Can Brazil Replace 5% of World Demand of Gasoline in 2025?

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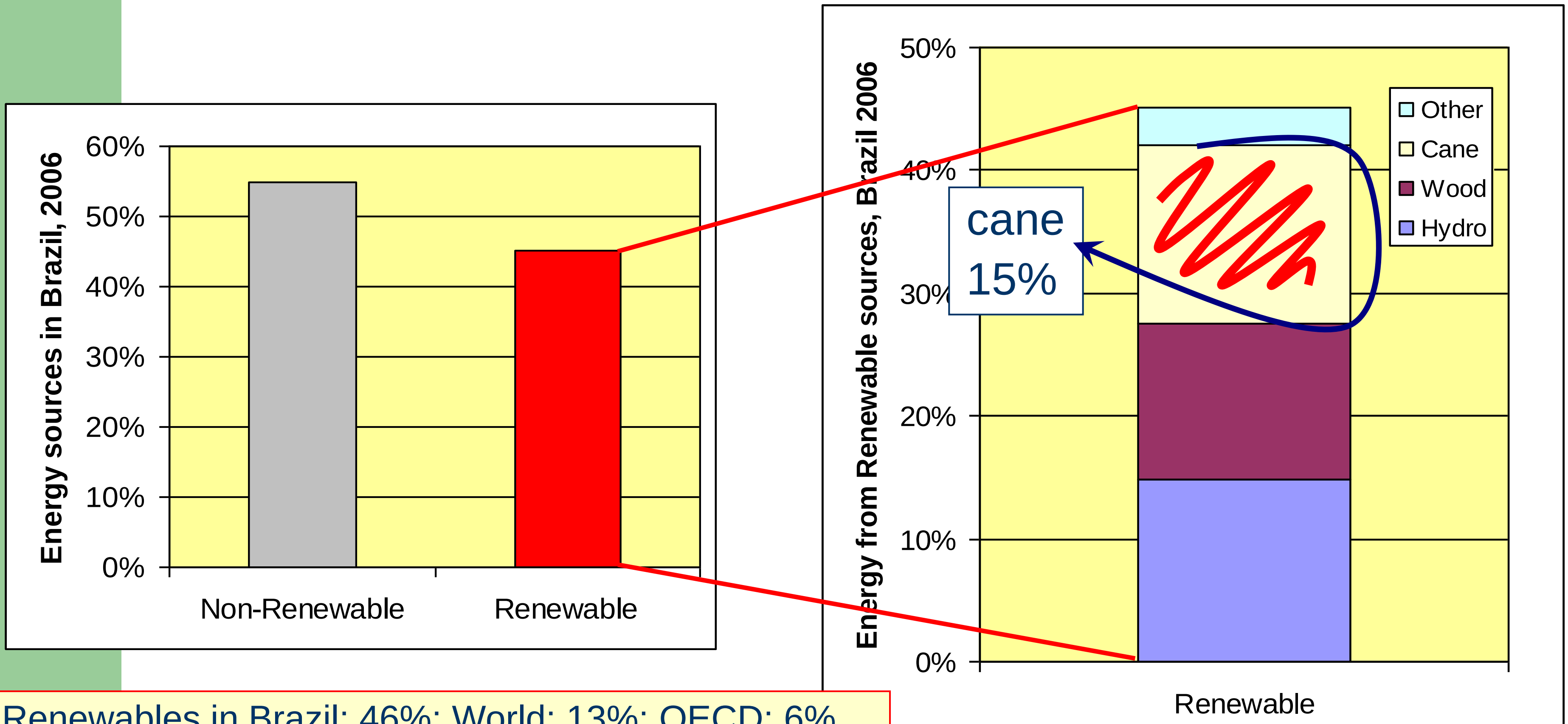
Presentation Content

- Brazil ethanol: reasons for success
- Use/availability of land in Brazil
- NIPE-UNICAMP/CGEE study (5% substitution)
- Important issues on ethanol sustainability:
    - integrating pasture/beef & cane ethanol
    - determining new CO_2 emissions: Ethanol LCA integrated with beef LCA
    - sugarcane productivity: what are the limits?
    - New sugarcane field management
- MAPA Agro-ecological Zoning

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

46% of Brazil's energy comes from renewable sources



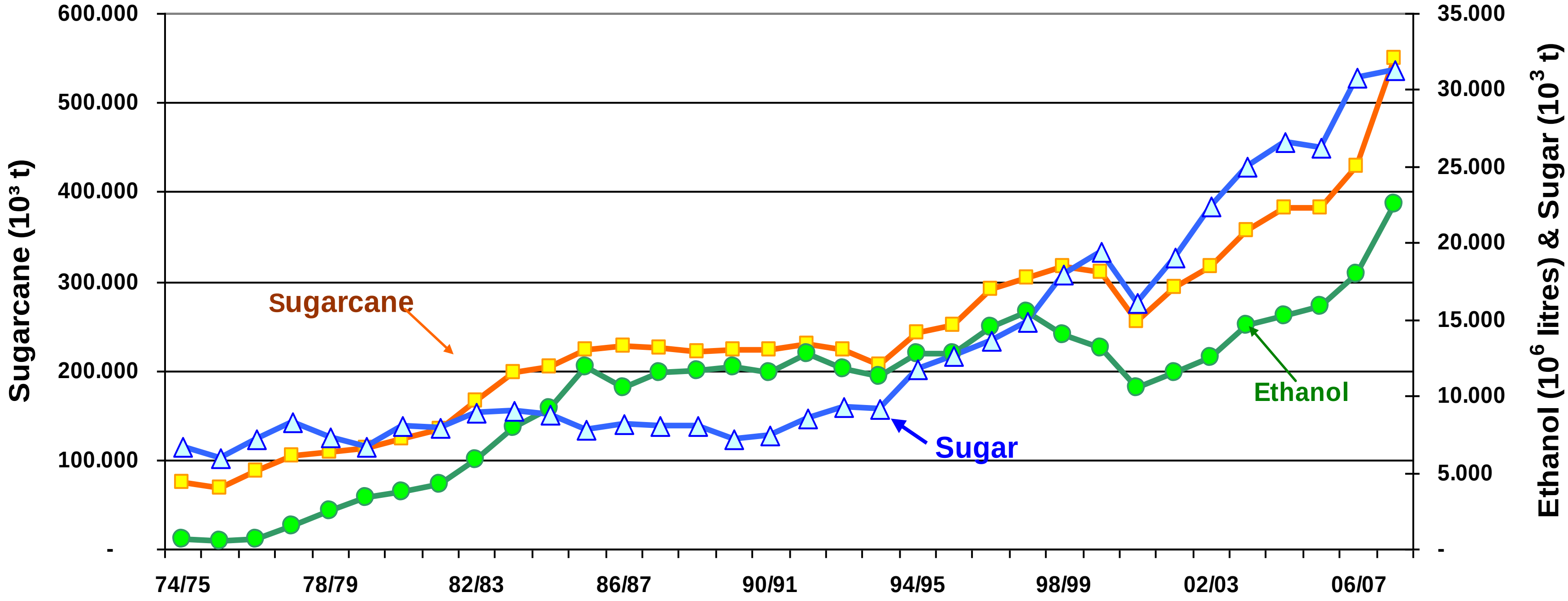
Renewables in Brazil: 46%; World: 13%; OECD: 6%

Source: MME-BEN (2007)

From C.H. Brito Cruz, http://www.fapesp.br/eventos/bioen0809/brito.pdf

Brazilian Cane, Sugar and Ethanol Production

First period: “necessity”   Now: a great “opportunity”!!



