FAPESP
Fundação de Amparo à Pesquisa do Estado de São Paulo

GSB
LATIN AMERICAN CONVENTION
GLOBAL SUSTAINABLE BIOENERGY PROJECT

AGRICULTURE FOR FOOD AND FOR BIOENEGY: IS IT POSSIBLE?

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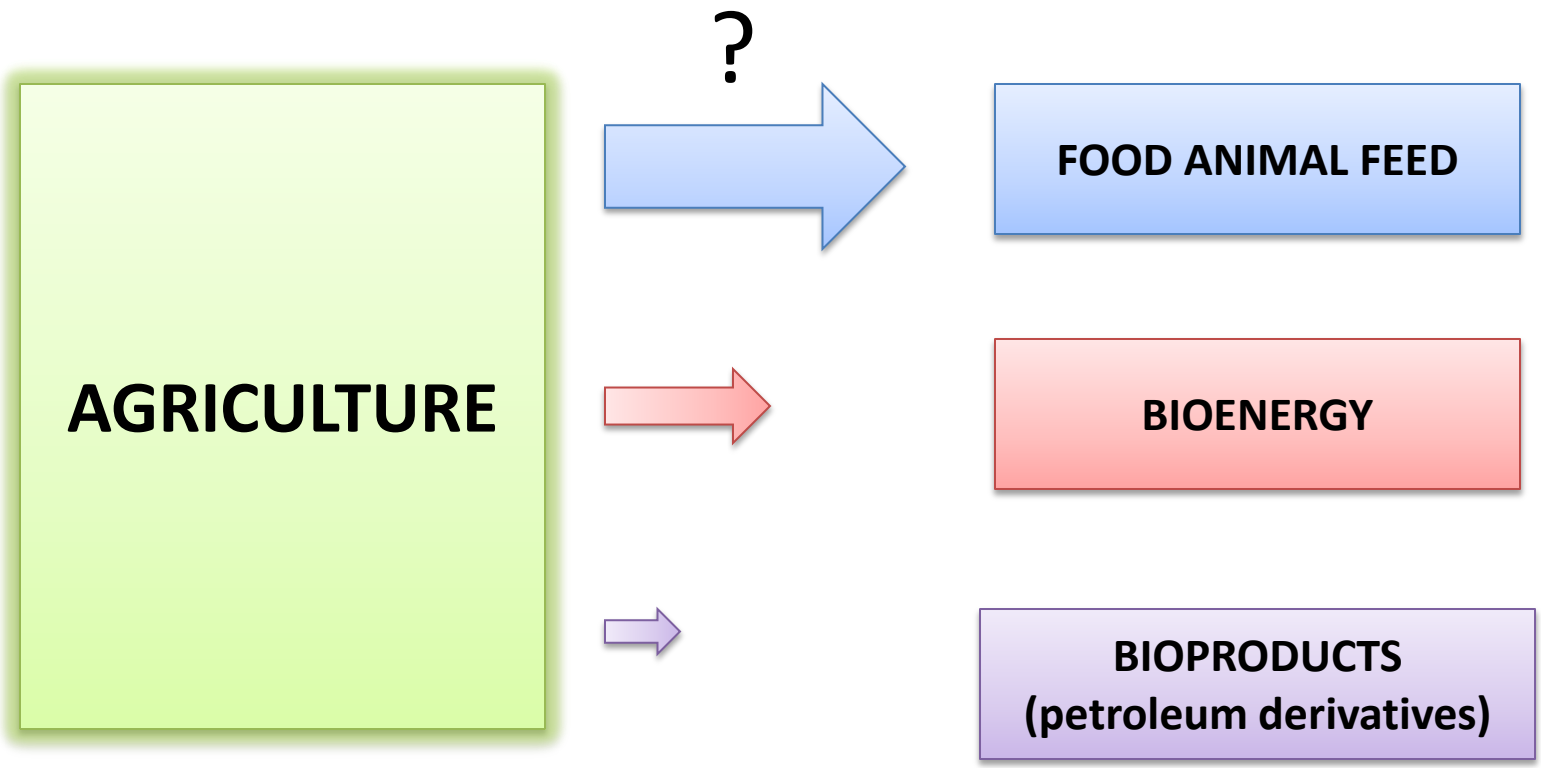
Casa abierta al tiempo
CUAJIMALPA

March 24th, 2010
Sao Paulo, Brazil



Working hypothesis: it is physically possible for bioenergy to sustainably meet a substantial fraction of future demand for energy services (≥ 25% of global mobility or equivalent) while feeding humanity and meeting other needs from managed lands, preserving wildlife habitant and maintaining environmental quality.

The question has been answered taking into account different point of view and always establishing scenarios that in someway define a sustainable future.

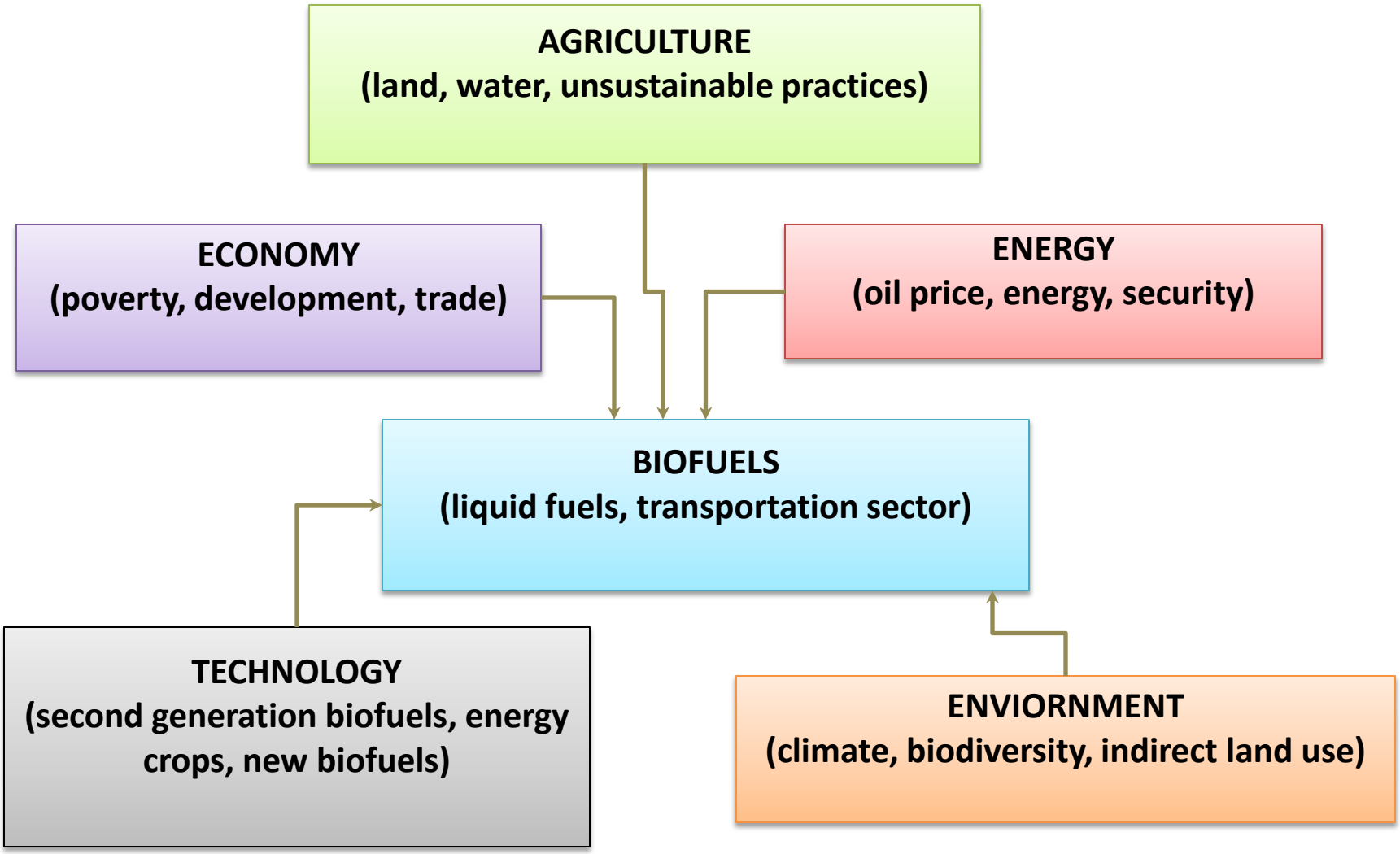
With regard to biofuels there is a general consensus that they contribute to:

- Energy security.
- Climate change mitigation.
- Rural development.

and the main concerns are related to its economic, environmental and social sustainability.

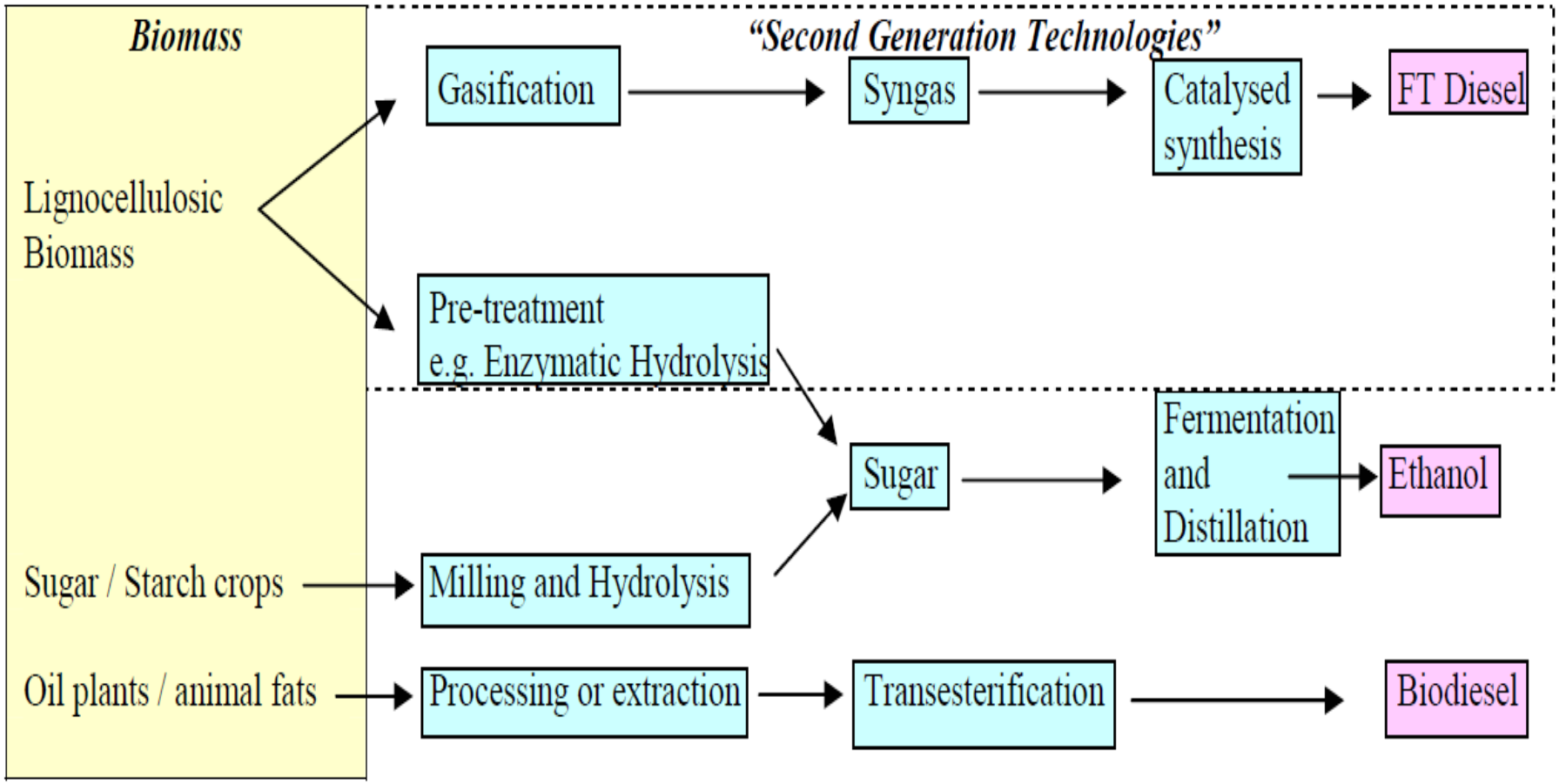
At the same time, current practice indicates that the focus has not been sustainability *per se*.

Population, GDP, timeframe



IT IS A COMPLEX PROBLEM

Biofuel production pathways



Source: adapted from BMU (2006) and Hamelinck and Faaij (2006)

Biofuels R&D

Year	Number of Patents
2002	147
2003	271
2004	302
2005	391
2006	640
2007	1045

Source: Kamis and Joshi 2008.

- There are more than 60 pilot plants /demonstration facilities for cellulosic ethanol in USA, Canada, Brazil, Spain, Denmark, Germany, Sweden and Japan.
- Plant biotechnologist are developing the new field of energy crops.

