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FAO Meeting on Bioenergy policy, markets and trade, and food security
FAO Meeting on Global perspectives on fuel and food security

Impacts on land and water resources

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National Reference Center on Biomass – CENBIO

FAO - Rome – Italy

February 18-20, 2008

WATER IMPACTS - AVAILABILITY

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Surface water supply and consumption, Brazil and the World

	Supply (1)		Consumption (2)	
	km^3/year	m^3/inhab .year	km^3/year	m^3/inhab .year
Brazil	**5,740**	**34,000**	**55**	**359**
World	**41,281**	**6,960**	**3,414**	**648**

Notes: (1) Mean runoff, 2000
(2) Consumption as evaluated in 1990

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The eight major water basins in Brazil

Source: FAO, 2004

Basin Name	Main cane producing region (Yes/No)	Area ($1000 km^2$)	Precipitation (mm/yr)	Evapo transpiration (mm/yr)
1. Amazon in Brazil	No	3935	8736	4919
2. Tocantins – Araguaia	No	757	1257	884
3. North and Northeast	Yes	1029	1533	1240
4. San Francisco	Yes	634	581	491
5. East Atlantic	Yes	545	321	246
6. Parana-Paraguai	Yes	1245	2140	1657
7. Uruguai	No	178	279	148
8. Southeast Atlantic	No	224	312	177
TOTAL		8547	15158	9761

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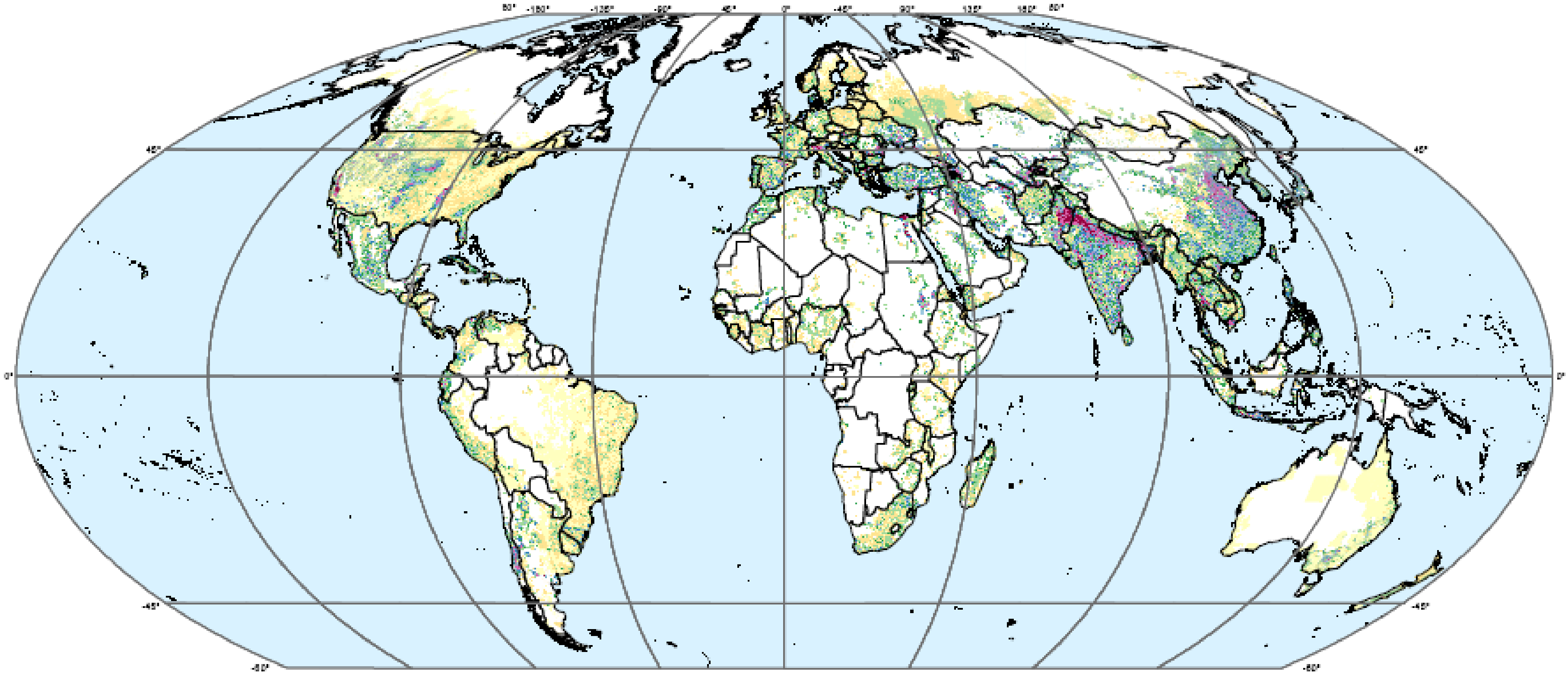
Source: FAO, 2004

Source:
FAO, 2004

The digital global map of irrigation areas

February, 2007



Area under irrigation in percentage of land area

	0		10 - 20
	<0.1		20 - 35
	0.1 - 1		35 - 50
	1 - 5		50 - 75
	5 - 10		75 - 100

The map depicts the area equipped for irrigation in percentage of cell area.
For the majority of countries the base year of statistics is in the period 1997 - 2002.

Projection: Mollweide

http://www.fao.org/ag/agl/aglw/aquastat/irrigationmap/index.stm

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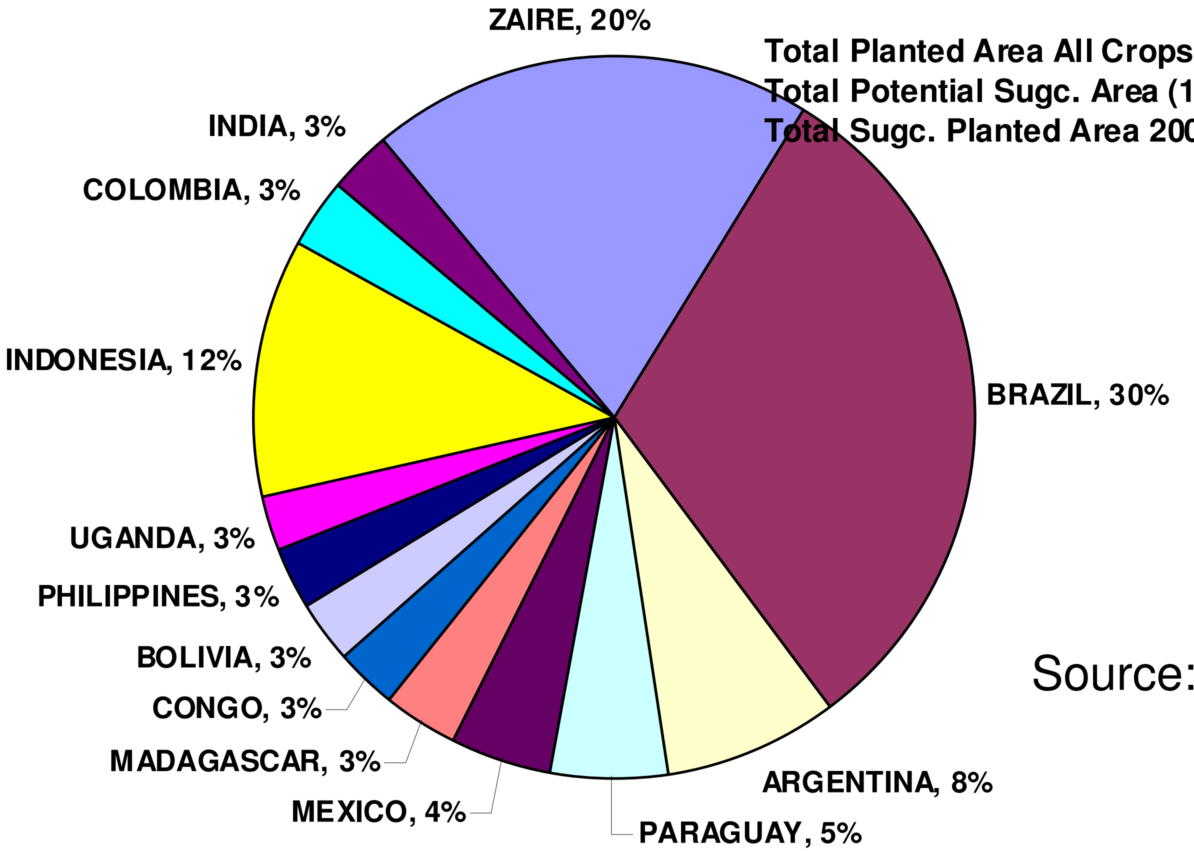
Very Suitable and Suitable Area in Major Potential Producer Countries for Sugar Cane Plantation Using High Technology Input and Preserving Forests by Year 2000