Brazil increased ethanol production and the same time that increased its sugar production

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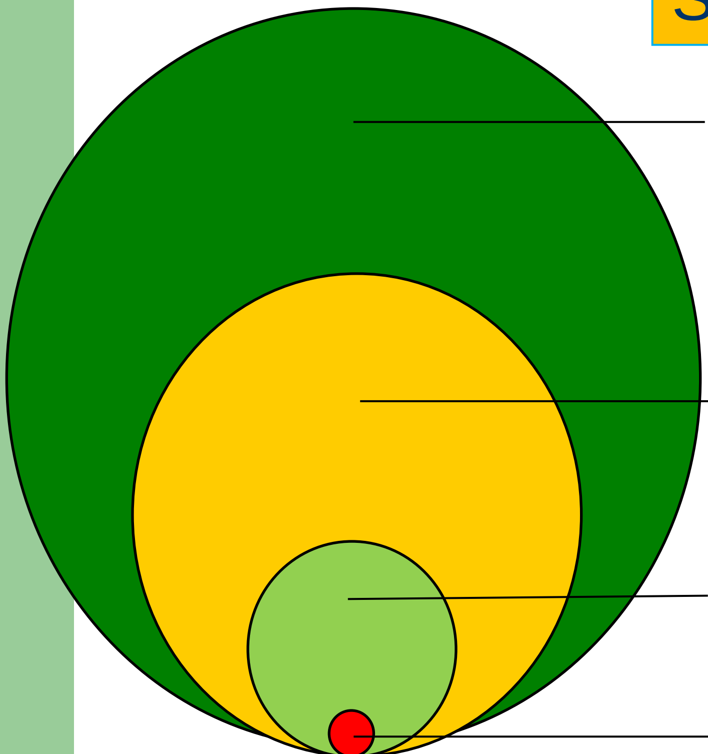
Source: UNICA

Sugarcane for ethanol uses 0.4% of total area

Small bioenergy footprint



Pasture 200 Mha

Soya 22 Mha

Source: Horta Nogueira e Seabra (2008)

Expanding Ethanol Production

- But the present questions are:
- **How much sustainable ethanol can Brazil produce**?
- What are the limits without touching the Amazon and other eco santuaries and preserving food and feed production?
- What could be the sugarcane ethanol contribution to **decrease GHG emissions**?
- What research can we do to reduce cost and improve sustainability indicators?

NIPE-Unicamp/CGEE Ethanol Project

- **<u>Coordinator</u>**:
  - Professor Rogério Cezar de Cerqueira Leite (UNICAMP)

- Vice-Coordinators:
  - Dr. Manoel Sobral Jr (phase I)
  - Dr. Manoel Regis Lima Verde Leal (phases I e II)
  - Dr. Luís Cortez (phase III)

  - **<u>9 senior researchers</u>**, around **<u>20 researchers involved</u>**

  - **<u>Collaboration</u>**: CGEE, MCT, MAPA, EMBRAPA, TRANSPETRO, PETROBRAS, DEDINI, CTC

  - Project in agreement with the Brazilian Agro energy Policy

The study considered 2 scenarios: substitution of 5 and 10% of gasoline consumed in the world by 2025

Source: Leite et al. 2009
Also at: http://www.cgee.org.br/

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Can Brazil replace 5% of the 2025 gasoline world demand with ethanol?

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ABSTRACT

Increasing use of petroleum, coupled with concern for global warming, demands the development and institution of CO_2 reducing, non-fossil fuel-based alternative energy-generating strategies. Ethanol is a potential alternative, particularly when produced in a sustainable way as is envisioned for sugarcane in Brazil. We consider the expansion of sugarcane-derived ethanol to displace 5% of projected gasoline use worldwide in 2025. With existing technology, 21 million hectares of land will be required to produce the necessary ethanol. This is less than 7% of current Brazilian agricultural land and equivalent to current soybean land use. New production lands come from pasture made available through improving pasture management in the cattle industry. With the continued introduction of new cane varieties (annual yield increases of about 1.6%) and new ethanol production technologies, namely the hydrolysis of bagasse to sugars for ethanol production and sugarcane trash collection providing renewable process energy production, this could reduce these modest land requirements by 29–38%.

Ref: Leite et al. 2009
Energy 34(2009) 655-661

Gasoline and Ethanol Fuel Consumption (million liters/year)

	2004	2025
Gasoline	1,200	1,700[1]
Ethanol Fuel	26[2]	205 (* subst. 10%)
		102 (* subst. 5%)

Sources:

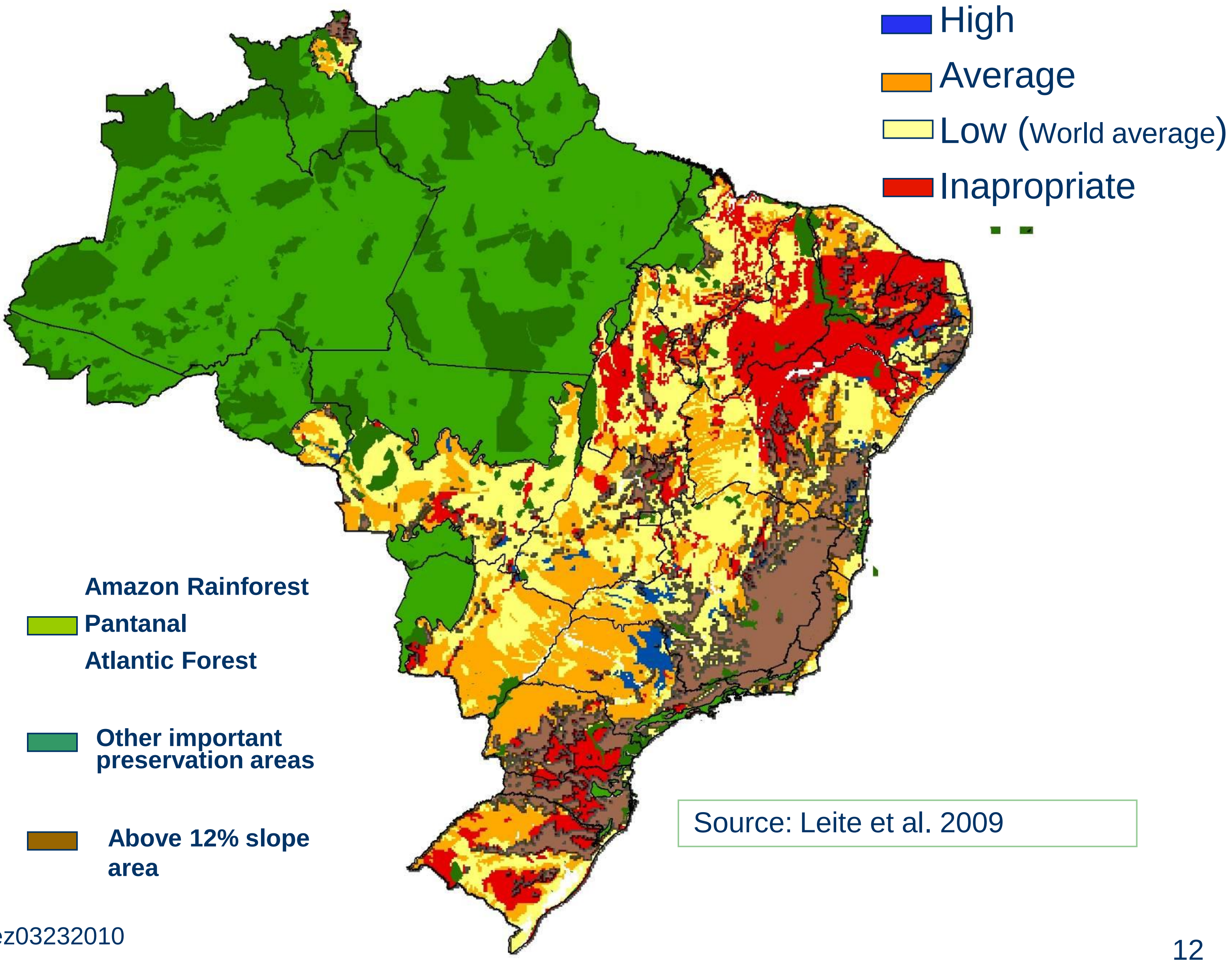
1) *National Energy Information Center* (NEIC)
2) Brazil and USA

Objectives

- **OE1**: **Present technology** and possible improvements **(**M. Regis Leal, E.Gomez**)**
- **OE2**: Assessment of **new technologies** (C. Rossell, A. Walter, and O. Braunbeck)
- **OE3**: Selection of **potential suitable areas** for sugarcane production in Brazil (M. Regis Leal)
- **OE4**: **Infra-Structure: existing and need for improvement and expansion** (M. Scandiffio)
- **OE5**: Assessment of **socio-economic impacts** (J.Scaramucci, M. Cunha)
- **OE6**: Construction of **ethanol production scenarios and socio-economic impacts** (A. Furtado)
- **OE7**: Assessment of **environmental impacts** (G. Jannuzzi)
- **OE8**: **Legislation and policies** in different countries: producers and buyers (M. Sobral Jr.)

