Global implications of biofuels and options for sustainable resource management

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Presentation
28 Aug 2009

IEA Bioenergy Conference
Vancouver

The presentation

- Recent reviews of biofuels
- Main findings

The International SCOPE biofuels project

- Rapid Assessment co-chaired by R.T. Howarth, Cornell University, and S. Bringezu, Wuppertal Institute
- involved 75 experts from 21 countries worldwide
- Download first scientific consensus report on biofuels: http://cip.cornell.edu/biofuels/

SCOPE
Scientific Committee on Problems of the Environment

Biofuels: Environmental Consequences and Interactions with Changing Land Use

edited by

R.T. Howarth & S. Bringezu

2009

Cornell University
College of Agriculture and Life Sciences

Wuppertal Institute for Climate, Environment and Energy

DFG Deutsche Forschungsgemeinschaft

International Panel for Sustainable Resource Management

- Peer reviewed (4/09) and approved for publication (6/09)
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Towards Sustainable Production and Use of Resources:

Assessing Biofuels

A report of the International Panel for Sustainable Resource Management

forthcoming (9/2009)

UNEP

International Panel for Sustainable Resource Management

International Panel for Sustainable Resource Management

The Resource Panel was established to :

- provide independent, coherent and authoritative scientific assessments of policy relevance on the sustainable use of natural resources and in particular their environmental impacts over the full life cycle
- contribute to a better understanding of how to decouple economic growth from environmental degradation.

It currently has four working groups:

- Decoupling
- Biofuels
- Prioritization of products and materials
- Global metal flows

Main findings

- Bioenergy use and trends in biofuels
- Global trends in yields, population and nutrition
- Environmental impacts of biofuels
- Land use change and implications
- Options for more efficient and sustainable resource use
- Conclusions and recommendations

Main findings

- **Bioenergy use and trends in biofuels**
- Global trends in yields, population and nutrition
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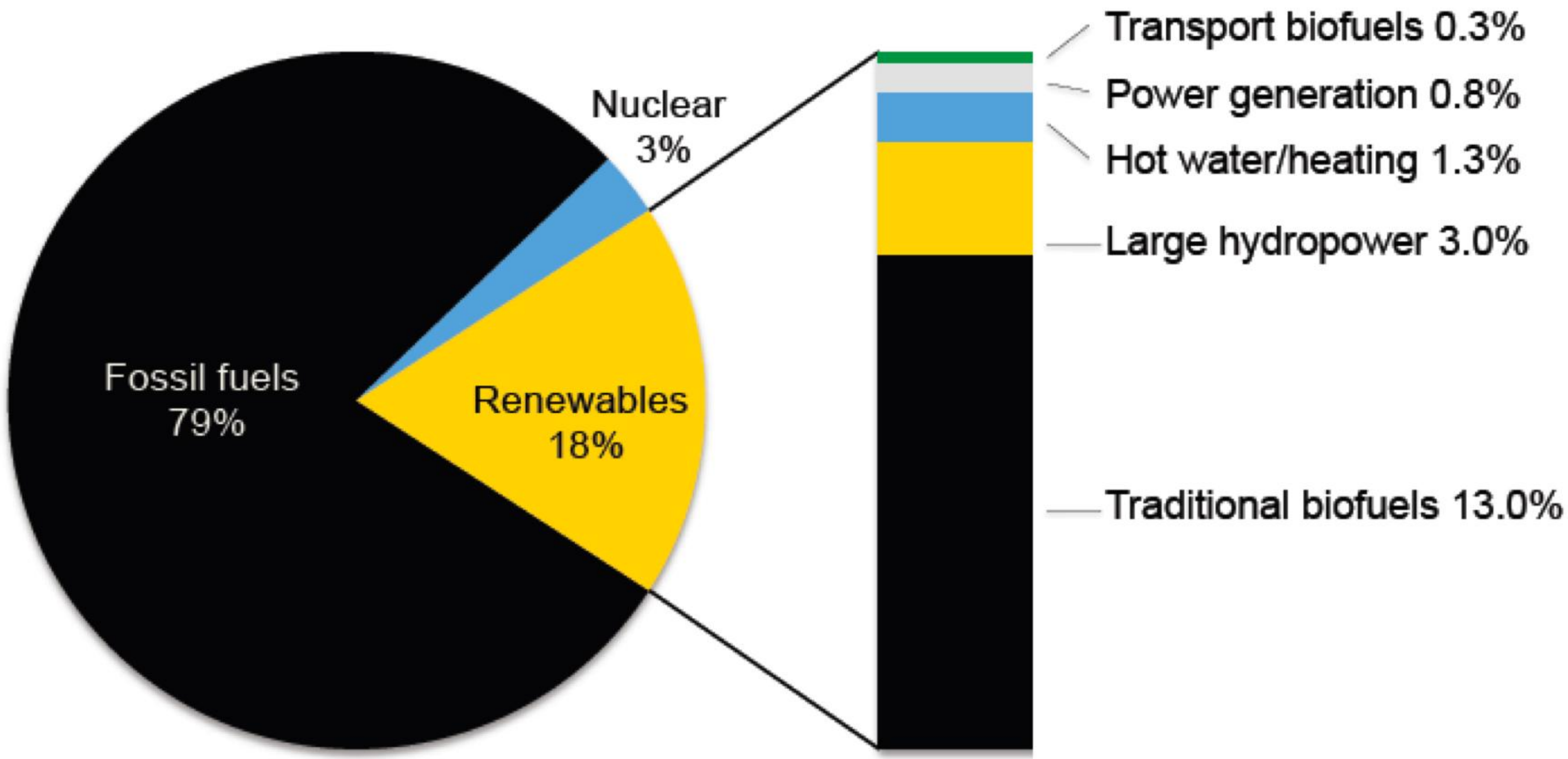
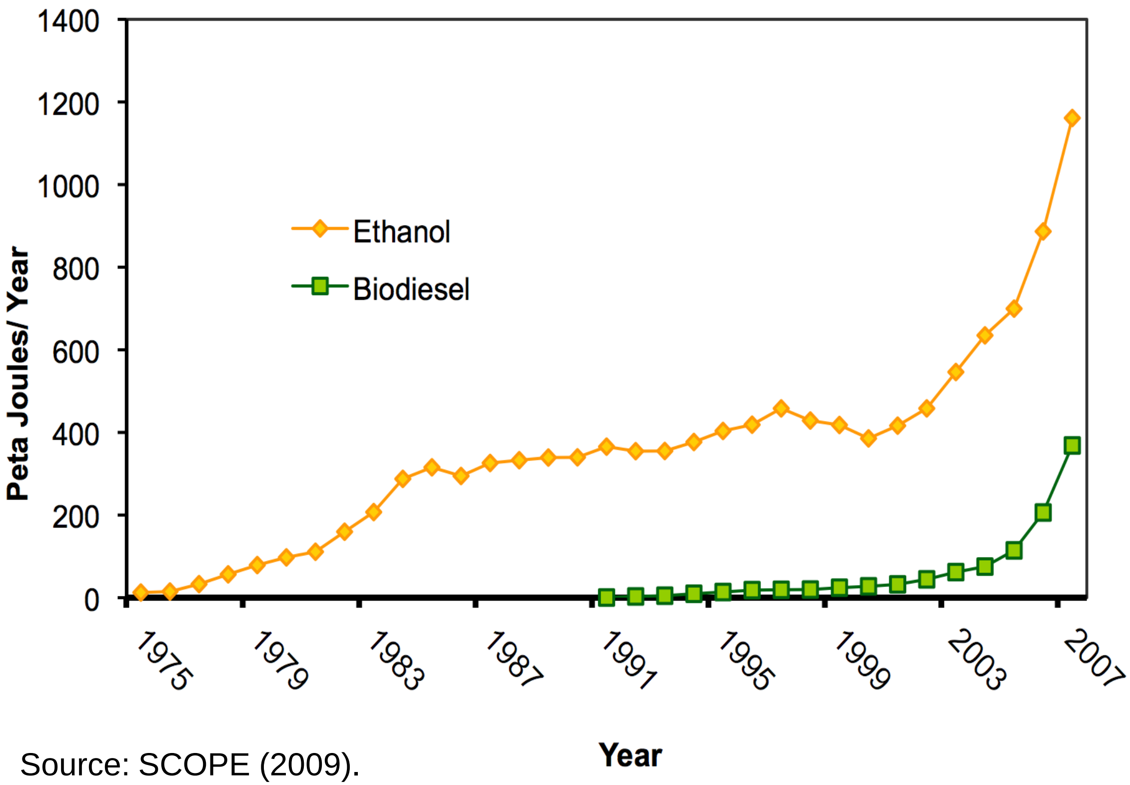
- Conclusions and recommendations

