



ORNL – Oak Ridge, TN

May 13th, 2011

A Preliminary Assessment of Sugarcane Feedstocks in LA and AF (considering the Brazilian experience)

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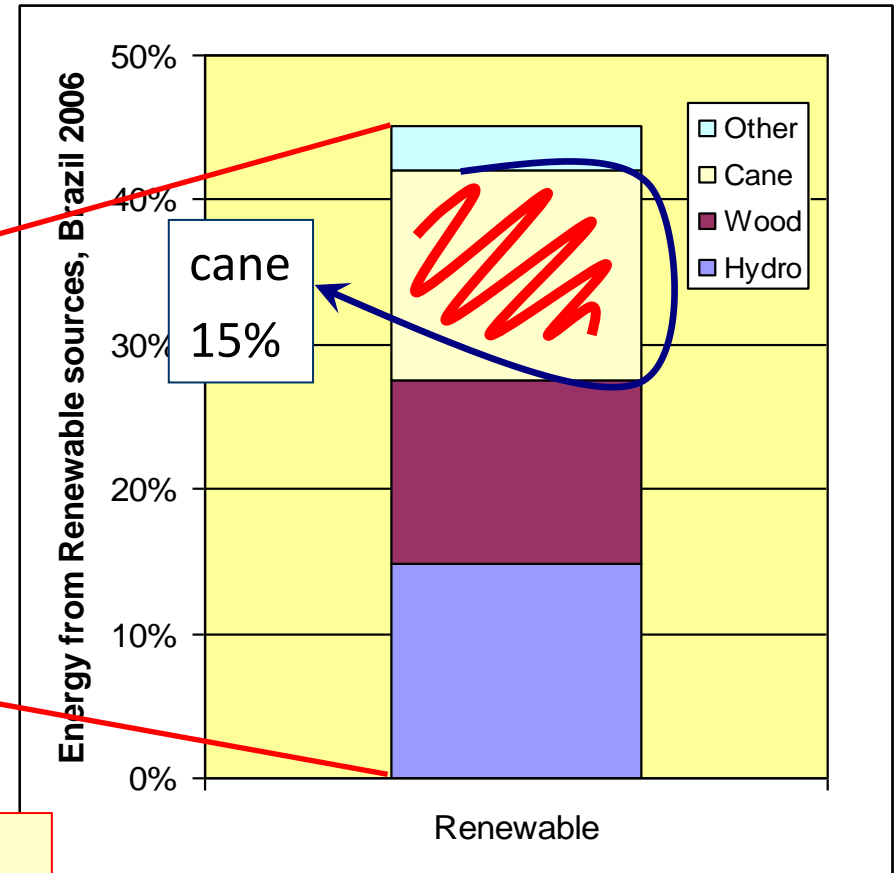
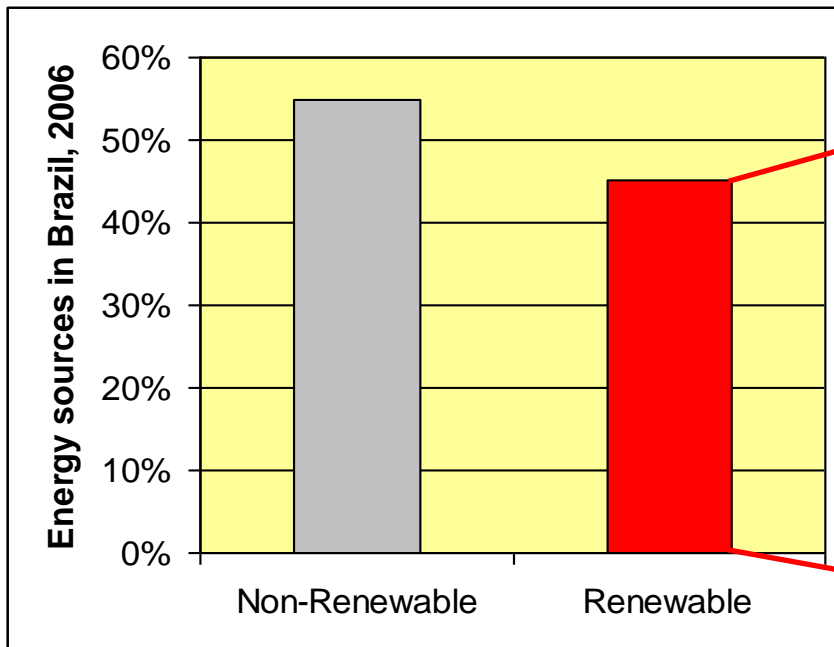


Structure of Presentation

- Present situation of the Brazilian sugarcane ethanol industry
 - **LACAF/FAPESP Project (Latin America and Africa):**
 - *Diagnosis on Food/Energy Situation*
 - *Sugarcane potential, land use and ethanol potential*
 - *Adopting the Brazilian model (sugar & ethanol)*
 - *Assessing socio-economic and development benefits*
 - *Analyzing ethanol production in case study countries: Colombia, Guatemala, South Africa and Mozambique*
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Present Situation of Ethanol in Brazil

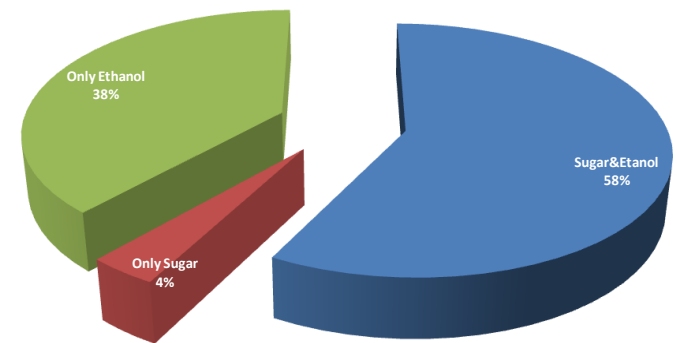
46% of Brazil's energy comes from renewable sources