Source: Leite et al. 2009

POTENTIAL FOR SUGAR CANE PRODUCTION: SOIL AND CLIMATE - **WITHOUT IRRIGATION**



Source: Leite et al. 2009

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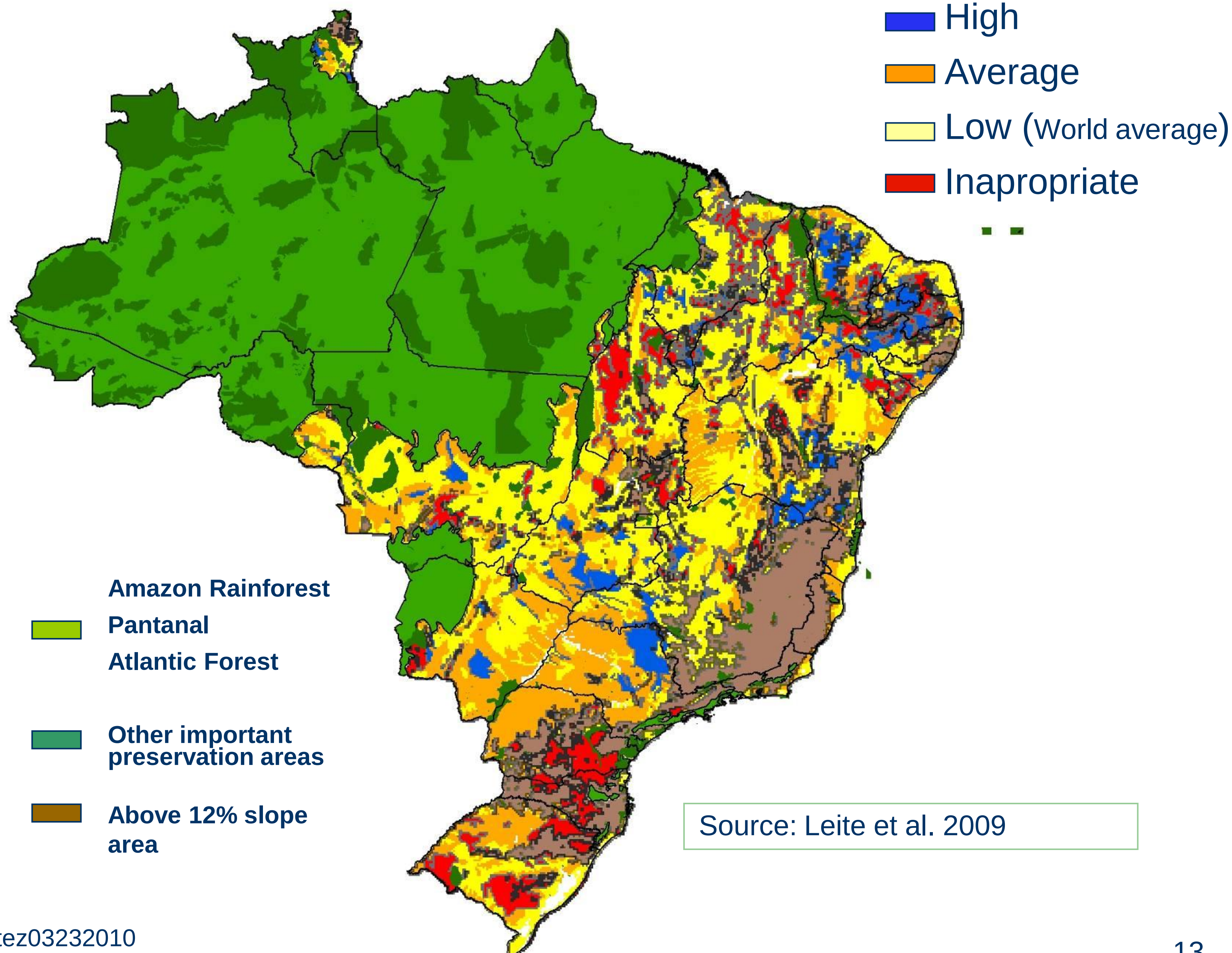
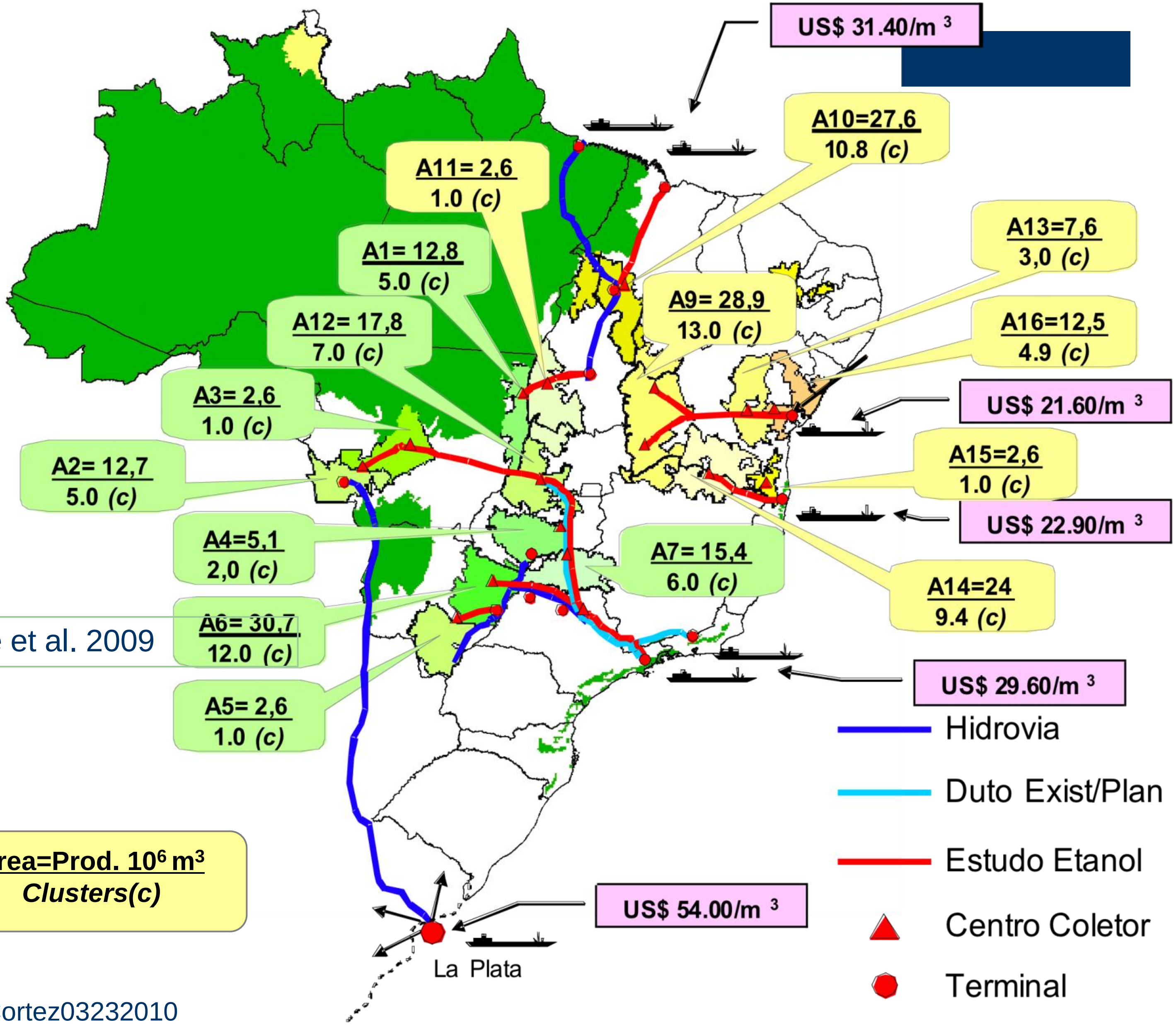


Source: Leite et al. 2009

Ethanol Exports 10% scenario: 205.5 million of m^3



Source: Leite et al. 2009

Area=Prod. 10^6 m^3
Clusters(c)

Expected Productivity Gains

	2005	2015	2025
Cane Prod. (tons/ha.year)	70	82	96
Pol (%) cane	14.5	15.9	17.3
Industrial efficiency (%)	83.5	90.0	90.0
Liters ethanol/ha.year	6,000	8,200	10,400

Source: Leite et al. 2009

Summary
Gasoline substitution of 5% in 2025

Investments in 20 years

Agricultural + Industrial + logistics	~ US$ 5 billion/year

Results

Ethanol production	104 billion liters/year in 2025
Land required	17 Mha (present tech) or 13-14 Mha (advanced tech)
Production of electricity	50,000 GWh/year => 15% of 2004
Production in Brazil in 2004	365,000 GWh/year
Income from Exports in 2025	US$ 31 billion
Increase in GDP (2025)	US$ 75 billion

Including direct, indirect and induced revenue (input-output matrix)

