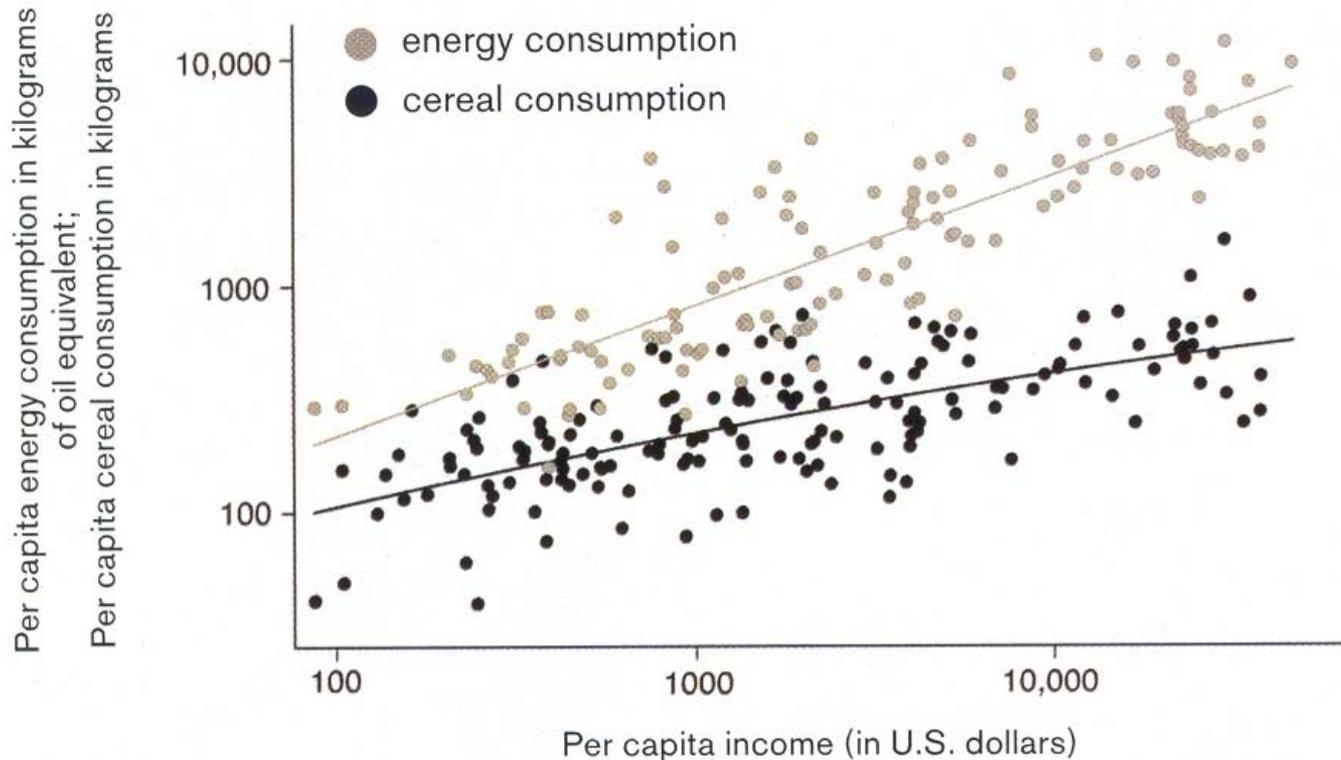


# Environmental and ecological dimensions of biofuels

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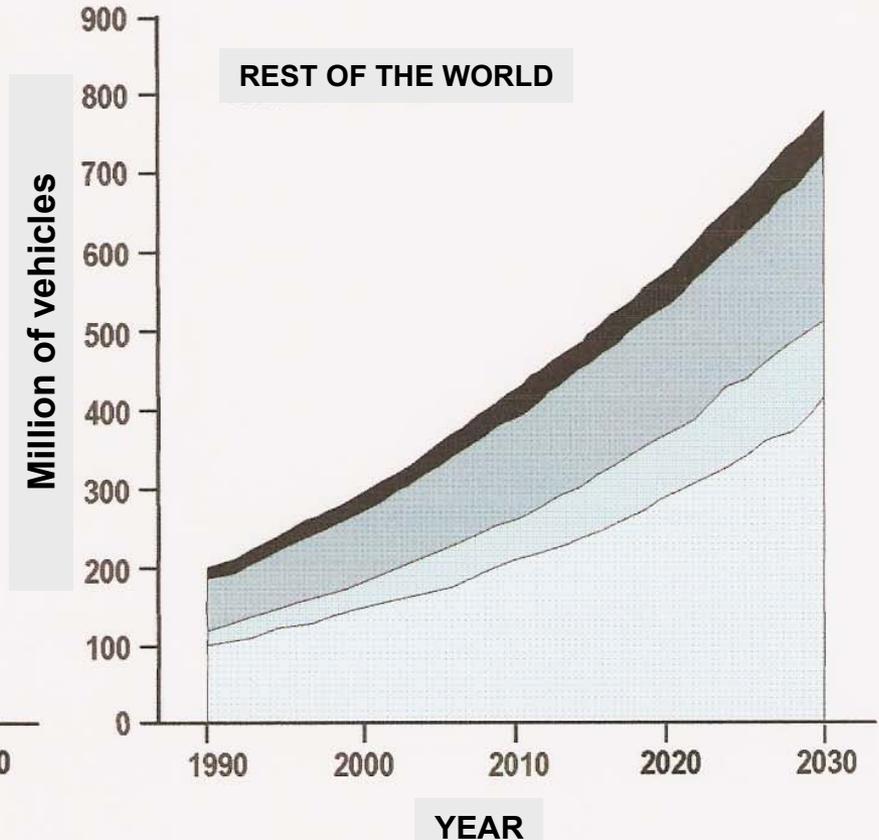
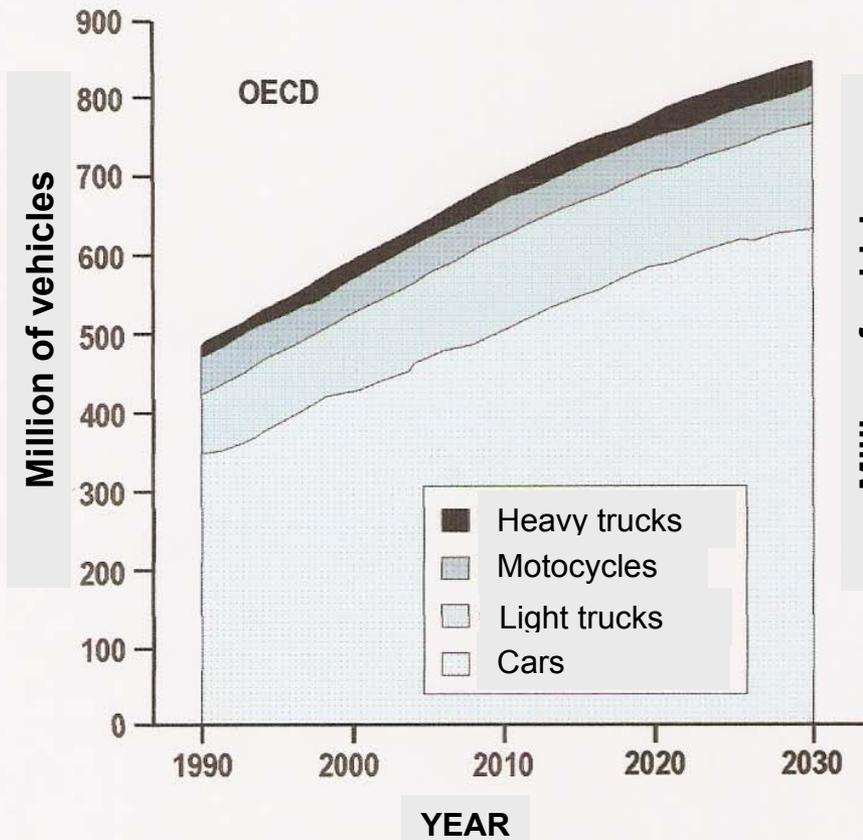
**Figure 1. Global per capita cereal and energy consumption versus per capita income for 2003–2004**



NOTE: Cereal consumption includes cereal consumed directly and feed grains fed to livestock.