Renewables in Brazil: 46%; World: 13%; OECD: 6%

Brazilian Ethanol: reasons for success

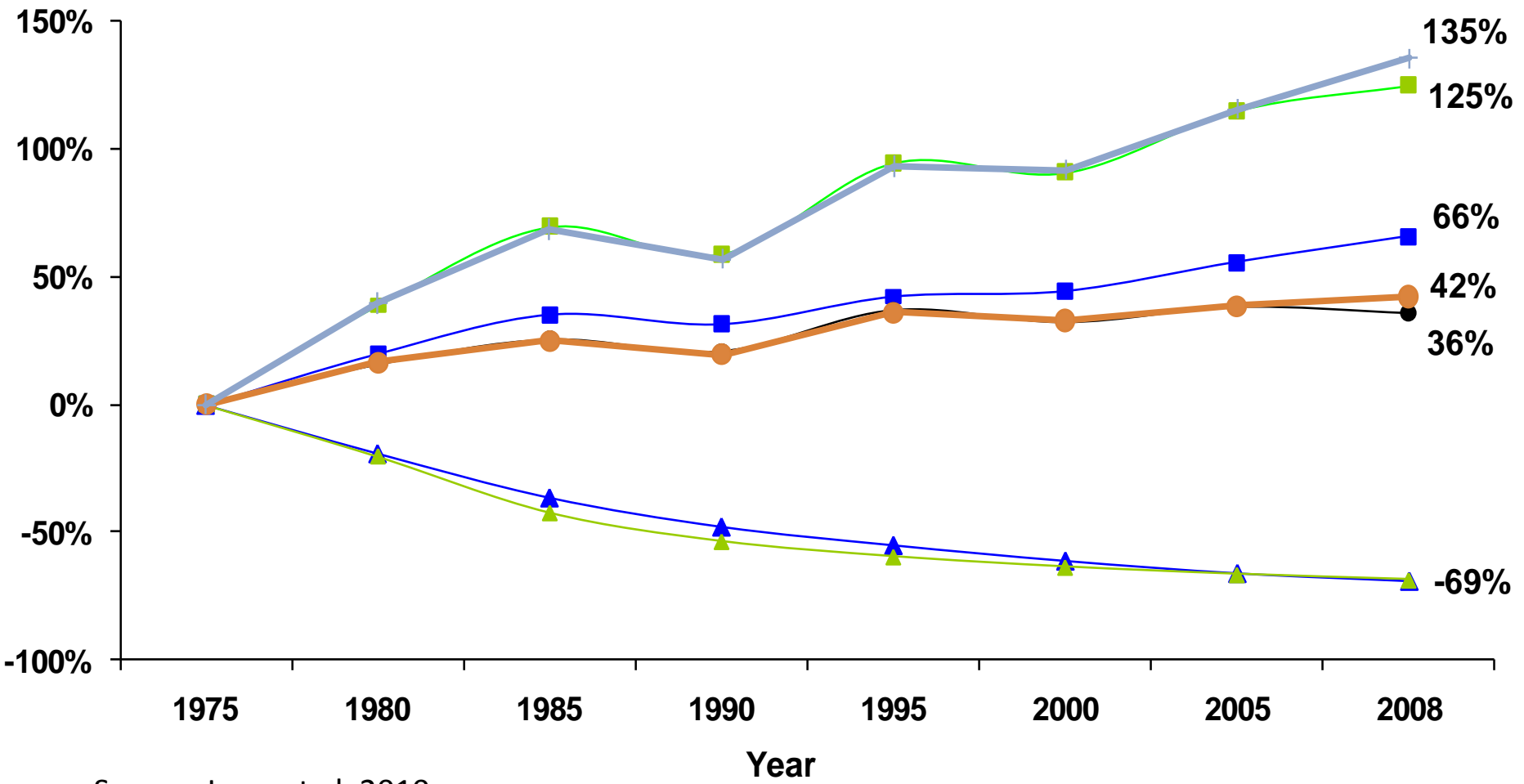
- Brazil established a dynamic relation between Research and Production particularly after 1975, involving govmt and private sectors
- Sugarcane, an excellent energy crop
- Creation of the “**Brazilian Model**” combining efficient sugar and ethanol production



Source: Brazilian Ministry of Agriculture/MAPA

Rise of yields and reduction on production costs for Brazilian sugarcane, ethanol and sugar - 1975 to 2008

- Sugarcane yield (from 46.8 to 77.5 ton/ha)
- Ethanol yield (from 2,772 to 6,234 L/ha)
- ▲ Ethanol cost (from 1.20 to 0.38 US\$/L)
- Sugaryield (from 4.7 to 11.0 ton/ha)
- Ethanol yield (from 59.2 to 80.4 L/ton of sugarcane)
- ▲ Sugarcane cost (from 44.4 to 13.8 US\$/ton)
- Sugar yield (from 99.9 to 142.0 kg/ton of sugarcane)



Source: Lago et al. 2010

What is currently been done in Brazil to improve the sugarcane ethanol industry

1. Building a New Agricultural Model :

- Improve sustainability indicators: direct planting and precision agriculture
- Use cane trash: mulching, soil conditioning and recovering it (energy use)
- Introduce energy cane (estimated 160 t/ha and 23,000 liters/ha)
- Integrate pasture land for sugarcane expansion (saving 54 Mha and improving LCA with negative LUC/ILUC) (1 to 3 animals/ha)

2. Building a New Industrial Model:

- Save bagasse for more energy use (ethanol and electricity)
- Introduce first commercial cellulosic ethanol plant

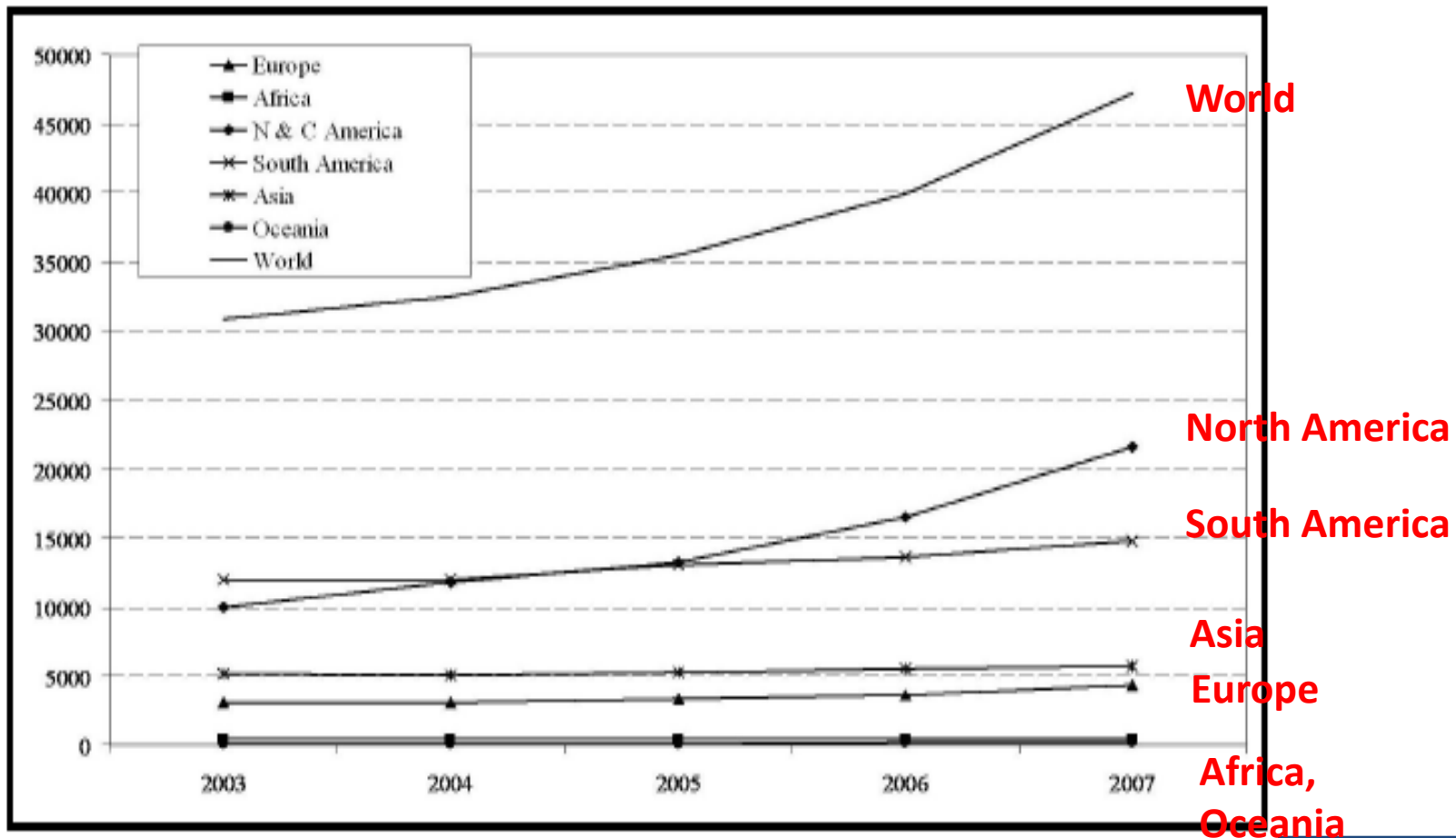
3. Needs a New generation of FFV Hybrid vehycles:

- Present FFV vehycles have emissions comparable to existing hybrid but the new generation could even be 50% more efficient

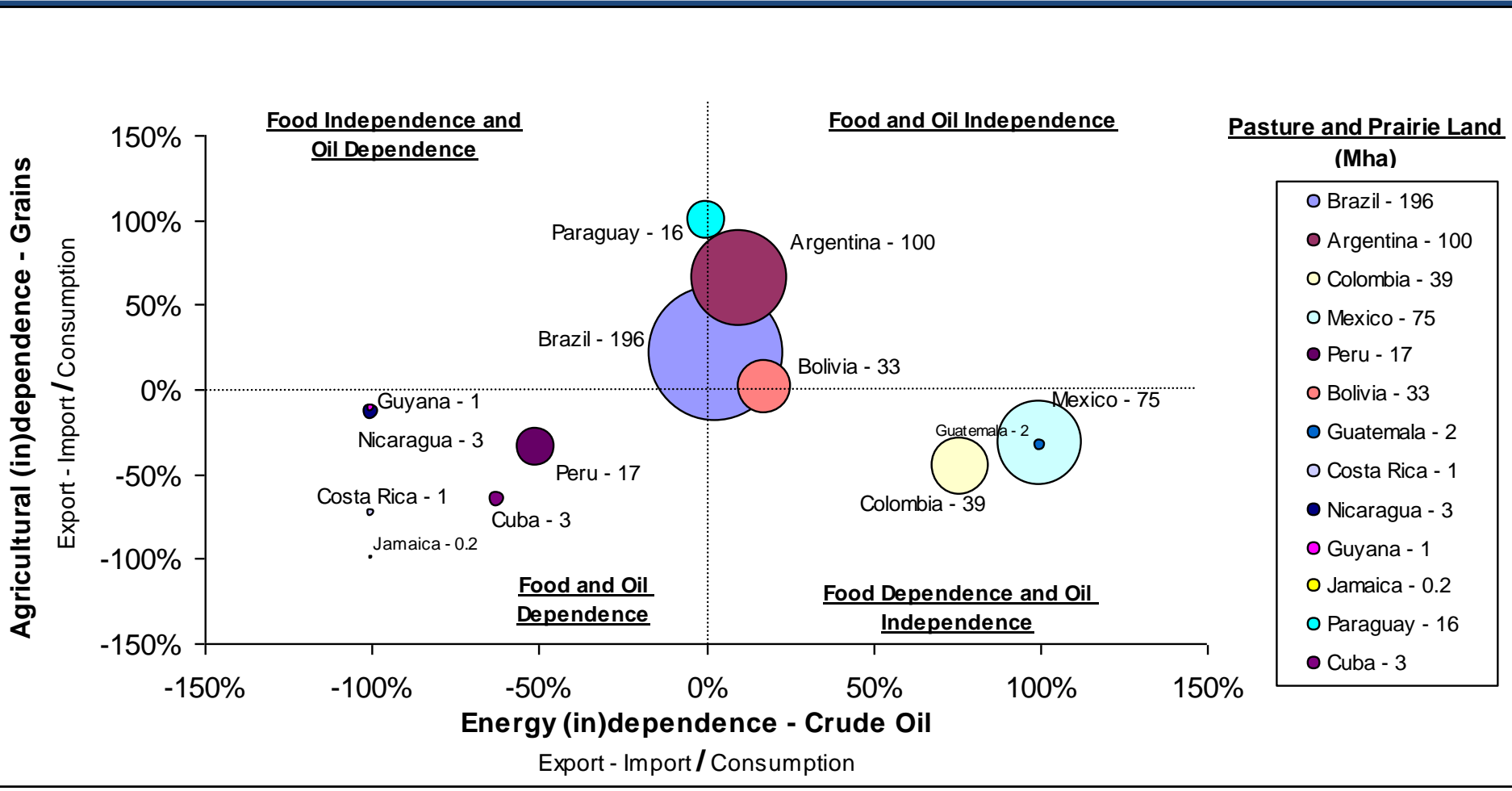
***LACAF/FAPESP Project
Diagnosis on Food/Energy Situation
in Latin America and Africa***