Increase Jobs	5.3 million
Average wage	50% above national average

Source: Leite et al. 2009

Conclusions from Unicamp/CGEE Study

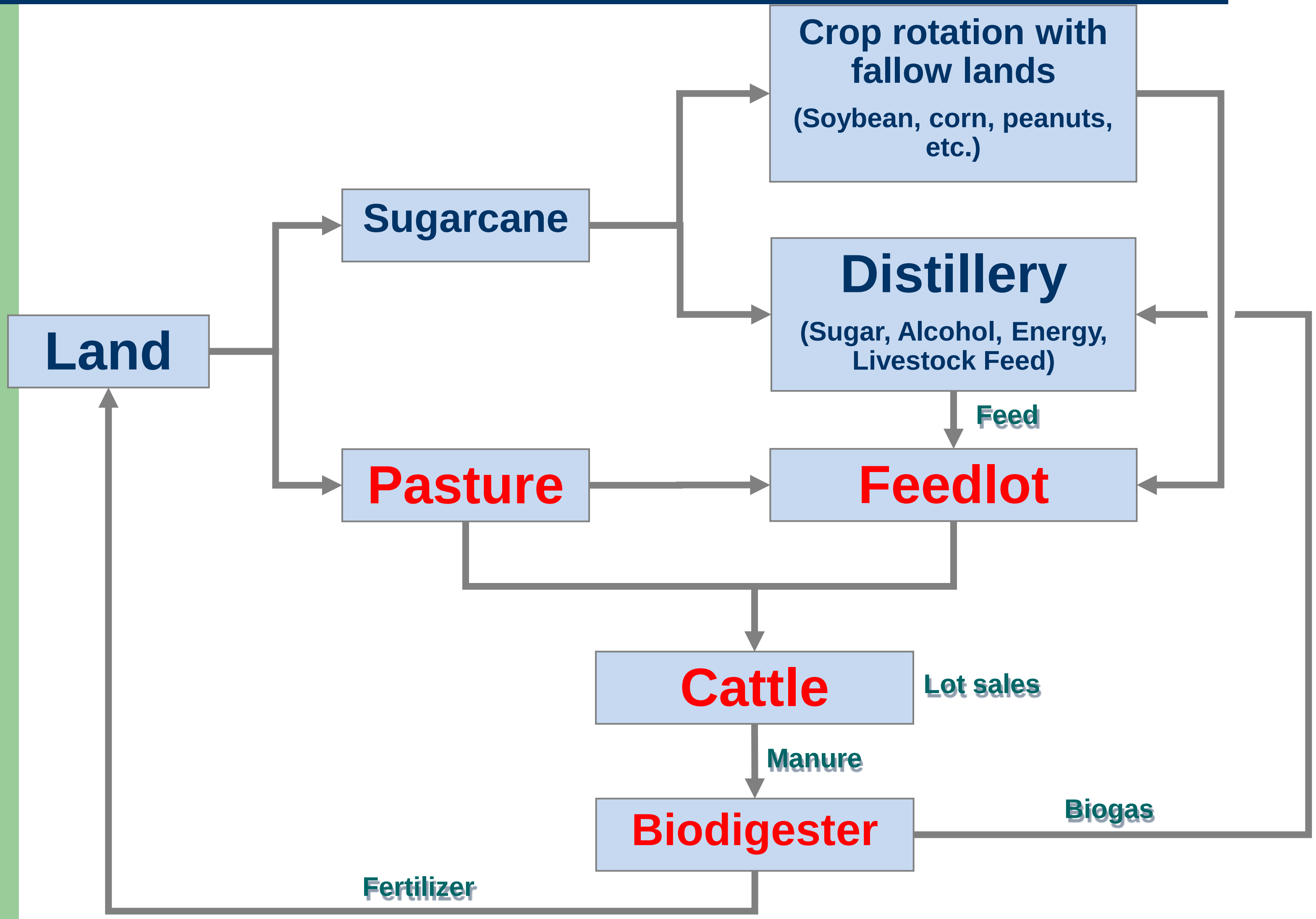
- Yes, **it is feasible** to produce in Brazil the equivalent of 5% gasoline used in the world in 2025
- However, with S&T this can be accomplished with much less land and resources
- Therefore, we need to develop a long-term R&D strategy for bioethanol production expansion in Brazil
- **Which can be a good criteria for the Research strategy**?

Source: Leite et al. 2009

Bioethanol Sustainability

- Expansion of ethanol production in Brazil will occur basically on pasture land
- Therefore, is essencial to “organize” other agricultural activities: pasture land (200 Mha); soya (22 Mha), bioethanol sugarcane land (4 Mha)
- Bioethanol sugarcane can help to optimize land use in Brazil (reduce pasture land while maintaing beef production and expanding biofuels production)

Bioethanol and Livestock Integration



Source: NIPE-CGEE (2009)

Crop rotation with fallow lands

2,520 ha
(60%)

Apr – May – Jun – Jul – Aug – Sep – Oct – Nov – Dec – Jan – Feb - Mar

Grain crop

1,033 ha
(41%)

1,487 ha
(59%)

Productivity (kg.ha^{-1})	3,600	6,600
Production (t)	3,719	9,814

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Source: NIPE=CGEE (2009)

Integration Pasture-Cane: a Case

- Vale do Rosário Plant:
  - Processes 6 Mt of sugarcane per year
  - Producing animal feed and providing feedlot confinement services for over 22 years
  - Feedlot capacity of over 20,000 animals
- It guarantees sugarcane suppliers loyalty:
  - 65%-70% of Vale do Rosário sugarcane providers are linked to cattle farming activities
- The manure is used as a biofertilizer in agricultural areas.
- It is a profitable business!

Source: NIPE=CGEE (2009)

Results Proposed Integration Pasture-Cane (first "exercise": using 100,000 ha)

Indicators	Traditional	Integrated
Pasture area (ha)	100,000	72,000
Feedlot confinement capacity (cattle)	0	12,130
Supplementation capacity (cattle)	0	19,450
Mean occupancy (A.U./ha)	0.67	0.74
Annual meat production (t)	18,663	19,324
Mean meat production (kg/ha)	186.6	268.4
Mean profitability (R$/ha)	118.13	145.43
Average slaughter age (months)	36.6	32.4
% of integrated cattle	0%	47.4%

- Initial scenario with 28,000 t of wet bagasse

Source: NIPE-CGEE (2009)

Direct effects of land use change

- Cane expansion since 2002 was over pasture lands (mainly extensive, degraded pastures) and annual crops:
  - Data source: satellite images (Landsate and CBERS), CONAB survey (MAPA/DCAA), IBGE data and preliminary IEA-RIMA data for new units (Nassar et al., 2008; CONAB, 2008; ICONE, 2008).
- This fact in addition to cropping practices in the new areas (mechanical harvesting of **unburned cane**; **semi-perennial** crop; high level of **residues**) indicates that land use change occurs without soil carbon emissions. In many cases, the land use change may **increase carbon stocks**.
- New efforts: BLUM, integrated LCA (beef + ethanol)