SOURCE: Energy and income data from World Bank, *World Development Indicators 2007* (Washington, DC: World Bank, 2007); cereal data from Food and Agriculture Organization of the United Nations, *FAOSTAT*, <http://faostat.fao.org>.

# Evolution of automobiles fleet



# EMISSIONS FROM TRANSPORTATION

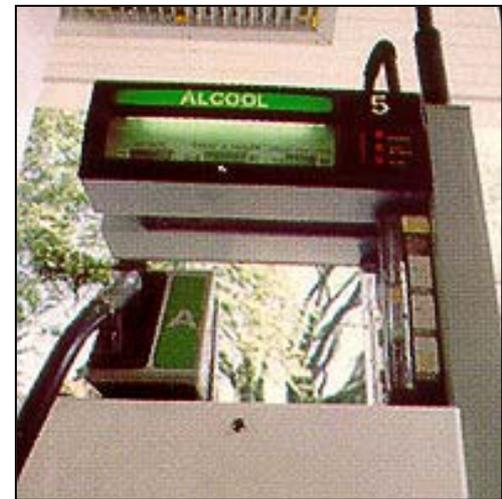
- More than 70 per cent of all carbon monoxide (CO) emissions;
- More than 40 per cent of nitrogen oxides (NO<sub>x</sub>) emissions;
- Almost 50 per cent of total hydrocarbons (HCs);
- Around 80 per cent of all benzene emissions; and
- At least 50 per cent of atmospheric lead emissions.
- 14% of all greenhouse gas emissions to the atmosphere and 19% of the CO<sub>2</sub> emitted

# Problems with the present energy system

- i. Exhaustion of fossil resources
- ii. Security of supply
- iii. Environmental impacts

# Introduction - The Brazilian Alcohol Program

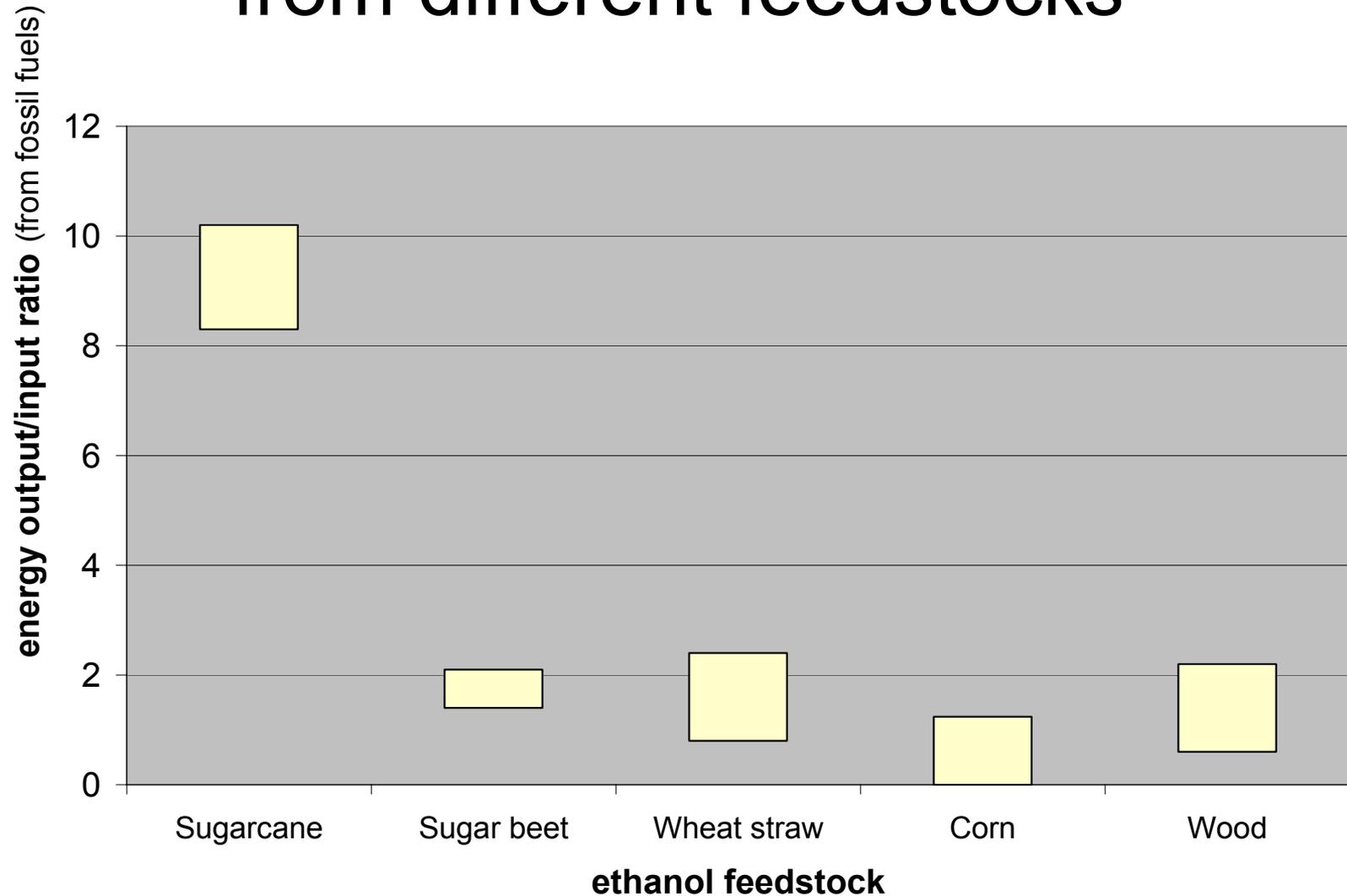
- The world largest commercial program on biomass
- Started in 1975 by Federal Government
- Decision from Brazilian Federal Government to produce ethanol in addition to sugar (from sugarcane): objective of reducing petroleum imports (Gulf War).
- High-octane fuel in vehicles, replacing lead and/or MTBE.
- 1,300,000 cars running on pure (hydrated) ethanol in Brazil
- 2,300,000 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



