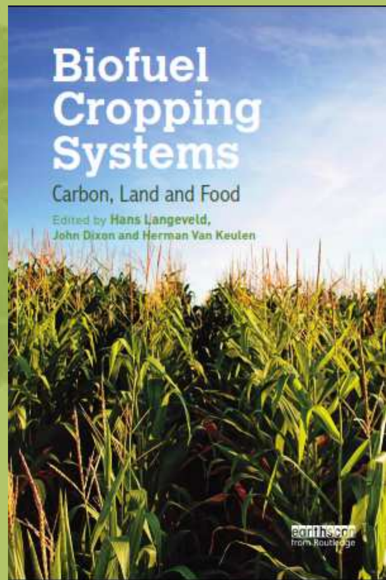
Biofuel cropping systems

biomass research

Quantifying indirect land use effects of biofuel production: defining a research agenda



ORNL
Oak Ridge, 6 January 2015

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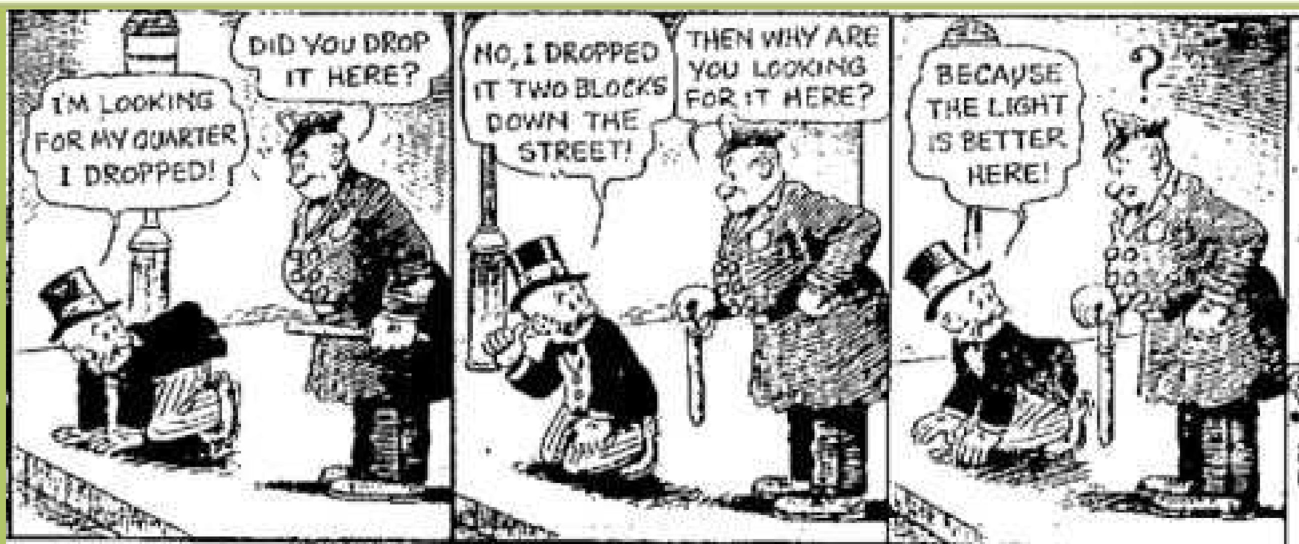
The team

- ¬ Hans Langeveld, Biomass Research
- ¬ Herman van Keulen (WUR): soil scientist
- ¬ John Dixon (ACIAR, ex-CIMMYT): economist
- ¬ Foluke Quist-Wessel, Agri-Quest
- ¬ Harry Croezen, CE Delft
- ¬ Maurits van den Berg, PBL, JRC
- ¬ Thea Hilhorst, Royal Tropical Institute/World Bank

Biofuel cropping systems



Streetlight effect

From Wikipedia, the free encyclopedia

The **streetlight effect** is a type of observational bias where people only look for whatever they are searching by looking where it is easiest.[1][2][3]

Biofuel impacts

biomass research

Biofuel policy impact asessment

¬ Ex-ante evaluation
- Modeling
- Commodity trade models
- Stakeholder inventories

¬ Limitations
- Conversion technology
- Coproducts (impacts of)
- Soil type, crop calendar
- Land use systems (rotations)