Total Planted Area All Crops (1000ha)= 387,067
Total Potential Sugc. Area (1,000ha)= 127,775
Total Sugc. Planted Area 2006 (1,000ha)= 12,885

Source: IIASA, 2000

Rain Feed Agriculture

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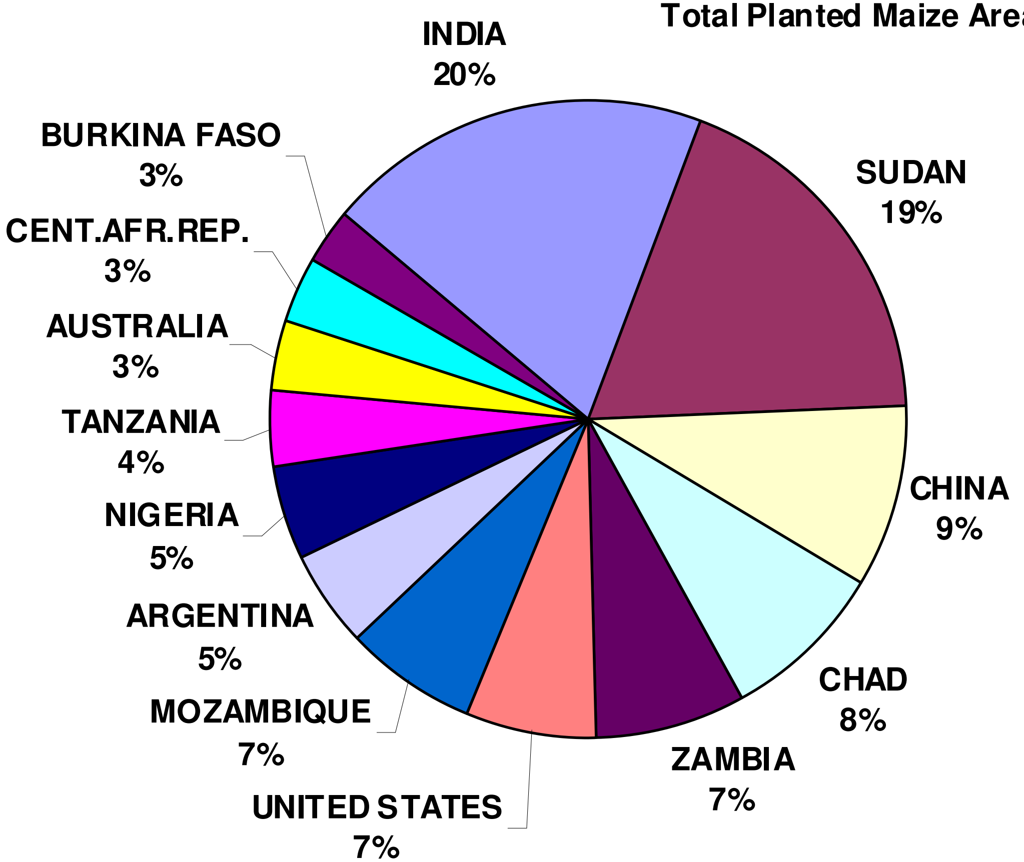
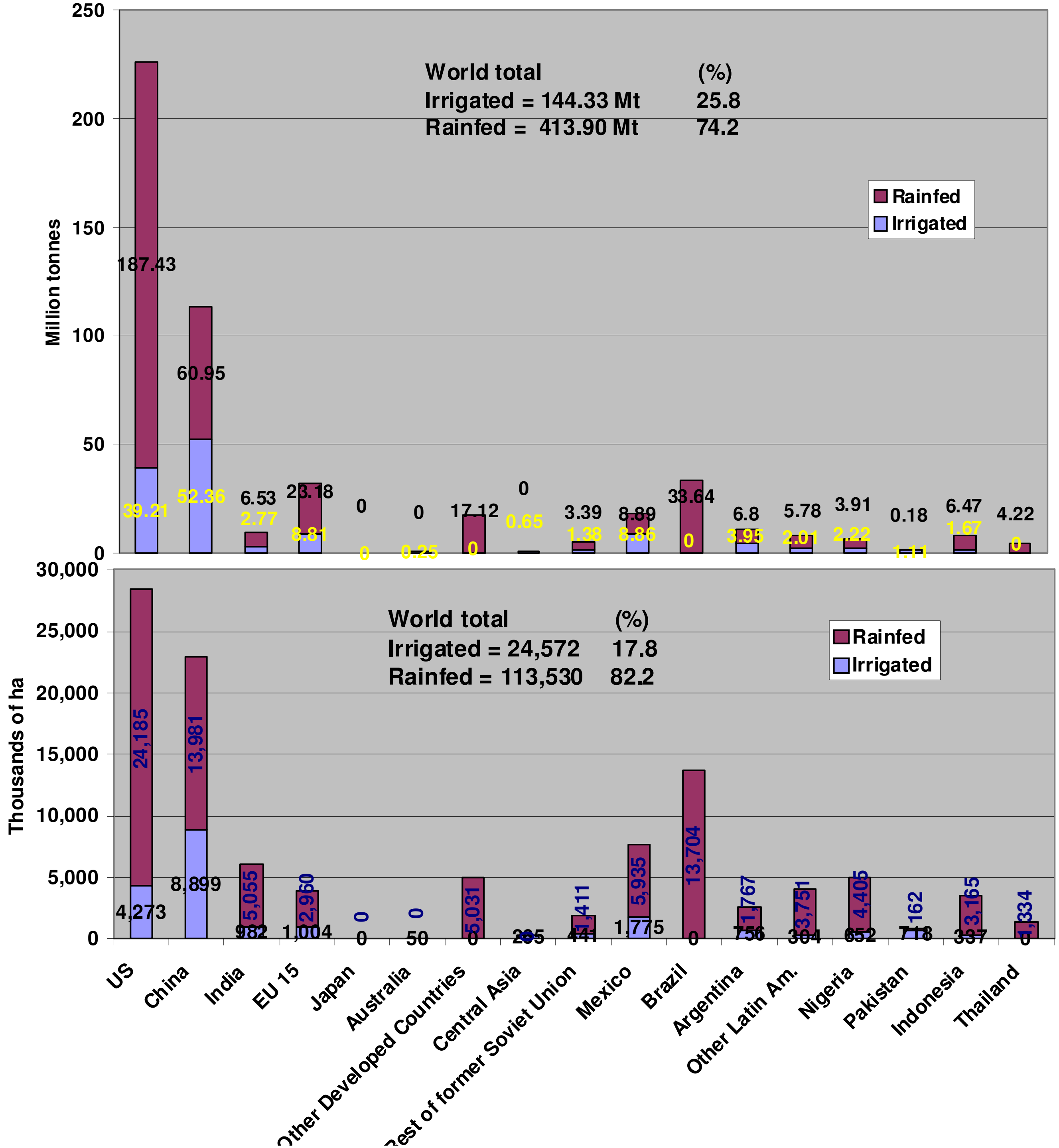
Very Suitable and Suitable Area in Major Potential Producer Countries for Maize Plantation Using High Technology Input and Preserving Forests by Year 2000