# Pollutants Concentration in SP Metropolitan Region

- Lead: dropped from 1,4  $\mu\text{g}/\text{m}^3$  in 1977 to less than 0,10  $\mu\text{g}/\text{m}^3$  in 1991.
- Sulfur: dropped from 50  $\mu\text{g}/\text{m}^3$  in 1984 to 15  $\mu\text{g}/\text{m}^3$  in 2003.
- Particulate Matter: dropped from 90  $\mu\text{g}/\text{m}^3$  in 1986 to 50  $\mu\text{g}/\text{m}^3$  in 2003.

# Energy balance of alcohol production from different feedstocks



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

# Land Use for Ethanol (2006)

	BRAZIL			
	Ethanol production from sugarcane		Agricultural area (million ha)	
	(billion litres/year)	(million bbl/day)	Sugarcane to ethanol	Sugarcane (total)
<b>Production</b>	17.8	0.31	2.9	5
<b>To replace 10% total gasoline consumption*</b>	189	3.3	31	---
<b>To replace 10% total petroleum consumption*</b>	746	13	123	---
<b>Sugarcane agricultural area in the world</b>	----	----	---	20
	UNITED STATES			
	Ethanol production from corn		Agricultural area (million ha)	
	(billion litres/year)	(million bbl/day)	Corn to ethanol	Corn (total)
<b>Production</b>	18.4	0.32	5.1	29
<b>Corn agricultural area in the world</b>	---	---	---	144