Biofuel impacts

biomass research

Alternative approach

¬ Bottom-up
- Local production conditions
- Soils, inputs, conversion
- National sources, technical literature

¬ Methodology
- Production statistics
- Infer land use, input use
- Land balances: complete
- Dynamic approach
- Local, historical perspective

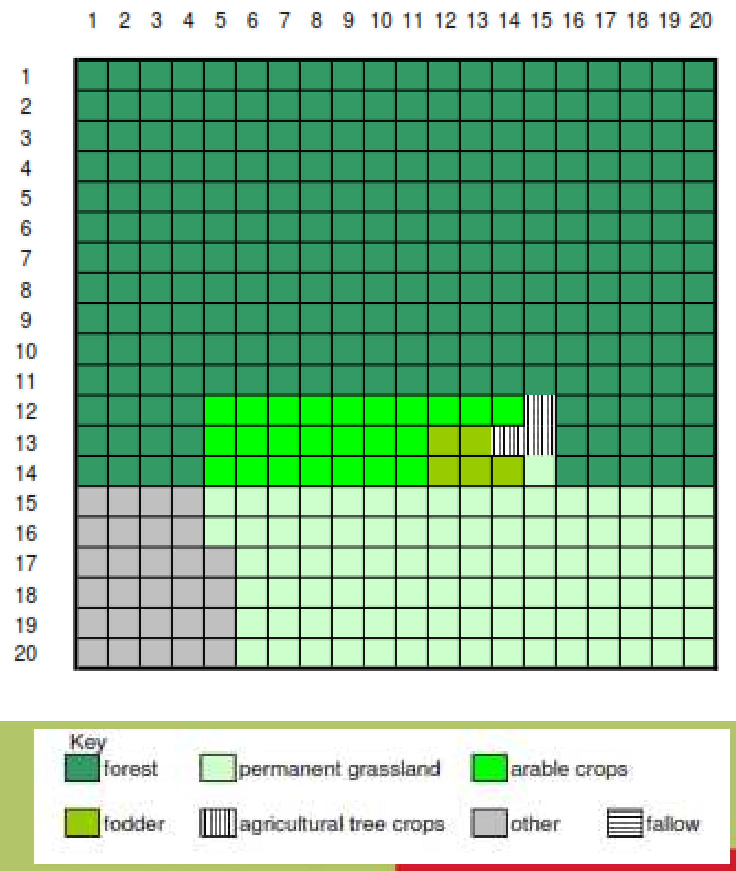
Biofuel impacts

Brazil

¬ Land area
- Forest
- Arable land, grassland
- Low other land

¬ Biofuel policies
- Ethanol
- Biodiesel

¬ Biofuel production
- Ethanol
- Biodiesel



Biofuel cropping systems

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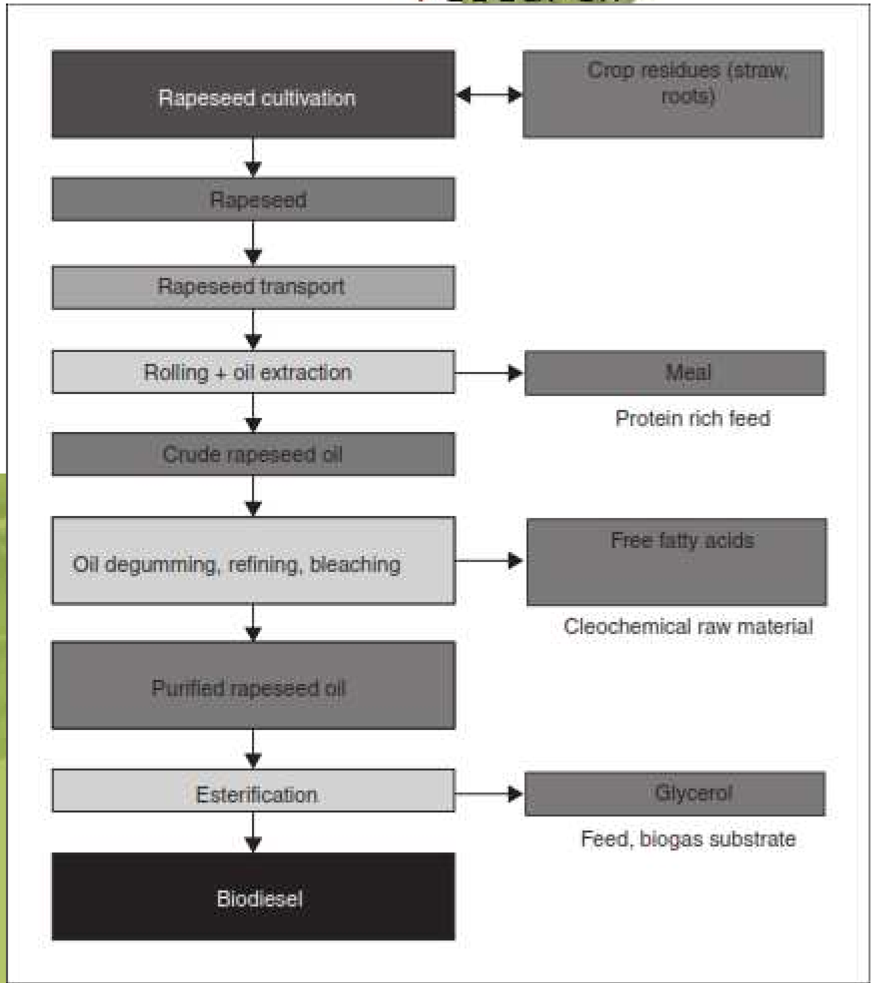
Table 8.6 Rapeseed production in the EU