Total Planted Area All Crops (1,000ha)= 634,298
Total Potential Maize Area (1,000ha)= 180,061
Total Planted Maize Area 2006 (1,000ha)= 74,390



Source: IIASA, 2000

Rain Feed Agriculture



Irrigated and rainfed maize annual production – 2010

Word total

Irrigated = 29.1 (%)

Rainfed = 70.9 (%)

Irrigated and rainfed maize plntation area (000ha) – 1995

World total

Irrigated = 18.9 (%)

Rainfed = 81.1 (%)

Source: Rosegrand et al, 2000, International Food Policy Research Institute

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WATER IMPACTS - POLLUTION

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Environmental impacts of ethanol production from sugar cane

* contamination of open water systems by agrochemicals and fertilizers;
* contamination of groundwater by agrochemicals, fertilizer and deposition of liquid and solid residues on the soil;
* pollution of open water systems by industrial effluents;
* soil erosion;
* pollution of water, air and soil due to accidents with transport and storage of (by)products;
* air pollution due to bagasse burning;
* air pollution and inconvenience due to cane and cane residue burning;
* air pollution and inconvenience due to storage and soil-application of vinasses;
* proliferation of insects due to vinasses;
* reduction of visibility on roads due to cane and cane residue burning;
* deforestation;
* substitution of food and other cultures;
* human health effects, for both workers and local population, due to agrochemicals;
* infrastructure over-use.

Sources: RIMA Batatais 1990

Intensity of fertilizer use in crops in Brazil

Crops	Area (1) (1,000ha)	Consumption (1,000 t)	Consumption / area (t/ha)
Herbaceous cotton	1,012	950	0.94
Coffee (3)	2,551	1,375	0.54
Orange (3)	823	406	0.49
Sugar cane (3)	5,592	2,600	0.46
Soybean	21,069	8,428	0.40
Corn (2)	13,043	4,082	0.31
Wheat (3)	2,489	742	0.30
Rice	3,575	872	0.24
Beans (2)	4,223	650	0.15
Reforestation	1,150	129	0.11

Notes: (1) Data from the Systematic Survey of Agricultural Production – LSPA – IBGE and CONAB

(2) These cultures total all of the harvested crops

(3) Crops planted and harvested in the same year

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Fertilizer use level in sugar cane: Australia and Brazil, kg/ha

Cane stage			Plant	Ratoon
Country	Australia	N	200	200
		P_2O_5	58	57
		K_2O	120	145
		Total 1	378	402
	Brazil	N	50	100
		P_2O_5	120	30
		K_2O	120	130
		Total 2	290	260
Total 1 / Total 2 ratio (%)			1.30	1.54

Source: Adapted from CaneGrowers' 1995; CTC, 1998; Manechini & Penatti, 2000

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Consumption of fungicides, insecticides, acaricides and agricultural defensives in 1999 and 2003 in Brazil (in kg active ingredient/ha/yr)

		Coffee	Sugar cane	Citric	Corn	Soybean
Fungicides	1999	1.38	0.00	8.94	0.00	0.00
	2003	0.66	0.00	3.56	0.01	0.16
Insecticides	1999	0.91	0.06	1.06	0.12	0.39
	2003	0.26	0.12	0.72	0.18	0.46
Acaricides	1999	0.00	0.05	16.00	0.00	0.01
	2003	0.07	0.00	10.78	0.00	0.01
Agricultural defensives	1999	0.06	0.03	0.28	0.05	0.52
	2003	0.14	0.04	1.97	0.09	0.51

Source: Macedo, 2005

Water uses (mean values) in mills having an annexed distillery

Sector	Process	Mean use (total m3/sugar cane t)	Distribution
Feeding	Sugar cane washing	5.33	25.4
Extraction (grinding)	Inhibition	0.25	1.2
	Bearing cooling	0.15	0.7
Juice treatment	Preparation of lime mixture	0.01	0.1
	Cooling sulphiting(1)	0.05	0.2
	Filter inhibition	0.04	0.2
	Filter condensers	0.30	1.4
Juice concentration	Condensers/multijets evaporation(1)	2.00	9.5
	Condensers/multijets heaters (1)	4.00	19.0
	Molasses dilution	0.03	0.1
	Crystallizer cooling (1)	0.05	0.2
	Sugar washing (1)	0.01	0.0
Electrical power generation	Steam production	0.50	2.4
	Turbo generator cooling	0.20	1.0
Fermentation	Juice cooling (2)	1.00	4.8
	Fermentation cooling (2)	3.00	14.3
Distillery	Condenser cooling (2)	4.00	19.0
Other	Floor & equipment cleaning	0.05	0.2
	Drinking	0.03	0.1
Total		**21.00**	**100.0**

Notes:
(1) in sugar production only;
(2) in ethanol production only.

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Water withdraw, consumption and release in 1990, 1997 and 2005 (in m^3/t cane)

	1990	1997	2005
Collection	**5.6**	**5.07**	**1.83/1.23(a)**
Release	**3.8**	**4.15**	**n/a**
Net Consumption	**1.8**	**0.92**	**n/a**

Note: a: 1.83 m^3/t cane is the average collection of all mills in São Paulo.
When the mills with the highest water consumption are excluded (8% of all mills), than the remaining
92% of the mills has an average water collection rate of 1.23m^3/t.
Source: Macedo 2005

Effluents from sugar mill with annexed distillery

Effluent	volume (l/tc)	BOD (mg/l)	T (ºC)
vacuum condenser system	10.000-30.000	10-150 (400-1000)	40-45
washing of cane	3.000-10.000	100-500 (2.000-4.000)	25-35
cooling water	1.500-5.000	-	35-45
evaporation condensates	500-650	100-800	70-80
vinasses	665-1260	6.000-25.000	85-90
washing of floor and equipment	30-100	800-1.500	25-50

Source: CTC and CETESB. Note: l/tc = litres per tonne of cane processed; figures between brackets represent closed systems and are only a very rough indication; the ranges are very significant, since modes of operation vary between different distilleries; more details on the various effluents are given in the text.

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Land Impacts - Deforestation

A survey to evaluate the dimensions and situations of permanent preservation areas (PPA) corresponding to old riverside woods, involving a large number of mills in São Paulo covering owned and leased land (around 750,000 ha), and in many cases, land owned by sugar cane suppliers, is shown.

Total PPA (banks, springs, lagoons)	**8.1% of the sugar cane area**
PPA with natural woods	**3.4%**
PPA with reforestation	**0.8%**
Abandoned PPA	**2.9%**
PPA with sugar cane	**0.6%**

Source: Barbosa, 2005

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Land Impacts – Soil Erosion

Soil erosion of various crops in Brazil	
crop	soil erosion (tonne/ha/year)
beans	38.5
cassava	33.9
peanut	26.7
rice	25.1
cotton	24.8
soya	20.1
potato	18.4
sugarcane	12.4
corn	12.0
corn and beans	10.1
sweet potato	6.6

Source: RIMA Batatais, 1990.

