bioethanol: R&D for Productivity and Sustainability*

- Launched Sept 2010
- 992 pages
- 76 chapters
- 139 authors
- Publisher: **Blucher**
- Ethanol PP Project:



*Sales by Amazon*



# *Conclusions*

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- There are good opportunities for bioenergy in Latin America and Africa reconciling food and energy securities
  - Brazil (bioethanol) is a good example for biofuels production but may be a different model must be created, particularly in Africa
  - Need to understand specific situation for selected countries: the FAPESP/LACAf project intends to be a contribution to GSB project, verifying its potential and constraints
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# *2nd Brazilian Bioenergy Science & Technology Conference - BBEST*

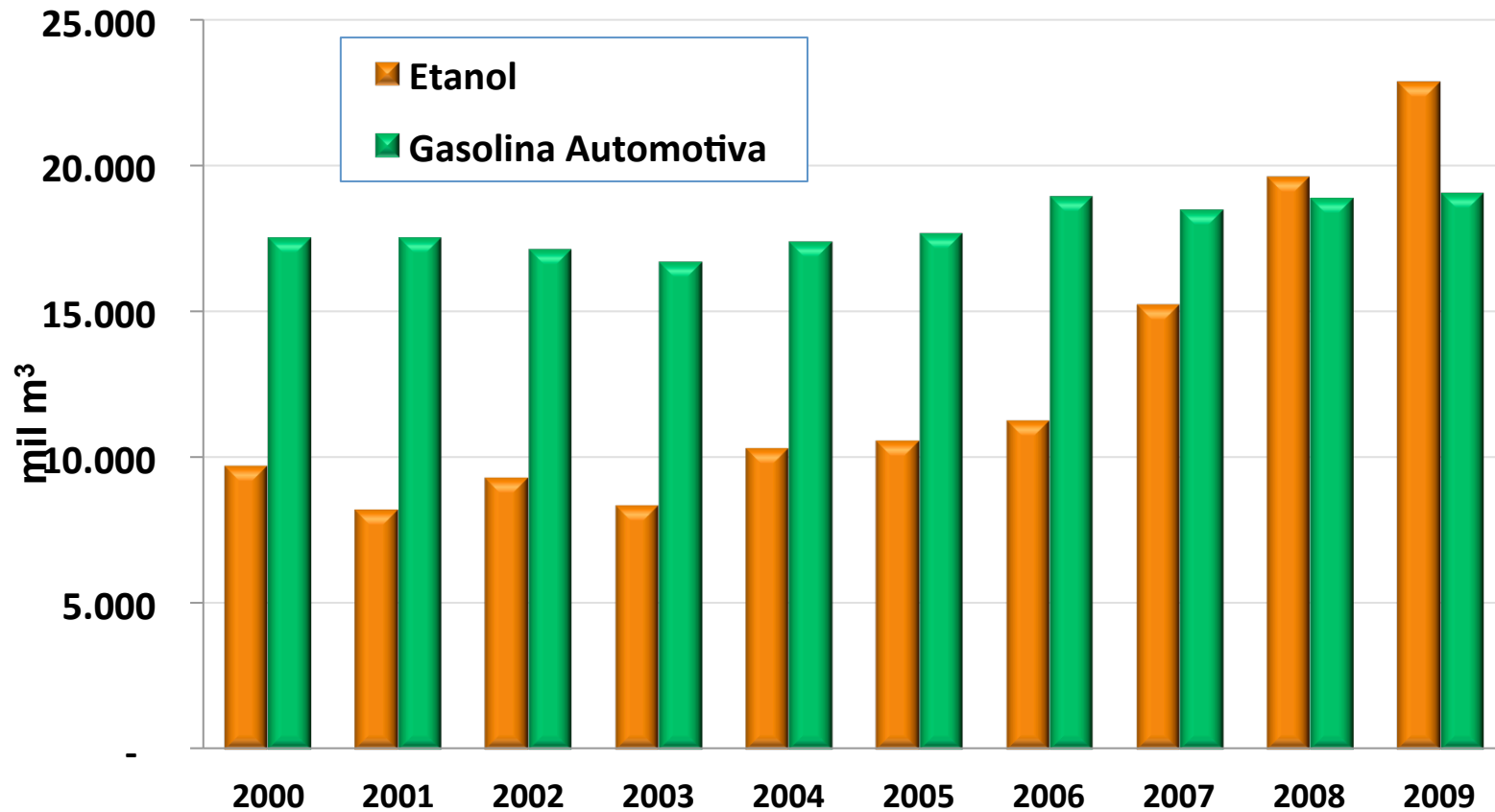
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- Venue: Campos do Jordão, SP, Brazil
- October 20-24, 2014
- <http://www.bbest.org.br/>