	Unit	*1980*	*1990*	*2000*	*2010*
Harvested area	million ha	1.5	3.0	4.1	6.9
Production	million tonne	3.6	8.6	11.3	20.4
Yield (three-year average)	tonne/ha	2.4	2.9	2.8	3.1
Average annual increase	kg/ha/year	–	63	–11	31

Note: Figures for 1980–1990 are presented in the column for 1990, figures for 1990–2000 are presented in the column for 2000, and so on.
Source: Calculated from FAOSTAT (2010-2013); http://www.faostat.fao.org.



Source: Langeveld, Quist-Wessel, Croezen (2014) Chapter 8 *Biofuel production in the EU.*

Biofuel cropping systems

Table 8.7 Rapeseed use for biodiesel production in the EU

	Unit	*2000*	*2005*	*2010*	*2020*
Use in biofuels	million ton	6	7	20	25
Share of all rapeseed	%	55%	43%	100%	100%
Biofuel feedstock harvested area	million ha	2.1	2.1	6.9	7.1

Source: Calculated from OECD-FAO (2007); FAPRI-ISU (2011); FAOSTAT (2010-2013); http://www.faostat.fao.org.

Table 8.11 Efficiency of rapeseed-to-biodiesel conversion in the EU

	Unit	*BioGrace*	*Other Sources*	
			2010	*2020*
Conversion efficiency	litre/tonne	416	396–441	439
Conversion efficiency	GJ/GJ	0.58	0.55–0.61	
Biofuel yield	litre/ha	1,300	1,100–1,400	1,500
Biofuel yield	GJ/ha	49	36–46	50
Co-product yield	tonne/ha	1.7		

Source: Calculated from BioGrace (2012); Stephenson et al. (2008); Elsayed et al. (2003); Burrell (2010).

Source: Langeveld, Quist-Wessel, Croezen (2014) Chapter 8 *Biofuel production in the EU.*

Biofuel impacts

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Definitions

¬1 Land use = Forest + Agriculture + Other

¬2 Agricultural area = Arable + Grassland + Tree crops

¬3 Arable land = Arable crops + Fodder + Fallow

¬4 Multiple Cropping Index = Area harvested / Arable area

Biobased economy

biomass research

Biofuel production

¬ Quick response
- Corn ethanol (USA)
- Biodiesel (EU, USA)
- Other (ethanol in EU, China, Far East..)

