

IEA Bioenergy

Workshop & Business Forum on Sustainable Biomass Production for the World Market

BRAZILIAN SUGARCANE ETHANOL: LESSONS LEARNED

Prof. Suani Coelho

CENBIO – The Brazilian Reference Center on Biomass

São Paulo State Secretary for the Environment – Deputy Secretary

December 2nd, 2005
Campinas, São Paulo

10 Myths about Ethanol

1. Brazilian experience is unique
2. incompatible with existing fleets;
3. low energy balances of biofuels
4. high pollutant emissions (cleaner fossil fuels preferable)
5. complex logistics
6. competition with food for land, unsustainable practices, deforestation
7. should only be produced domestically by developed countries
8. only subsidized production is possible
9. imports destroy local agriculture of developed countries
10. energy efficiency alone will preserve oil resources and fulfill Kyoto targets

Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

Outline

- i. Introduction – The Brazilian Alcohol Program**
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

Introduction - The Brazilian Alcohol Program

- The world largest commercial program on biomass
- Started in 1975 by Federal Government
- Decision from Brazilian Federal Government to produce ethanol in addition to sugar (from sugarcane): objective of reducing petroleum imports (Gulf War).
- High-octane fuel in vehicles, replacing lead and/or MTBE.
- 4,000,000 cars running on pure (hydrated) ethanol in Brazil
- 700,000 flex-fuel vehicles (both ethanol and gasoline, any blend)
- all gasoline blended with (anhydrous) ethanol: 20 to 26% of ethanol in volume basis – gasohol
- Nowadays - economically competitive to gasoline



Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies**
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

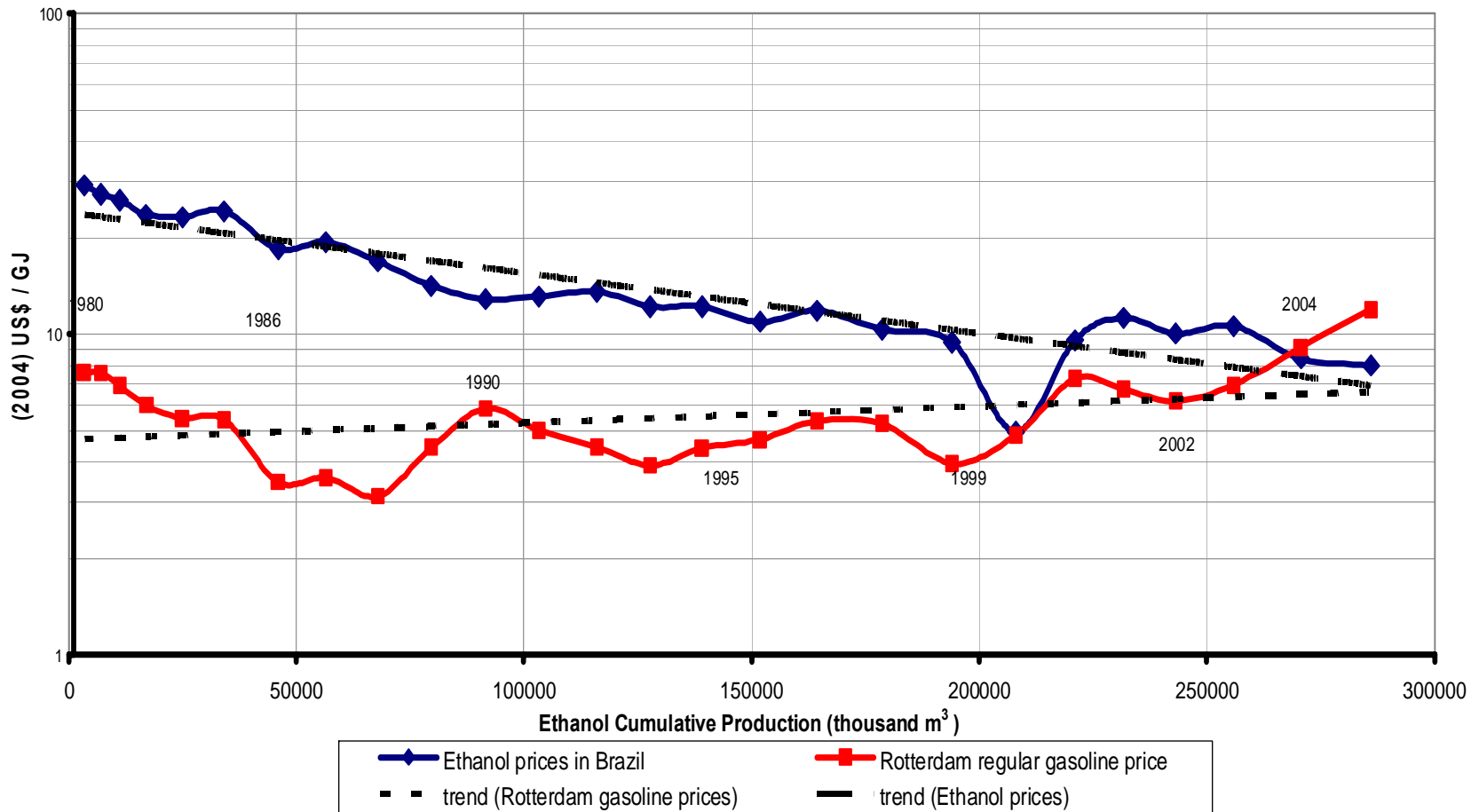
Ethanol Production Costs Vs Sunk Costs and Subsidies (Brazil)