# Brazil: Gasoline and Ethanol consumption

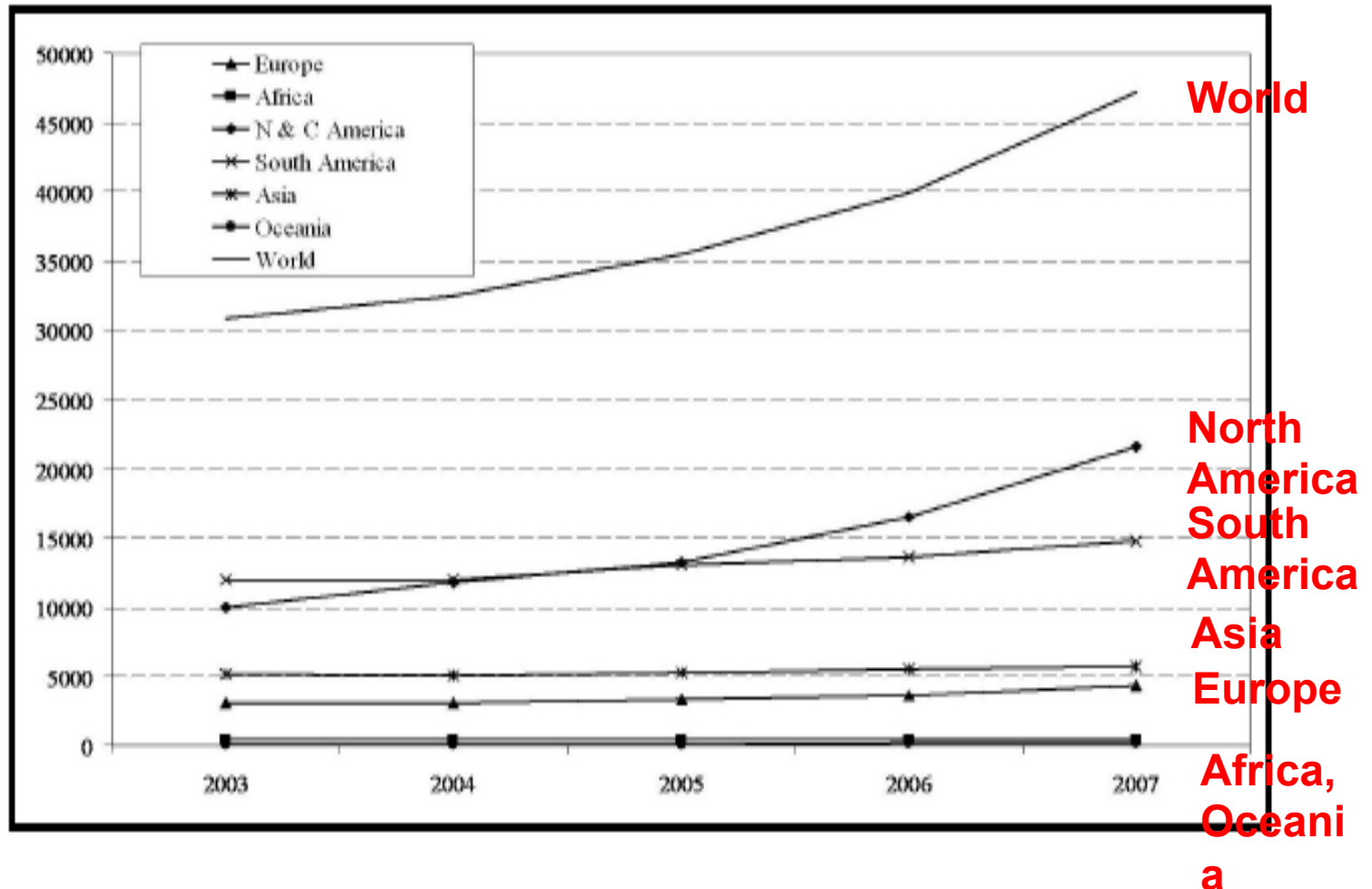


Fonte: ANP/SPP

<sup>1</sup>Inclui as vendas de etanol hidratado e anidro misturado na gasolina C. <sup>2</sup>Inclui apenas a gasolina A. Exclui o etanol anidro misturado à

# Latin America is the 2nd largest Ethanol producer

Figure 1. World ethanol production, by continent (in 1,000 tons)



Source: FO LICHT (2006a)

# Reference quantities

Area available in South & Central America by 2050: 0,25 Gha  
Area available in Africa by 2050: 0,18 Gha  
(both according to Doornbosch & Steenblik, OECD, 2007)  
So. And Central America + Africa: 0,430 Gha  
10% of 0.43GHa @ 10kL/Ha.yr → 430 GL /yr (in 2005: 40 GL)

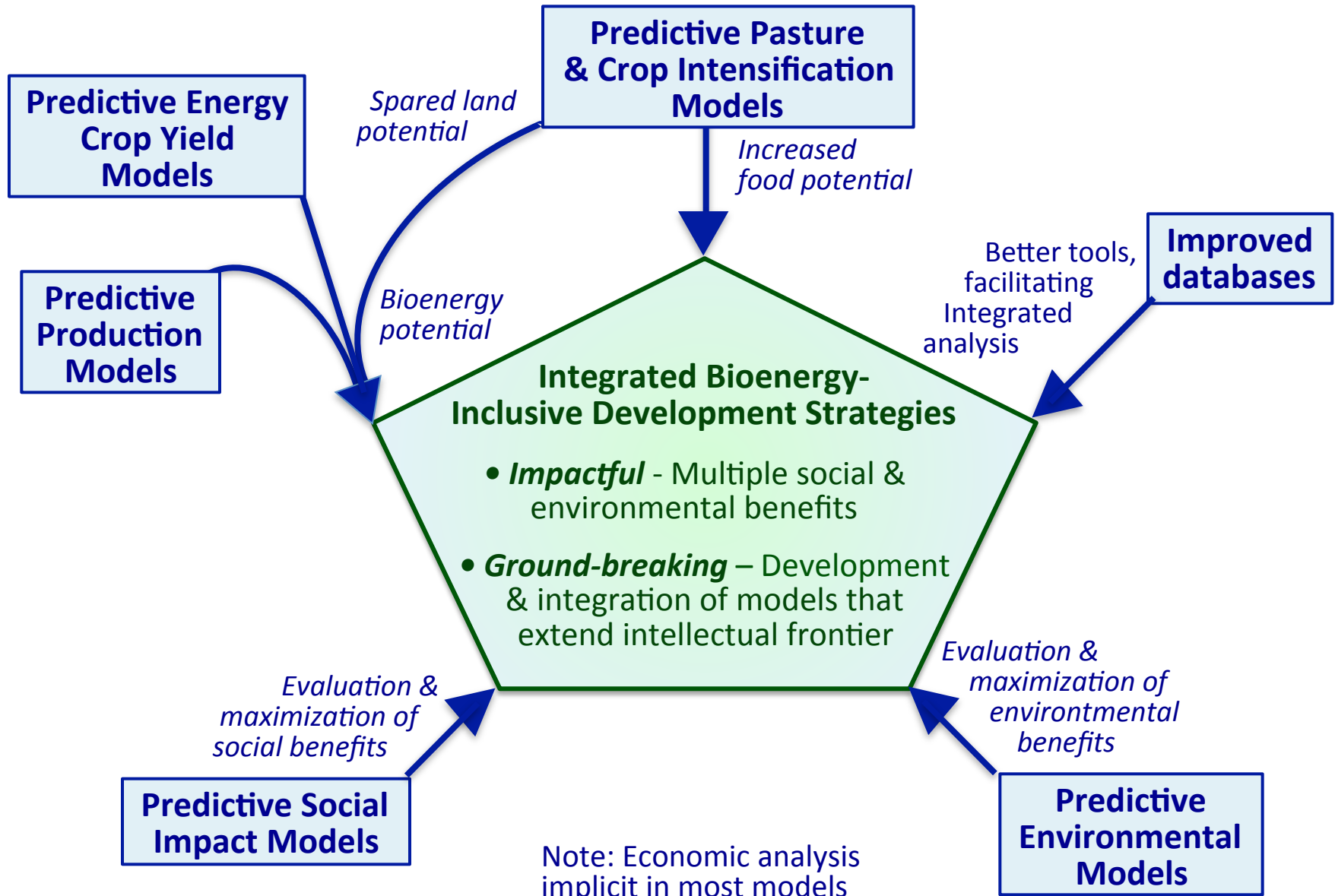
	2004	2050
Gasoline consumption <sup>(1)</sup>	1,200 GL	2,200 GL
Ethanol consumption	30 GL	
Ethanol substituting 15% gasoline		400 GL
Ethanol substituting 100% gasoline		2,650 GL