¬ Policy targets are not met:
- Lignocellulosic ethanol USA
- Biodiesel (Brazil)
- China
- Indomalaysia

Biobased economy

biomass research

Table 15.1 Biofuel production in 2000 and 2010 (billion litres)

	Ethanol			*Biodiesel*		
	2000	*2010*	*Increase*	*2000*	*2010*	*Increase*
Brazil	9.7	27.6	17.9	Neg	2.1	2.1
USA	6.1	49.5	43.4	Neg	2.1	2.1
EU	1.5	6.4	4.9	0.8	10.3	9.5
Indonesia/Malaysia	NI	NI	NI	Neg	0.2	0.2
China	Neg	2.1	2.1	Neg	0.4	0.4
Mozambique	Neg	0.02	0.02	Neg	0.05	0.05
South Africa	Neg	0.02	0.02	Neg	0.05	0.05
All	17.3	85.6	68.3	0.8	15.1	14.3

Billion = thousand million; NI = not included; Neg = negligible.

China
- Indomalaysia

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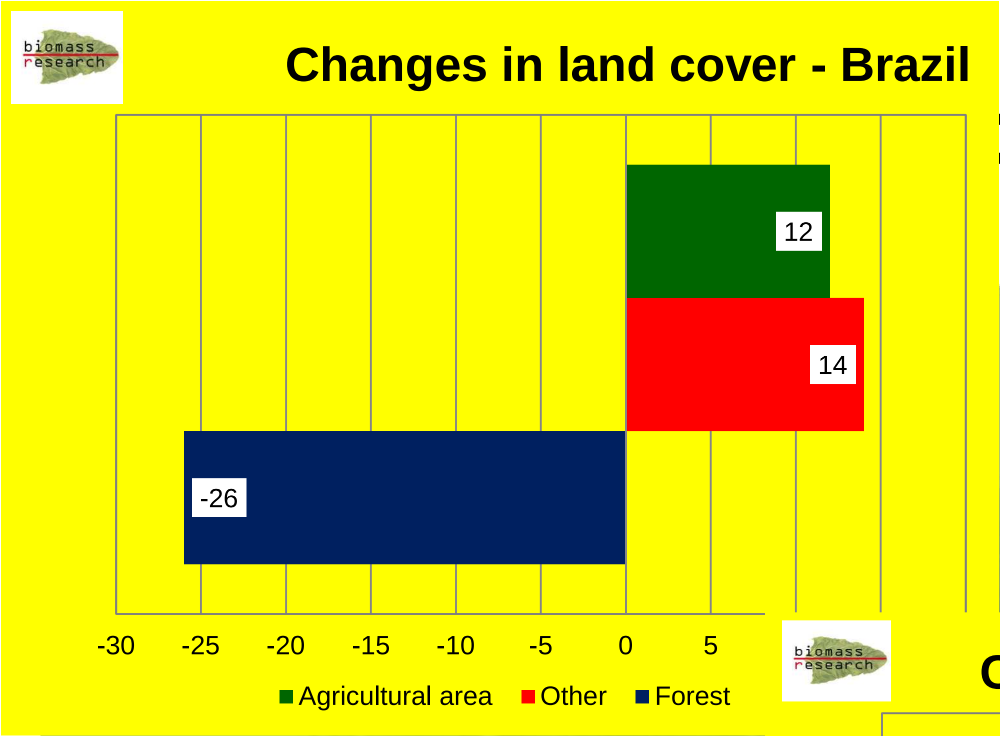
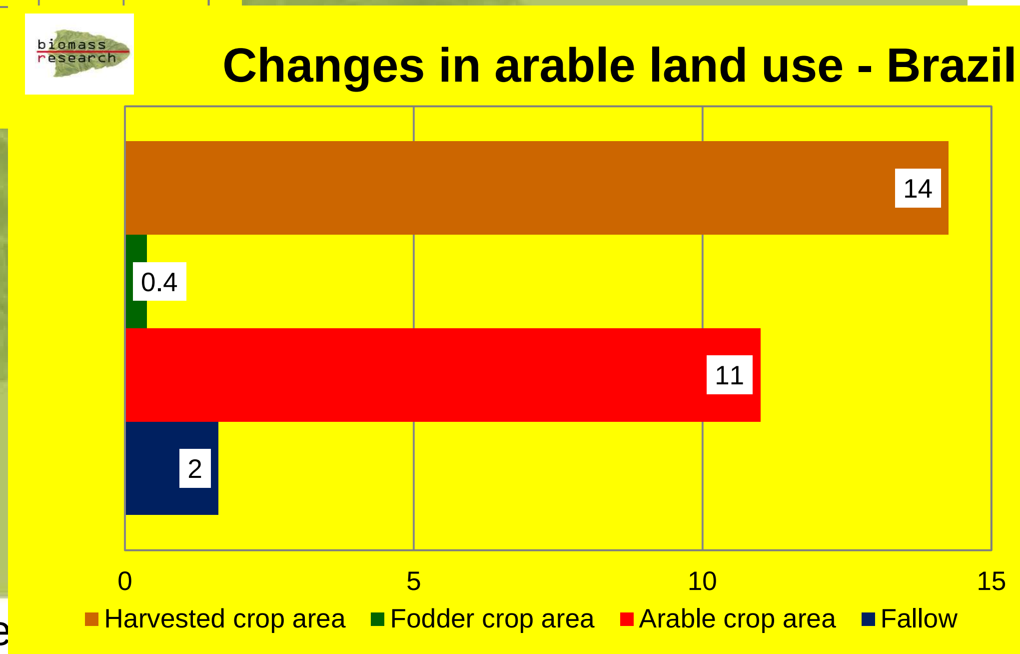
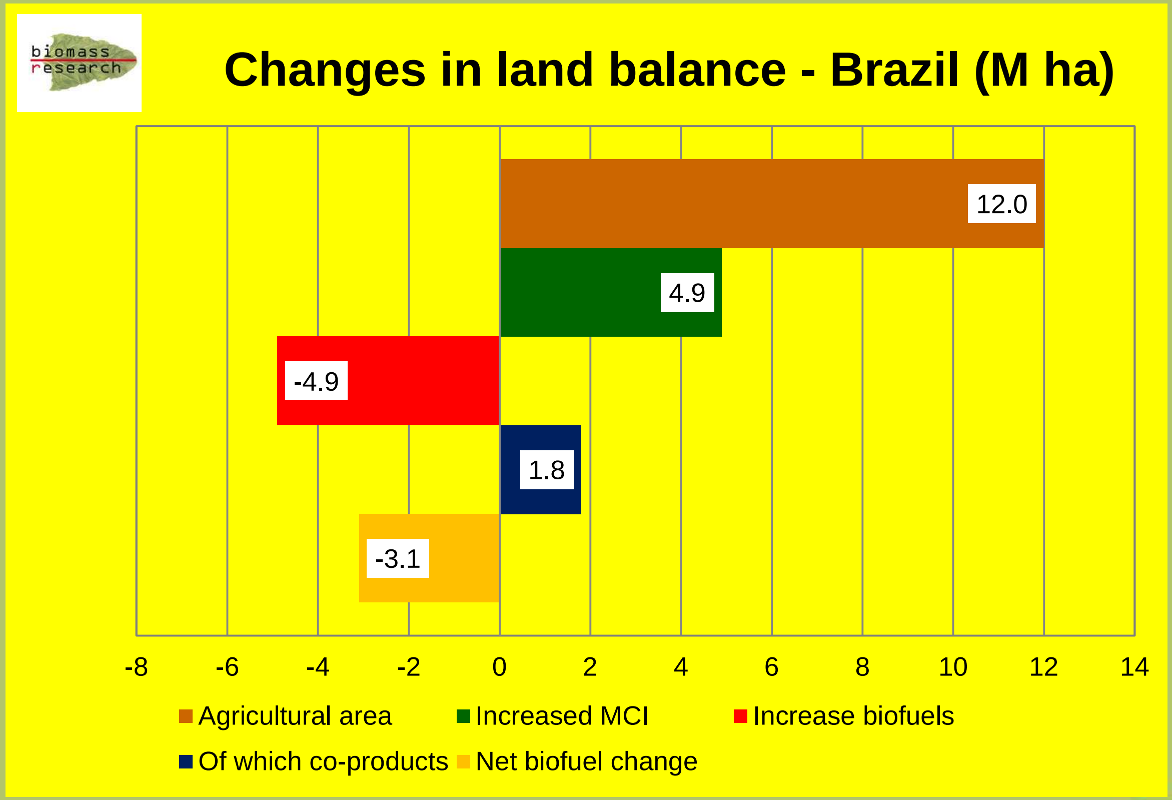




Source: Langeveld and Quist-We
production in Brazil

Biofuel crop production



Source: Langeveld and Quist-Wessel (2014) Chapter 6 *Biofuel production in Brazil*

Biofuel impacts

biomass research

Table 3. Crop, biofuel and coproduct yields.