Land Impacts – Food vs. Fuel

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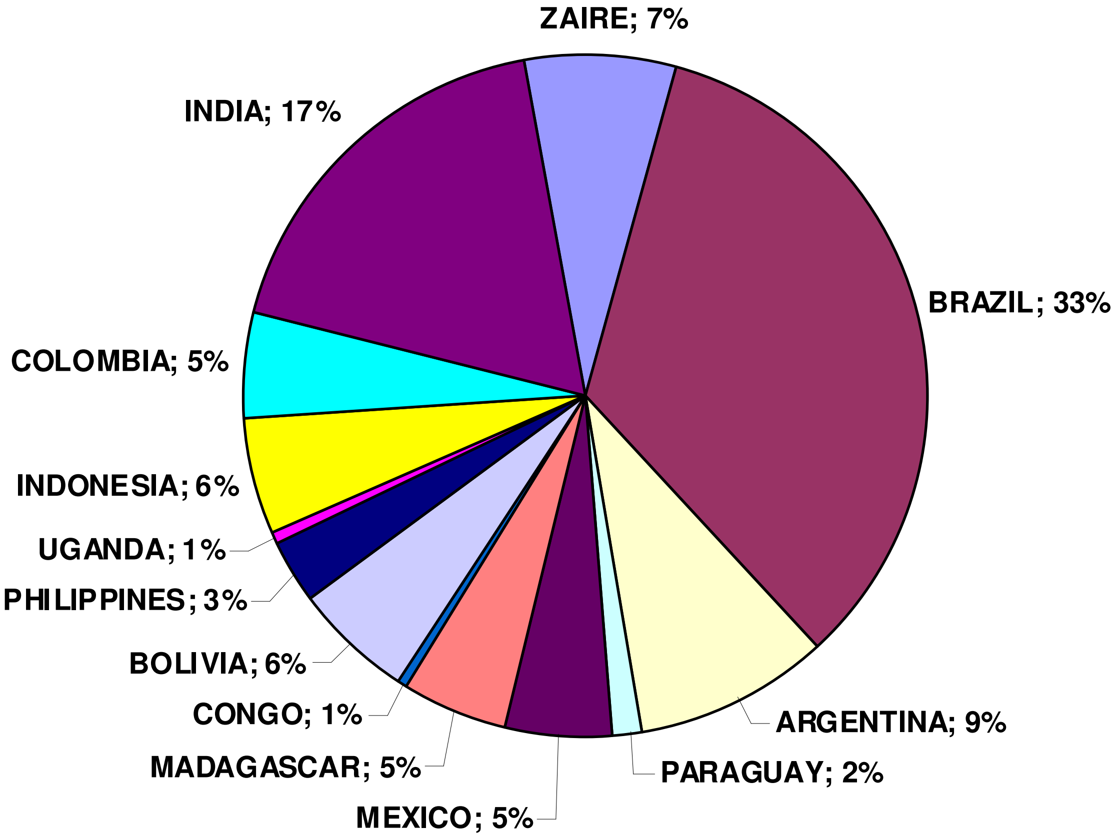
Useful Areas for Agricultural Activities with No Climate Constraints, and with No and Modest Soil/Terrain Constraints in Major Potential Sugar Cane Producer Countries by Year 2000

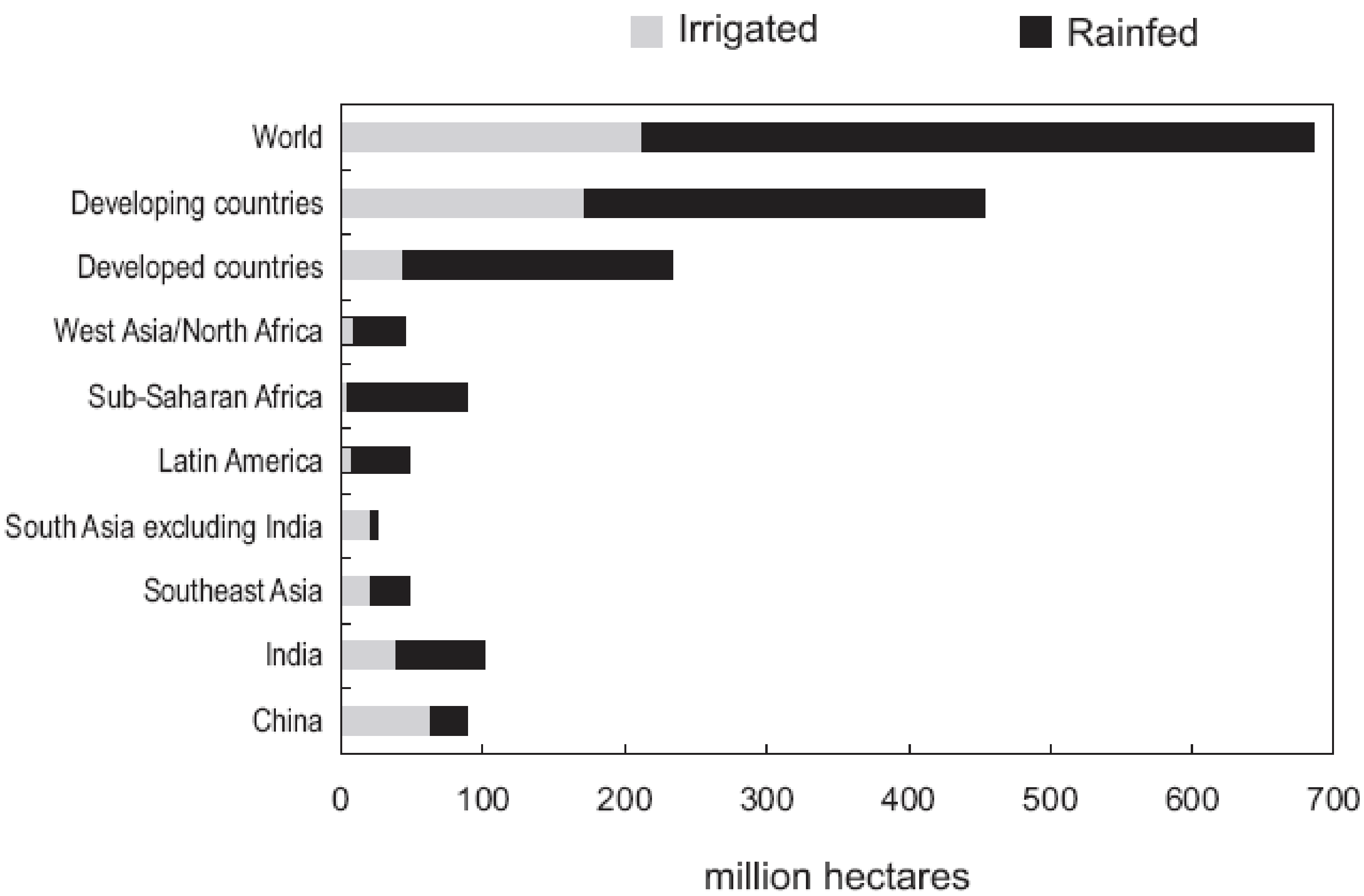
Total Area (1,000ha) = 653,845



Rain Feed Agriculture

Land Impacts – Food vs. Fuel

Figure 4.16—Cereal area, 1995



Source: Author estimates based on FAO (1999) and Cai and Rosegrant (1999).