(1) Source: National Energy Information Center (NEIC)

Potential for substituting for 15% of the world gasoline demand considering only the available area in South and Central America and Africa

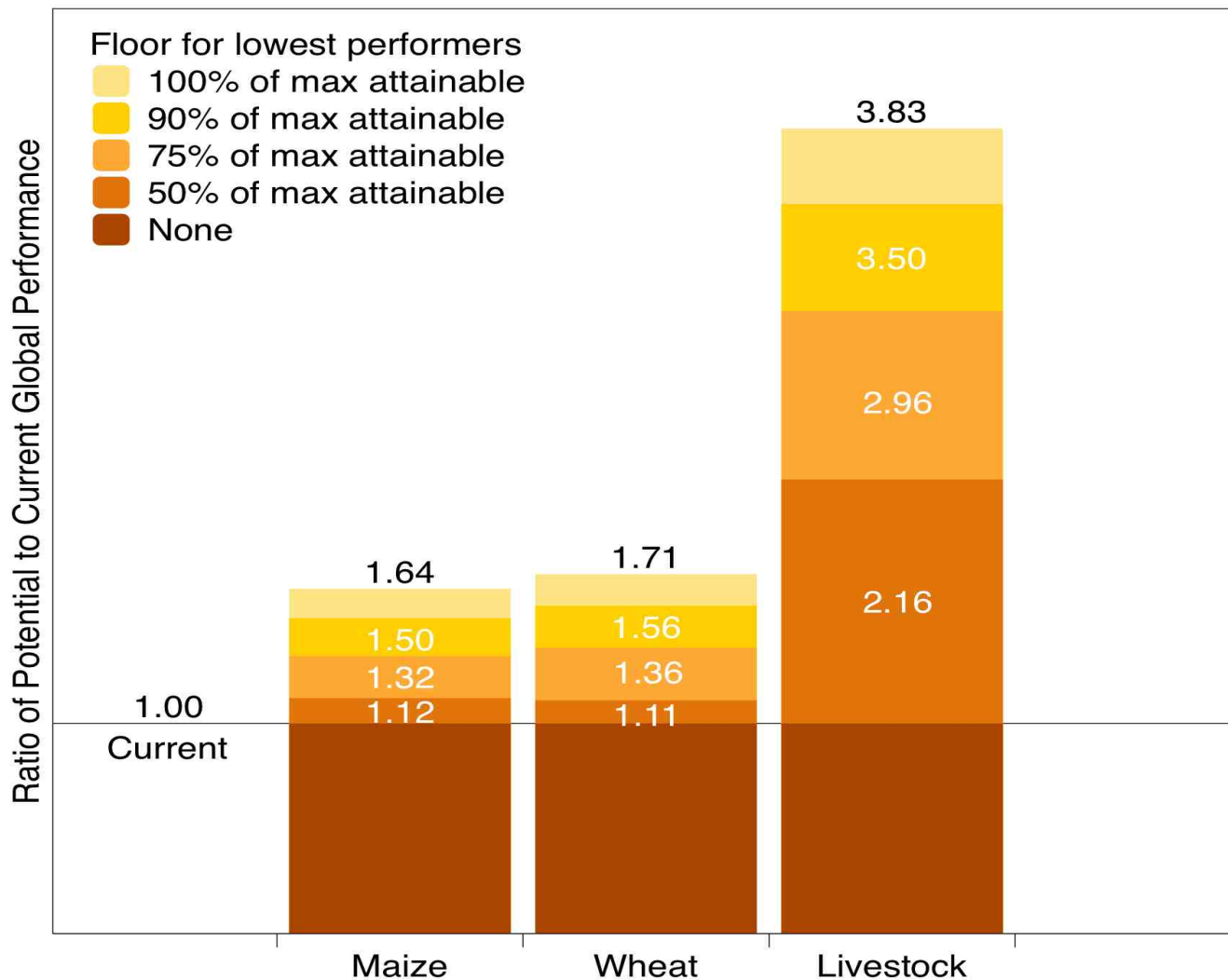
# Key words for GSB & LACAf:

*Convergent, Predictive, Ground-Breaking, Integrated, Impactful, Analysis*



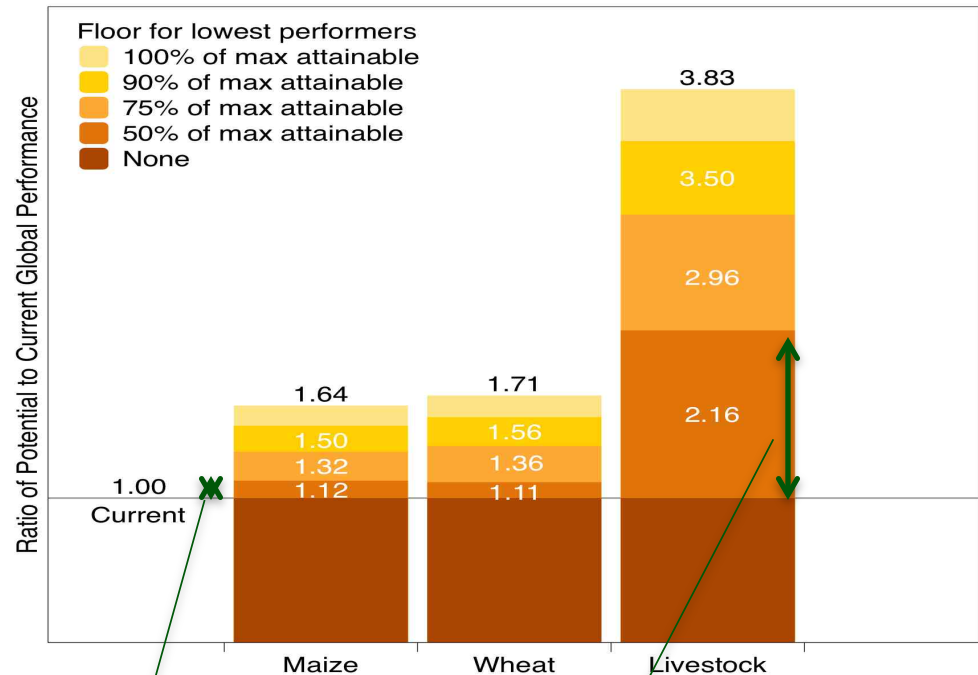
# Application to Pastured Animal Production