Region	Feedstock	Crop yield (ton/ha)	Biofuel yield (l/ha)	Biofuel yield (GJ/ha)	Co-product yield (ton/ha)
Brazil	Sugarcane	79.5	7200	152	–
Brazil	Soybean	2.8	600	18	1.8
USA	Corn	9.9	3800	80	4.2
USA	Soybean	2.8	600	18	1.8
EU	Wheat	5.1	1700	37	2.7
EU	Rapeseed	3.1	1300	43	1.7
EU	Sugarbeet	79.1	7900	168	4.0
Indonesia and Malaysia	Palm oil	18.4	4200	90	4.2
China	Corn	5.5	2200	46	2.9
China	Wheat	4.7	1700	36	2.5
Mozambique	Sugarcane	13.1	1100	23	–
South Africa	Sugarcane	60.0	5000	107	–

Source: crop yields calculated from FAOSTAT (2013),[18] biofuel and co-product yields calculated from literature.

Source: Langeveld et al. (2014) *Chapter 15. Impact on land and biomass availability*

Biofuel crop production

Brazil

USA

EU

China

Biofuel impacts

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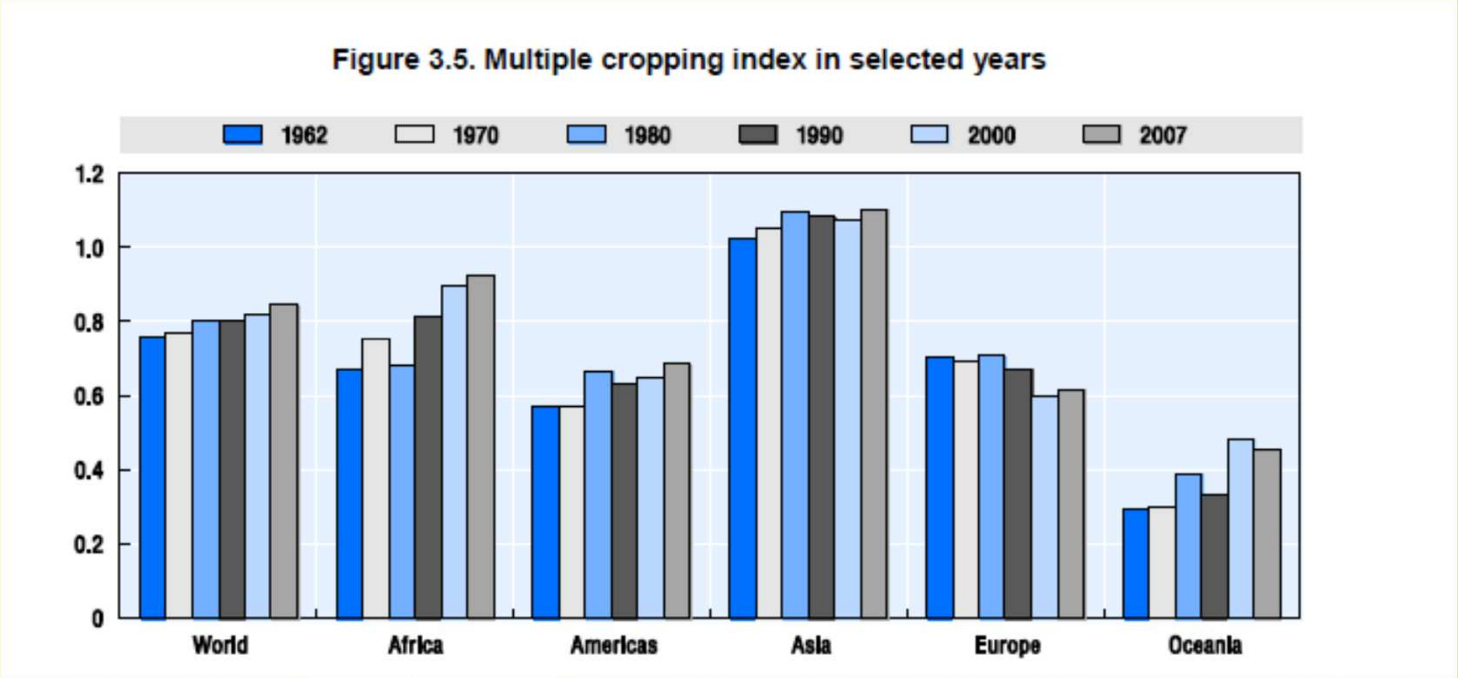
Table 5. Net changes in land availability.