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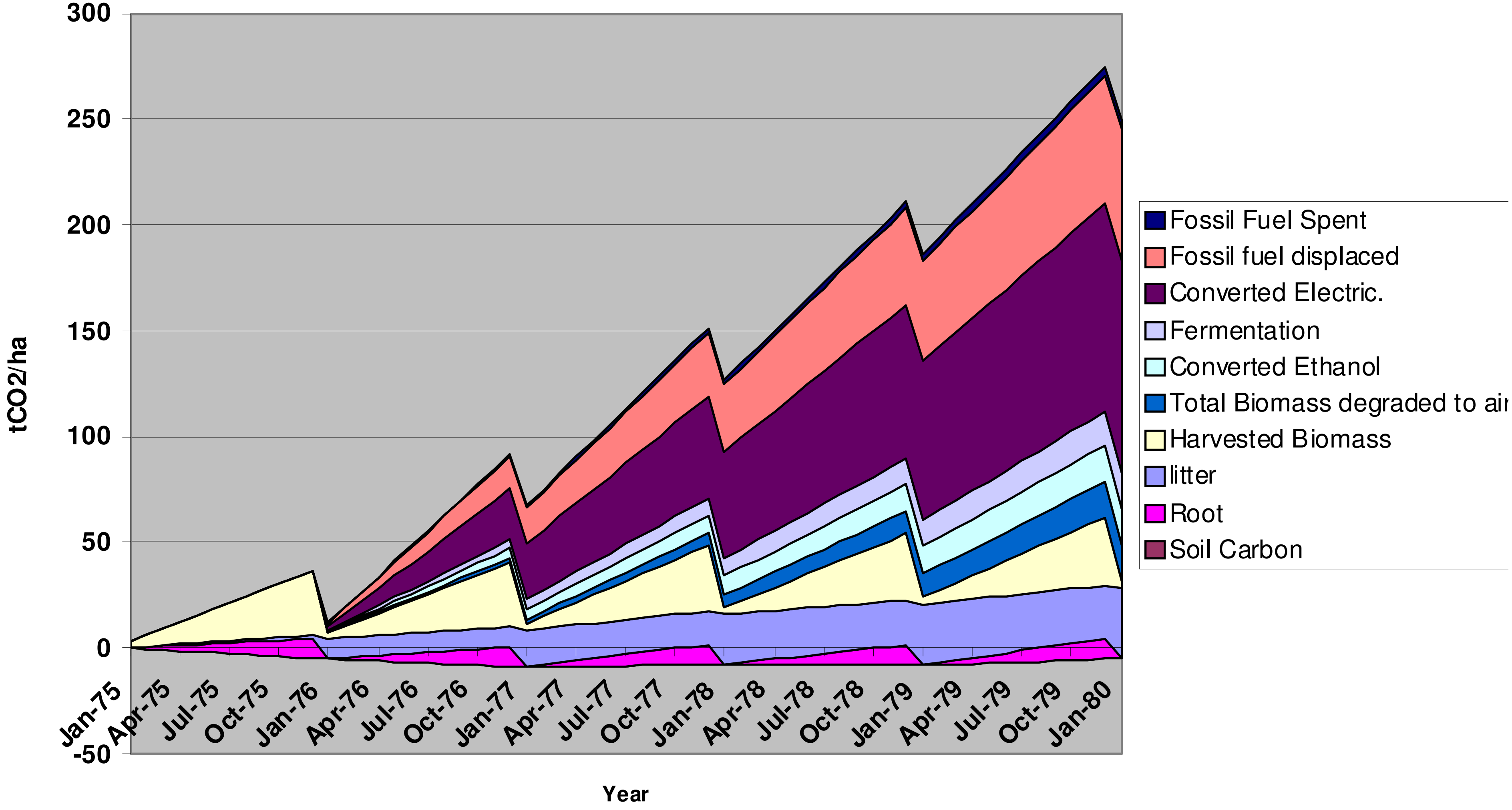
Sugar cane biomass and its CO2 generation portfolio - 5 years



Source: Author

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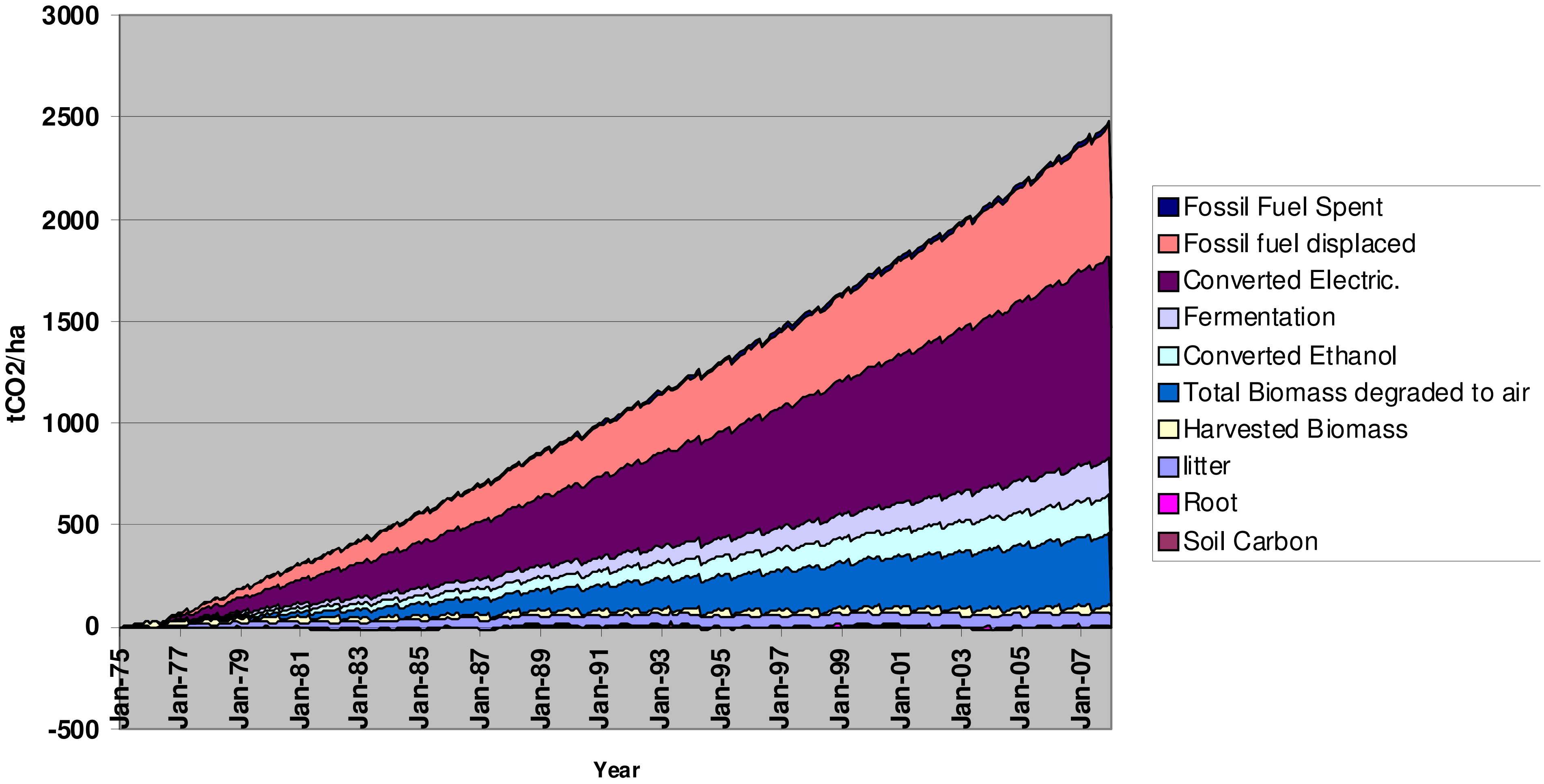
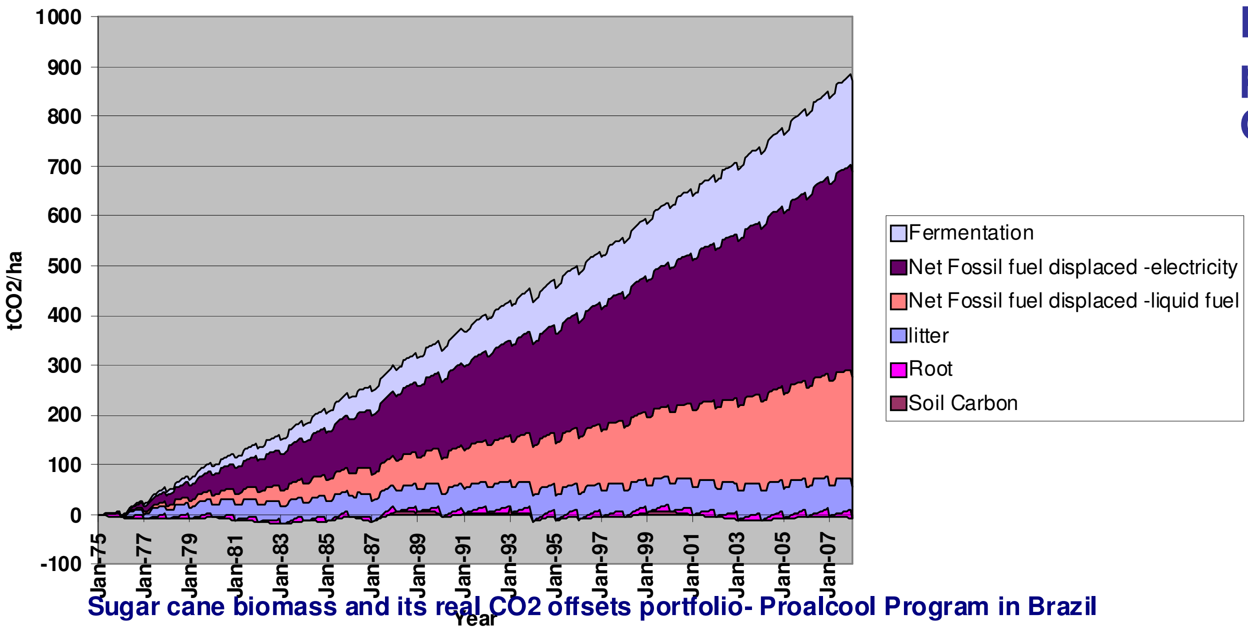
Sugar cane biomass and its potential CO2 generation portfolio- Proalcool Program in Brazil From 1975 to 2007 (32 years)