Comparative intensification potential: pastured livestock stocking density, wheat and maize yields



# Application to Pastured Animal Production

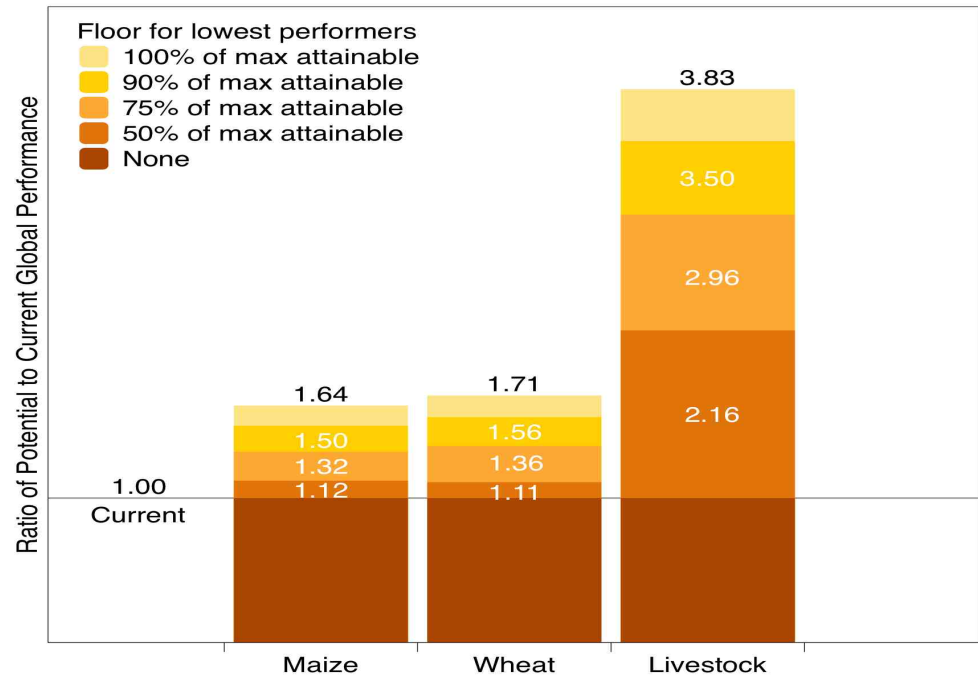
Comparative intensification potential: pastured livestock stocking density, wheat and maize yields



Minimum Performance (% Attainable Maximum)	Added Production		Ratio (a/b)
	a) Maize-Wheat Average	b) Pasture	
50	0.12	1.16	<b>10.1</b>

# Application to Pastured Animal Production

Comparative intensification potential: pastured livestock stocking density, wheat and maize yields



Minimum Performance (% Attainable Maximum)	Added Production		
	a) Maize-Wheat Average	b) Pasture	Ratio (a/b)
50	0.22	1.19	<b>10.1</b>
75	0.34	1.96	<b>5.8</b>
90	0.53	2.50	<b>4.7</b>
100	0.68	2.83	<b>4.2</b>

# Brazil: Important and Instructive Example of Pasture Intensification

	1985	2006	% Change
<b>Pasture area</b> (10 <sup>6</sup> Ha)	179	159	-11.2
<b>Production</b> (10 <sup>6</sup> tons)	2.22	6.89	+310
<b>Yield</b> (kg/ha) = 1000*Production/area	<b>12.4</b>	<b>43.3</b>	<b>+349</b>

- Less land, more production

- Per ha yield more than tripled in 21 years

<b>Stocking Density</b> (head/ha)	0.71	1.11	+156
<b>Animal Performance</b> (kg/head)	17.4	40.13	+231

- Stocking density is responsible for less than half of the observed yield gain

- Intensification potentials presented thus far have been based on stocking density only, and are thus likely quite conservative. Factor of 2?

*Data courtesy G. Martha, EMBRAPA*

- Scientific and Technology roadmap
  - Research Project in Public Policy Program (PPP Ethanol)
- Bioenergy Research Program (BIOEN)
  - Research program; 5-10 anos
  - Basic research core
  - Connections to application through partnership with companies
- Bioenergy State Research Center
  - Hubs in the three state universities – USP, Unicamp, Unesp
  - Funding: State Government, FAPESP and the Universities

# *FAPESP's Research Program on Bioenergy (BIOEN): 5 areas*

- Improvements in the feedstock: building a better cane plant for energy - EnergyCane
- Production of Ethanol and other products: hydrolysis, pyrolysis, gasification, fermentation, distillation
- New processes in alcohol-chemistry
- Ethanol based engine and fuel cell developments
- The Economics of Ethanol, Ethanol production and the environment, Social impacts, the new agriculture of food and energy



# Programs for Cooperative University-Industry Research

- [Research Partnership for Technological Innovation \(PITE\):](#)

- To finance Technological Innovation projects in the productive sector, developed in partnership with R&D institutions in the State of São Paulo and businesses located in Brazil and abroad.

Technological Innovation projects involve scientific and technical knowledge with the objective of developing a product, process, system or service in which there is entrepreneurial or social interest.

The part of the project under the responsibility of the research institution will be financed with no expectation of any return. It will be up to **partnering businesses to match-fund** either from their own or third-party resources.

- [Innovative Research in Small Businesses \(PIPE\)](#)

- The program aims to support the development of innovative pieces of research, to be carried out in small businesses that have their headquarters in the State of São Paulo, centered on significant science and technology problems which have a high potential for commercial or social return. The projects may be developed by researchers who have links to the **small businesses** or which are associated with them for the implementation of the project.