Biofuel production in 2008 by country

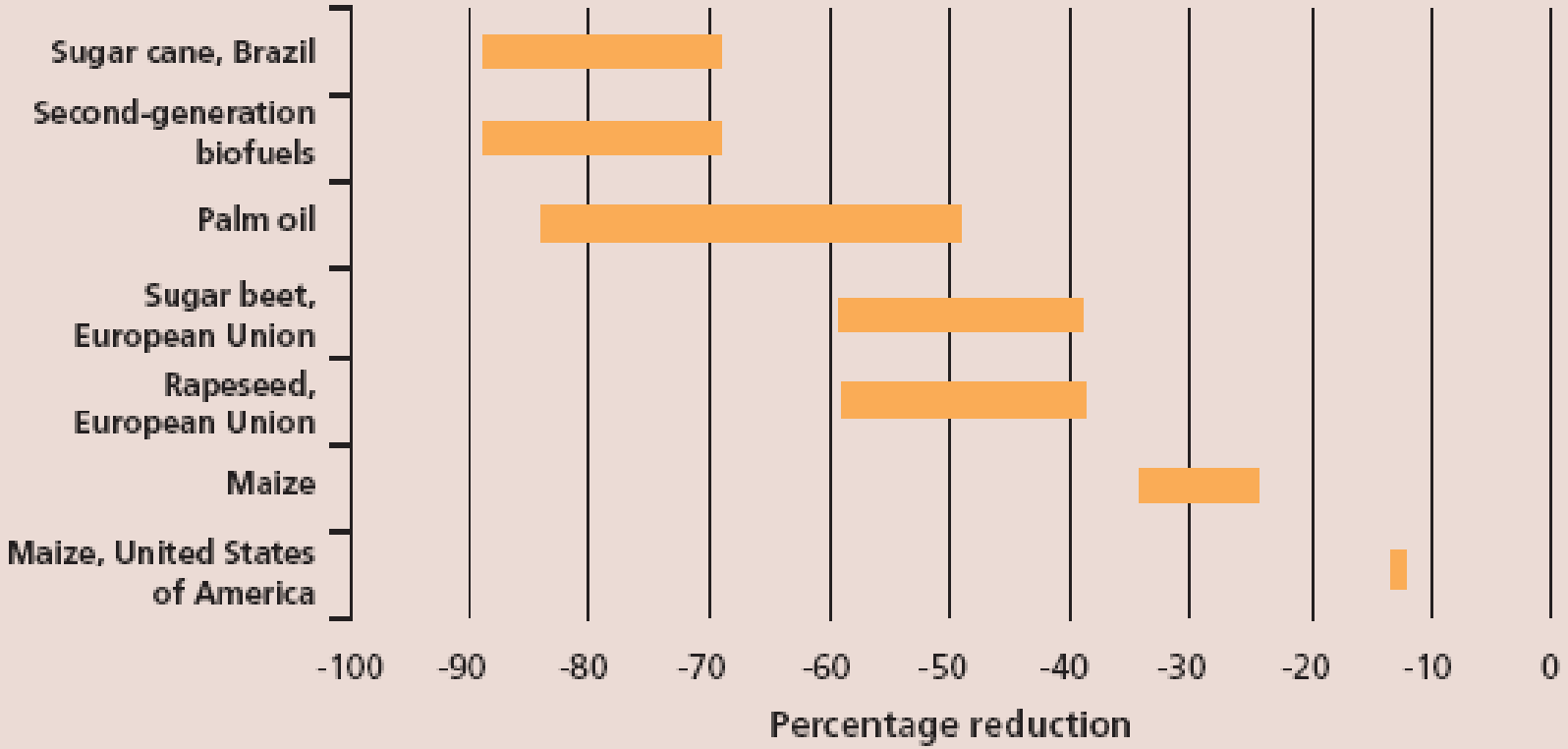
billion litres	Bioethanol		Biodiesel		Total biofuels		Share in total
World	*67.0*	*(32.8)*	*12.0*	*(9.4)*	*79.0*	*(42.2)*	*100.0%*
US	34.0	(16.7)	2.0	(1.6)	36.0	(18.2)	45.6%
Brazil	27.0	(13.2)	1.2	(0.9)	28.2	(14.2)	35.7%
EU	2.8	(1.4)	8.0	(6.3)	10.8	(7.6)	13.7%
China	1.9	(0.9)	0.1	(0.1)	2.0	(1.0)	2.5%
Canada	0.9	(0.4)	0.1	(0.1)	1.0	(0.5)	1.3%
India	0.3	(0.1)	0.02	(0.0)	0.32	(0.2)	0.4%

Source: REN 21 (2009). Note: units are billion litres; Mtoe (in brackets) was calculated. Share in total is in volume.

[Other countries not named in Table 1.1 have a combined 0.8% share of the world total.]

- Ethanol represents 77% of total biofuels; U. S. and Brazil produced 81% of total biofuels and 91% of ethanol.
- Nevertheless total biomass accounted for 3.5% of total primary energy supply in 2007, with liquid biofuels accounting for about 0.28% of total.

Reductions in greenhouse gas emissions of selected biofuels relative to fossil fuels



Note: Excludes the effects of land-use change.

Sources: IEA, 2006, and FAO, 2008d.

Situation in U.S.A.

- It is the world leader in corn production (~ 40%) more than 90 countries import U. S. corn. In 2009 produced 10,600 million gallons of ethanol, requiring 18 million acres, which is 21% of the total area dedicated to corn production.
- EPA is currently reviewing an increase in the ethanol content in gasoline from 10% to 12-15%. And established ethanol consumption goals up to 2022.

U.S. New renewable fuels standard schedule (billion gallons per year)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Renewable Biofuel	9.0	10.5	12.0	12.6	13.2	13.8	14.4	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Advanced Biofuel		0.6	0.95	1.35	2.0	2.75	3.75	5.5	7.25	9.0	11.0	13.0	15.0	18.0	21.0
Cellulosic Biofuel			0.1	0.25	0.5	1.0	1.75	3.0	4.25	5.5	7.0	8.5	10.5	13.5	16.0
Biomass-based Diesel		0.5	0.65	0.8	1.0										
Undifferentiated Advanced Biofuel		0.1	0.2	0.3	0.5	1.75	2.0	2.5	3.0	3.5	4.0	4.5	4.5	4.5	5.0
Total RFS	9.0	11.1	12.95	13.95	15.2	16.55	18.15	20.5	22.25	24.0	26.0	28.0	30.0	33.0	36.0

Source: 2010 Ethanol Industry Outlook. Renewable Fuel Association

- The use of ethanol in 2009 reduced GHG emissions from vehicles by 16.5 million metric tons, the equivalent to removing 2.7 million vehicles from the road.
- The latest published LCA indicates a reduction of GHG emissions of almost 60%. Nevertheless there is not consensus in how to estimate the impacts of the indirect land use change.
- Policies concerning biofuels include: consumption, subsidies, mandated minimum levels of consumption, production subsidies (including feedstocks), import barriers and sustainability standards, which complement existing energy policies such as fuel taxes and cap and trade. Additionally there are farm subsidy programs.
- The cost of tax credits of 52 ¢/gal for corn ethanol, $1 gal for biodiesel and $1.01 gal for cellulosic ethanol were in 2008 over $6.5 billions, but they will increase to $21 billion by 2022. In total between 2008 and 2022 tax payers could pay out over $200 billion.