Traditional bioenergy use still dominating Global final energy consumption in 2006

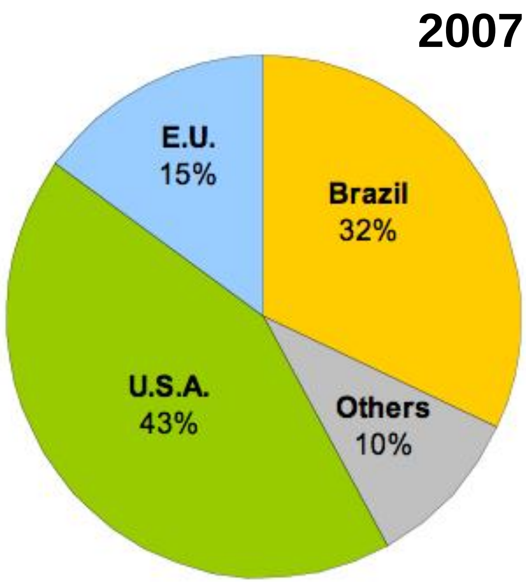


Source: REN21 (2007).

Global production of liquid biofuels



Source: SCOPE (2009).



Source: SCOPE 2009

2007: 1.8% of global fuel

2008: 3.4% (ethanol 5.46%, biodiesel 1.5%)

Source: OECD/FAO 2008.

- Bioenergy use and trends in biofuels
- **Global trends in yields, population and nutrition**
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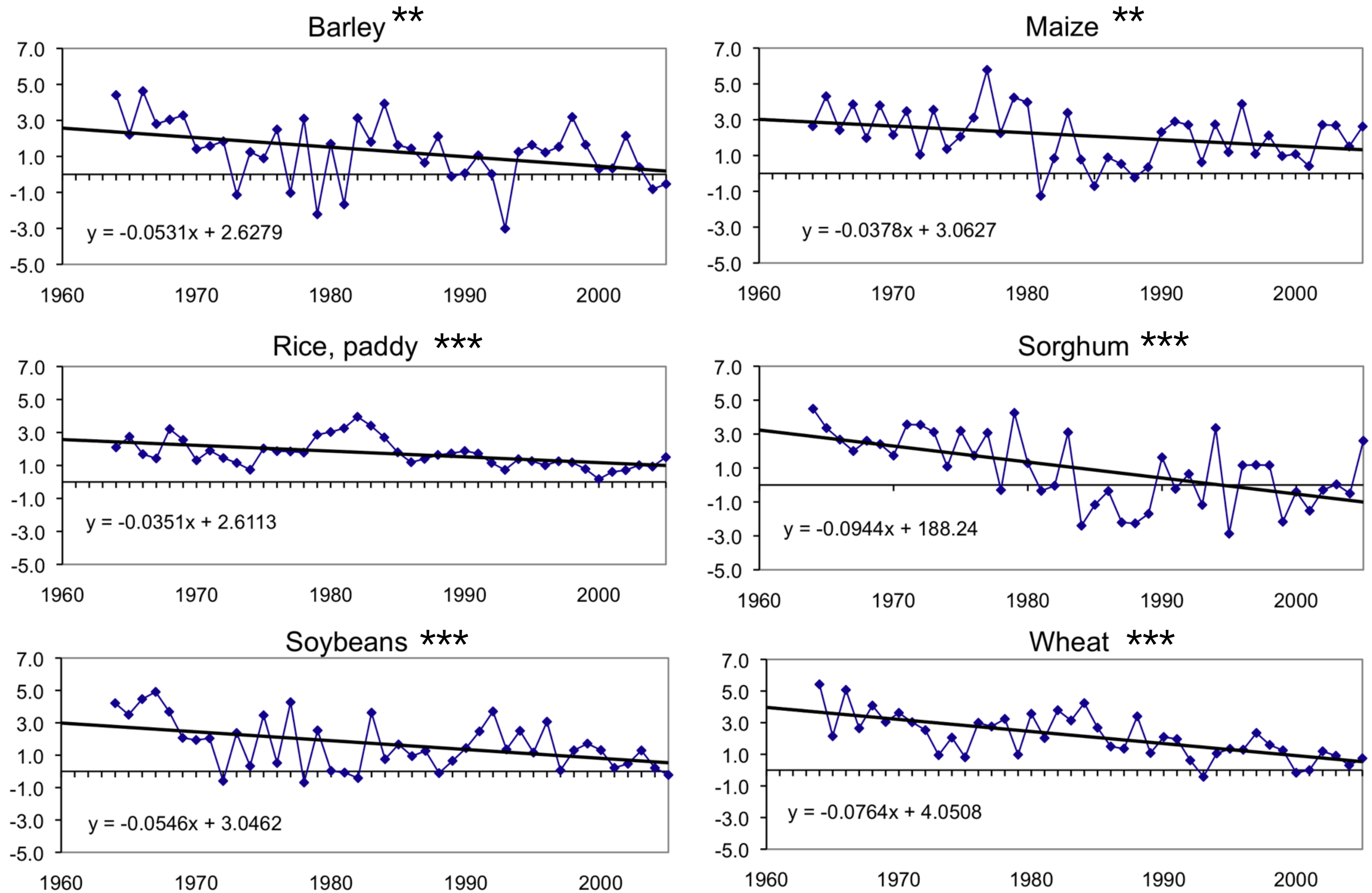
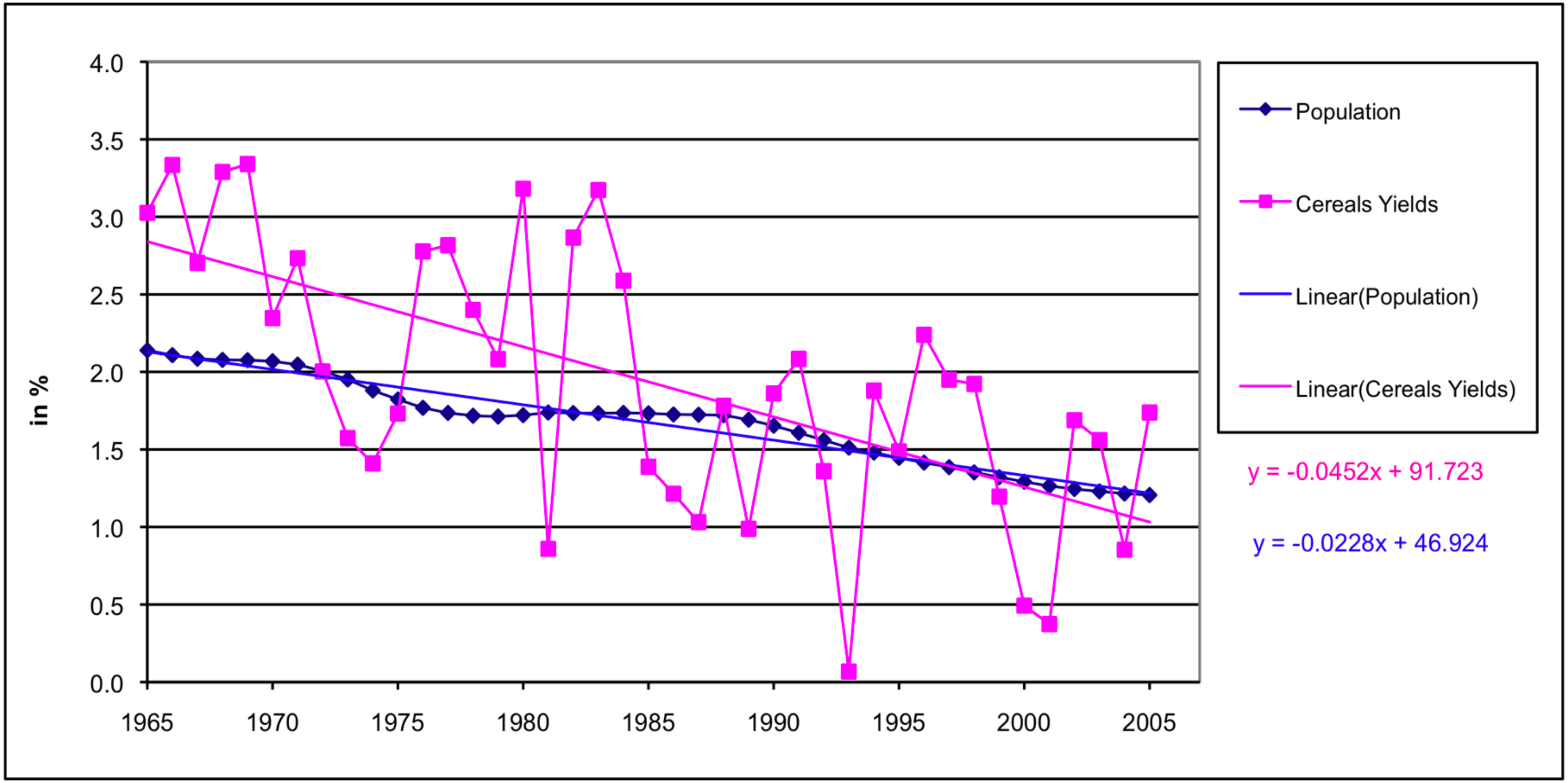
Global crop yields grow slower than in past
5years moving averages (%)