World's total agricultural area: 1,228 million hectares

\*World petroleum consumption (2005): 4,478 billion litres/year

\* World gasoline consumption (2005): 1,292 billion litres/year

# ETHANOL DEMAND PROJECTIONS

## 1<sup>st</sup> Generation Technology

	Maize (US) <sup>a</sup>			Sugarcane (Brazil) <sup>b</sup>			European Union <sup>iii</sup>	
	Area used million/ha	Liters (billion)	Gallons (billion)	Area million/ha	Liters (billion)	Gallons (billions)	Liters (billion)	Gallons (billion)
2006	5.1 <sup>c</sup>	18.6	4.9	2.9 <sup>d</sup>	17.8	4.7	-	-
2012/13	-	-	-	4.9	36	9.5	-	-
2015	13	56.8	15	-	-	-	-	-
2020 <sup>e</sup>	-	-	-	-	-	-	15	3.9
<b>2<sup>nd</sup> Generation Technology</b>								
	US		Brazil			European Union		
	Liters (billion)	Gallon (billion)	?			?		
2022	79.5	21	-			-		

a.productivity in 2006: 3,647 l/ha corn

b.productivity in 2006: 6,138 l/ha sugarcane

c.18% of total maize area in the US; 3.2% of total maize area in the world.

d.13% of total sugarcane area in the world; 47% of the sugarcane area in Brazil.

a.present EU production 2 billion liters/year mainly from sugarbeets.

<sup>iii</sup> Biofuels Research Advisory Council, 2006. Biofuels in the European Union – A vision for 2030 and beyond. — 40 pp. — 29.7 x 21.0 cm. ISBN 92-79-01748-9. ISSN 1018-5593 (EUR series – Luxembourg). Available at:

[http://ec.europa.eu/research/energy/pdf/biofuels\\_vision\\_2030\\_en.pdf](http://ec.europa.eu/research/energy/pdf/biofuels_vision_2030_en.pdf)

**Table R12. Biofuels Blending Mandates**

Country	Mandate
Australia	E2 in New South Wales, increasing to E10 by 2011; E5 in Queensland by 2010
Argentina	E5 and B5 by 2010
Bolivia	B2.5 by 2007 and B20 by 2015
Brazil	E22 to E25 existing (slight variation over time); B2 by 2008 and B5 by 2013
Canada	E5 by 2010 and B2 by 2012; E7.5 in Saskatchewan and Manitoba; E5 by 2007 in Ontario
China	E10 in 9 provinces
Colombia	E10 existing; B5 by 2008
Dominican Republic	E15 and B2 by 2015
Germany	E2 and B4.4 by 2007; B5.75 by 2010
India	E10 in 13 states/territories
Italy	E1 and B1
Malaysia	B5 by 2008
New Zealand	3.4 percent total biofuels by 2012 (ethanol or biodiesel or combination)
Paraguay	B1 by 2007, B3 by 2008, and B5 by 2009
Peru	B5 and E7.8 by 2010 nationally; starting regionally by 2006 (ethanol) and 2008 (biodiesel)
Philippines	B1 and E5 by 2008; B2 and E10 by 2011
South Africa	E8-E10 and B2-B5 (proposed)
Thailand	E10 by 2007; 3 percent biodiesel share by 2011
United Kingdom	E2.5/B2.5 by 2008; E5/B5 by 2010
United States	Nationally, 130 billion liters/year by 2022 (36 billion gallons); E10 in Iowa, Hawaii, Missouri, and Montana; E20 in Minnesota; B5 in New Mexico; E2 and B2 in Louisiana and Washington State; Pennsylvania 3.4 billion liters/year biofuels by 2017 (0.9 billion gallons)
Uruguay	E5 by 2014; B2 from 2008-2011 and B5 by 2012

*Note:* Table shows binding obligations on fuel suppliers; there are other countries with future indicative targets that are not shown here; see the Biofuels Policies section, page 27. Mandates in some U.S. states take effect only in future years or under certain future conditions, or apply only to portions of gasoline sold. *Source:* All available policy references, including the IEA on-line Global Renewable Energy Policies and Measures database and submissions from report contributors.