- economic cost of production: US\$0.18–0.25 per liter of gasoline-equivalent:
 - average export price of ethanol (2001-2003): US\$ 0.23 per liter
- initial investment: US\$ 60 million (2005 prices)
 - SEVERAL NEW PLANTS
 - processing capacity: 2.16 million tonnes of sugarcane per year
 - average yield 79.39 liters of anhydrous ethanol equivalent (82.86 liters of hydrous) per tonne of sugarcane.
 - Price paid per tonne of sugarcane is US\$11.4 (UNICA, 2005)
 - plant lifetime of 25 years
 - feedstock cost of US\$ 0.143 per liter of ethanol
 - investment cost around US\$ 0.017 per liter of ethanol.

2005 → NEW INVESTMENTS ARE PRIVATE

Ethanol international competitiveness

Ethanol Learning Curve



Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol**
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

Positive Ethanol Energy Balance

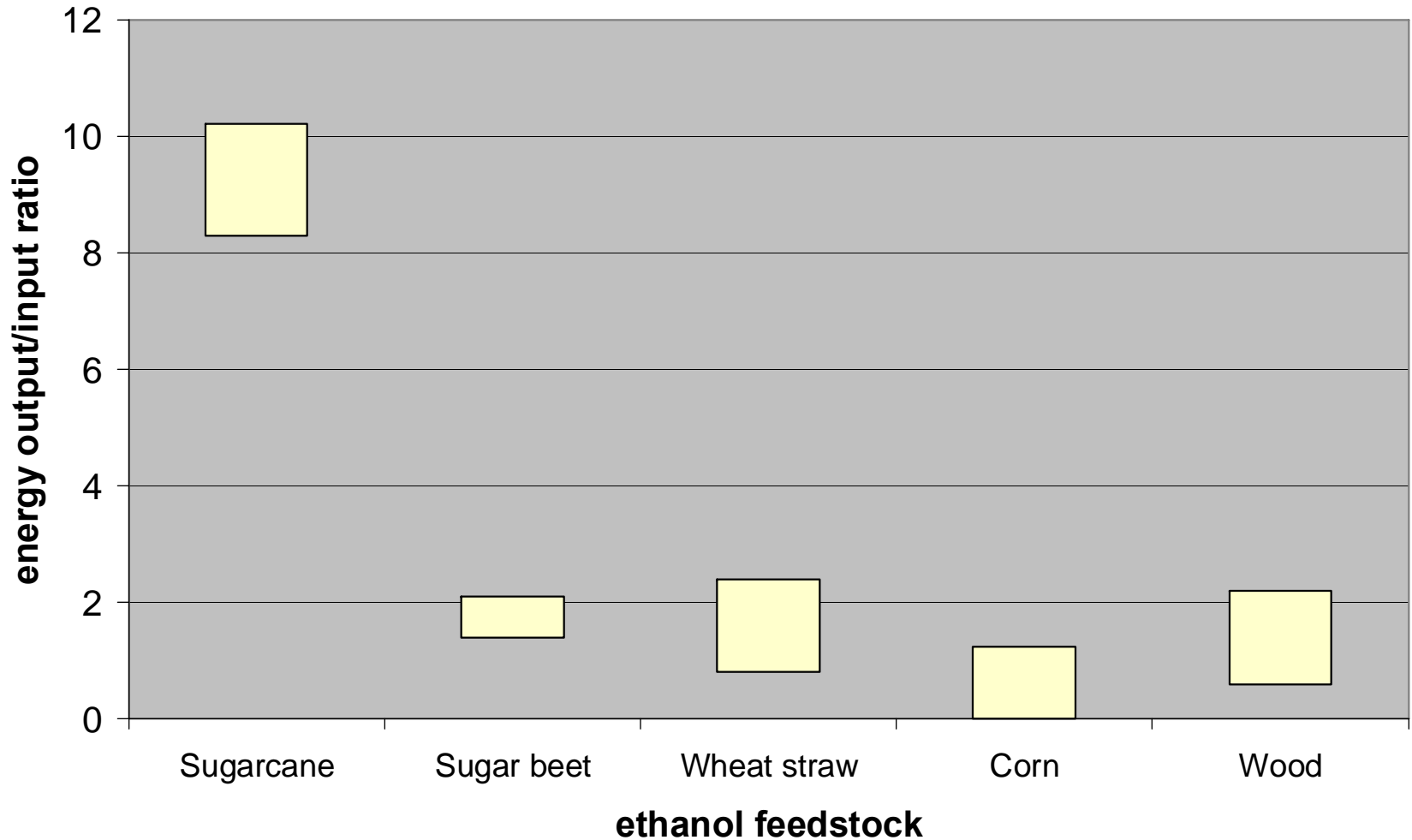
- All energy needs in sugarcane mills are provided without any external energy source;
- Cogeneration process: production of steam and electric/mechanical energy to the process from sugarcane bagasse.
- Presently up to 80 kWh/tonnes of cane can be sold to the grid
- 1975 – 2000: low-pressure boilers (22 bar- 20 kWh/tonnes of cane)
- Since 2000: high pressure ones (up to 80 bar). Outputs of 120kWh/tonne → better technology and recovery of sugarcane by-products (green cane harvesting).
- Gasification technology (under development): 300kWh/tonne of cane.