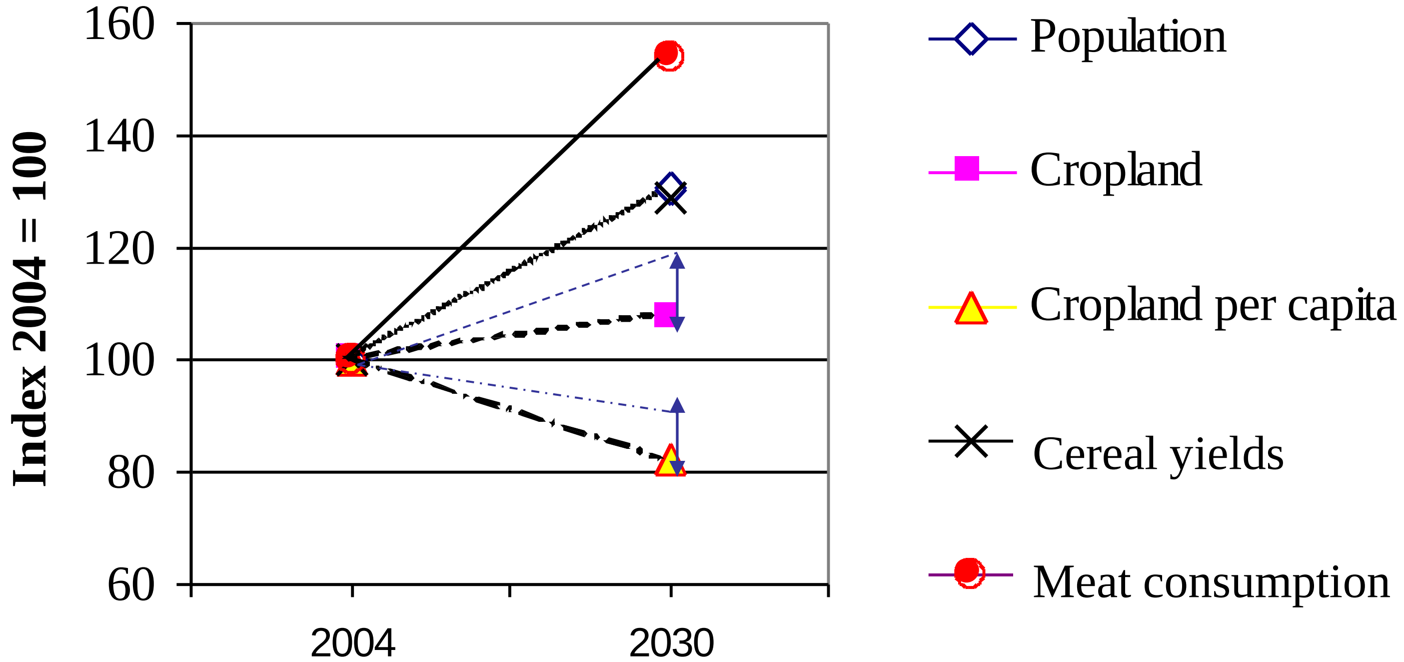
Signifance of t-statistics: ** $p<0.05$, *** $p<0.01$; Data source: based on FAOSTAT online data 2008

Cereal yield increase came down to meet growth rate of world population



5-years moving average; correlations significant with p<0.01; data source: UN population statistics online; FAOSTAT online.