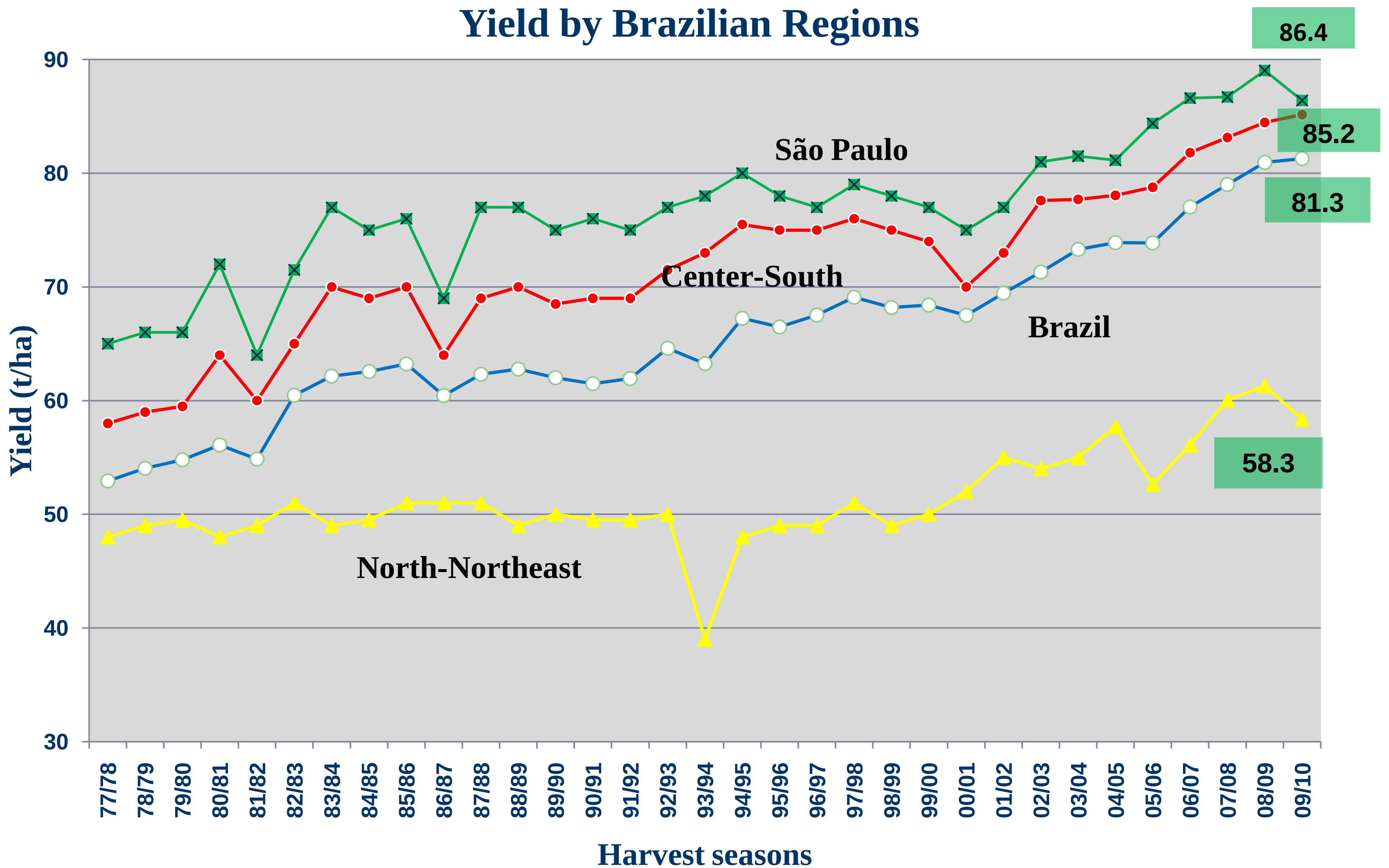
Source: Macedo and Seabra (2008)

Combined Production of Food with Bioethanol

- Sugar – Brazil model (*)
- Integration Pasture Land (beef/milk) and Sugarcane (*)
- Grains (peanuts, soya, corn) (*)
- Natural or Planted Forest, Fruits on high slopes areas
- Horticulture with Ethanol Mills

(*) currently done in Brazil

Productivity (tons of cane/ha.year)



Source: IBGE, 2003

Sugarcane Primary energy

	Sugarcane	Energy Cane
Productivity (tons/ha.year)	70	100
Fiber (%) cane	13.5	26.0
Trash (%) cane	140	25.0
Pol (%) cane	14.5	12.0
Total fiber (tons/ha.year)	19.3	51.0
Primary Energy (GJ/ha.year)	520 (12.5 toe)	1,100 (26 toe)

It is important to create "another" raw material...

Source: M. Regis L.V. Leal

Average, maximum and theoretical sugarcane yields (Australia, Colombia, and South Africa) and total dry matter production

Type of yield	Cane yield ($t\ ha^{-1}\ yr^{-1}$)	Biomass*	
		($t\ ha^{-1}\ yr^{-1}$)	($g\ m^{-2}\ d^{-1}$)
Commercial Average	84	39	10.7
Commercial maximum	148	69	18.8
Experimental maximum	212	98	27.0
Theoretical maximum	472	219	72.4

Source: Waclawovsky et al. (2009)

No tillage x Conventional tillage

CT

- soil erosion
- decline in OM content
- increase level of CO_2 released to atmosphere

NT

- Less soil disturbance
- reduction of gas emissions
- carbon storage - the main effect is in the topsoil layers

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Source: NIPE-CGEE (2009)

Sugarcane Trash

- 10 ~ 15 $t.ha^{-1}$ (d.b.) – stay in the field today
- São Paulo – 4.2 million ha of sugarcane
- 7 ton/ha should remain in the field for soil protection, weed control and make no tillage cultivation viable
- There is a potential for 12.6 ~33.6 Mt of trash to be recovered
- Equivalent to 214 ~ 570 $x10^6$ GJ (HHV = 17 $MJ.kg^{-1}$)

Source: NIPE-CGEE (2009)

Integral cane (chopped) harvesting

Reduce the speed of the exhausters.

Transport to the mill - cane + trash

Reception

Dry cleaning station

cane

trash

Source: NIPE-CGEE (2009)