Global ethanol medium-term supply/demand outlook

billion liters	2009		2010		2015	
Country	Supply	Demand	Supply	Demand	Supply	Demand
World *	***83.4 (40.9)***	***82.2 (40.3)***	***101.4 (49.7)***	***99.4 (48.7)***	***168.6 (82.6)***	***147.3 (72.2)***
USA	42.4 (20.8)	42.4 (20.8)	49.2 (24.1)	49.2 (24.1)	61.7 (30.2)	60.5 (29.6)
Brazil	27.5 (13.5)	22.0 (10.8)	29.7 (14.6)	25.9 (12.7)	54.0 (26.5)	47.2 (23.1)
EU	3.4 (1.7)	4.8 (2.4)	4.4 (2.2)	6.0 (2.9)	6.0 (2.9)	9.2 (4.5)
China	3.1 (1.5)	8.5 (4.2)	3.4 (1.7)	8.8 (4.3)	12.8 (6.3)	11.5 (5.6)
India	1.7 (0.8)	0.8 (0.4)	1.8 (0.9)	1.6 (0.8)	9.3 (4.6)	2.1 (1.0)
Indonesia	0.7 (0.3)	0.18 (0.1)	2.2 (1.1)	0.6 (0.3)	6.5 (3.2)	1.1 (0.5)
Malaysia	0	0	0	0	0	0

Source: Hart/GBC 2009.

Note: Units are billion litres, Mtoe (in brackets) was calculated.

*World was calculated as the sum of regional supply/demand data provided in the above source

**Petrobras has set a target of 0.8 billion litres (0.6 Mtoe) per year by 2011 (Biodiesel magazine, August 2006)

Global biodiesel medium-term supply/demand outlook

billion liters	2009		2010		2015	
Country	Supply	Demand	Supply	Demand	Supply	Demand
World*	***48.2 (37.7)***	***13.1 (10.3)***	***59.6 (46.7)***	***18.3 (14.3)***	***94.4 (73.9)***	***36.5 (28.6)***
USA	2.8 (2.2)	2.8 (2.2)	3.1 (2.4)	3.1 (2.4)	8.4 (6.6)	8.4 (6.6)
Brazil**	2.9 (2.3)	1.0 (0.8)	4.5 (3.5)	1.8 (1.4)	6.0 (4.7)	2.1 (1.6)
EU	18.6 (14.6)	9.6 (7.5)	21.5 (16.8)	12.8 (10.0)	28.1 (22.0)	16.1 (12.6)
China	5.3 (4.1)	0	6.3 (4.9)	0	11.5 (9.0)	3.5 (2.7)
India	1.8 (1.4)	0	2.0 (1.6)	0	4.2 (3.3)	4.1 (3.2)
Indonesia	2.9 (2.3)	0.08 (0.1)	7.4 (5.8)	0.2 (0.2)	10.4 (8.1)	0.5 (0.4)
Malaysia	4.3 (3.4)	0.25 (0.2)	5.5 (4.3)	0.25 (0.2)	10.5 (8.2)	0.3 (0.2)

Source: Hart/GBC 2009.

Note: Units are billion litres, Mtoe (in brackets) was calculated.

*World was calculated as the sum of regional supply/demand data provided in the above source

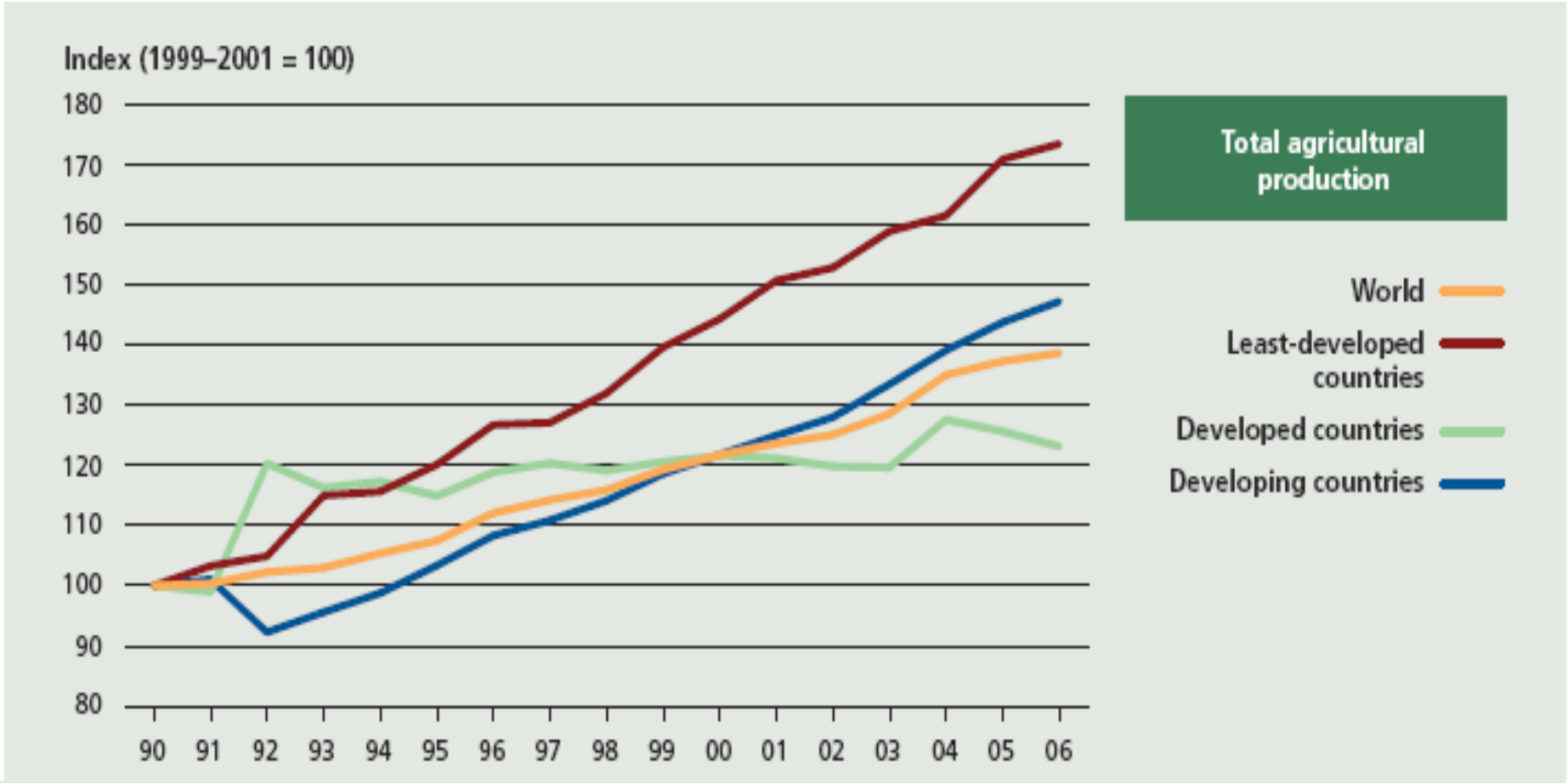
**Petrobras has set a target of 0.8 billion litres (0.6 Mtoe) per year by 2011 (Biodiesel magazine, August 2006)