Global trends of population, yields and diet: cropland will expand for feeding the world with protein rich meals



Source: UN population statistics ; FAO (2003, 2006); estimates based on Gallagher report 2008

Interim conclusion

➔ **Only to feed the world population will require the expansion of global cropland**

➔ **Any additional demand for non-food biomass will add on top of this**

- Bioenergy use and trends in biofuels
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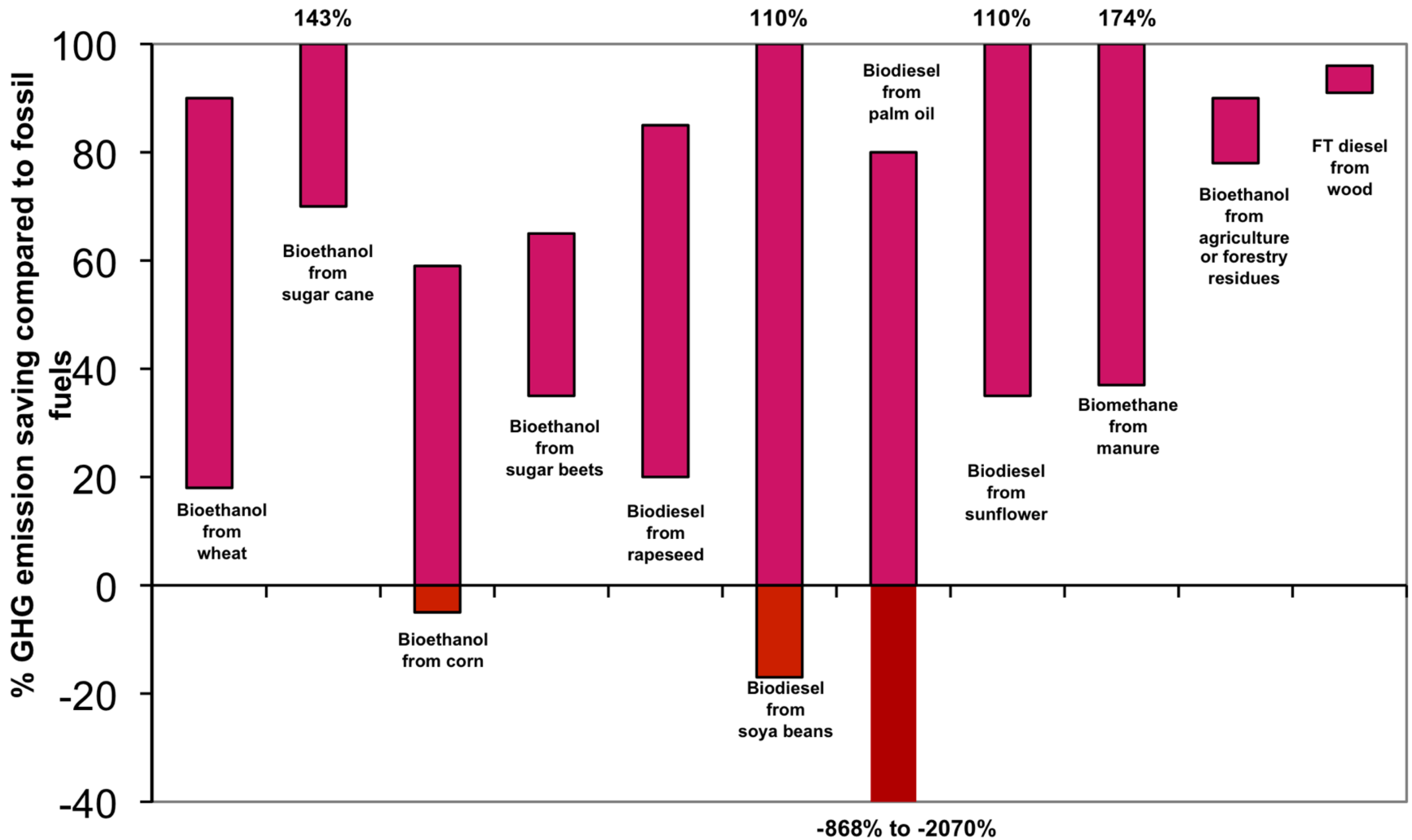
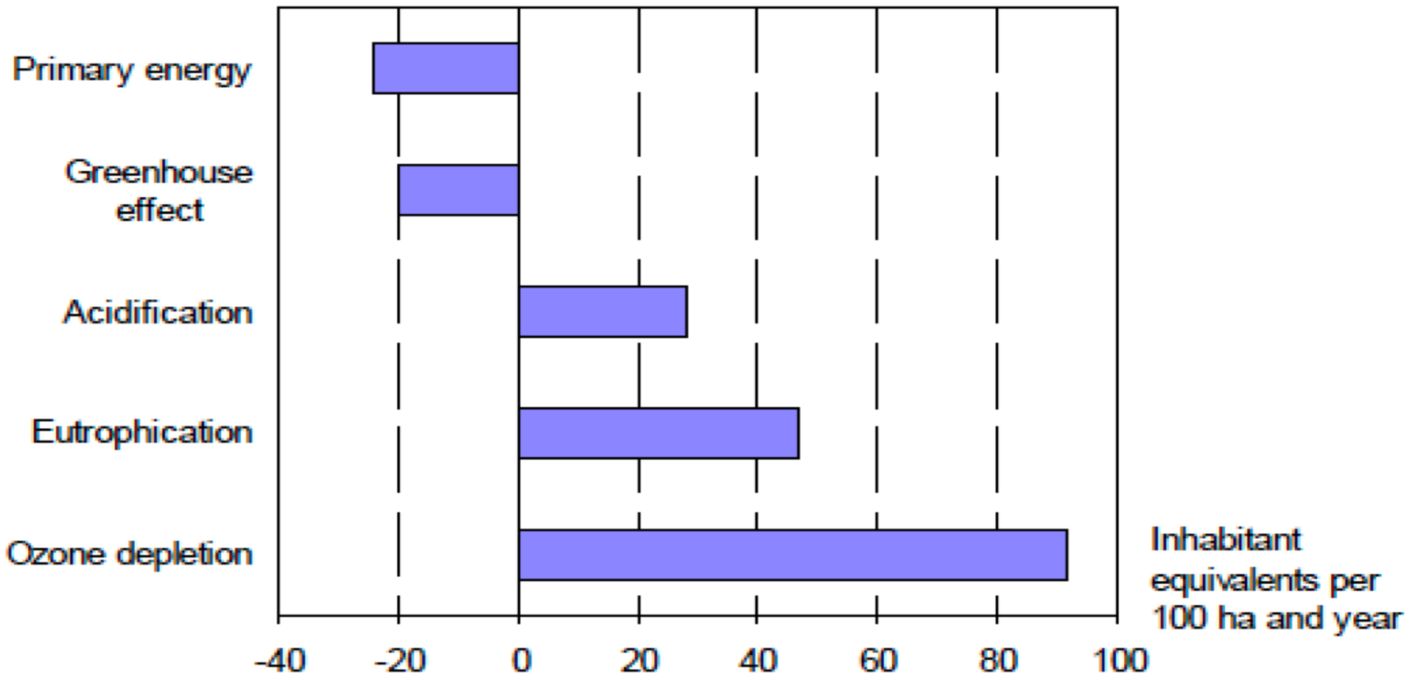
Greenhouse gas savings of biofuels compared to fossil fuels



Sources: own compilation based on data from Menichetti/Otto 2008 for bioethanol and biodiesel, IFEU (2007) for sugar cane ethanol, and Liska et al. (2009) for corn ethanol; RFA 2008 for biomethane, bioethanol from residues and FT diesel.