	Increased land requirement (mln ha)	Associated with co-products (mln ha)	Net biofuel area increase (mln ha)	Changes in agricultural area (mln ha)	Extra harvested area due to increased MCI (mln ha)	Change in NHA (mln ha)
Brazil	4.9	1.8	3.1	12.0	4.9	13.8
USA	11.0	5.9	5.1	–3.5	10.9	2.3
EU	6.6	3.2	3.4	–11.5	3.6	–11.2
Indonesia, Malaysia	0.02	0.01	0.01	8.9	2.0	10.9
China	2.2	0.4	1.8	–13.4	20.3	5.1
Mozambique	0.13	0.03	0.1	1.3	0.9	2.0
South Africa	0.12	0.04	0.1	–2.7	–1.2	–4.0
All	24.9	11.4	13.5	–9.0	41.5	19.0
Global total				–47.8	91.5	

Source: Langeveld et al. (2014) *Chapter 15. Impact on land and biomass availability*

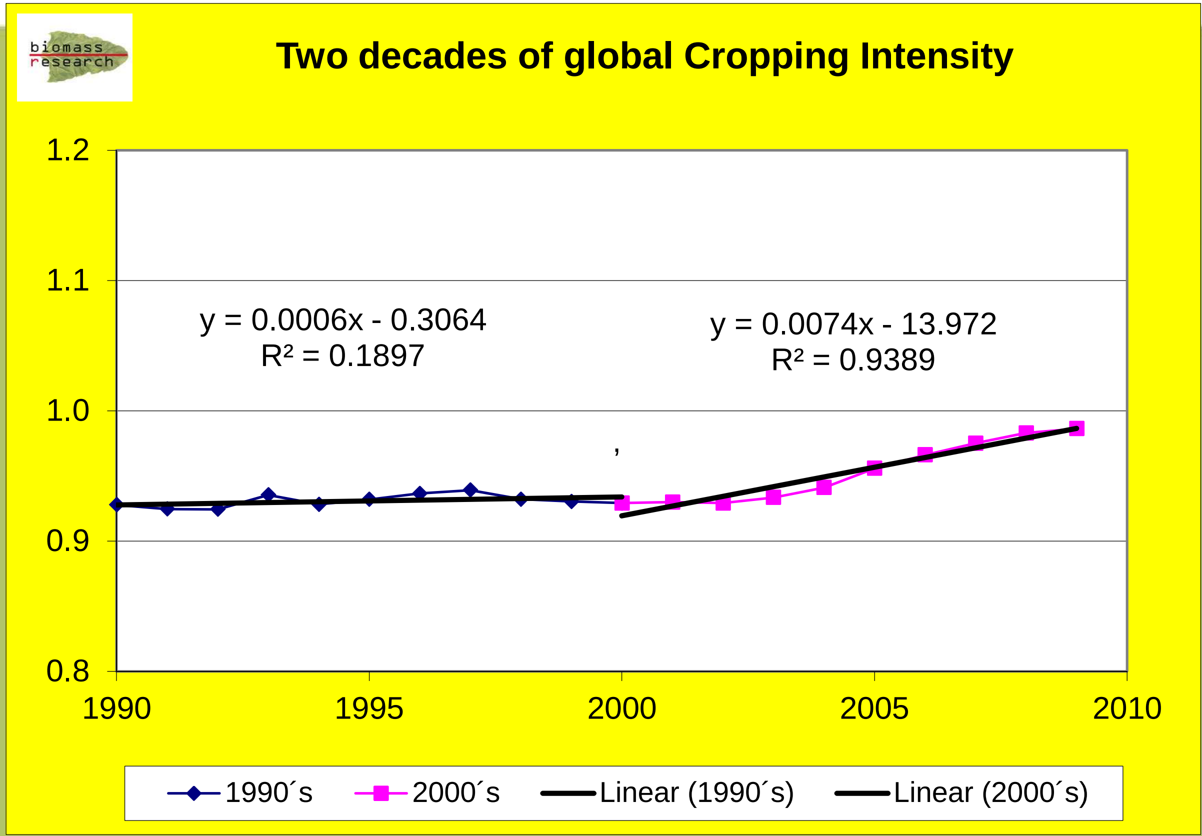
Biofuel impacts