Latin America is the 2nd largest Ethanol producer

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

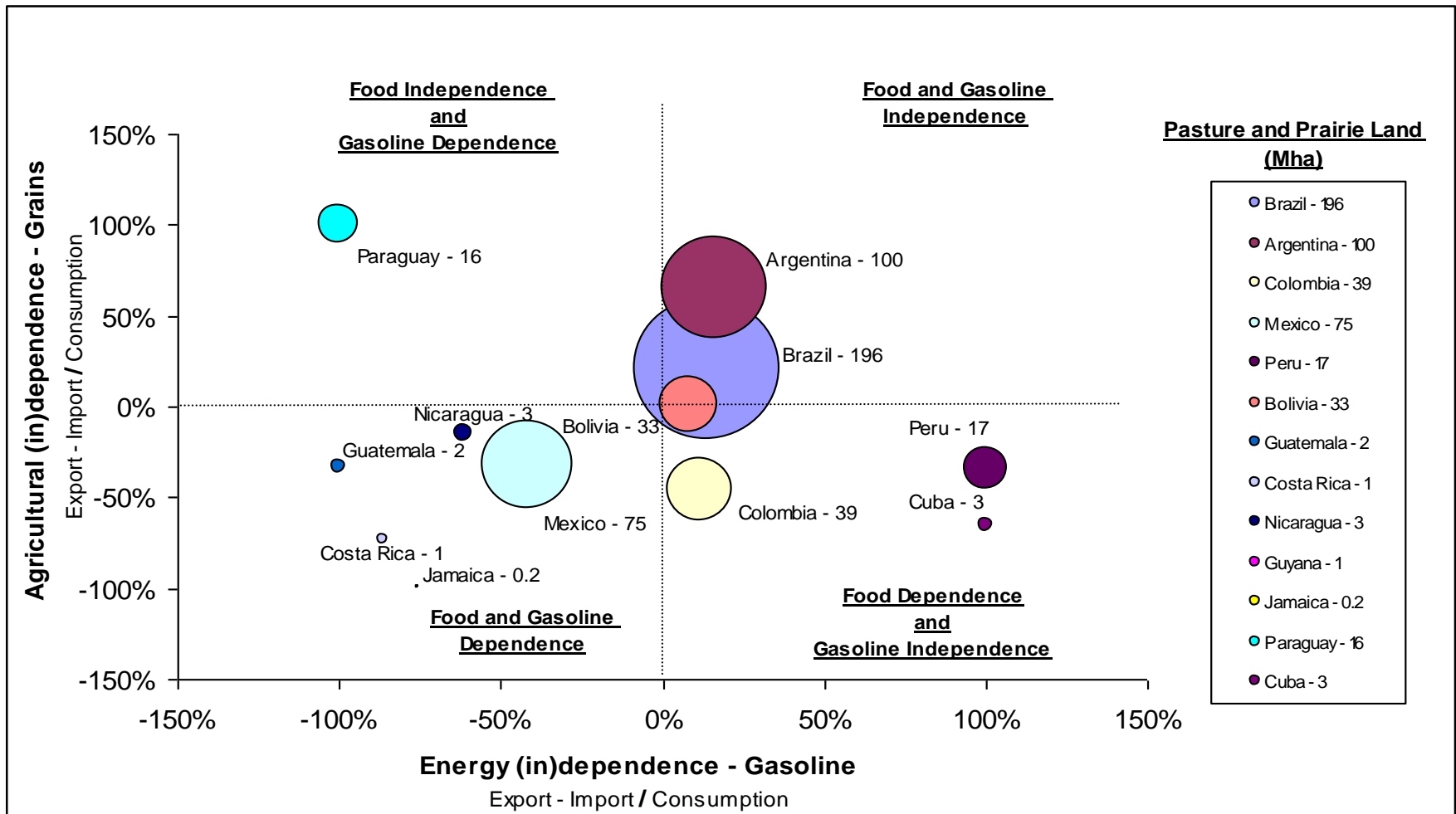


Food (Grains) and Energy (Crude Oil) Dependence in Latin America



Source: FAO (2008), IEA (2008)

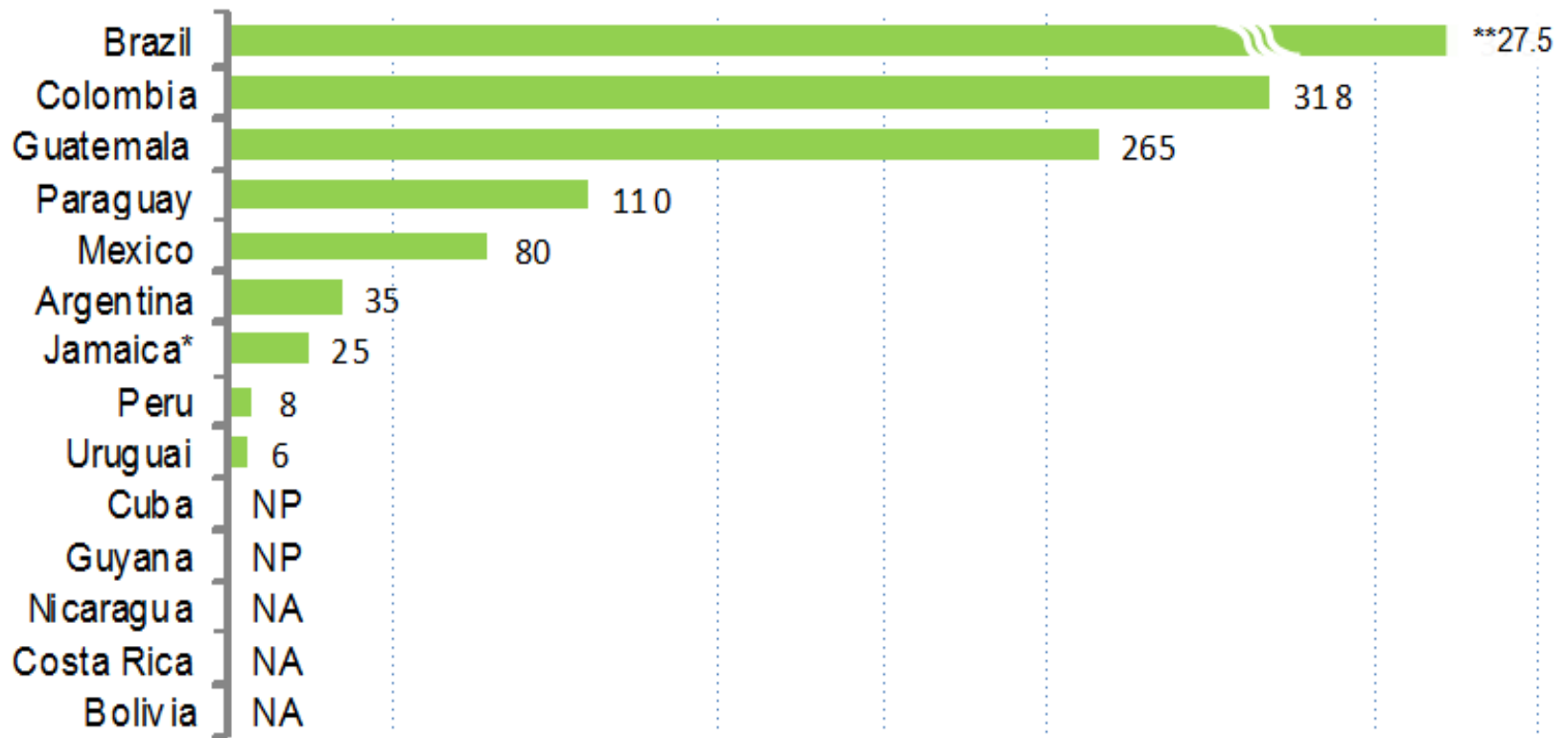
Food (Grains) and Energy (Gasoline) Dependence in Latin America



Source: FAO (2008), IEA (2008)