Comparison of various biofuel long-term outlooks

Scenario		Base year		2020		2030	
				Demand	Share of total transport demand	Demand	Share of total transport demand
OFID/IIASA 2009 TAR (Consumption)	Mtoe	24.4	*2006*	189	7%	295	10%
OPEC WOO 2009 Ref (Supply)	mb/d (Mtoe)	1.3 (43.7)	*2008*	2.9 (97.5)	4.1%	4.7 (158)	6%
IEA WEO 2009 450 Scenario (Consumption)	Mtoe	34	*2007*	123	4.8%	278	9.3%
EIA Outlook 2009 (Consumption)	mb/d (Mtoe)	0.8 (27.0)	*2006*	3.9 (131.1)	5.0%	5.9 (198.3)	6.5%

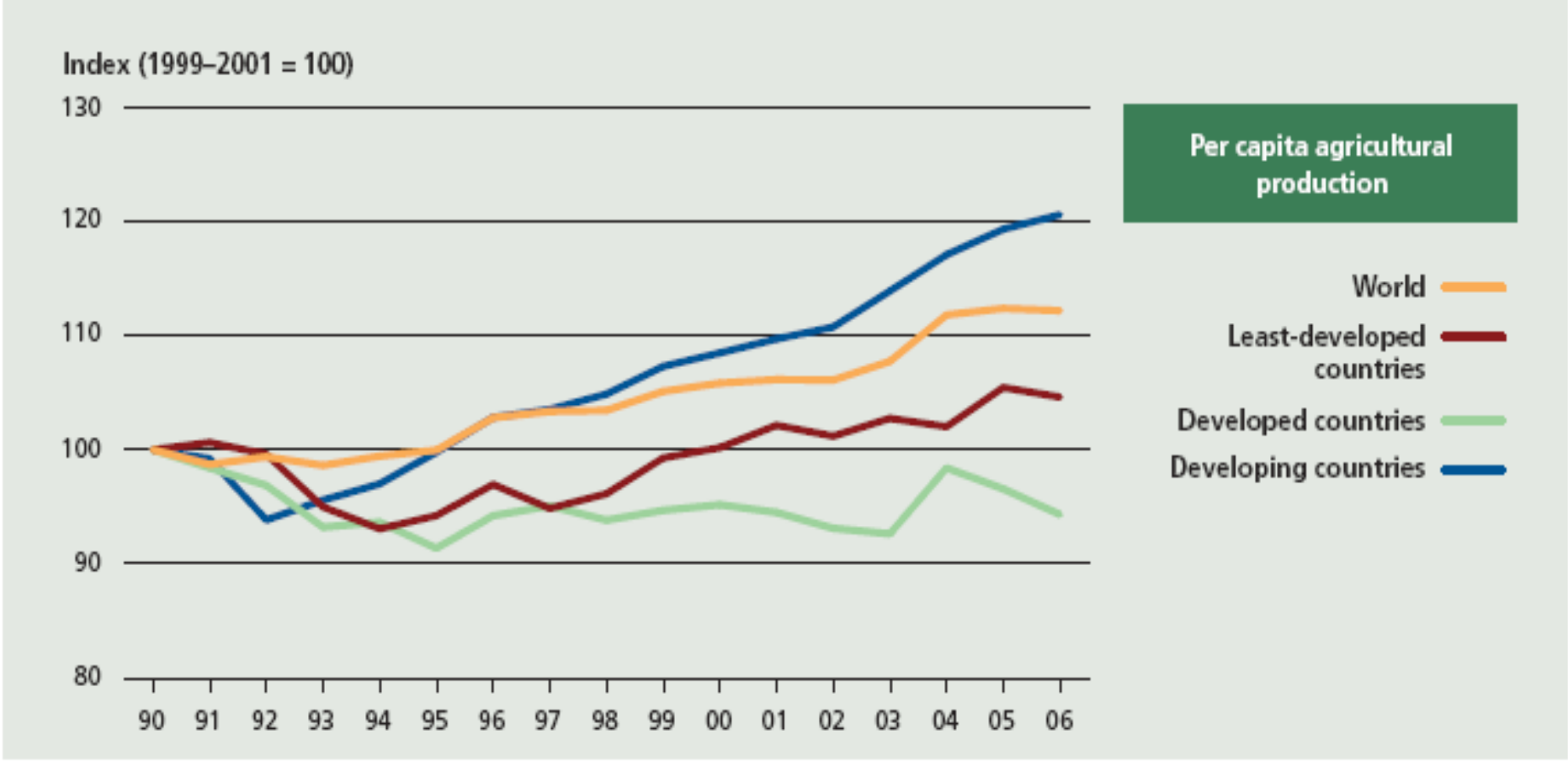
Source: OFID/IIASA 2009, OPEC WOO 2009, IEA 2009, EIA 2009. Notes: units are shown in the first column. Mtoe (in brackets) was calculated.