Source: Author

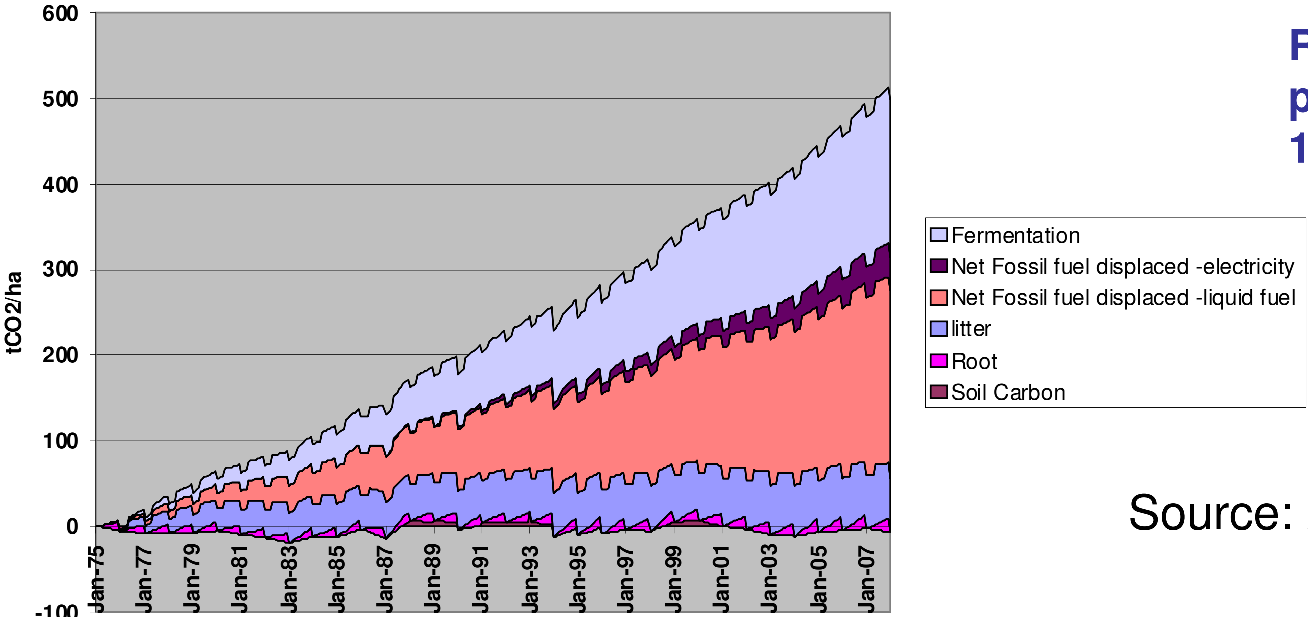
Sugar cane biomass and its potential CO2 offsets portfolio- Proalcool Program in Brazil From 1975 to 2007 (32 years)



Potential Offset in the period = 900*3*10^6 =2.7 GtCO2

Potential Offset in the next 32 years = 1600*6*10^6 =7.6 GtCO2

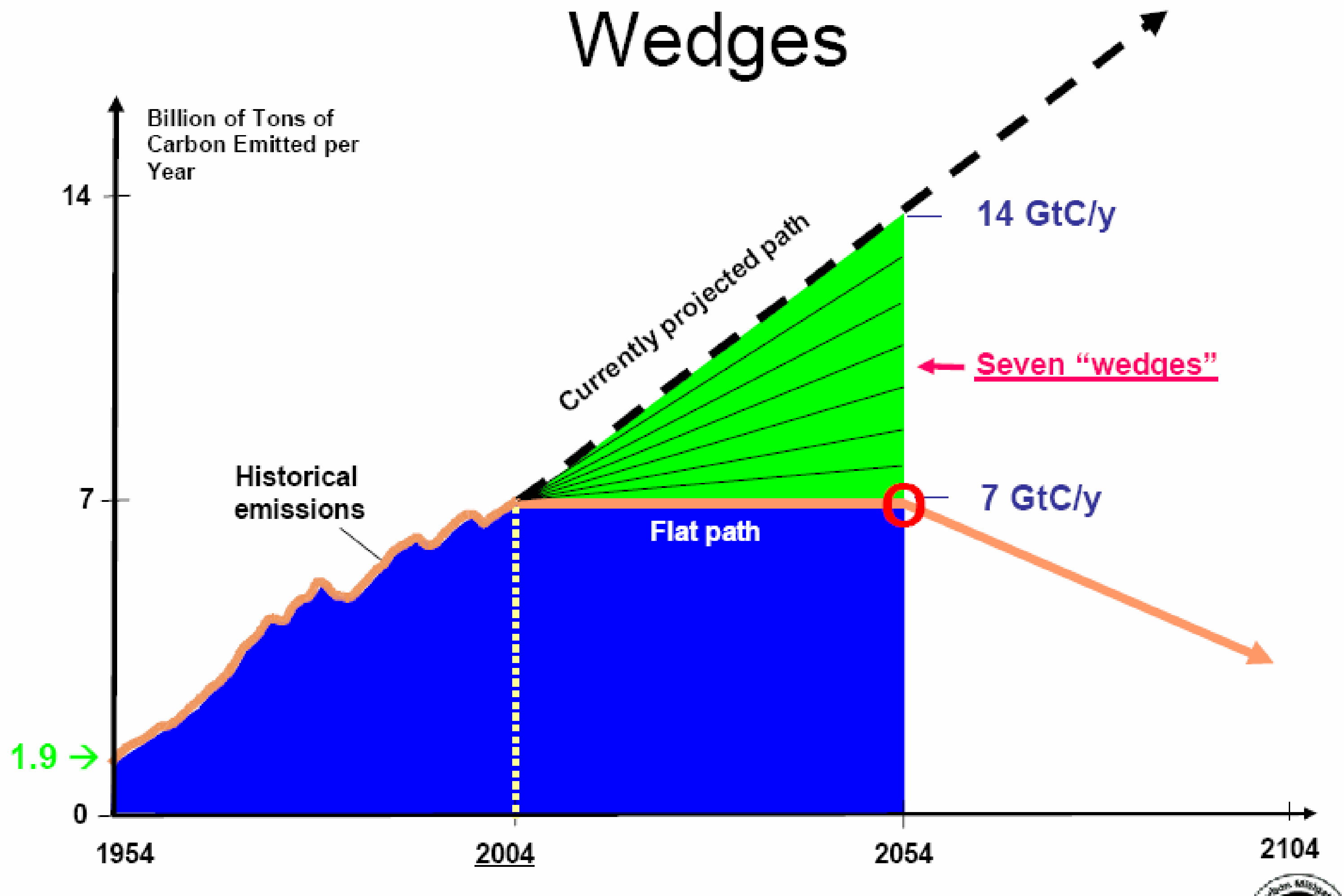
Sugar cane biomass and its real CO2 offsets portfolio- Proalcool Program in Brazil From 1975 to 2007 (32 years)