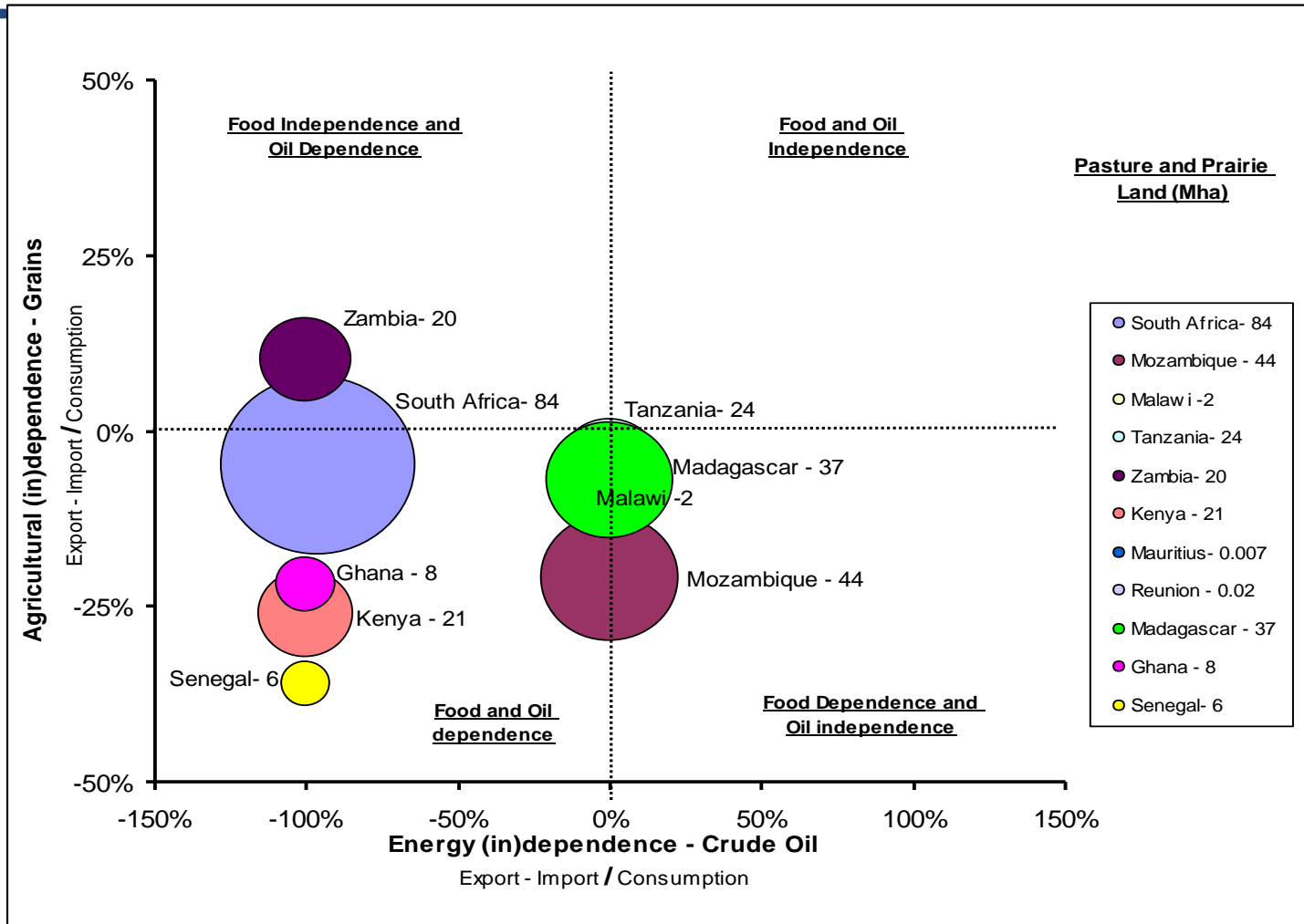
Ethanol production in Latin America

Ethanol Fuel Production - 2009 (MI)



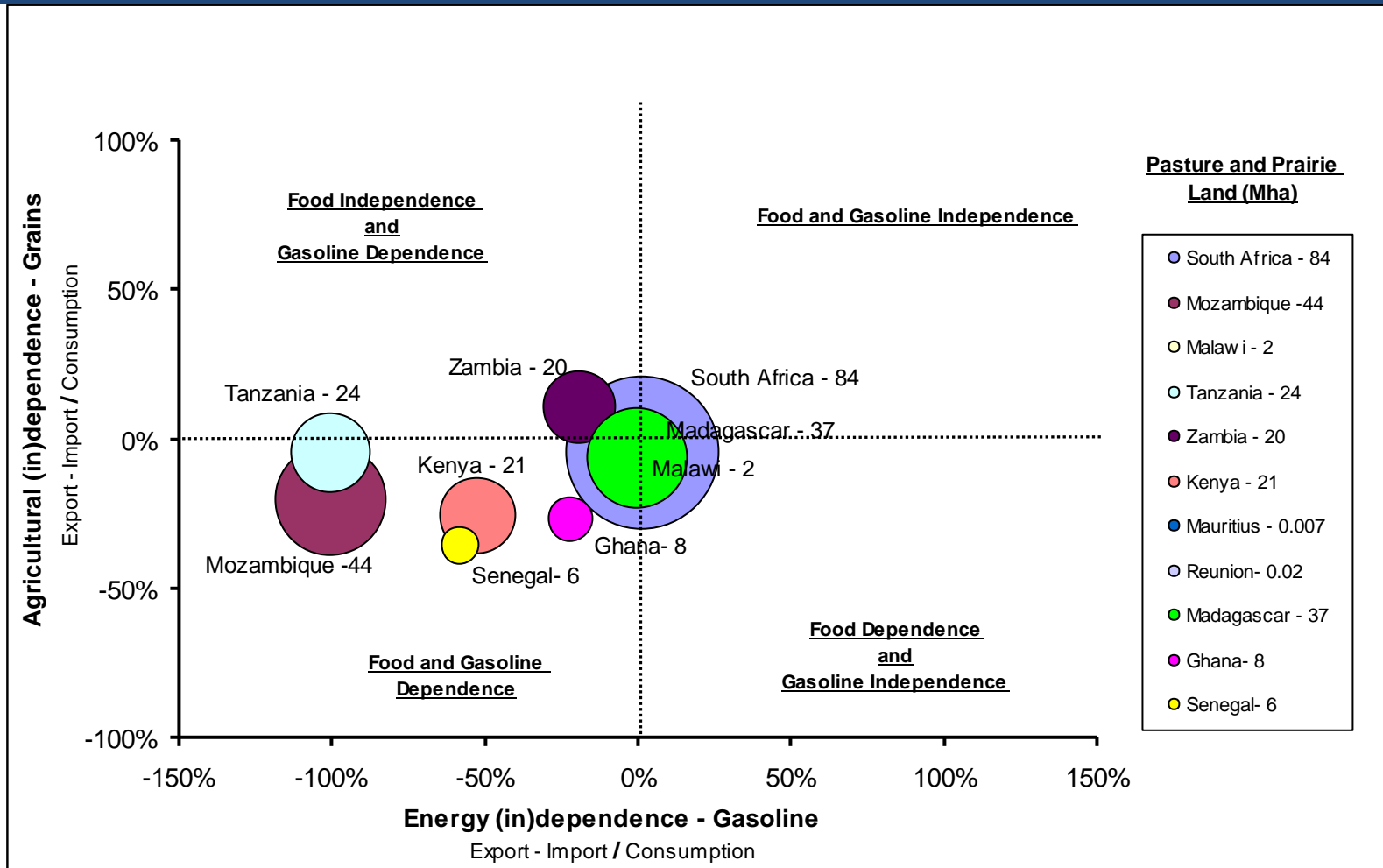
Source: USDA (2010)

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



Source: FAO (2008), IEA (2008)