For some environmental impacts biofuels perform worse than fossil fuels: The example of rape seed biodiesel



Source: Reinhardt et a. 2008

Constraints and uncertainties of LCA on biofuels

- N_2O emissions: 1% derived from default values of IPCC (2006) vs. 3-5% (Crutzen et al. 2008)
- other GHG emissions: NOx, CH4
- Co-product allocation and allocation method
- Depreciation of shock impacts over longer periods

Main shortcoming:

➔ **product based approach cannot account for macro effects due to (indirect) land use changes**

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Land use for fuel crops

- 2007: 27 Mha; 2008: 36 Mha for liquid biofuels (2% gobal cropland)
- Trends for expansion particular in tropical countries (high yields)

- Brasil:
- Sugare cane 9 mill ha in 2008 (up 27% since 2007)
- Potential area for soybeans: 100 mill ha (23 Mha in 2005)
- expansion at the expense of grasslands, savannahs (Cerrado) and tropical forests
- Indonesia:
- oil palm plantations often on cleared forest land (2/3)
- applications for expansion: 6 mio ha -> 25 mio ha
- forest clearing 1/4 on peat soils

Estimates of future global biofuels use and crop land requirement - 1/2 -

Source	Target	Energy contribution	Cropland requirement
I. Projections			
IEA (2006) reference case	3% of transport energy in 2030	92 Mtoe (3.9 EJ)	34.5 Mha
OECD/FAO 2007	Projected increase until 2020	n.a. (default crop reference development)	35 Mha
Eickhout et al. 2008	Like OECD/FAO 2007 plus EU 10% and USA target for 2020	n.a.	60 Mha
Eickhout et al. modified by own calculation and after CEC (2006)	Like OECD/FAO 2007 plus EU 10% and USA target for 2020	n.a.	64 to 80 Mha *)
RFA (2008),	all major countries and regions were to attain their stated targets to 2020	n.a	56 to 166 Mha **)

Notes: *) lower value from linear interpolation of estimates for 7% biofuels to 14% biofuels (the latter as average of more domestic supply and more imports), upper value for 14% and more domestic supply.
**) The lower figure takes into account the avoided land use benefits of co-products, 2nd generation technologies from wastes and residues and assumes significant improvements in yield. The higher estimate is a gross figure, for the low yield scenario, not taking into account the anticipated benefits of co-products and without a positive contribution from 2nd generation technologies.

Estimates of future global biofuels use and crop land requirement - 2/2 -

II. Potentials			
Source	Target	Energy contribution	Cropland requirement
IEA (2006), alternative scenarios	alternative policy scenario: 5% of transport energy in 2030	147 Mtoe (6.2 EJ)	52.8 Mha
	second generation biofuels case: 10% of transport energy in 2030	294 Mtoe (12.3 EJ)	58.5 Mha
Dornburg et al. (2008)	bionergy potentials from agricultural and pasture lands in total in 2050	ca. 2860 Mtoe (120 EJ)	180 Mha of abandoned agricultural land, and a further 300 Mha of extensively used grasslands
Gurgel et al. (2007): a) reference scenario; b) policy scenario	bionergy potentials in total 2010 to 2100; data here for 2050	a) 836 to 931 Mtoe ***) (35 to 39 EJ)	a) 419 to 476 Mha ***)
		b) 2914 to 3201 Mtoe ***) (122 to 134 EJ)	b) 1461 to 1668 Mha ***)
Ravindranath et al. (2009)	10% by energy of gasoline and diesel demand in 2030	339 Mtoe (14.2 EJ)	118 to 508 Mha ****)
IEA (2008) BLUE Map scenario	26% by energy of total transport fuel demand in 2050	611 Mtoe (25.6 EJ)	160 Mha

Source: Bringezu et al. 2009.

Notes: ***) The lower figures refer to the OLSR version, higher figures for the PCCR version of the EPPA model (MIT Emissions Predictions and Policy Analysis Model). OLSR stands for Observed Land Supply Response and considers the response in land conversion in recent years representative of the long-term response. PCCR means Pure Conversion Cost Response and simulates unrestricted conversion of natural forest and grassland as long as costs are covered by returns. ****) The least amount of land is required when palm oil and sugarcane is considered (142 Mha), whereas soybean and maize crops at indicative yields require 600 Mha.

Implications of land use change

GHG emissions - mitigation by 1st generation biofuels questionable

GHG balance estimate*, in 2030

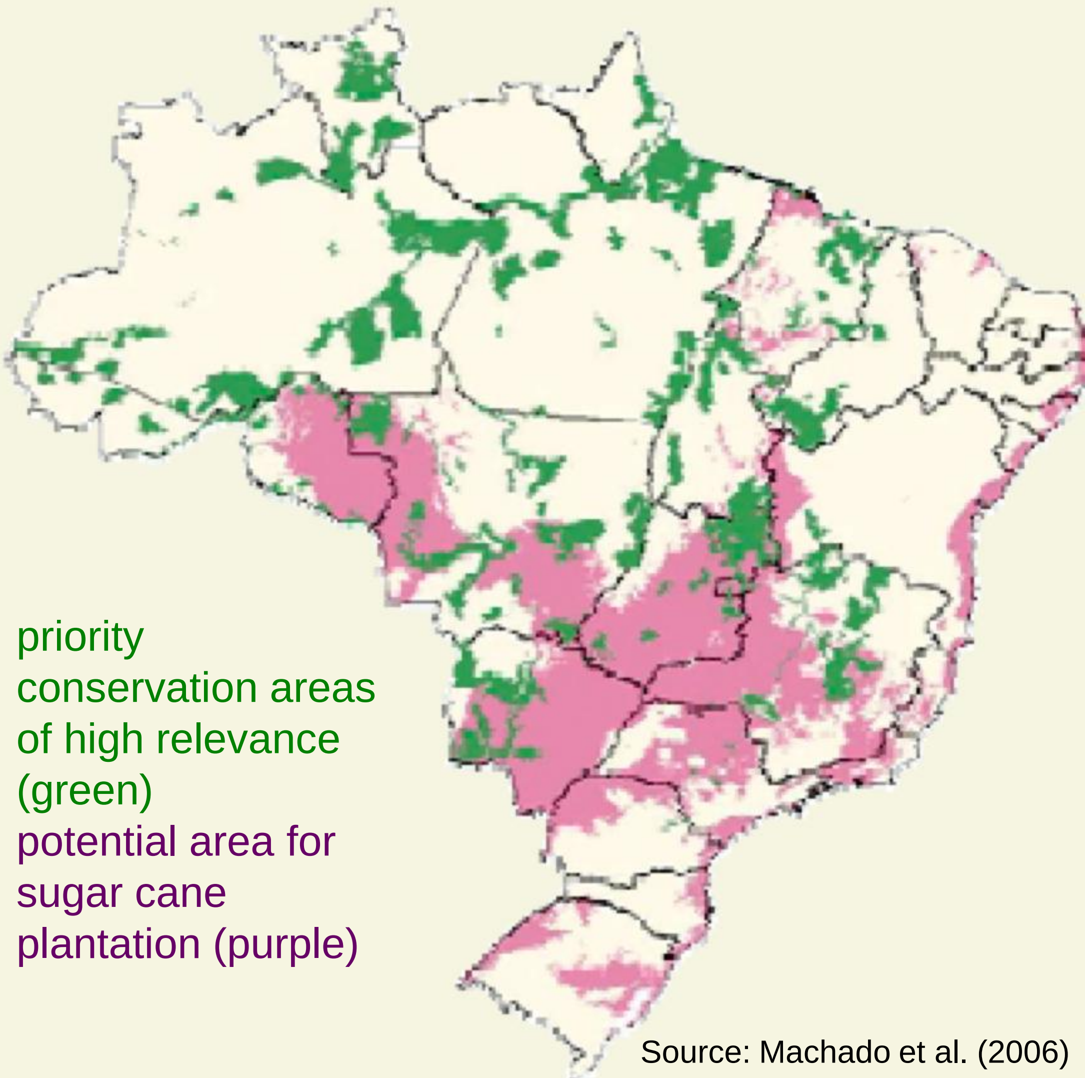
- 10% biofuels could substitute fossil fuels emitting 0.84 Gt CO_2
- substitution potential 20-90%: 0.17-0.76 Gt CO_2
- LUC induced additional emissions: 0.75 to 1.83 Gt CO_2