Ethanol Energy Balance

Activity	Energy consumption			
	Scenario 1 (kcal/TC)		Scenario 2 (kcal/TC)	
Sugar cane production (total)	48,208		45,861	
Agricultural operations	9,097		9,097	
Transportation	10,261		8,720	
Fertilizers	15,890		15,152	
Lime, herbicides, pesticides etc.	4,586		4,586	
Seeds	1,404		1,336	
Equipment	6,970		6,970	
Ethanol production (total)	11,800		9,510	
Electricity	0		0	
Chemicals, lubricants	1,520		1,520	
Buildings	2,860		2,220	
Equipment	7,420		5,770	
External energy flows	Input	Output	Input	Output
Agriculture	48,208	-	45,861	-
Factory	11,800	-	9,510	-
Ethanol produced	-	459,100	-	490,100
Surplus bagasse	-	40,300	-	75,600
Total	60,008	499,400	55,371	565,700
Output/input	8.3		10.2	

Source: Macedo, I et alli, 2004

Energy balance of alcohol production from different feedstocks



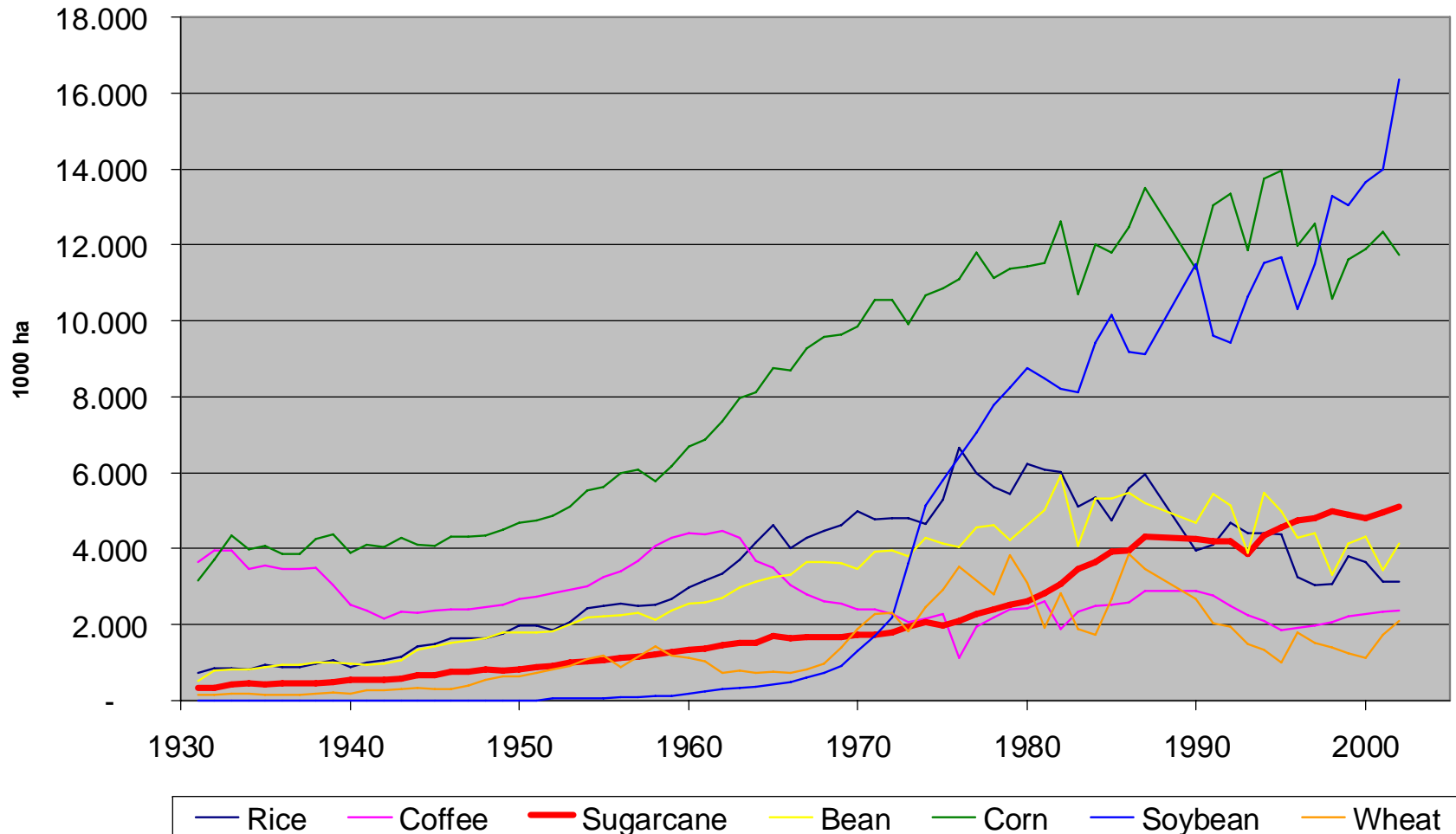
Sources: (Macedo et alii, 2004; UK DTI, 2003 and USDA, 1995)

Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food**
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

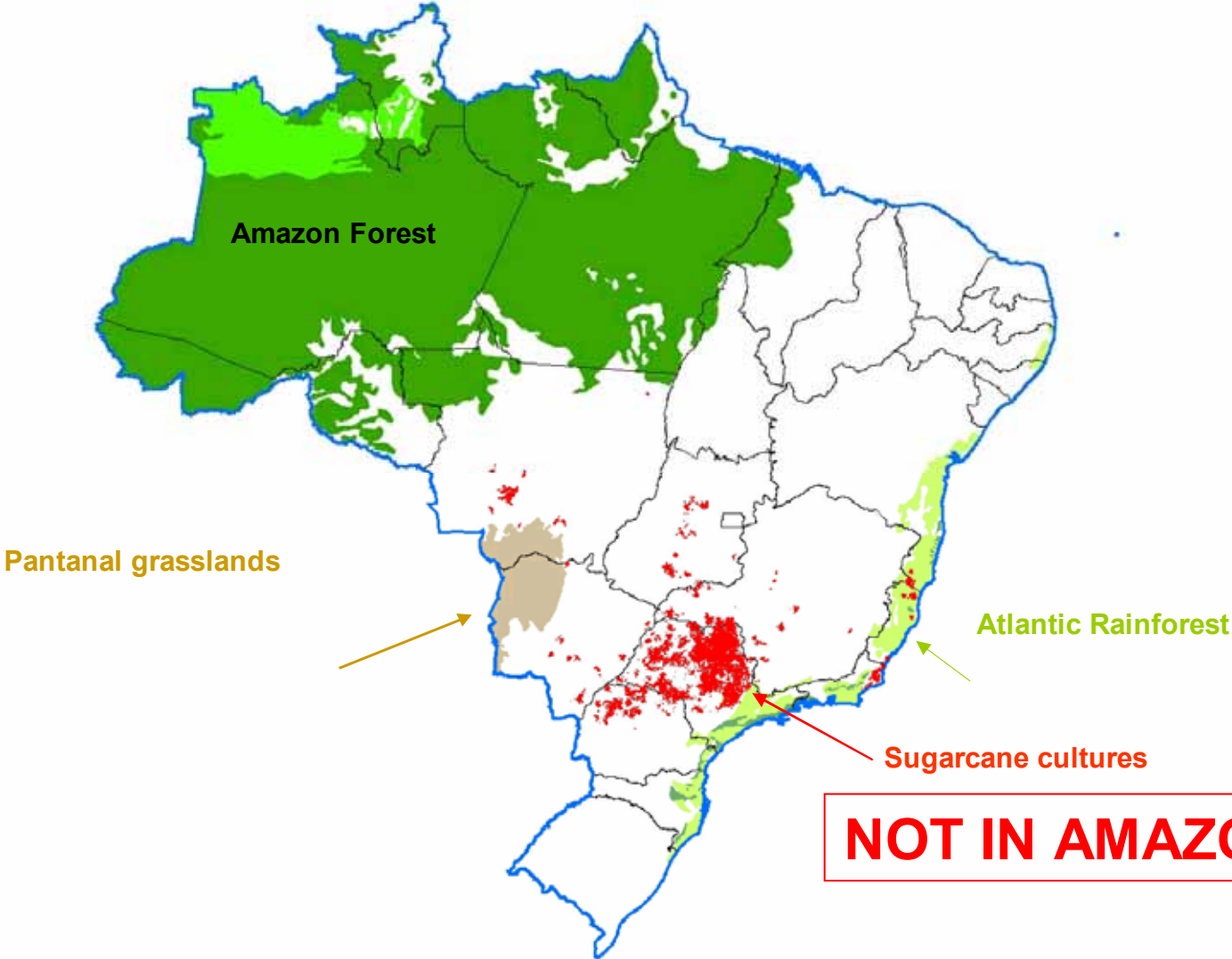
The lack of competition for land with food