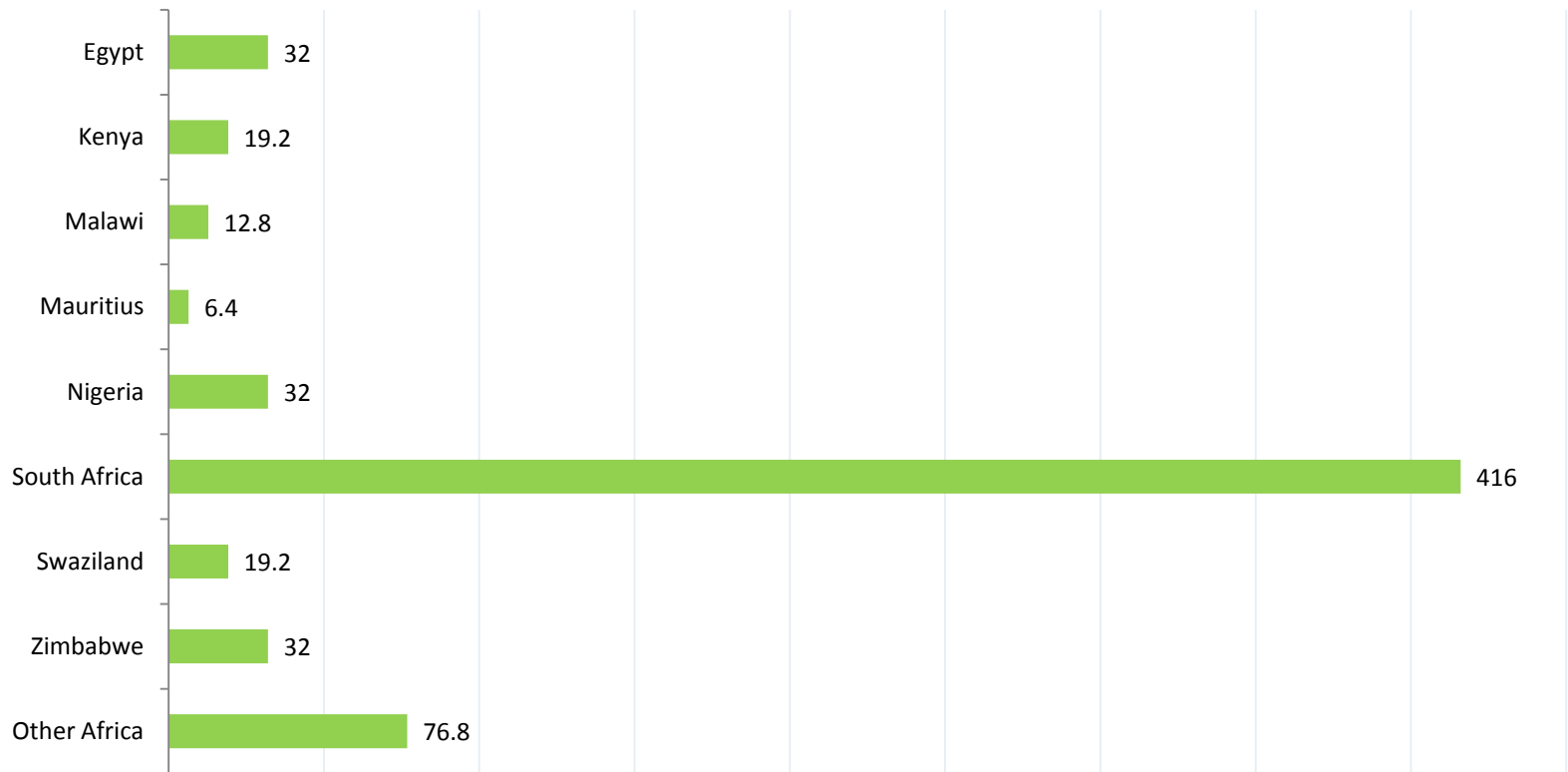
Food (Grains) and Energy (Gasoline) Dependence in Africa



Source: FAO (2008), IEA (2008)

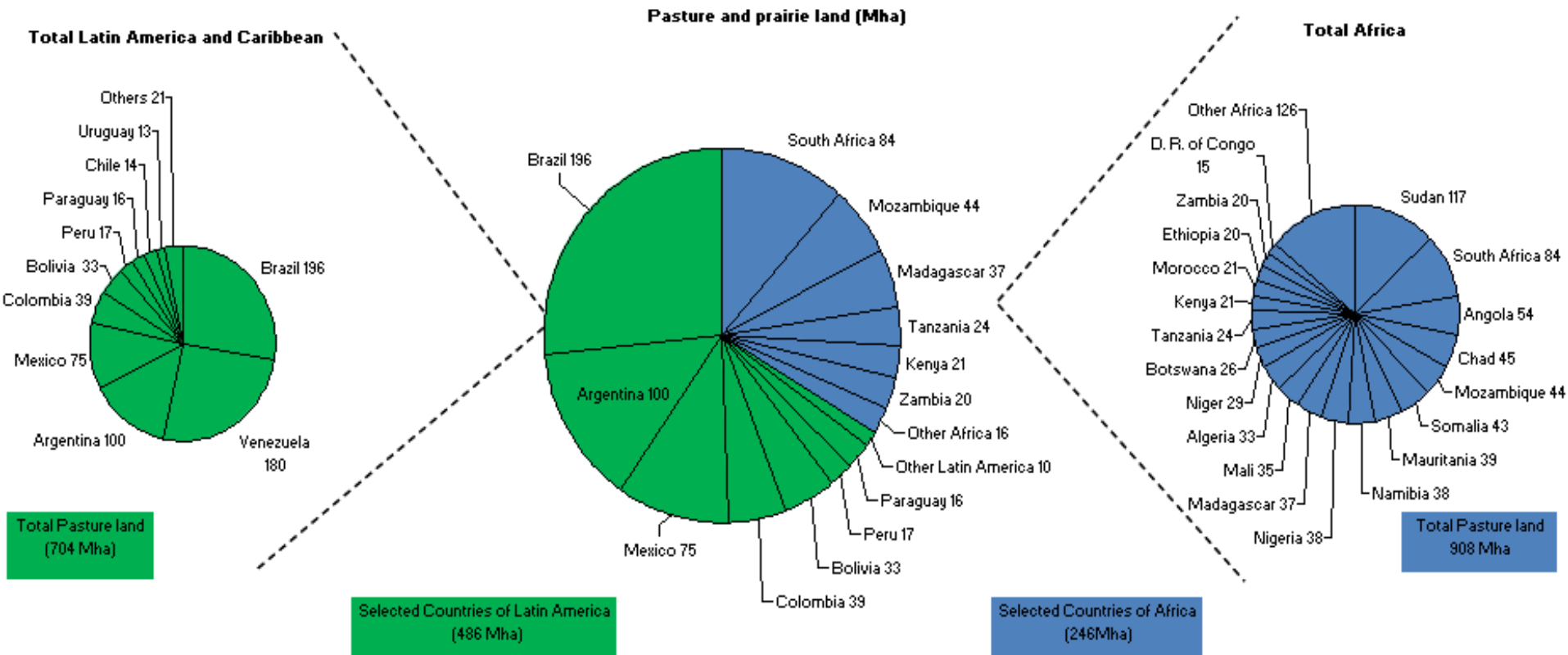
Ethanol production in Africa

Ethanol Fuel Production - 2007 (MI)