*Ravindranath, N.H. et al. (2009) *GHG Implications of Land Use and Land Conversion to Biofuel Crops.* In: R. W. Howarth and S. Bringezu (editors), *Biofuels: Environmental Consequences and Interactions with Changing Land Use.* Report of the Internatinal SCOPE Biofuels Project. (http://cip.cornell.edu/biofuels/)

Implications of land use change

Expansion of sugar cane at the expense of high biodiversity

- about 20% of Cerrado and Pantanal is rated as high priority for conservation
- expansion of sugar cane continues also in these (non-protected) areas
- despite of other land available already converted



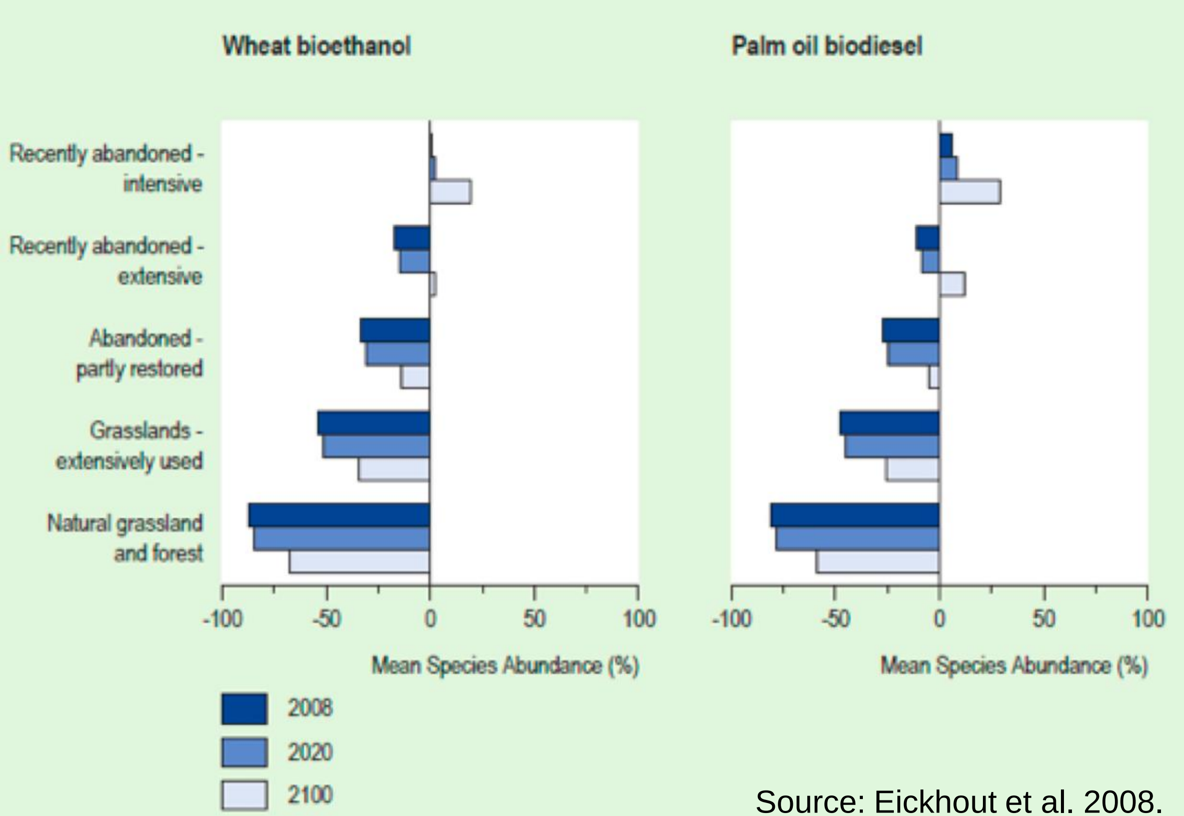
priority conservation areas of high relevance (green)
potential area for sugar cane plantation (purple)

Source: Machado et al. (2006)

Implications of land use change

Biodiversity loss due to biofuel feed-stock production

- losses due to habitat change, invasive species, pollution
- benefits from mitigated climate change can not compensate losses by habitat conversion for decades



Source: Eickhout et al. 2008.

Interim conclusion

➔ **Expansion of global cropland for fuel crops may lead to inreased net GHG emissions over the next 30 years as well as losses of biodiversity**

➔ **This cannot be avoided by production standards and product certification as long as the demand for biomass is growing globally (indirect land use changes)**