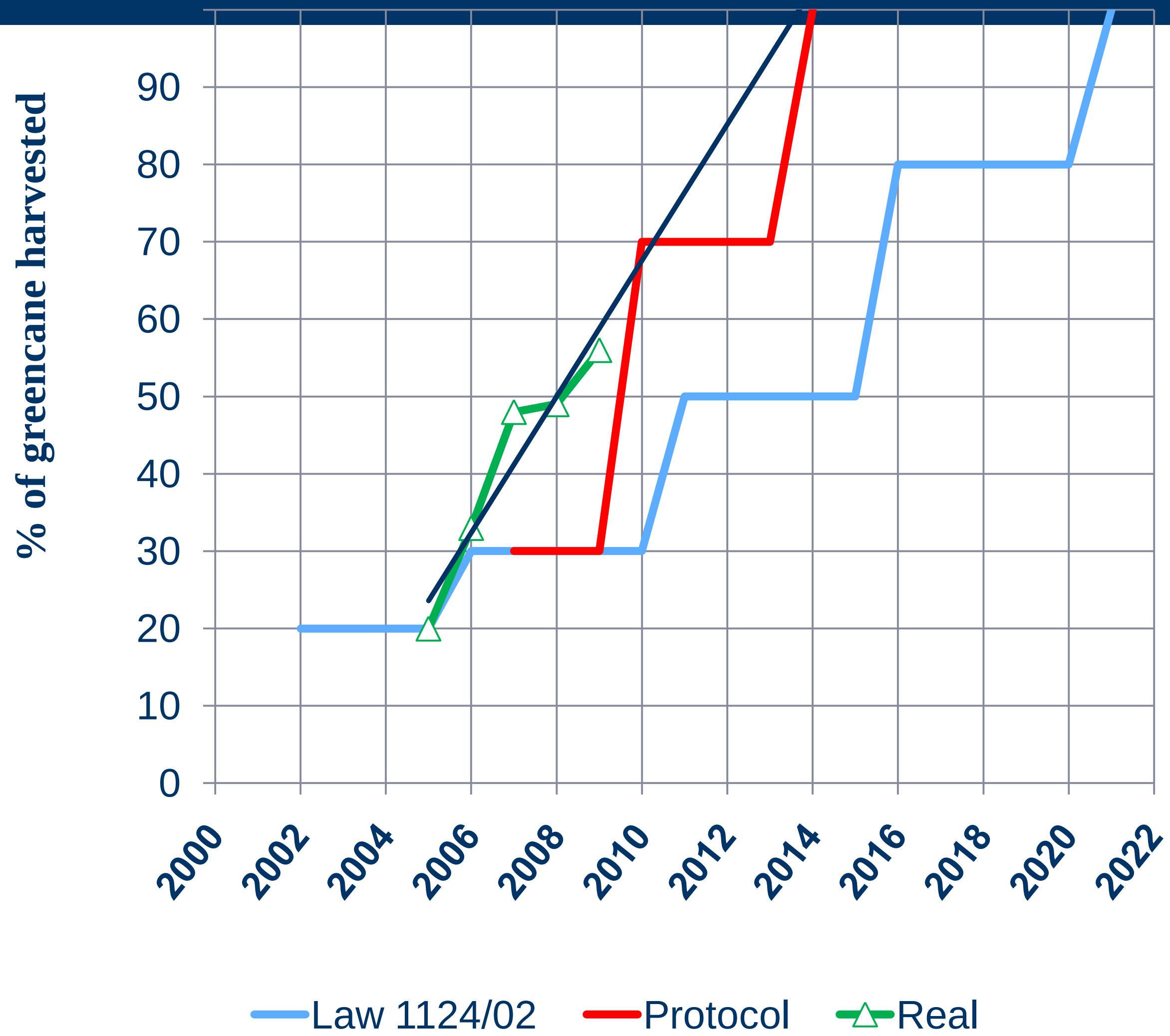
Analysis of simulated trash recovery

Equipment	Power (kW)	Volume (m^3)	Bulk density (kg m^3)
Baler round	90	3.82	160
Baler square	120	3.45	192
Forage harvester	210	---	-----
Forage wagon	90	45.4	4
Loafer	120	45.4	112

Option	Energy (MJ dt^{-1})	CO_2 (kg dt^{-1})
Option 1. Square bale and stack using one step load 8 bale and stack	258.7	20.295
Option 2. Round bale load on wagon with 17 bales and stack using a loader	290.1	22.55
Option 3. Loaf and stack	319.4	24.75
Option 4. Dry chop and pile	467.1	36.483

Source: Sokhansanj et al., 2008

Evolution of green sugarcane harvesting in São Paulo State



- 2009/2010 season - 55% green harvested

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Source: NIPE-CGEE (2009)

Controled Traffic Structure - ETC

Main characteristics

- Track width 9 m
- Clearance 2 m
- Transport width and height 3x4 m
- Load capacity 5 t
- Transport weight 20 t
- Working velocity 2-8 km/h
- Transport velocity 10-20 km/h

Source: NIPE-CGEE (2009)

ETC

Traffic control

No soil compaction

No need for soil cultivation

No tillage

Sustainable crop production

Source: NIPE-CGEE (2009)

Sugarcane Agroecologic Zoning in Brazil

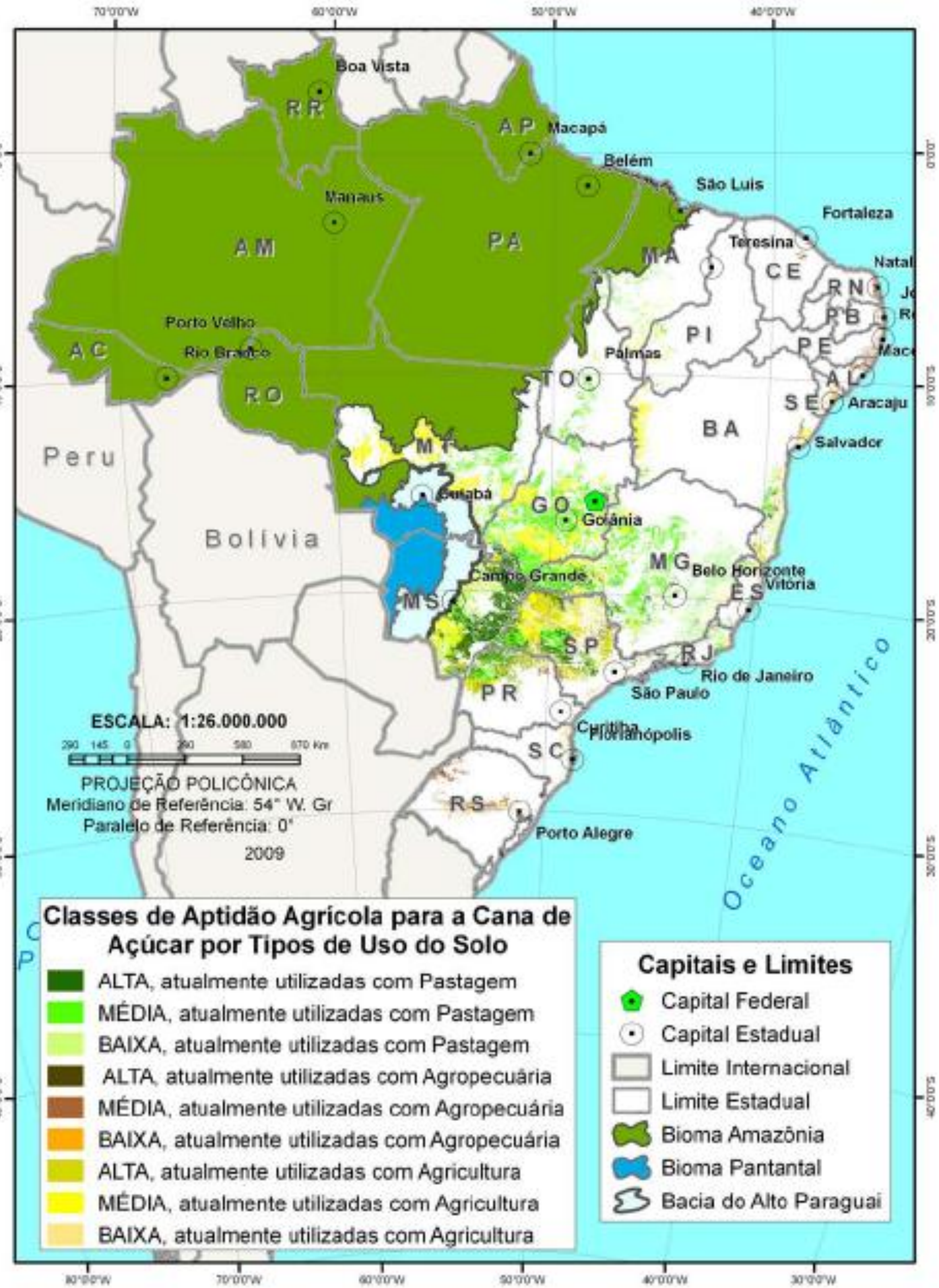
Tabela 7 - Síntese das áreas aptas para a expansão do cultivo da cana-de-açúcar no Brasil, considerando as classes de aptidão agrícola e os tipos de uso da terra predominantes em 2002.