# *Main Partnerships FAPESP- industry in bioenergy*

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FAPESP-DEDINI: Ethanol Production (US\$ 60 million)

FAPESP-BRASKEM/IDEOM: Green Polymers (US\$ 5 million)

FAPESP-OXITENO: Alcoholchemistry and Sugarchemistry

FAPESP-VALE: Biodiversity

[www.fapesp.br](http://www.fapesp.br)



DIRETRIZES DE POLÍTICAS PÚBLICAS  
PARA A AGROINDÚSTRIA CANAVIEIRA  
DO ESTADO DE SÃO PAULO



Workshops

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## > Novidades e eventos

26/09/2007

CONFERÊNCIA NACIONAL DE BIOENERGIA - USP -  
UNIVERSIDADE DE SÃO PAULO OBJETIVOS DA  
BIOCONFERÊNCIA ...

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25/09/2007

SIMPÓSIO DE AGROENERGIA E  
BIOCOMBUSTÍVEL: "Oportunidades para Um Novo  
Modelo Energético" Período: ...

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20/09/2007

XX SEMANA DA AGRONOMIA - CANA-DE-AÇÚCAR  
O Centro Acadêmico da Agronomia e a UNESP Iha  
Solteira p...

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## > Newsletter

Enviar



## Bem vindo ao nosso Web Site

Este projeto tem por objetivo propor diretrizes,  
estratégias e políticas para o desenvolvimento  
do setor sucroalcooleiro no Estado de São  
Paulo. Para tal está sendo realizado um  
projeto de pesquisa integrado, a partir da  
cooperação de uma equipe interdisciplinar de  
pesquisadores com vasta experiência  
acadêmica e profissionais do setor.

[> saiba mais](#)

## > Workshops

- [VII Workshop - Pragas da  
Cana-de-Açúcar](#)
- [VI Workshop - Produção Vegetal e  
Modelagem Agrícola](#)
- [V Workshop - Melhoramento Genético  
e Biotecnologia](#)