Real CO2 offset in the period = 330*3*10^6 = 1GtCO2

Source: Author

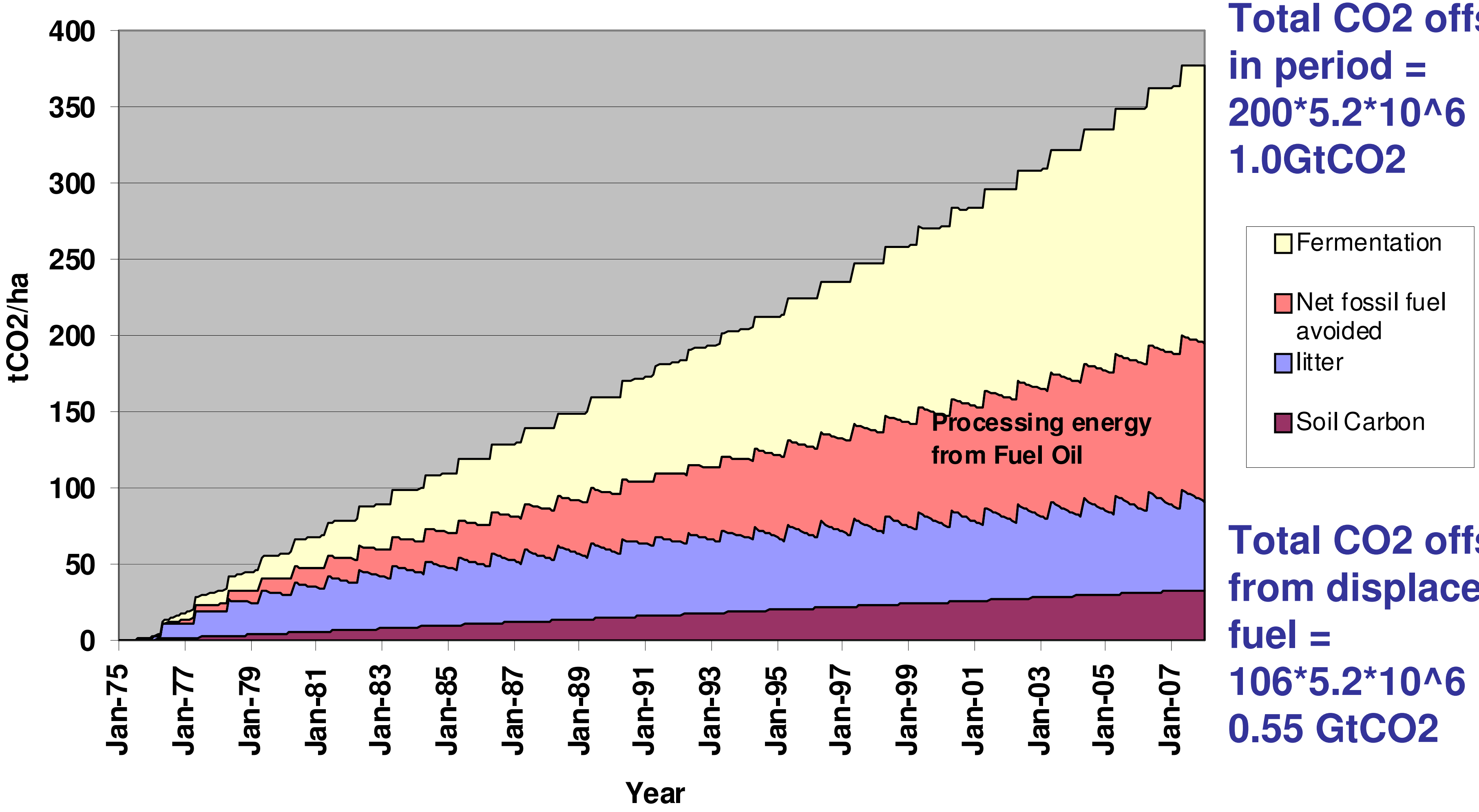
Wedges



1 GtC*50yrs = 25GtC = 92 GtCO2 in 50 yrs

Potential Offset in the next 50 years = 7.6 GtCO2*50/32 = 11.9 GtCO2 in 50 yrs or 1/8 of 1 Pacala&Socolow wedge

Corn Crop and its real CO2 offsets portfolio- Assuming Plantation Has Started in 1975 With the Same Yield and Inputs Used Today (32 years)



Total CO2 offset in period = 200*5.2*10^6 = 1.0GtCO2

Total CO2 offset from displaced fuel = 106*5.2*10^6 = 0.55 GtCO2

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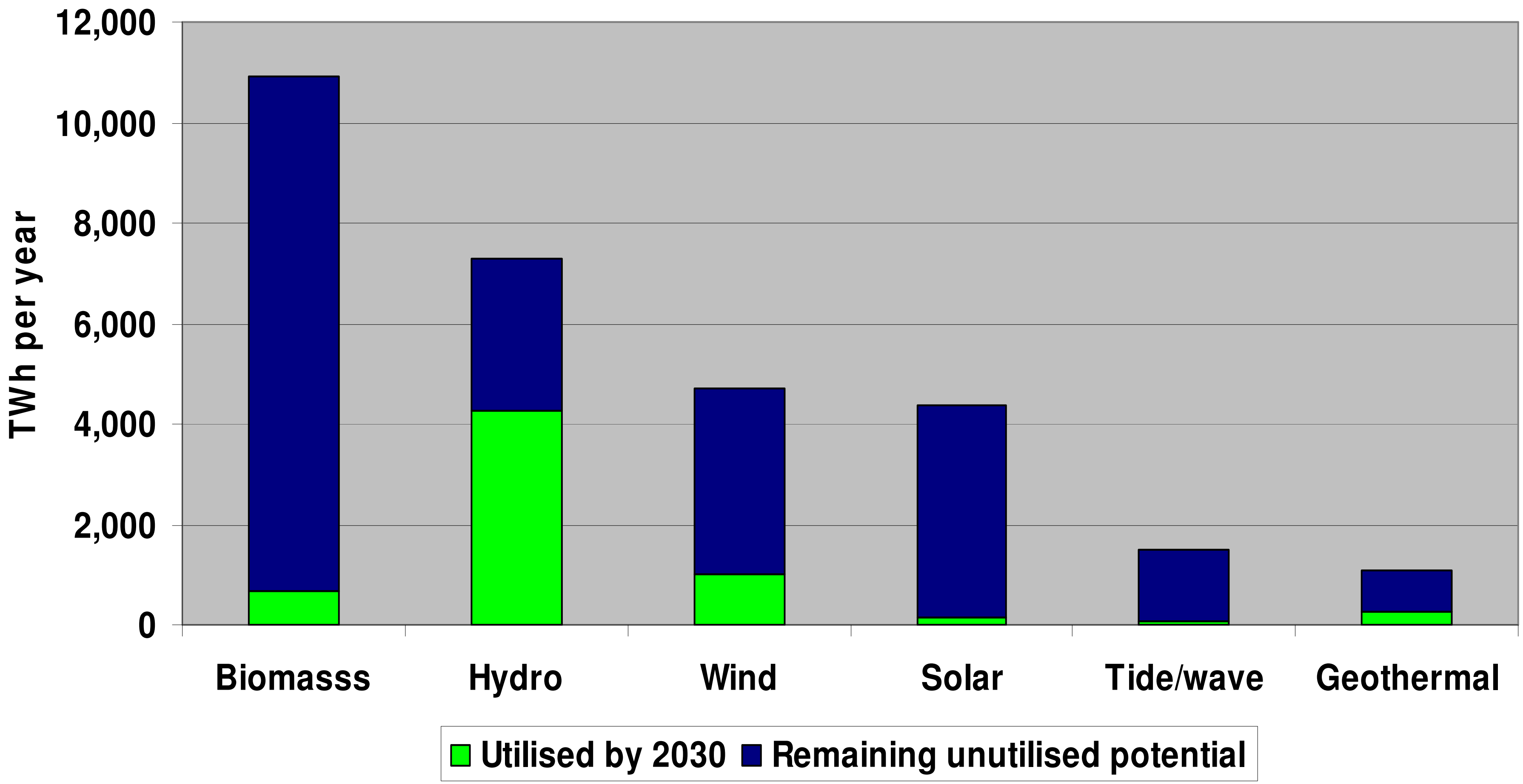
World Long-Term Renewable-Energy Potential for Electricity Generation