Agricultural production indices, total



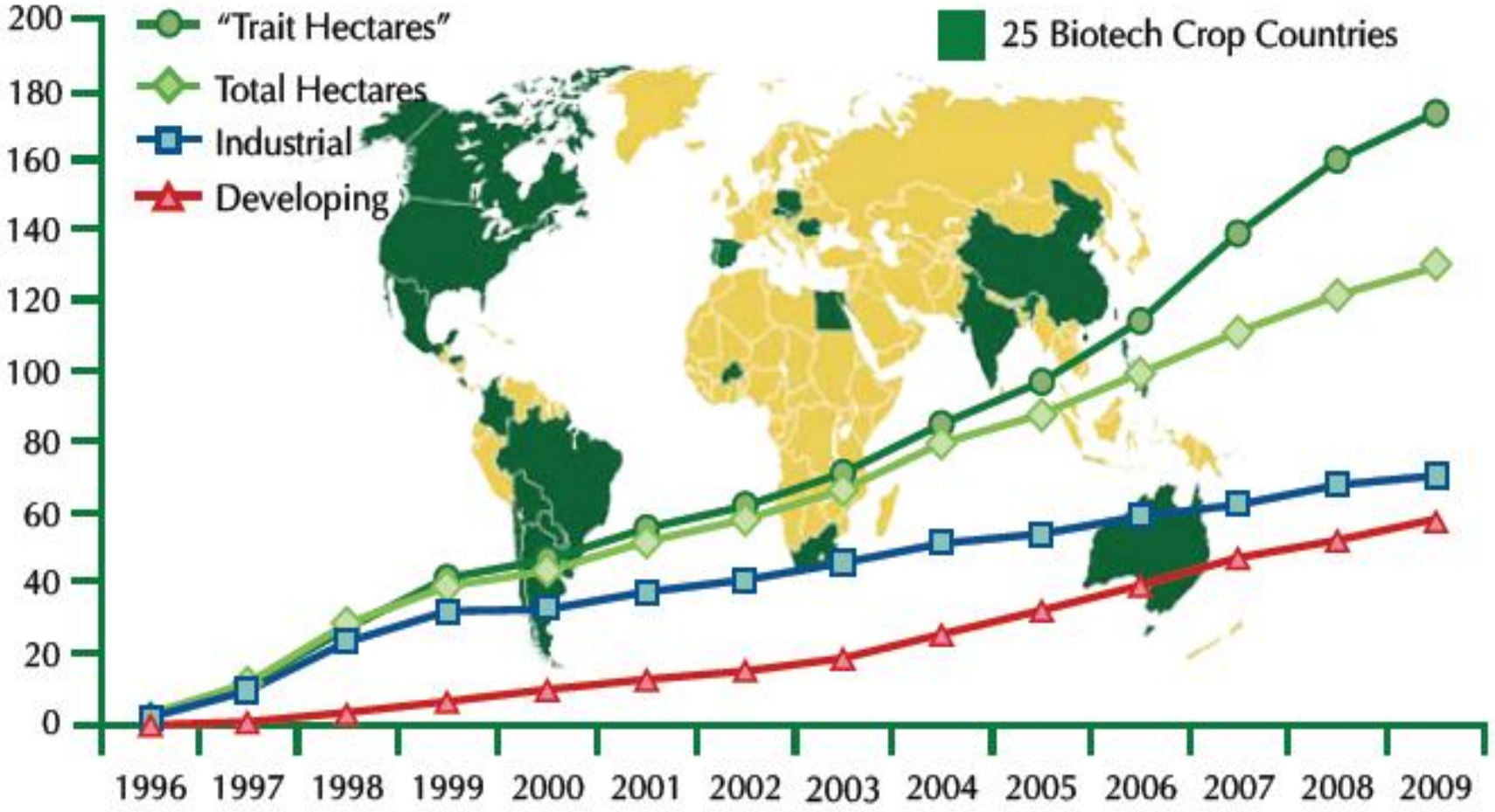
Source: FAO, 2008l.

Agricultural production indices, *per capita*



Source: FAO, 2008l.

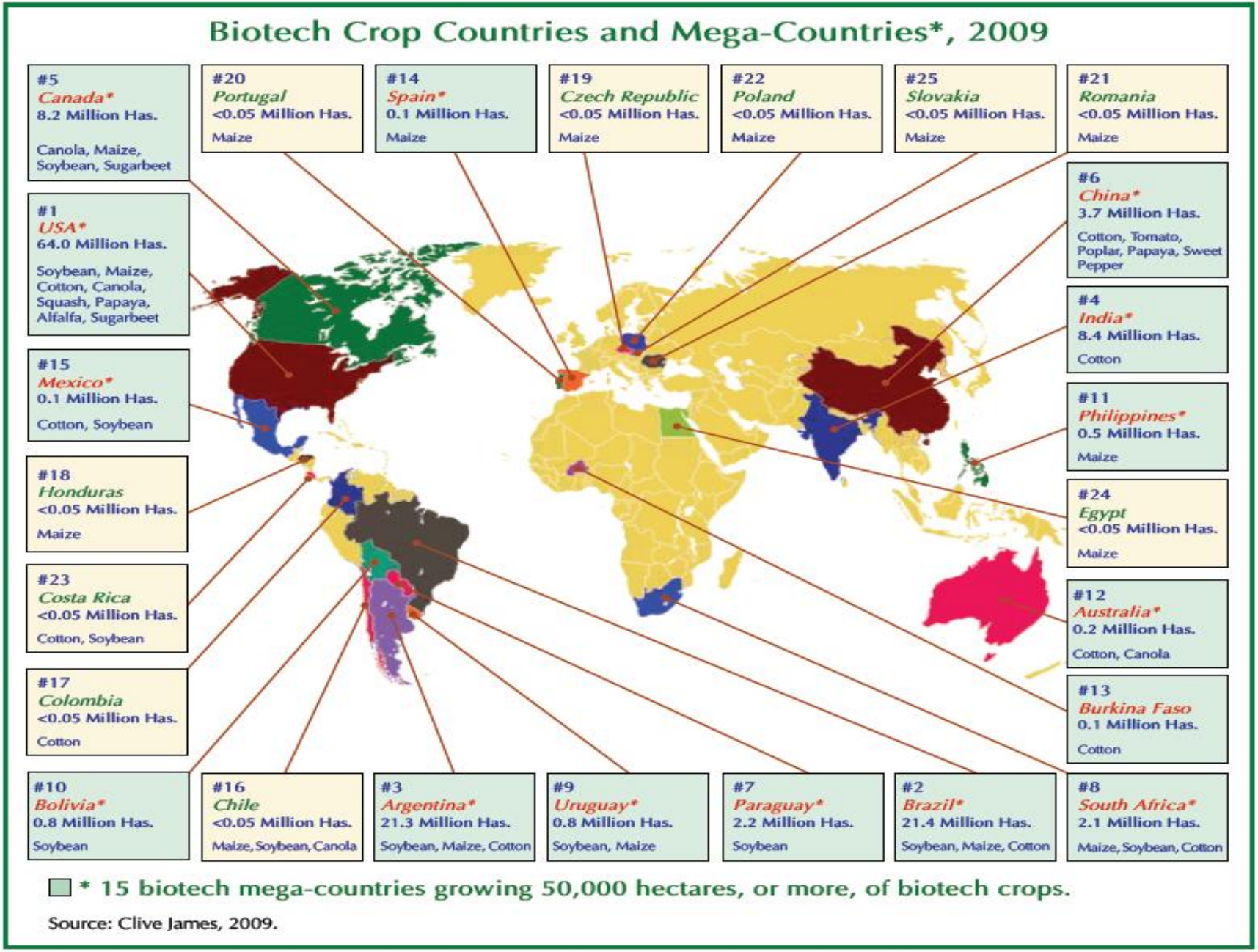
GLOBAL AREA OF BIOTECH CROPS
Million Hectares (1996-2009)



A record 14 million farmers, in 25 countries, planted 134 million hectares (330 million acres) in 2009, a significant increase of 7% or 9 million hectares (22 million acres) over 2008.