## OUTROS ARQUIVOS

- Cronograma 2007 
- Metodologia Workshop 
- Projeto PPP 

## > Parceiros

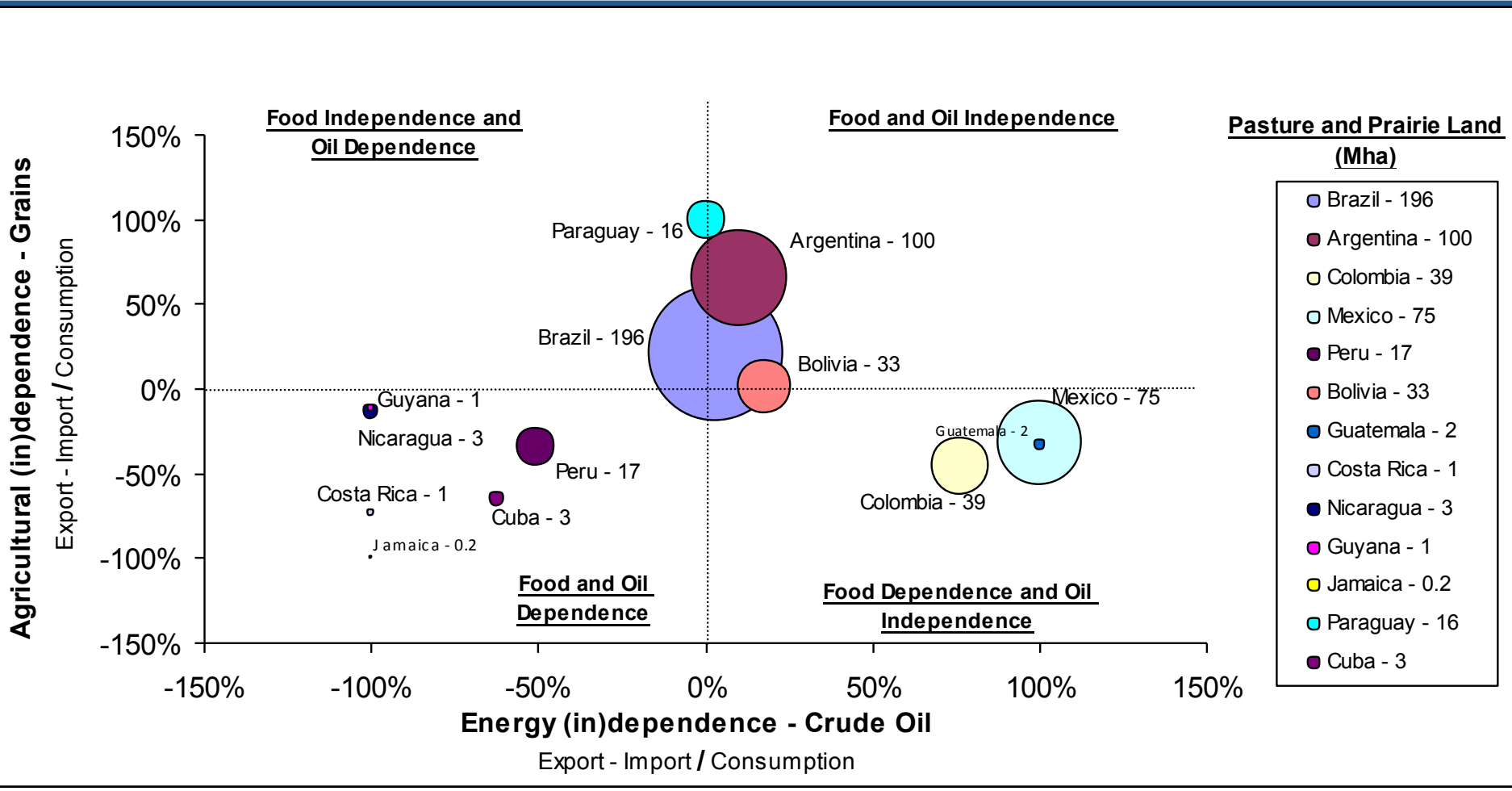
Apoio Financeiro



Parceiros

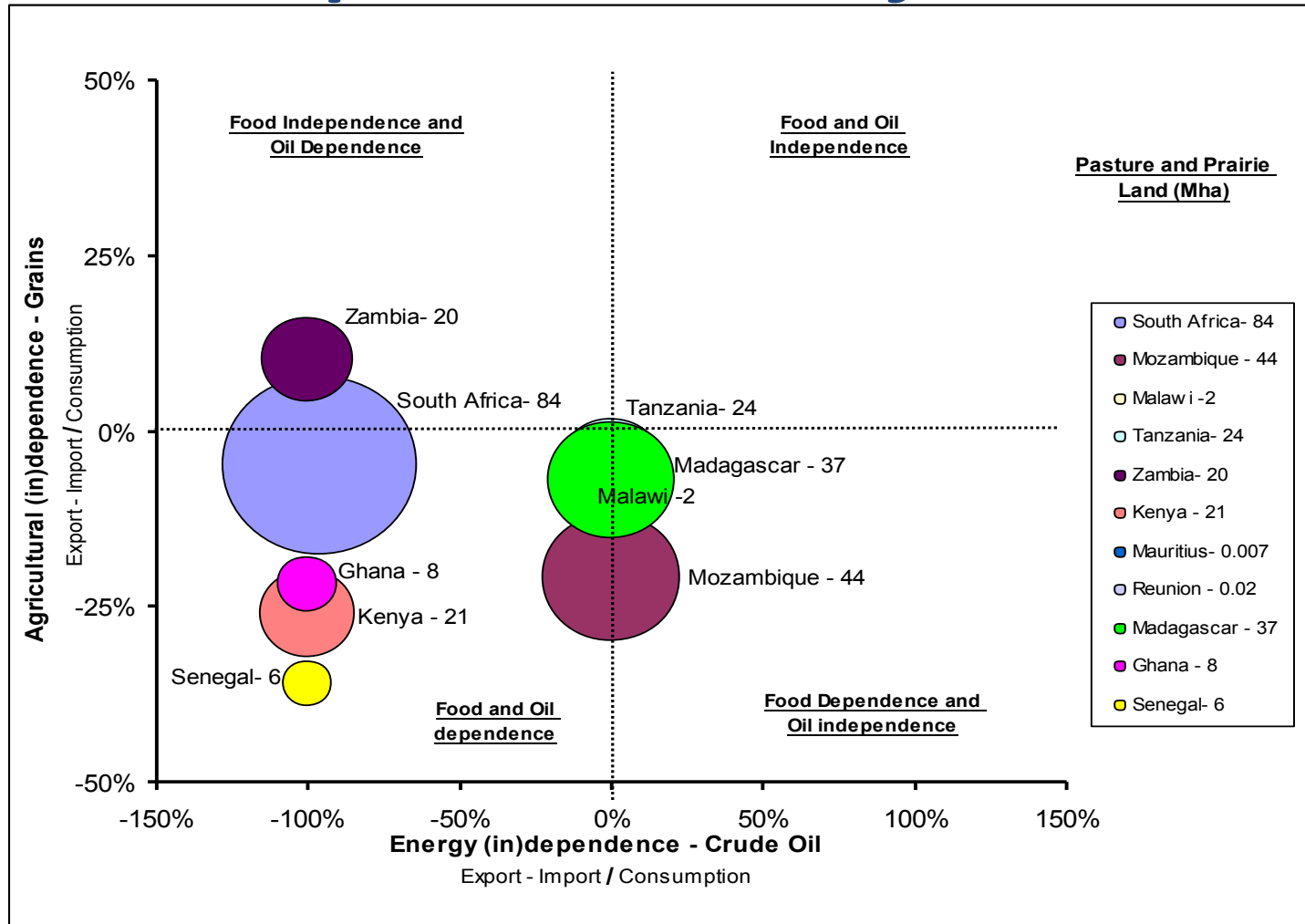


# Food (Grains) and Energy (Crude Oil) Dependence in Latin America



Source: FAO (2008), IEA (2008)

# Food (Grains) and Energy (Crude Oil) Dependence in Africa



Source: FAO (2008), IEA (2008)

# *Sugarcane, Products and Trade in Selected Latin American & Caribbean Countries*

<b>Country</b>	<b>**Sugarcane production</b>	<b>**Sugarcane harvested</b>	<b>Sugar Production</b>	<b>Sugar Consumption</b>	<b>Sugar Import</b>	<b>Sugar Export</b>	<b>*Molasses Export</b>	<b>*Molasses Import</b>
	<b>10<sup>6</sup> ton</b>	<b>10<sup>3</sup> ha</b>	<b>x 10<sup>3</sup> ton</b>	<b>x 10<sup>3</sup> ton</b>	<b>x 10<sup>3</sup> ton</b>	<b>x 10<sup>3</sup> ton</b>	<b>x 10<sup>3</sup> ton</b>	<b>x 10<sup>3</sup> ton</b>
<b>Argentina</b>	29.9	355	2,470	1,870	5	605	25.18	0.014
<b>Bolivia</b>	7.44	164	360	355	60	35	0	0.002
<b>Brazil</b>	690	8,598	39,950	13,200	NA	26,750	12.23	2.21
<b>Colombia</b>	38.5	379	2,600	1,610	NA	990	0	0.030
<b>Costa Rica</b>	4.1	53	410	252	NA	175	7.10	13.88
<b>Cuba</b>	14.9	435	1,275	680	20	615	4.60	0
<b>Guatemala</b>	21.45	287*	2,325	725	NA	1,600	339.2	0.414
<b>Guyana</b>	3.5	49*	240	28	10	222	13.32	NA
<b>Jamaica</b>	1.97	31*	160	130	105	135	0.001	10
<b>Mexico</b>	51.1*	669*	5,435	5,075	50	410	347.2	0.020
<b>Nicaragua</b>	5.46	54*	545	240	NA	305	36.99	0.071
<b>Paraguay</b>	5.1*	100	160	132	5	30	7.18	0.551
<b>Peru</b>	10.1	77	1,050	1,240	215	25	1.38	0

Sources: ISO (2010), FAO (2008), FAO (2009)

# *Estimating ethanol production from C sugar and molasses in Latin America*

Country	C sugar		Molasses	
	Available Raw Material	Ethanol Produced	Available Raw Material	Ethanol Produced
	10 <sup>6</sup> ton	10 <sup>6</sup> liters	10 <sup>6</sup> ton	10 <sup>6</sup> liters
Argentina	1.59	550	1.10	263
Bolivia	0.40	137	0.28	67
Brazil	36.78	12,696	25.86	6,208
Colombia	2.05	708	1.44	347
Costa Rica	0.22	75	0.16	39
Cuba	0.79	274	0.55	133
Guatemala	1.14	395	0.47	112
Guyana	0.19	64	0.12	28
Jamaica	0.11	36	0.08	20
Mexico	2.72	940	1.57	377
Nicaragua	0.29	100	0.17	40
Paraguay	0.27	94	0.18	44
Peru	0.54	186	0.38	91