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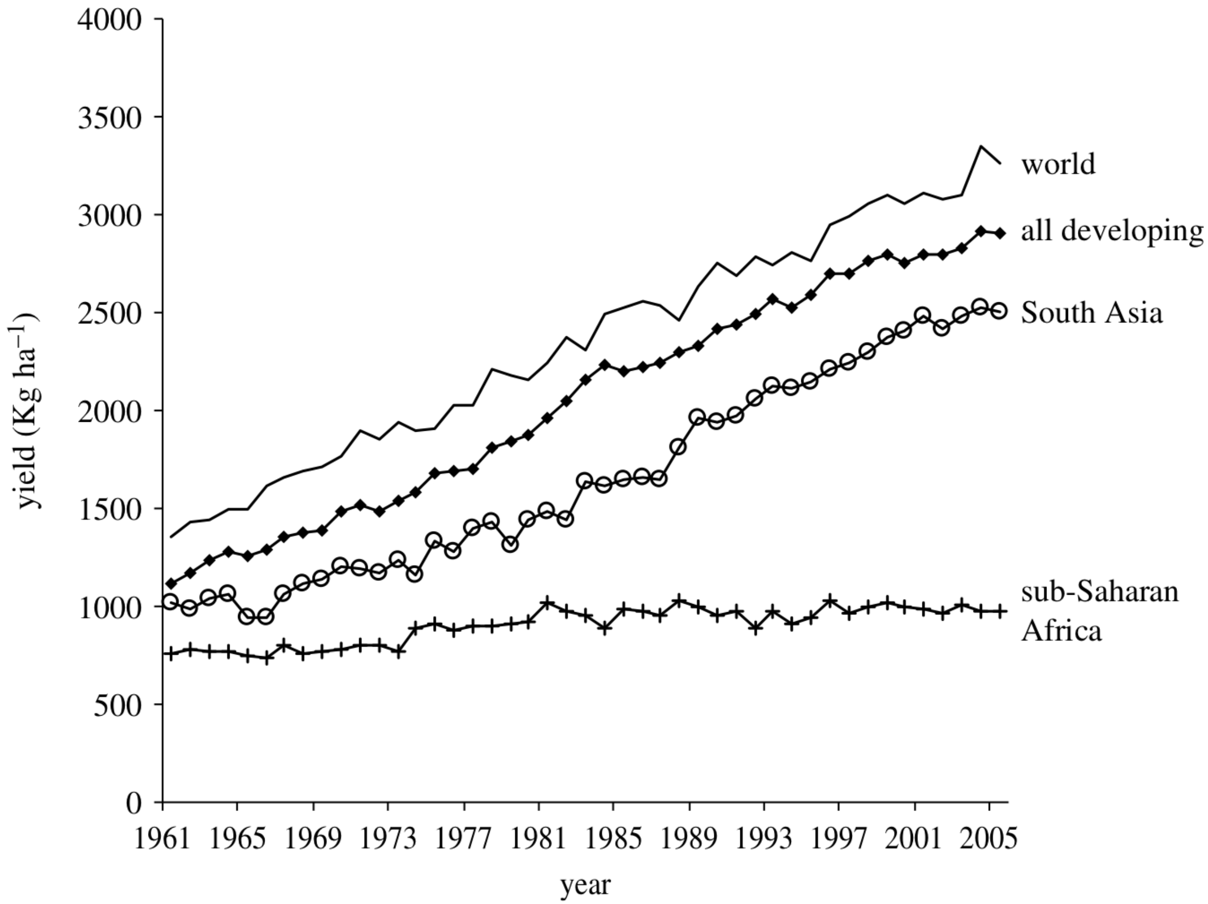
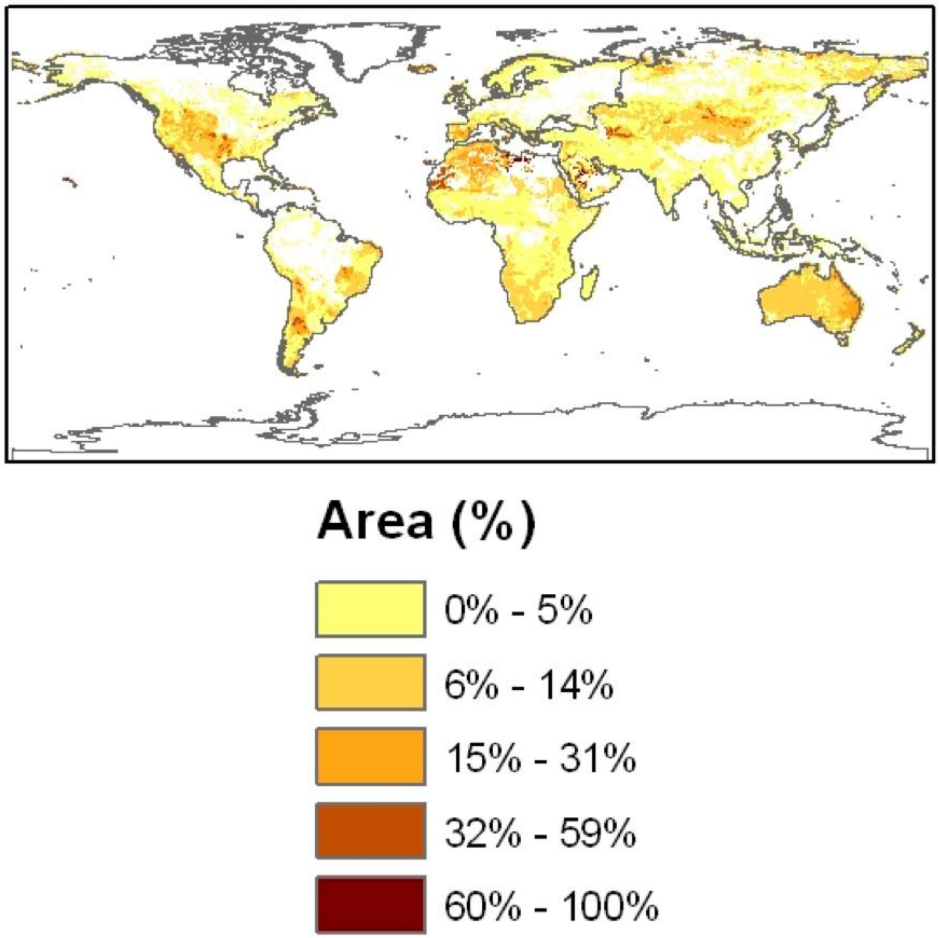
Global trends in cereal yields by region



Source: Hazel and Wood (2008)

Potential use of abandoned land



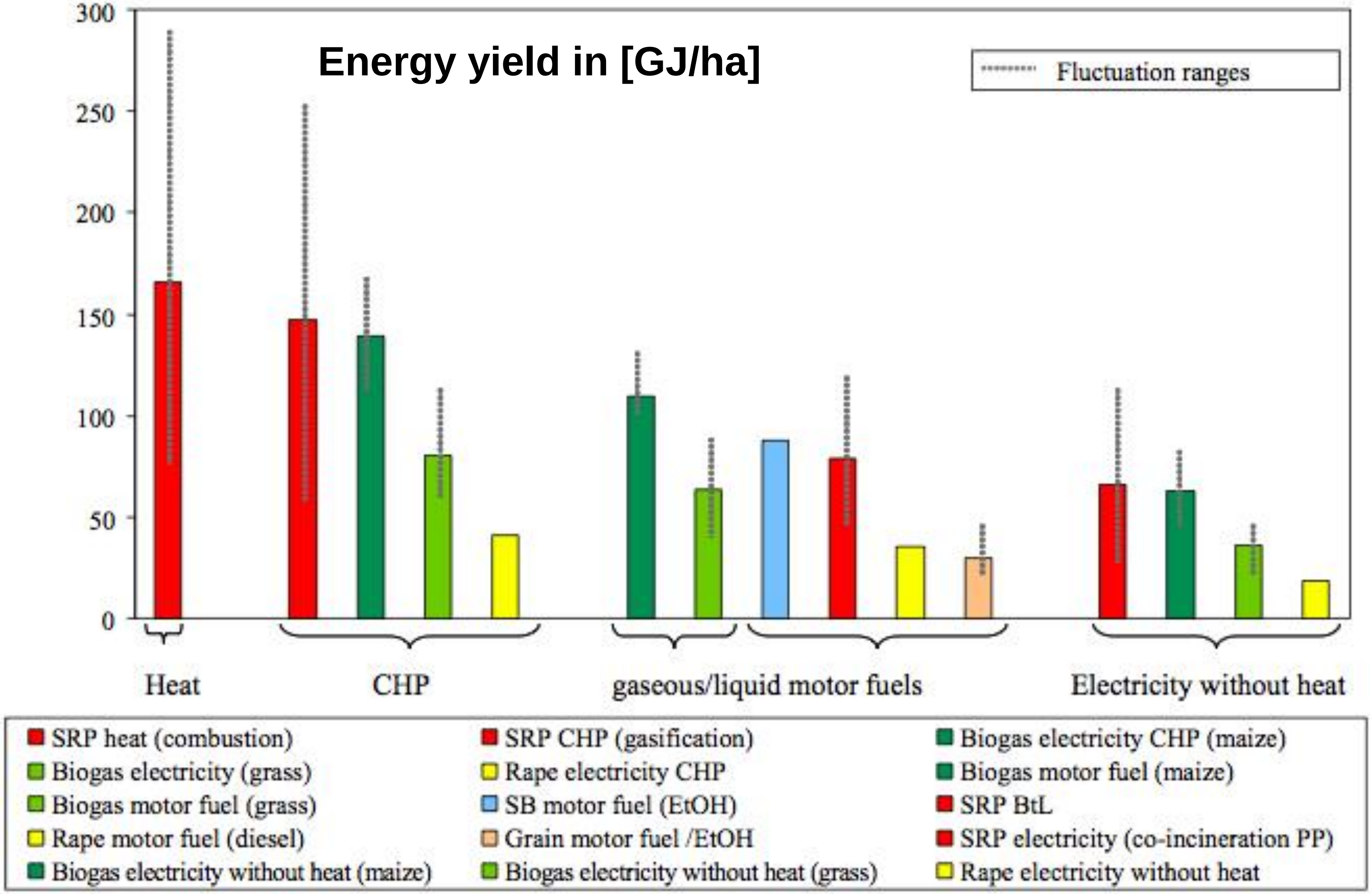
Source: Campbell et al. 2007

Campbell et al. estimate 385 - 472 Mha abandoned land which could produce 32 – 41 EJ/a