***LACAF/FAPESP Project
Sugarcane potential, land use
and ethanol potential in Latin
America and Africa***

Land Availability for bioenergy in LA and AF



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)

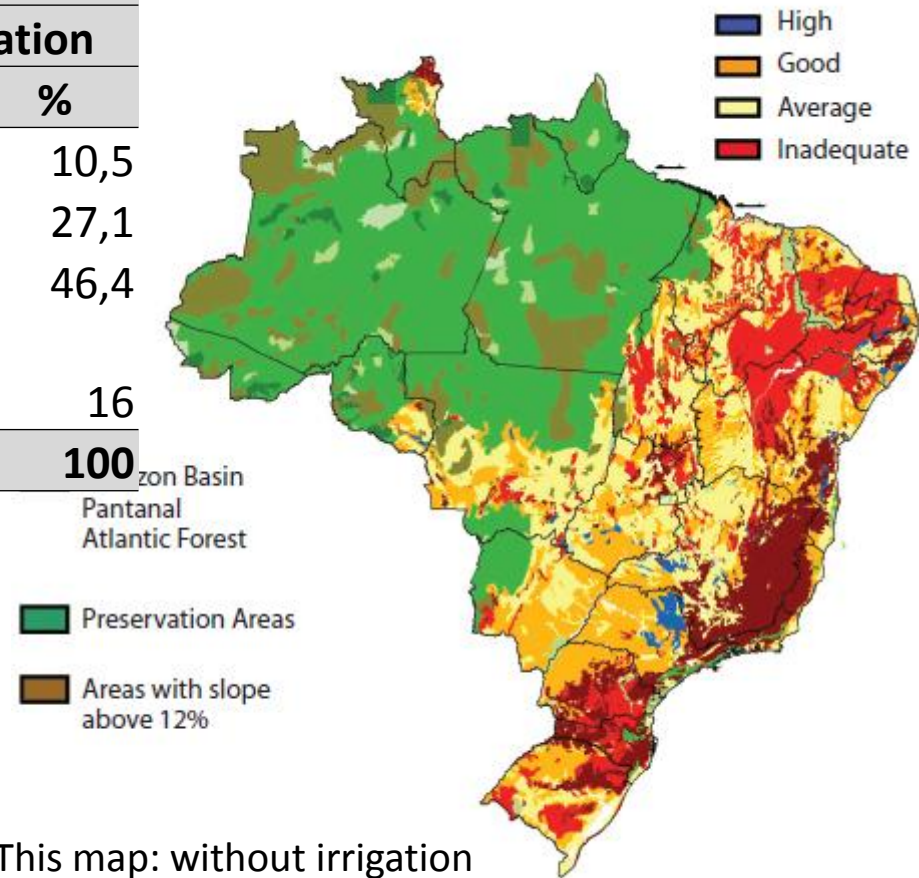
	2004	2050
Gasoline consumption ⁽¹⁾	1,200 GL	2,200 GL
Ethanol consumption	30 GL	
Ethanol substituting 15% gasoline		400 GL
Ethanol substituting 100% gasoline		2,650 GL

(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

A similar estimate for Brazil

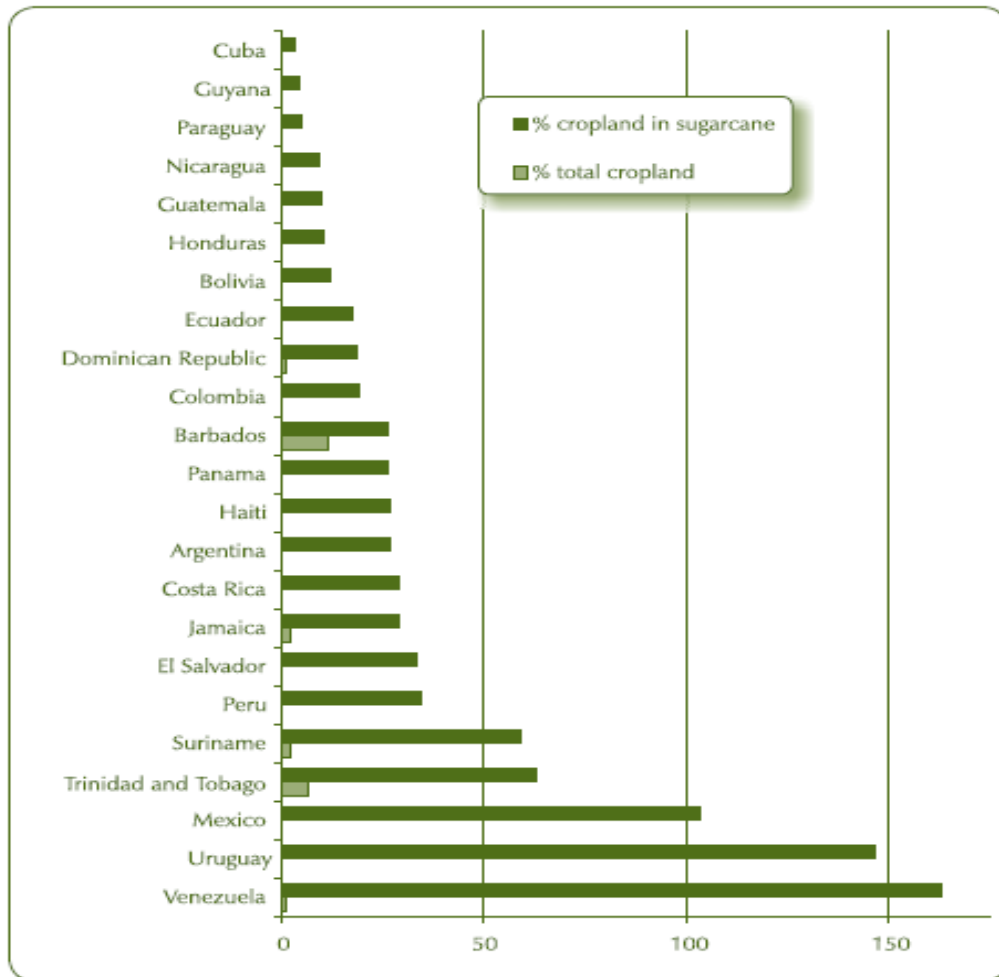
Area classification					
	Prodvty	No irrigation		W. irrigation	
Potential	(ton/ha)	MHa	%	MHa	%
High	> 80	7,9	2,2	37,9	10,5
Medium	>73	113,9	31,5	98,0	27,1
Low	> 65	149,2	41,3	167,7	46,4
Inadequate	< 65	90,6	25,1	58,0	16
Total	-	361,6	100	361,6	100



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.bioetanoldecana.org/en/download/bioetanol.pdf>

LACAF/FAPESP Project
Adopting the Brazilian model (sugar & ethanol) in Latin America and Africa