# Land Use – United States (2006)

Main crops	hectares	
Rice	1,142,000	1.0%
Barley	1,194,240	1.0%
Sorghum	1,998,000	1.7%
Maize (for forage and silage)	2,395,760	2.0%
Seed cotton	5,187,000	4.4%
Cotton lint	5,586,000	4.7%
Cottonseed	5,586,000	4.7%
Alfalfa for forage and silage	9,067,890	7.6%
Wheat	20,280,480	17.0%
Maize	28,590,000	24.0%
Soybeans	28,983,680	24.4%
Other crops	8,957,325	7.5%
Total	118,968,375	100.0%

Source: [faostat.fao.org](http://faostat.fao.org)

# Land Use – Brazil (2006)

Main crops	hectares	
Wheat	1,558,241	2.4%
Cassava	1,901,561	3.0%
Coffee	2,325,261	3.6%
Rice	2,974,596	4.6%
Beans	4,016,797	6.2%
Sugar cane	6,152,929	9.6%
Maize	12,602,652	19.6%
Soybeans	22,006,677	34.2%
Other crops	10,786,303	16.8%
Total	64,325,017	100.0%

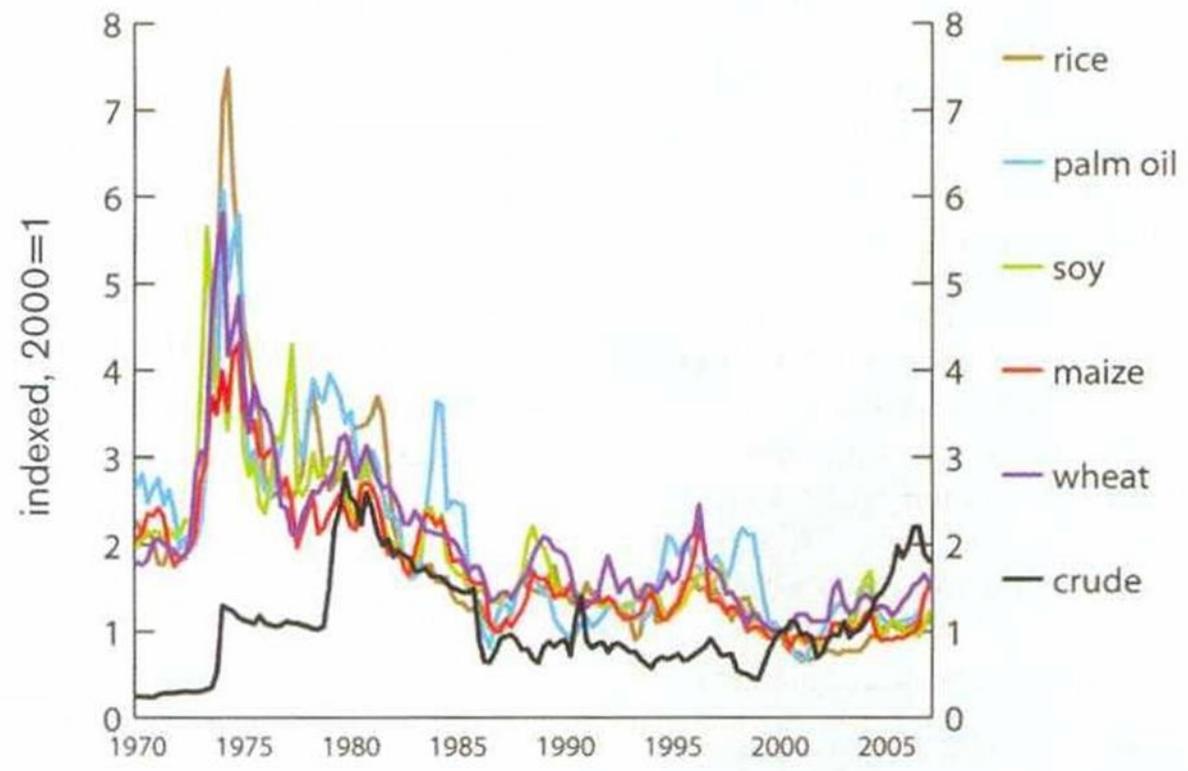
Source: [faostat.fao.org](http://faostat.fao.org)

# Land Use – World (2006)

Main Crops	hectares	
Sugar cane	20,398,731	1.5%
Groundnuts	22,231,685	1.7%
Sunflower seed	23,700,249	1.8%
Bean	26,540,002	2.0%
Rapeseed	27,796,428	2.1%
Millet	32,845,741	2.5%
Seed cotton	34,732,705	2.6%
Cotton lint	35,021,144	2.6%
Cottonseed	35,291,977	2.6%
Sorghum	41,500,111	3.1%
Barley	55,516,996	4.1%
Soybeans	92,988,859	6.9%
Maize	144,376,477	10.8%
Rice	154,323,697	11.5%
Wheat	216,100,018	16.1%
Other crops	375,478,442	28.0%
Total	1,338,843,261	100.0%

Source: [faostat.fao.org](http://faostat.fao.org)

# Global trends in prices of food commodities and crude oil 1970-2007



Long-run trends in inflation-corrected prices

NOTE: Crude prices are international averages.