Harvested Area in Brazil



Source: Brazilian Statistics Bureau, several years

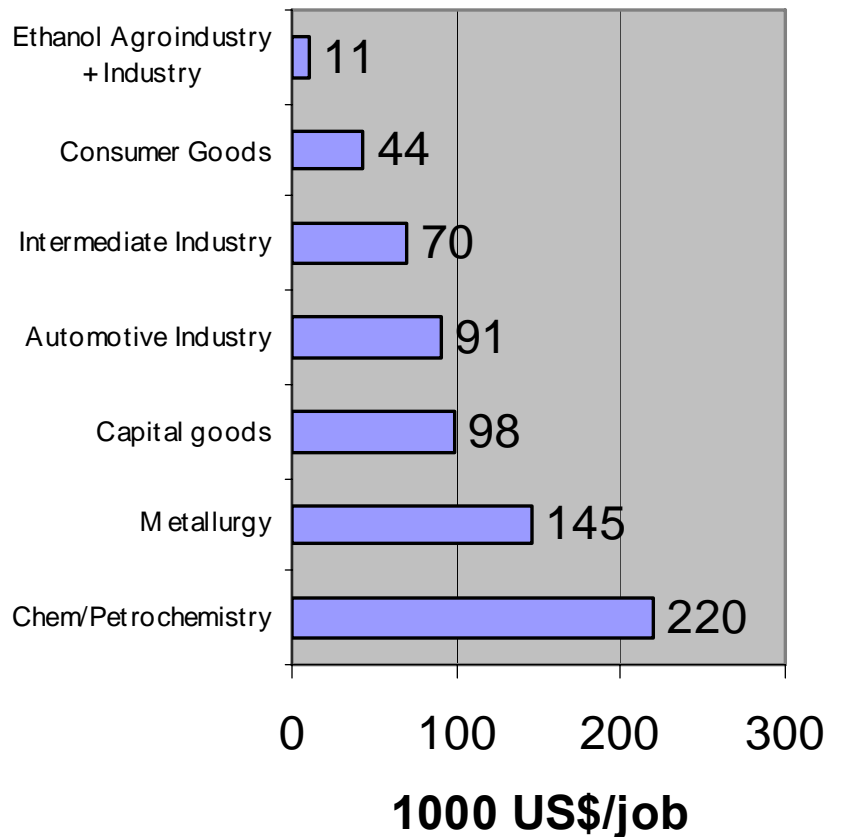
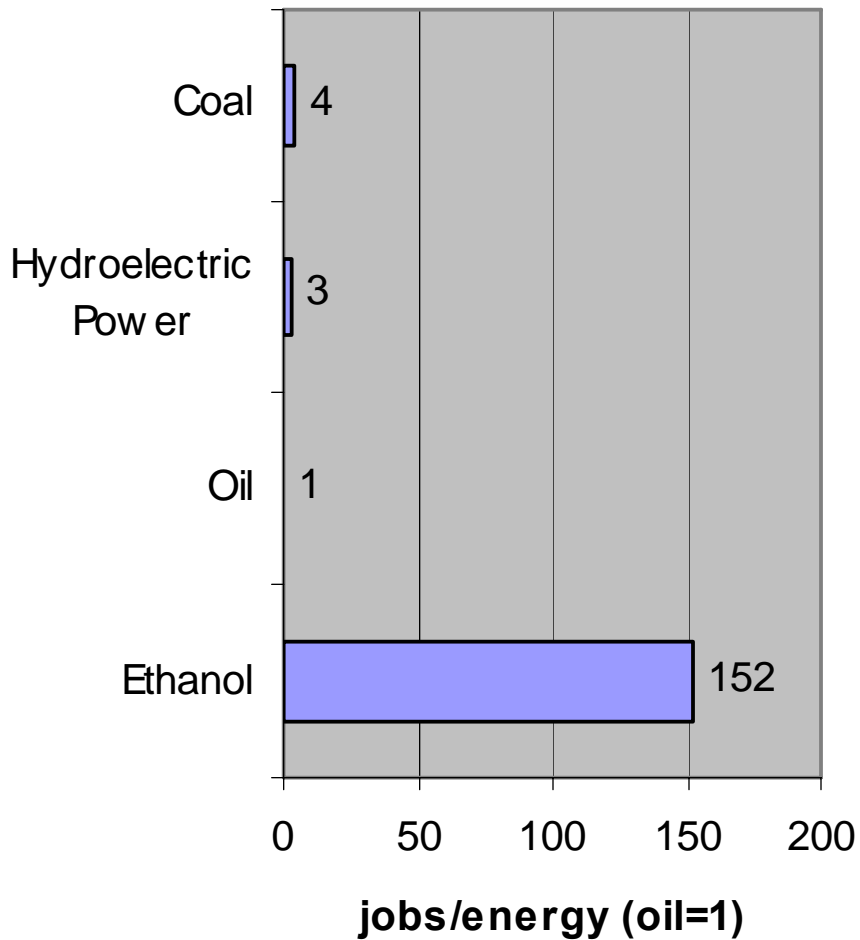
Map of Brazil locating sugarcane cultures



Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts**
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

Quality of Jobs and Other Socioeconomic Issues



Quality of Jobs and Other Socioeconomic Issues

- Every 300 million tones of sugarcane produced in Brazil: creation of approximately 700,000 jobs.
- Formal Jobs:
 - National average (Brazil): 55%
 - Sugarcane sector: 68.5%
- Sugarcane production is seasonal but many jobs are formal and annual (equipment maintenance during off season).

Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends**
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

Compatibility of Existing Fleets with Ethanol-gasoline Blend

Ethanol Content in the Fuel	Carburetor	Fuel Injection	Fuel Pump	Fuel Pressure Device	Fuel Filter	Ignition System	Evaporative System	Fuel Tank	Catalytic Converter	Basic Engine	Motor Oil	Intake Manifold	Exhaust System	Cold Start System	
≤ 5%	For any vehicle NN														
5 ~ 10%	For relatively new fleets (10 ~ 15 years old) - - NN - - -														
10 ~ 25%	Brazilian Application - PN - - - - - NN - - - - -														
25 ~ 85%	USA Application PN - - - - - NN														
≥ 85%	Brazilian Application PN - - - - -														

 - Not Necessary

 - Probably Necessary

Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production**
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

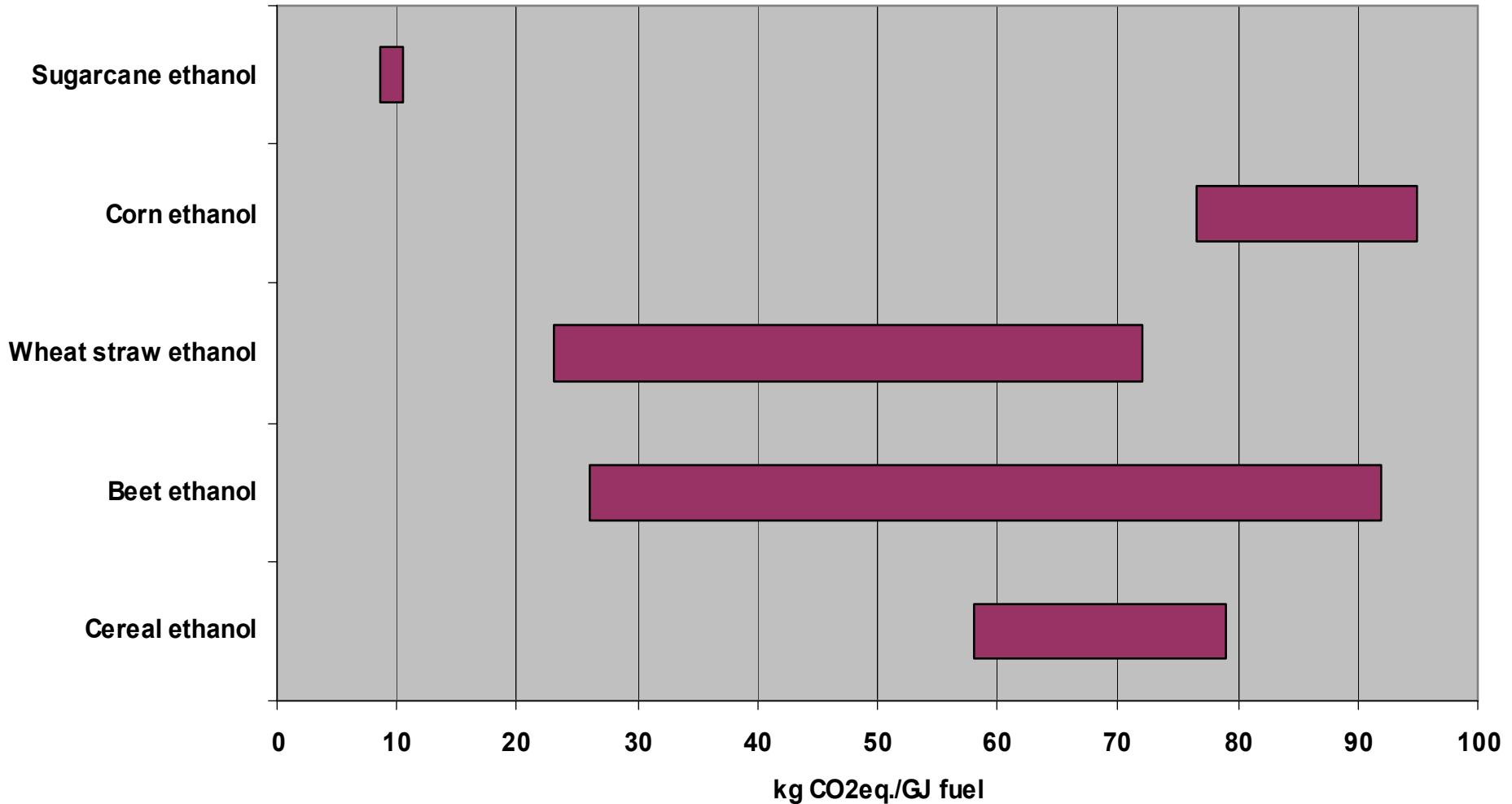
Environmental Impacts on Ethanol Production