Source: Clive James, 2009.

Global map of biotech crop countries and mega-countries in 2009



Biofuel yields for different first generation feedstocks and countries

Crop	Global/national estimates	Biofuel	Crop yield (tonnes/ha)	Conversion efficiency (liters/tonne)	Biofuel yield (liters/ha)
Sugar beet	Global	Ethanol	46.0	110	5060
Sugar cane	Global	Ethanol	65.0	70	4550
Cassava	Global	Ethanol	12.0	180	2070
Maize	Global	Ethanol	4.9	400	1960
Rice	Global	Ethanol	4.2	430	1806
Wheat	Global	Ethanol	2.8	340	952
Sorghum	Global	Ethanol	1.3	380	494
Sugar cane	Brazil	Ethanol	73.5	74.5	5476
Sugar cane	India	Ethanol	60.7	74.5	4522
Oil palm	Malaysia	Biodiesel	20.6	230	4736
Oil palm	Indonesia	Biodiesel	17.8	230	4092
Maize	USA	Ethanol	9.4	399	3751
Maize	China	Ethanol	5.0	399	1995
Cassava	Brazil	Ethanol	13.6	137	1863
Cassava	Nigeria	Ethanol	10.8	137	1480
Soybean	USA	Biodiesel	2.7	205	552
Soybean	Brazil	Biodiesel	2.4	205	491

Source: FAO 2008

Typical yields of second generation feedstocks
(using IEA Bioenergy typical biofuel yields for forest residue)

Dry tons/ha	Current yield, Dry t/ha	GJ/ha	Litres/ha	Expected yield	GJ/ha	Litres/ha
Miscanthus	10	200	1250- 3000	20	400	2500-6000
Switchgrass	12	240	1500- 3600	16	320	2000-4800
Willow	10	200	1250- 3000	15	300	1875-4500
Poplar	9	180	1125- 2700	13	260	1625-3900

Source: Worldwatch Institute 2007: Biofuels for Transport: Global Potential and Implications for Sustainable Energy & Agriculture; IEA Bioenergy

Oil yields for algae and other biodiesel feedstocks

Feedstocks	Oil yield (barrels/ha/yr)
Soybean	2.5
Sunflower	5
Jatropha	12
Palm oil	36
Algae	360

Source: Global Biofuels Center 2008

Hypothetical potential for ethanol for principal cereal and sugar crops

CROP	GLOBAL AREA	GLOBAL PRODUCTION	BIOFUEL YIELD	MAXIMUM ETHANOL	PETROL EQUIVALENT	SUPPLY AS SHARE OF 2003 GLOBAL PETROL USE[1]
	(Million ha)	*(Million tonnes)*	*(Litres/ha)*	*(Billion litres)*	*(Billion litres)*	*(Percentage)*
Wheat	215	602	952	205	137	12
Rice	150	630	1 806	271	182	16
Maize	145	711	1 960	284	190	17
Sorghum	45	59	494	22	15	1
Sugar cane	20	1 300	4 550	91	61	6
Cassava	19	219	2 070	39	26	2
Sugar beet	5.4	248	5 060	27	18	2
Total	599	...	...	940	630	57

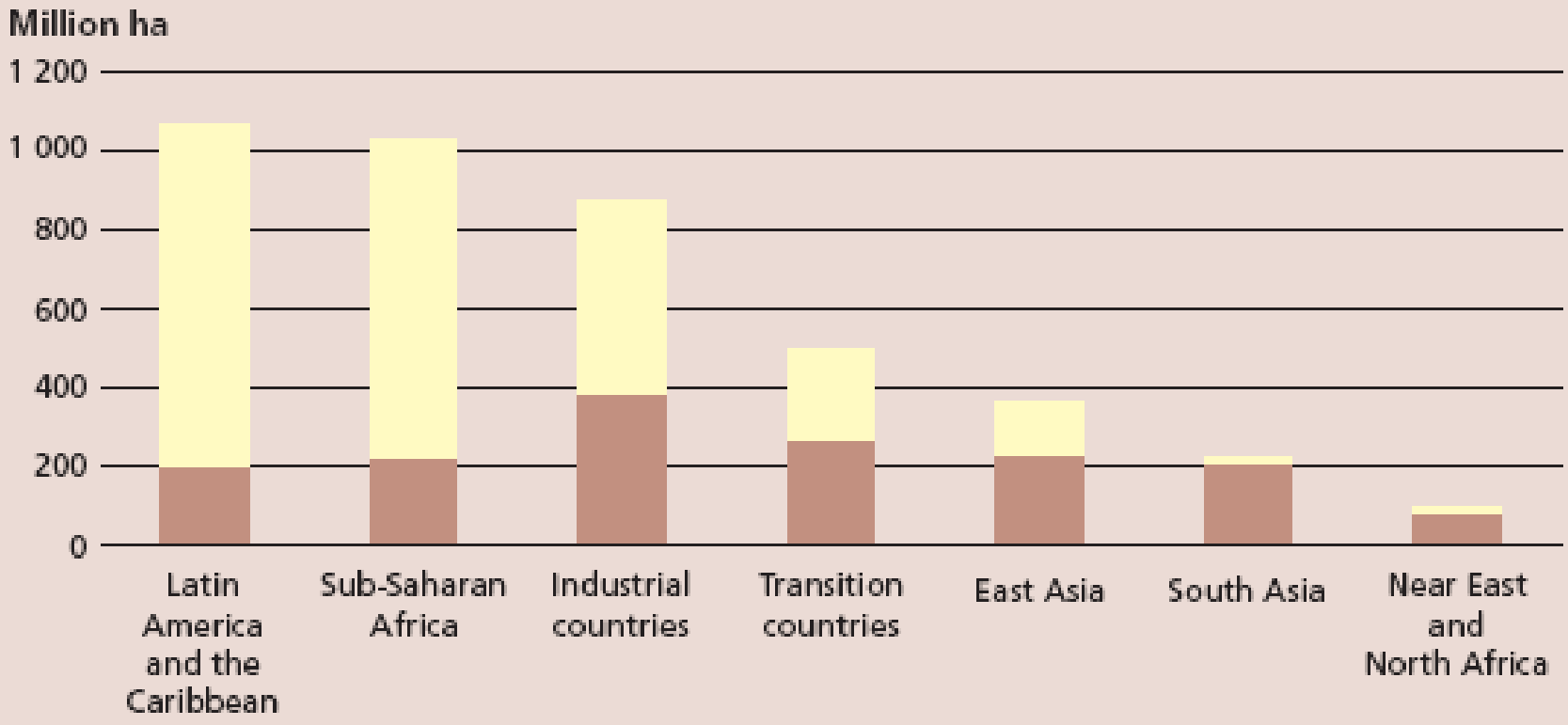
Note: ... = not applicable. Data presented are subject to rounding.
[1] Global petrol use in 2003 = 1 100 billion litres (Kim and Dale, 2004).
Source: Rajapogal *et al.*, 2007.