Experimental Results with Irrigated Sugar Cane

Irrigation Level	Yield (t/ha)	Seed Density (seed/m)	Total Reduc. Sugars (t/ha)	Production of dry matter (t/ha)
High	298	27	45.6	88.5
Medium	321	27	50.0	94.3
Low	283	27	42.2	83.1
None	202	23	30.1	59.6
Current Average Results	120	27	14.5	38.8

Source: FCA/Unesp/Botucatu 2000

Amount of energy produced from sugar/alcohol mills distributed over world agricultural land area at a density of 1 every 6,200km^2 –BIG, Combined Cycle, and 40% more yield – Total number of renewable energy producing units is 4,000

FINAL ENERGY CATEGORY	PRIMARY ENERGY (EJ/yr)	FINAL ENERGY (EJ/yr)	TOTAL LAND AREA USED FOR CROPS
ELECTRICITY	94.1	37.9	
LIQUID FUEL	69.9	51.5	
TOTAL	163.9	89.5	1.43 X 10^6 km^2 (143 MHA)

Source: Author

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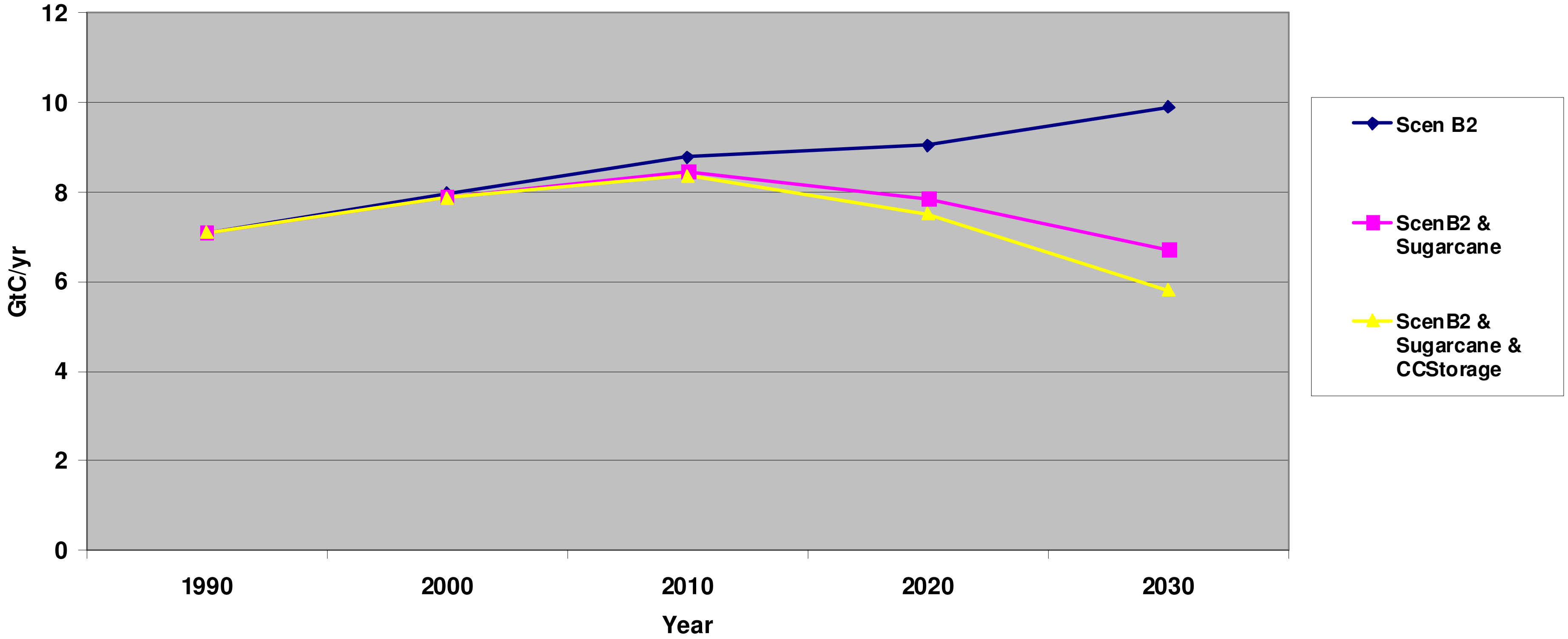
CO2 ENERGY EMISSION IN SCENARIO IPCC B2 WITH AND WITHOUT SUGARCANE



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Summary and Conclusions (1)

- **Most of the present ethanol producer countries have significant water availability. Water shortage is serious in some high populated countries and for these bioenergy isn't recommended.**
- **The present use of irrigation for maize is very small (24.5 Mha, compared to 138 Mha harvested in the world).**
- **Sugarcane crops in Brazil, which implies in 6 Mha harvested, are virtually not irrigated except for some small areas (salvation irrigation). In many of the more than 100 producer countries, which implies in other 15 Mha, sugar cane isn't irrigated. Thus, less than 10Mha of this plantation is irrigated, which is a very small share of the total irrigated world area (227 Mha)**
- **The levels of water withdraw and release for industrial sugar cane use have substantially decreased over the past few years, from around 5m3/sugar cane t in 1990 and 1997 to 1.83m3/sugar cane t in 2004 (sampling in São Paulo). For maize it is even lower.**
- **It seems possible to reach rates near 1m3/tonne sugar cane (collection) and zero (release) by optimizing both the reuse and use of wastewater in ferti-irrigation.**

Summary and Conclusions (2)

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- The average intensity of fertilizers use for sugar cane and maize is significant but lower than some other crops and comparable with crops cultivated worldwide in large scale (soybeans, corn, wheat).

- The intensity of use of fungicides, inseticides and other agricultural defensives is low, at least for sugar cane, when compared with most crops, since biological defensives are the preferred solution

- The most polluting waste – vinasses is used for ferti-irrigation with significant economic advantage to sugar mill owners or for by-product in maize-based ethanol. Strong regulation exists to monitor vinasses use

- Thus, water availability is not a serious concern. Water pollution is more important but manageable.

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Summary and Conclusions (3)

- The Permanent Preservation Areas (PPA) relating to riverside woods have reached 8.1 percent of the sugar cane crop area in São Paulo, 3.4 percent of which having natural riverside wood restoration programs, in addition to the protection of water springs and streams, can promote the restoration of plant biodiversity in the long term. More efforts to reach 20% for PA is necessary
- The average intensity of soil erosion due sugar cane and maize plantations are significant but lower than some other crops and comparable with crops cultivated worldwide in large scale (soybeans, corn, wheat).
- Regarding climate change mitigation the use of sugar cane as a source of biofuel and as a source of electricity can make significant contribution. Even using modest technologies and assuming no further gains on learning-by-doing, plantation over an extension of 36 Mha is enough to fulfill one of the Pacala&Socolow wedges
- Enough very suitable and suitable land is available in several potential producer countries to increase sugar cane and maize planted area, without causing deforestation, by more than 100 Mha for each one. Thus, competition with food/feed can be minimized
- Competition with food/feed can improve these prices pushing more already available technologies to rural areas and improving life conditions of farmers – a significant share of the global poors

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THANK YOU VERY MUCH

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