- Legislation improved and enforced specially in the State of São Paulo (60% of all Brazilian sugarcane mills);
- Discharge of effluents with high organic loads replaced by controlled fertirrigation practices (CETESB);
- Harvest burning practices are being phased-out, through a strict legal enforcement;
- Land use is severely controlled: preserving riparian forests and other natural ecosystems and avoiding deforestation;
- Industrial sugarcane and ethanol plants have their atmospheric emissions controlled;
- Spill offs and other accidents are rare and of low impact;

Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use**
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries

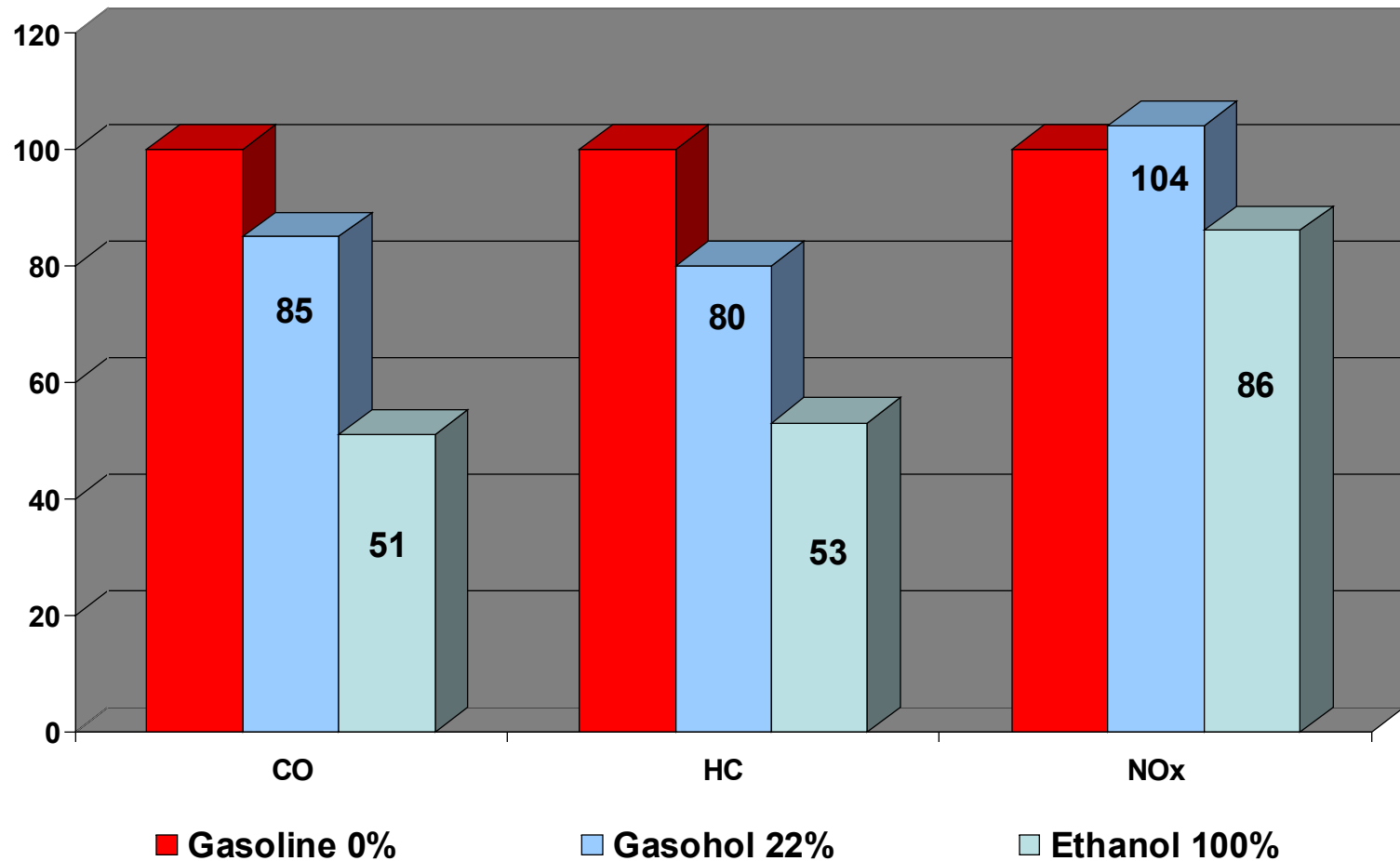
GHG emissions from different types of ethanol



Sources: Macedo et. alii, 2004, UK DTI, 2003 and USDA, 2004

Environmental Impacts on Ethanol Use

Comparative Raw Exhaust Emission



Pollutants Concentration in SP Metropolitan Region

- Lead: dropped from 1,4 ug/m³ in 1977 to less than 0,10 ug/m³ in 1991.
- Sulfur: dropped from 50 ug/m³ in 1984 to 15 ug/m³ in 2003.
- Particulate Matter: dropped from 90 ug/m³ in 1986 to 50 ug/m³ in 2003.