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

Country	**Sugarcane production	**Sugarcane harvested	Sugar Production	Sugar Consumption	Sugar Import	Sugar Export	*Molasses Export	*Molasses Import
	10⁶ ton	10³ ha	x 10³ ton	x 10³ ton	x 10³ ton	x 10³ ton	x 10³ ton	x 10³ ton
Argentina	29.9	355	2,470	1,870	5	605	25.18	0.014
Bolivia	7.44	164	360	355	60	35	0	0.002
Brazil	690	8,598	39,950	13,200	NA	26,750	12.23	2.21
Colombia	38.5	379	2,600	1,610	NA	990	0	0.030
Costa Rica	4.1	53	410	252	NA	175	7.10	13.88
Cuba	14.9	435	1,275	680	20	615	4.60	0
Guatemala	21.45	287*	2,325	725	NA	1,600	339.2	0.414
Guyana	3.5	49*	240	28	10	222	13.32	NA
Jamaica	1.97	31*	160	130	105	135	0.001	10
Mexico	51.1*	669*	5,435	5,075	50	410	347.2	0.020
Nicaragua	5.46	54*	545	240	NA	305	36.99	0.071
Paraguay	5.1*	100	160	132	5	30	7.18	0.551
Peru	10.1	77	1,050	1,240	215	25	1.38	0

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 ⁶ ton	10 ⁶ liters	10 ⁶ ton	10 ⁶ 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 ⁶ ton	**Sugarcane harvested x10 ³ ha	Sugar Production x 10 ³ ton	Sugar Consumption x 10 ³ ton	Sugar Import x 10 ³ ton	Sugar Export x 10 ³ ton	*Molasses Export x 10 ³ ton	*Molasses Import x 10 ³ 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 ⁶ ton	Ethanol Produced 10 ⁶ liters	Available Raw Material 10 ⁶ ton	Ethanol Produced 10 ⁶ 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

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 ⁶ ton	10 ⁶ liters	10 ⁶ ton	10 ⁶ liters
Latin America & Caribbean	49.38	17,048	33.73	8,094
Africa	4.95	1,709	3.07	738

***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)

- 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: André Nassar (ICONE) ou Heitor Cantarella (APTA/IAC)

- 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-ICONE team)
- Use a Sugarcane Crop Model and Estimate Total Sugarcane Ethanol Production in LA and AF (Edgar Beauclair, Fabio Marin, Durval Dourado)

LACAF-FAPESP Project: a contribution to the GSB Project

2. Determining the Physical Potential for Sugarcane Ethanol Production in Latin America and Africa (cont.)

Coordinator: André Nassar (ICONE) ou Heitor Cantarella (APTA/IAC)

- Analyzing the Increase Productivity in Agriculture: Pasture Productivity (Geraldo Martha), Sugarcane Expansion with Pasture Integration (UNISOMA), Double Crops in Land Use (Embrapa?)
- Estimating the Future Inorganic Fertilizer Demand and Recycling Nutrients in Sugarcane Ethanol Production (Cantarella, Raffaella)
- Analyzing the Possible Impact of Advanced Technologies in Agriculture: precision agriculture, no-till, soil conditioning (Braunbeck, Graziano, Cantarella, Bonomi)

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-FAPESP Project: a contribution to the GSB Project

4. Assessing Constraints/Benefits of sugarcane ethanol production in LA and AF **Coordinator: José Antonio Scaramucci (NIPE/UNICAMP)**

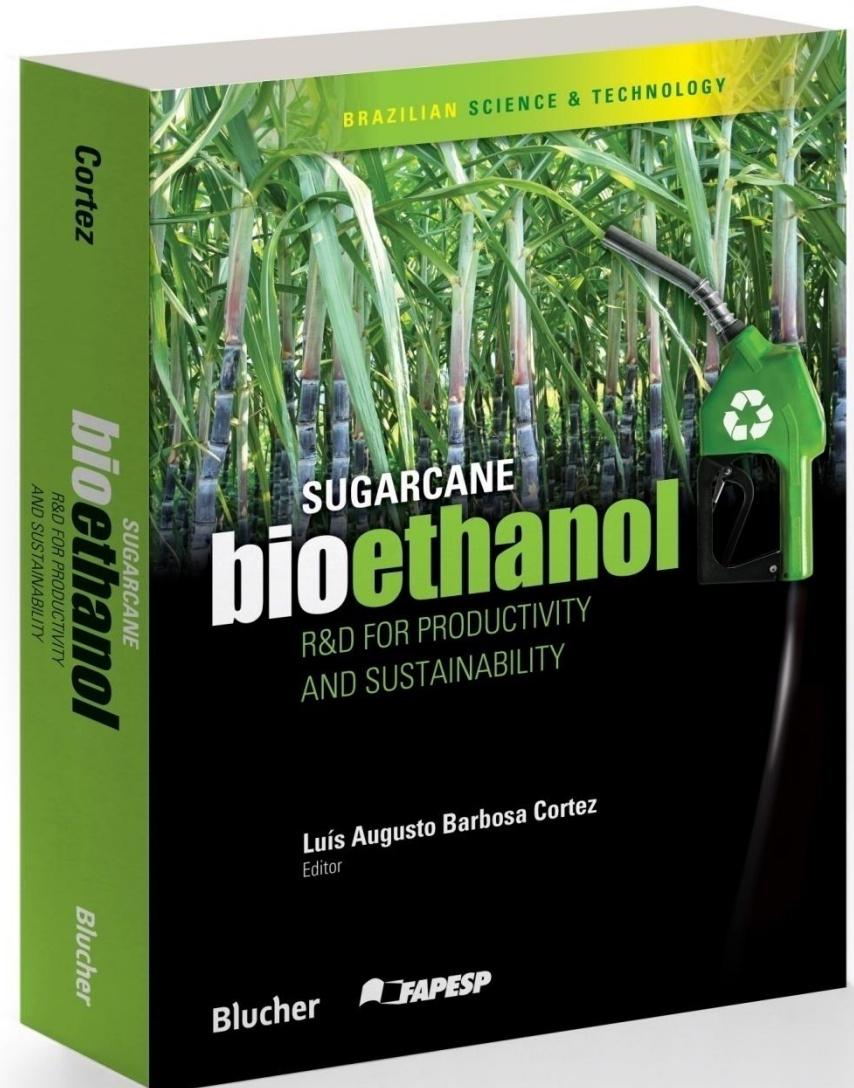
- Agriculture and energy issues analysis in Latin America and Africa (Jeremy Woods, Frank Rosillo-Calle, Alexandre Strapasson, Francis Yamba)
- Expected future food consumption, impact of dietary choice in agriculture land use in LA and AF (Geraldo Sant'Anna de Camargo Barros/CEPEA)
- Economic analysis of the advancement of sugarcane bioenergy in Latin America and Africa: the cases of Colombia, Guatemala, South Africa and Mozambique (Scaramucci, Edmar, Bento, José Rincón, Emile Van Zyl, Francis Yamba)
- Impacts on socio-economic development from Sugarcane Ethanol Production Latin America and Africa: the cases of Colombia, South Africa and Mozambique (André Furtado, Marcia Azanha, Annie Chimphango, José Rincón, Emile Van Zyl, Francis Yamba)

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



1st Brazilian Bioenergy Science & Technology Conference - BBEST

- Venue: Campos do Jordão, SP, Brazil
- August 14-18, 2011

<http://www.bbest.org.br/>