Using:  
 Anhydrous Ethanol from C  
 Sugar = 18.4 l/tc  
 Production of Molasses =  
 37.5 kg/tc  
 Production of Ethanol from  
 Molasses = 240 l/t of  
 molasses

# Sugarcane, Products and Trade in Selected African Countries

Table 6. Sugarcane, Products and Trade in Selected African Countries

Country	**Sugarcane production x10 <sup>6</sup> ton	**Sugarcane harvested x10 <sup>3</sup> ha	Sugar Production x 10 <sup>3</sup> ton	Sugar Consumption x 10 <sup>3</sup> ton	Sugar Import x 10 <sup>3</sup> ton	Sugar Export x 10 <sup>3</sup> ton	*Molasses Export x 10 <sup>3</sup> ton	*Molasses Import x 10 <sup>3</sup> ton
Ghana	0.15	6	0	245	245	0	0	14
Kenya	5.11	55	585	850	375	20	1.78	11.24
Madagascar	2.6	82	16	153	152	15	0	8.6
Malawi	2.5	23	310	191	NAD	119	5.43	1.3
Mauritius	4.53	62	495	43	15	467	73.35	0.6
Mozambique	2.45	180	400	200	NAD	200	16.22	13
@Reunion	1.77	25	NAD	NAD	NAD	NAD	NAD	NAD
Senegal	0.84	7	100	220	120	NAD	2.94	2.2
South Africa	20.5	314	2,270	1,980	260	550	68	173.4
Tanzania	2.37	23	335	425	140	50	25.93	23.99
Zambia	2.5	24	450	130	NAD	320	6.42	1.1

Source: ISO (International Sugar Organization), 2010

\*FAO, 2008

\*\*FAO, 2009

NAD= Not Available Data

@ French Overseas Territory

# *Estimating ethanol production from C sugar and molasses in Africa*

Country	C sugar		Molasses	
	Available Raw Material 10 <sup>6</sup> ton	Ethanol Produced 10 <sup>6</sup> liters	Available Raw Material 10 <sup>6</sup> ton	Ethanol Produced 10 <sup>6</sup> liters
Ghana	0.01	3	0.02	5
Kenya	0.27	94	0.20	48
Madagascar	0.14	48	0.11	25
Malawi	0.13	46	0.09	22
Mauritius	0.24	83	0.10	23
Mozambique	0.13	45	0.09	21
Reunion	0.09	33	0.07	16
Senegal	0.04	15	0.03	7
South Africa	1.09	377	0.87	210
Tanzania	0.13	44	0.09	21
Zambia	0.13	46	0.09	21

Anhydrous Ethanol from C  
 Sugar = 18.4 l/tc  
 Production of Molasses = 37.5  
 kg/tc  
 Production of Ethanol from  
 Molasses = 240 l/t of molasses

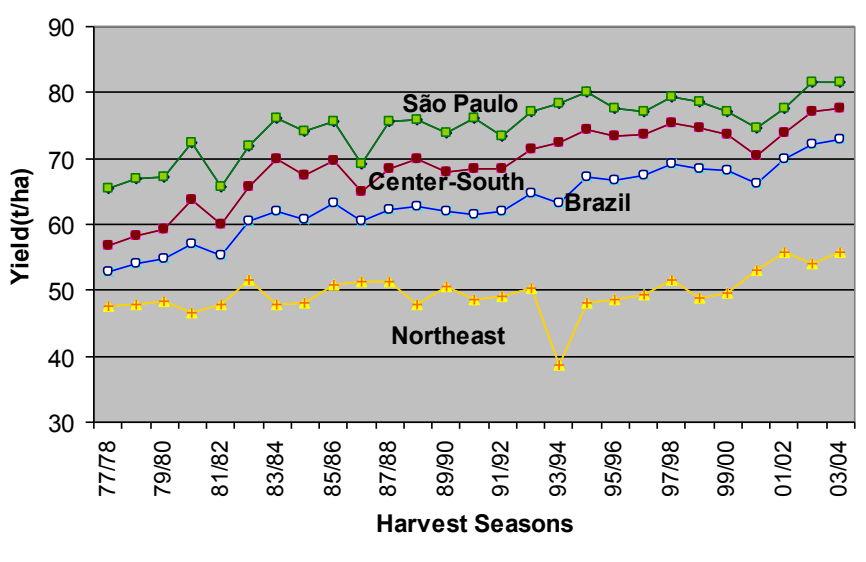
Source: DFID (2007) Jumbe et al (2009)

# *Pre-Estimating ethanol production from C sugar and molasses in LA and AF*

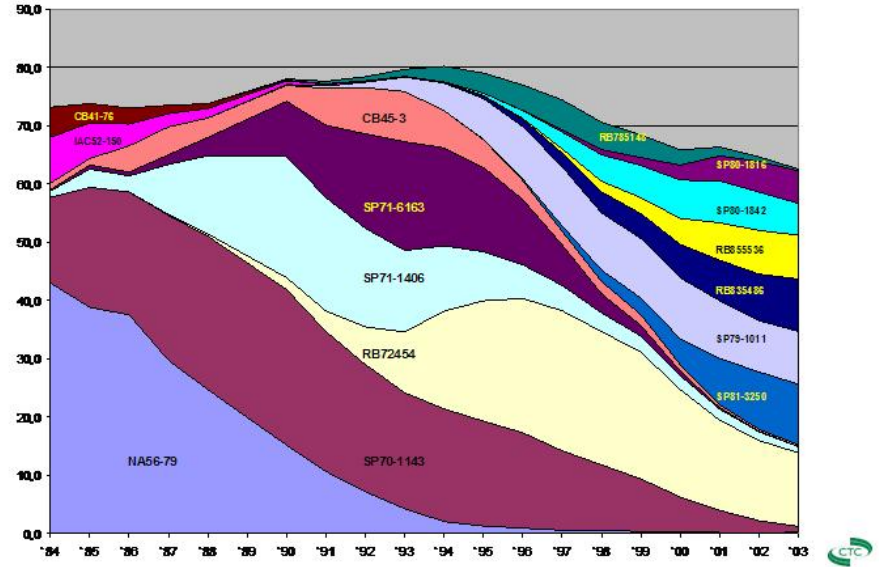
Region	C sugar		Molasses	
	Available Raw Material	Ethanol Produced	Available Raw Material	Ethanol Produced
	10 <sup>6</sup> ton	10 <sup>6</sup> liters	10 <sup>6</sup> ton	10 <sup>6</sup> liters
<b>Latin America &amp; Caribbean</b>	49.38	17,048	33.73	8,094
<b>Africa</b>	4.95	1,709	3.07	738