However, new cultivation

- **may competes with nature restoration**
- **requires higher inputs (if land is degraded)**
- **may save less GHG (if forests regrow on productive land)**

Energy yields for different use paths of biomass: Higher potential of stationary use



Source: SRU 2007 (adapted from LFU 2004: Arnold et al. 2006; DENA 2006; FNR 2005b: 2005a; 2006a; Keymer & Reinhold 2006; Schindler & Weindorf 2006)
Note: SRP = short-rotation plantation, BtL = biomass-to-liquid, PP = power plant, CHP = combined heat and power, EtOH = ethanol, SB = sugar beet

Stationary use of biofuels provides communities in DCs with high valued power supply

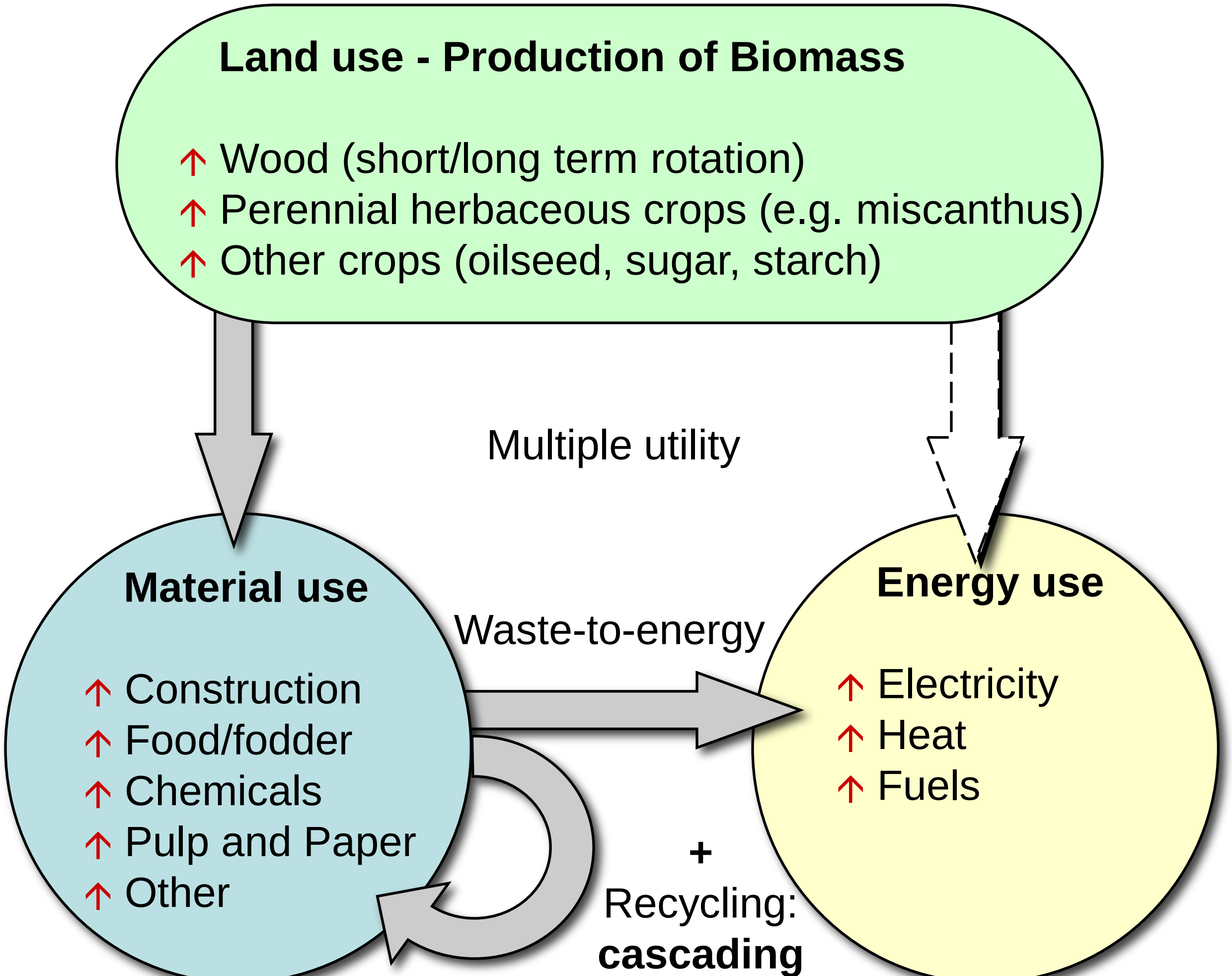
Source: http://www.sonne-ueber-mbinga.de/
Location: Mbinga/Tansania

Estimates of bioenergy potential: significant contribution of residues and waste

Biomass category	Main assumptions and remarks	Energy potential in biomass up to 2050
Residues from agriculture	Potential depends on yield/product ratios and the total agricultural land area as well as type of production system. Extensive production systems require re-use of residues for maintaining soil fertility. Intensive systems allow for higher utilisation rates of residues.	15 – 70 EJ
Forest residues	The sustainable energy potential of the world's forests is unclear – some natural forests are protected. Low value: includes limitations with respect to logistics and strict standards for removal of forest material. High value: technical potential. Figures include processing residues	30 - 150 EJ
Dung	Use of dried dung. Low estimate based on global current use. High estimate: technical potential. Utilisation (collection) in the longer term is uncertain	5 – 55 EJ
Organic wastes	Estimate on basis of literature values. Strongly dependent on economic development, consumption and the use of bio-materials. Figures include the organic fraction of MSW and waste wood. Higher values possible by more intensive use of bio-materials.	5 – 50 EJ

Source: IEA 2007b after Berndes et al., 2003; Smeets et al., 2007; Hoogwijk et al., 2005a.

Multifunctional Biomass Systems
Schematic Overview



Source: after Dornburg (2004).

Mineral based systems capture solar energy more efficiently than biomass in terms of land use

Biomass: captures 1-6% of solar radiation

Solar systems: 10-20% (currently, >40% reached, 60% under development)

Tanzania. Source: German Federal Ministry of Economics and Technology Kigali, Rwanda.

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Conclusions

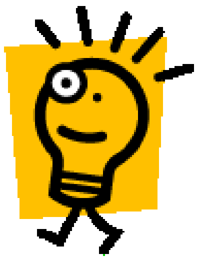
- Using biomass for capturing solar energy is rather inefficient
- Biomass is better used for material purposes
- Energy should then be recovered from waste and residues
- Cascading need to be further explored and developed
- Enhancing efficient u s e of biomass and minerals may be more rewarding than increasing the supply

Recommendations – 1/2

- increase agricultural production in low yield regions in env. & socially benign manner
- limit expansion of cropland and direct this to degraded land
- explore low input cultivation of perennials (limit eutrophication)
- use bioenergy in stationary appliances rather for transport fuels
- prefer energy from residues/waste rather than energy crops
- foster cascading use of biomass

Recommendations – 2/2

- develop production standards and product certification of biofuels to consider all relevant environmental and social impacts
- complement this with effective measures to limit overall biomass & energy demand (efficiency in fuel consumption etc.)
- reconsider current policy mandates, targets, quota (limit demand to levels which can sustainably be supplied)



- develop national and regional **resource management programmes**
  - incl. climate and biodiversity protection, food and energy security),
  - considering also global land use for domestic consumption (limit burden shifting)

Many thanks for your attention !

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