Brasil	Classes de aptidão	Áreas aptas por tipo de uso da terra por classe de aptidão (ha)				
		Ap	Ag	Ac	Ap + Ag	Ap + Ag + Ac
Áreas totais para o Brasil	Alta (A)	11.302.342,95	600.766,55	7.360.310,26	11.903.109,50	19.263.419,76
	Média (M)	22.863.866,09	2.126.394,55	16.496.735,67	24.990.260,64	41.486.996,31
	Baixa (B)	3.041.122,07	483.326,14	731.076,97	3.524.448,21	4.255.525,18
	A+M	34.166.209,05	2.727.161,10	23.857.045,93	36.893.370,15	60.750.416,07
	A+M+B	37.207.331,12	3.210.487,24	24.588.122,90	40.417.818,36	65.005.941,25

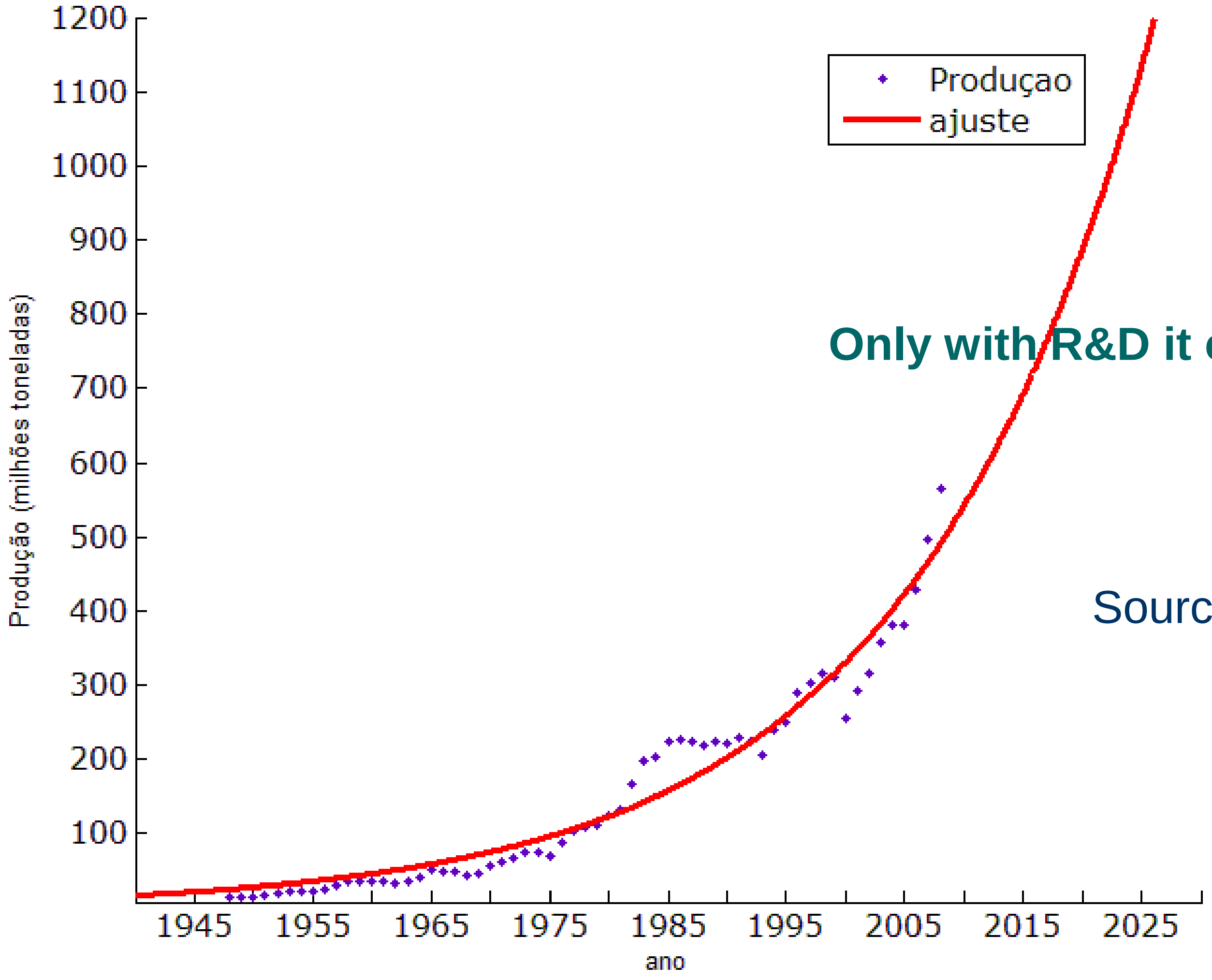
Nota: Classes de Aptidão: A: Alta; M: Média; B: Baixa – Uso atual: Ac: Agricultura; Ag: Agropecuária; Ap: Pastagem.

Source: MAPA Agroecologic Zoning of Sugarcane. 2009

Source: MAPA, 2009



Expected expansion of sugarcane production in Brazil



Only with R&D it can be sustainable!

Source: MAPA, 2009

Conclusions 1/2

- The conducted studies have demonstrated that 5% of world gasoline consumption by 2025 can be substituted with Brazilian sugarcane ethanol
- However, if more intensive research effort is made to develop a **totally new technology**) from agriculture to industry), the sustainability indicators can be greatly improved
- Additional effort should be made in producing **human resources at all levels** (qualified people)
- ….

Conclusions 2/2

- **Important research centers:**
  - CTC: private center to assist industry
  - Ridesa: public/private network for cane breeding
  - IAC: public center on agronomic research
  - EMBRAPA Agroenergy Center
- **New science-oriented centers:**
  - CTBE: Bioethanol Science and Technology Center
  - FAPESP BIOEN Program
  - São Paulo Bioenergy Research Centers (USP, UNICAMP and UNESP)