Sources: CASTANHEDA AYARZA, J.(2007); DFID (2007) Jumbe et al (2009)

# Cane Productivity (t/ha)

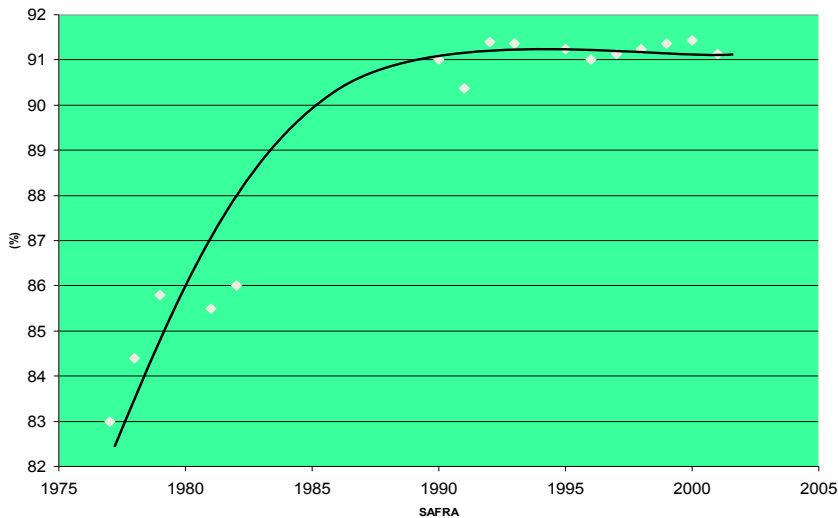


# New Cane Varieties

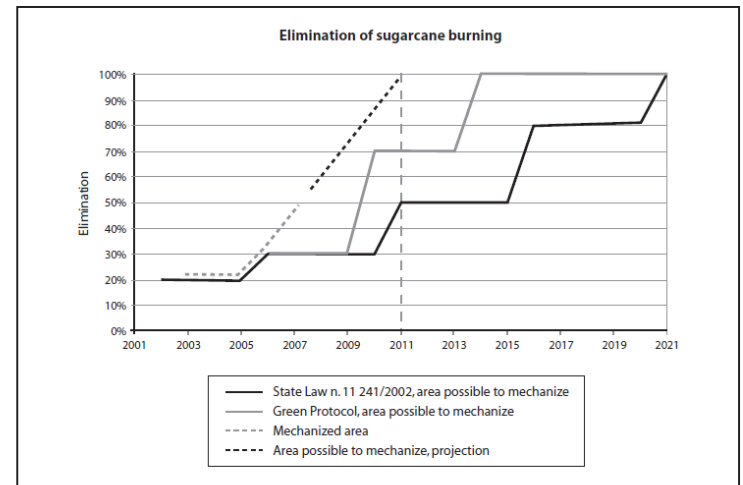


# Fermentation Yield (%)

RENDIMENTO FERMENTATIVO(%)



# No Burning/Mechanization



Source: Available at: <<http://homologa.ambiente.sp.gov.br:80/etanolverde/resultado.asp>>.

FIGURE 4 Evolution of mechanized harvesting for sugarcane.

## LACAf Program/Bioen/FAPESP (August 15th, 2013)

Project	“LACAf”-I Potential Production of Bioenergy LA and Af			“LACAf”-II Socio-Economics			“LACAf”-III Fertility (Soil)			“LACAf-IV” Environment Impacts			“LACAf – V” Geospace analysis, Land Use		
Resp (PR)	Luís Cortez			Márcia Azanha			Heitor Cantarella			Luiz Martinelli			Jansle Rocha		
Sub-Project	Diagnosis Energy and Food Situation and Integrated Analysis	Determining Land Use and Physical Potential	Production Models and Innovation	Food Security	Scenarios for food demand in LA and Af	Social Impacts and Economic Development	Future Inorganic fertilizer demand and Nutrients	Effect of Sugar cane and Trash in soil fertility	Precision Agriculture and Soil Conditioning	Impacts on water (quantity and quality) of Biofuels Prod	Impacts on GHG (climate)	Impacts on Biodiversity of Biofuels Prod	Pasture Intensification	Land Use Data Base (World)	Global Energy Crop Model
Main (PP)	Luiz A. Horta Nogueira	Edgar Beauclair	Manoel Regis L V Leal	Jeremy Woods	André Furtado	Márcia Azanha	Raffaella Rossetto	Heitor Cantarella	Braunbeck	Luiz Martinelli	TBD	TBD	Jansle	André Nassar	TBD
Associated (PA)	Rincon, Emile, Melgar, Kafarov, Jean Claude, Annie, Francis J, Laurent, Frank, José Maria,	CTC, ICONE, ORNL, Beauclair, Fábio, Cantarella, Alexandre, SASRI, CENICAÑA	Bonomi, Jean Claude, Francis Y, Emile, Rincon, Geraldo Martha, Beauclair, Leonard, Keith Kline	Frank Rosillo-Calle, Marcia, Annie, Emile, Horta, Regis, Geraldo Martha, Marco Túlio	Márcia Azanha, Jeremy Woods, Frank Calle, Horta, Alexandre Strapasson	Annie Chimphango, Jeremy Woods, Frank, André Furtado, Regis, José Maria, Patricia	Heitor Cantarella, Oscar Braunbeck, Paulo Magalhães	Raffaella, Beauclair, Fábio, ORNL, Regis, Galdos, Braunbeck	Cantarella, Raffaella, Graziano, Bonomi, Edgar, Beauclair, Fábio, Zigomar	Suani Coelho, Osvaldo Lucon, Folegati, ORNL, Silvia Nebra, ICONE			Rubens Lamielli, John Sheehan, Keith Kline		