SOURCE: Historical data from International Monetary Fund, *International Financial Statistics*, <http://ifs.apdi.net/imf/>. Futures data from Chicago Board of Trade, <http://cbot.com>; and <http://tradingcharts.com>.

# Sustainability Criteria

1. GHG Balance
2. Competition with food & energy supply, and others
3. Biodiversity
4. Wealth
5. Welfare
  - a. Labor conditions
  - b. Human rights
  - c. Property and use rights
  - d. Social conditions of local pollution
  - e. Integrity
6. Environment
  - a. Waste management
  - b. Use of agrochemical (including fertilizers)
  - c. Prevention of soil erosion and nutrient depletion
  - d. Preservation on surface & ground water
  - e. Airbone emissions
  - f. Use of GMOs

# Comparison between São Paulo State and Dutch sustainability criteria, indicators/procedures and suggested levels for 2007 and 2011 (Cramer, 2006 apud Smeets et al, 2006)

Criterion and level	Indicator/procedure 2007 Dutch criteria	São Paulo State (2007)
<b>1. GHG balance</b> , net emission reduction by >=30% in 2007 and >=50% in 2011	Use of developed methodology. Use of reference values for specific steps in logistic chain	Energy ratio (renewable energy production / fossil fuel consumption) in the ethanol production is 8:1.*
<b>2. Competition with food supply, local energy supply, medicines and building materials</b> Supply is not allowed to decrease	For this criterion a reporting obligation applies. A protocol for reporting will be developed.	Presently, no competition
<b>3. Biodiversity,</b> No decline of protected areas or valuable ecosystems in 2007 also active protection of local ecosystems in 2011	No plantations near gazetted protected areas or high conservation value areas; max. 5% conversion of forest to plantations within 5 years, Footnote a	Decree for Legal Reserve
<b>4. Wealth</b> , no negative effects on regional and national economy in 2007, and active contribution to increase of local wealth in 2011	For this criterion a reporting obligation applies. A protocol for reporting will be developed, based on Economic Performance indicators of the global reporting initiative	Occurring in all sugarcane regions.
<b>5. Welfare</b> , including	Compliance with Social Accountability 8000 and other treaties	Best conditions in rural areas for sugarcane workers.
5.a Labor conditions		
5.b Human rights	Compliance with universal declaration of HR As 2007 Three criteria from existing systems (RSPO 2.3, FSC 2, FSC 3)	Compliance with universal declaration of HR
5.c Property and use rights		Well enforced local legislation
5.d Social conditions of local population	For this criterion a reporting obligation applies. A protocol for reporting will be developed.	
5.e Integrity	Compliance with Business principles of countering bribery	
<b>6. Environment</b> , including		
6.a Waste management	Compliance with local & national laws; Good Agricultural Practice	Compliance with local / national legislation.
6.b Use of agro-chemicals (incl. Fertilizers)	Compliance with local & national laws	Compliance with local / national legislation.
6.c Prevention of soil erosion and nutrient depletion	Erosion management plan Avoid plantations on marginal or vulnerable soils, or with high declivity Monitoring soil quality Nutrient balance	No information available
6.d Preservation of quality and quantity of surface water and ground water	For this criterion a reporting obligation applies. A protocol for reporting will be developed, special attention for water use and treatment	Controlled by São Paulo State Environmental Agency.
6.e Airborne emissions	Comply with national laws	State Decree to phase-out sugarcane burning.
6.f Use of genetically modified organisms (GMOs)	Compliance with USA (safely) rules	Presently not authorized