Land requirements for biofuel production

COUNTRY GROUPING	2004		2030					
			Reference scenario		Alternative policy scenario		Second-generation biofuels case	
	(Million ha)	*(Percentage of arable land)*	*(Million ha)*	*(Percentage of arable land)*	*(Million ha)*	*(Percentage of arable land)*	*(Million ha)*	*(Percentage of arable land)*
Africa and Near East	–	–	0.8	0.3	0.9	0.3	1.1	0.4
Developing Asia	–	–	5.0	1.2	10.2	2.5	11.8	2.8
European Union	2.6	1.2	12.6	11.6	15.7	14.5	17.1	15.7
Latin America	2.7	0.9	3.5	2.4	4.3	2.9	5.0	3.4
OECD Pacific	–	–	0.3	0.7	1.0	2.1	1.0	2.0
Transition economies	–	–	0.1	0.1	0.2	0.1	0.2	0.1
United States of America and Canada	8.4	1.9	12.0	5.4	20.4	9.2	22.6	10.2
World	**13.8**	**1.0**	**34.5**	**2.5**	**52.8**	**3.8**	**58.5**	**4.2**

Note: – = negligible.
Sources: FAO, 2008a; IEA, 2006.

Potential for cropland expansion



Source: FAO, 2003.

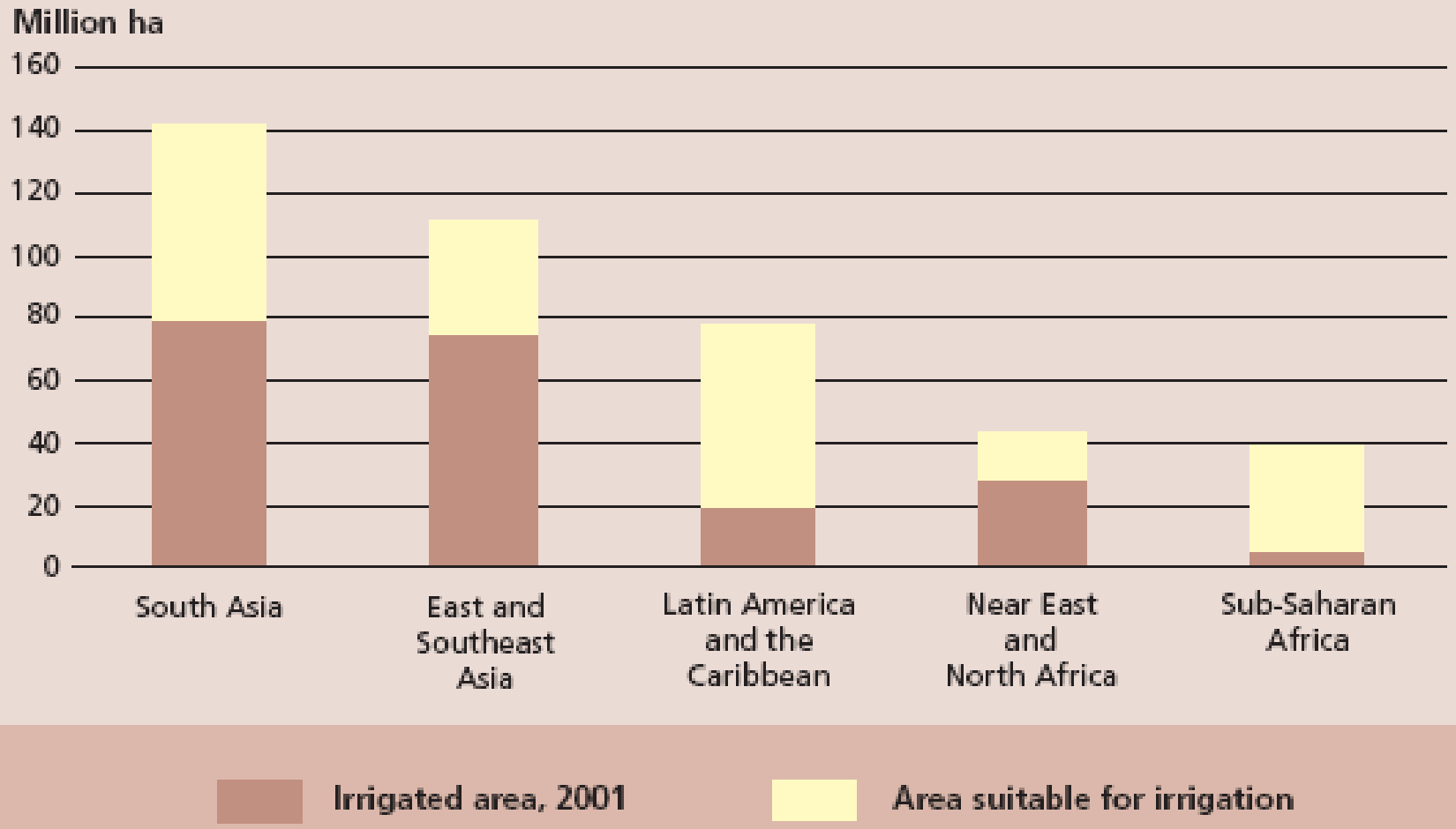
Water requirements for biofuel crops

CROP	Annual obtainable fuel yield	Energy yield	Evapotranspiration equivalent	Potential crop evapotranspiration	Rainfed crop evapotranspiration	Irrigated crop water requirement	
	(Litres/ha)	*(GJ/ha)*	*(Litres/litre fuel)*	*(mm/ha)*	*(mm/ha)*	*(mm/ha)*[1]	*(Litres/litre fuel)*
Sugar cane	6 000	120	2 000	1 400	1 000	800	1 333
Maize	3 500	70	1 357	550	400	300	857
Oil palm	5 500	193	2 364	1 500	1 300	0	0
Rapeseed	1 200	42	3 333	500	400	0	0

[1] On the assumption of 50 percent irrigation efficiency.

Source: FAO.

Potential for irrigated area expansion



Source: FAO.

Crucial questions

- What is the reality in terms of sustainability for a particular date in the future?
- How fast will crop productivity increase?:
  - Land demand estimation depends on it.
  - Price incentive and investment are needed to raise crop productivity.
- When will second generation biofuels come in place?:
  - Its impact on food prices will be low but as land is needed, there will be some impacts.
- How to assess indirect land use impacts? because they will occur. GHG balance calculations need to consider this issue and it must be recognized at international level.
- Will there be an international position to set up specific rules for taxes and regulations related to biofuels?

Conclusion

- There will be an impact on food prices but exact effect of biofuels can not be assessed presently. And price effects are needed for agricultural investments.