Outline

- i. Introduction – The Brazilian Alcohol Program
- ii. Ethanol production costs vs sunk costs and subsidies
- iii. The favorable energy balance of ethanol
- iv. The lack of competition for land with food
- v. The quality of jobs and social impacts
- vi. The compatibility of existing fleets with ethanol-gasoline blends
- vii. Environmental impacts on ethanol production
- viii. Environmental impacts on ethanol use
- ix. Perspectives for the replication of Brazilian ethanol program in other developing countries**

Perspectives for the Replication of Brazilian Ethanol Program in Other Developing Countries

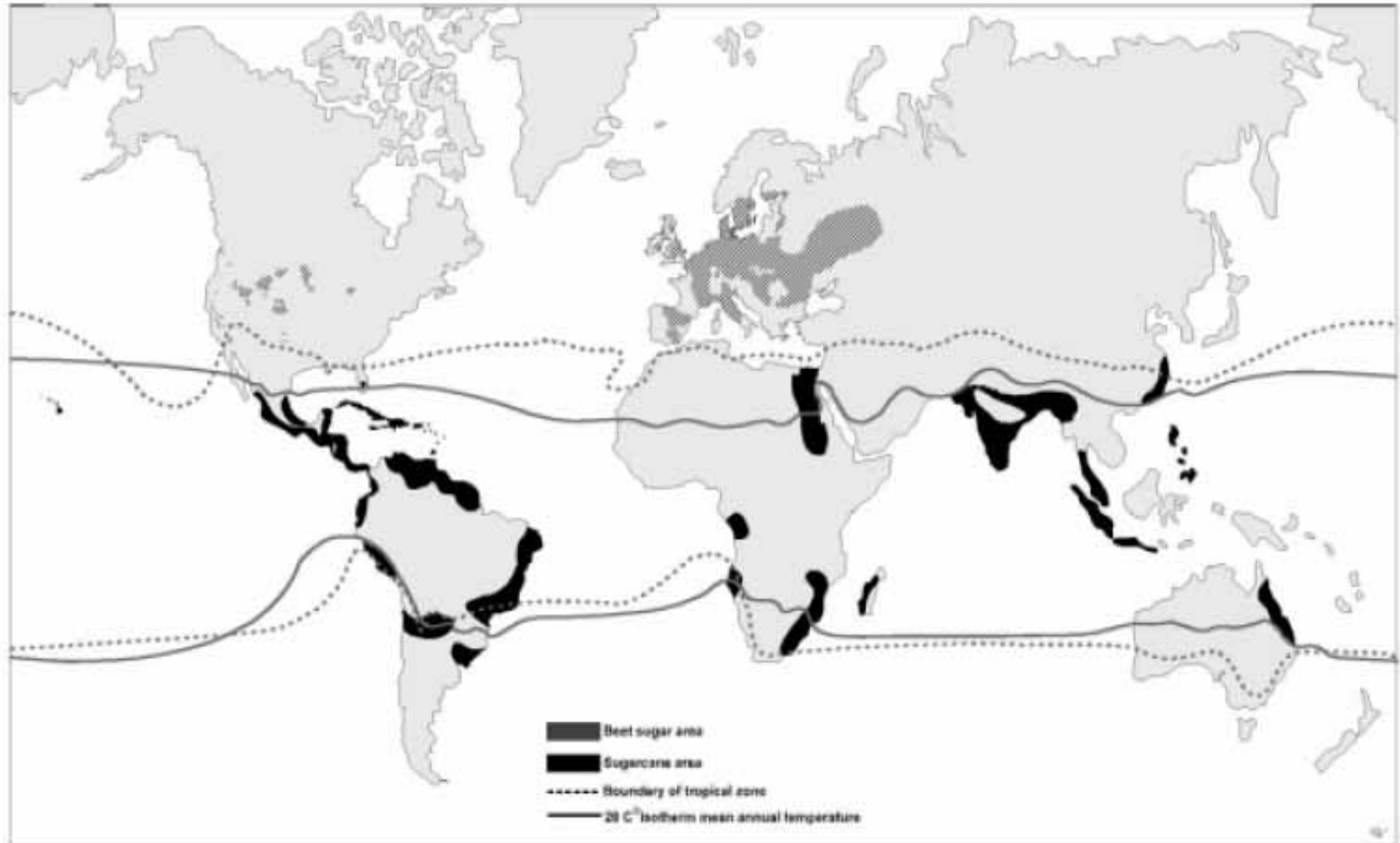


Figure 3.5. Global Distribution of Sugar Beet and Sugarcane Production. Redrawn from Helmut Blume, *Geography of Sugar Cane* (Berlin, 1985), 22.

Perspectives for the Replication of Brazilian Ethanol Program in Other Developing Countries

- Technological aspects - Brazilian experience:
 - Existing technology for alcohol production: efficient and commercially available. Cogeneration process from bagasse → high efficient steam systems are commercially available.
- Opportunities from the **Clean Development Mechanism** → good option for developed countries, collaborating for the sustainable development of poor countries.