Source: FAO-OECD (2009) *Agricultural outlook 2009-2019. p 58.*

MCI calculations based on data from FAOSTAT.fao.org

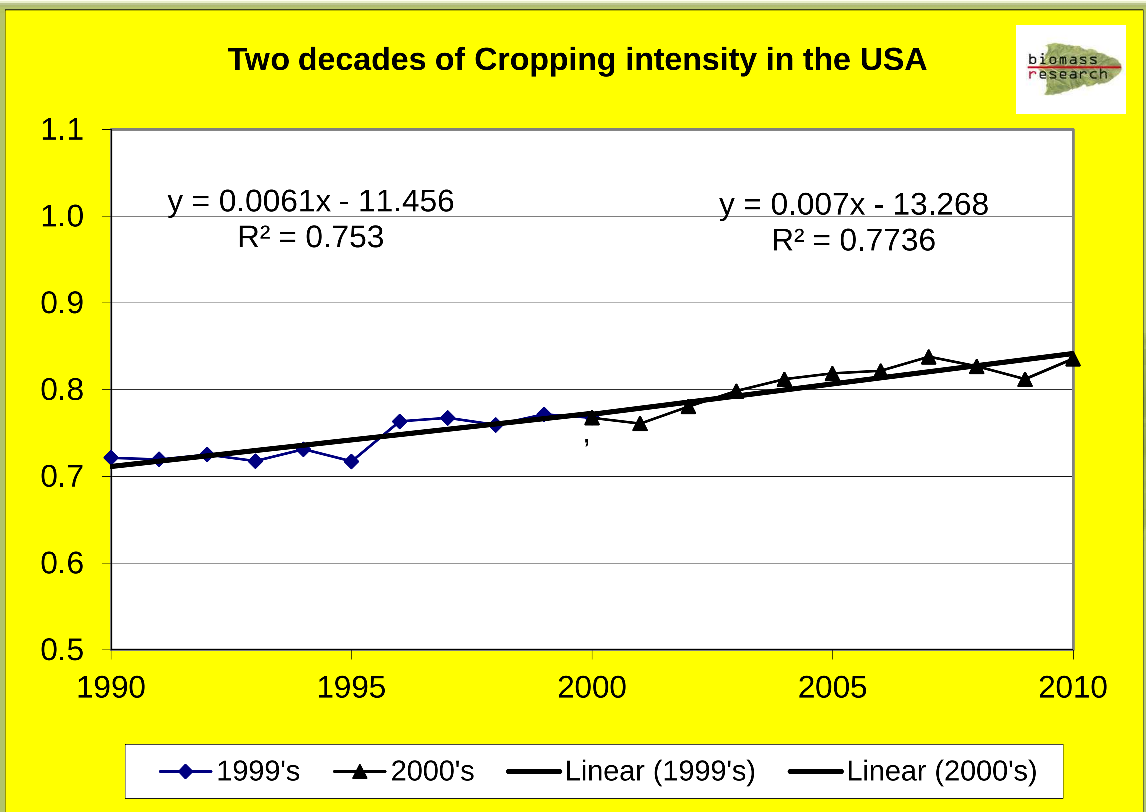
Biofuel impacts



Source: FAO-OECD (2009) *Agricultural outlook 2009-2019. p 58.*

MCI calculations based on data from FAOSTAT.fao.org

Biofuel impacts



Source: FAO-OECD (2009) *Agricultural outlook 2009-2019. p 58.*

MCI calculations based on data from FAOSTAT.fao.org

Biofuel impacts

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Table 15.6 Global food availability and undernutrition

	Average Dietary Energy Supply (% of required)		*Number Undernourished (million)*		*Decline Number Undernourished*	
	2000	*2010*	*2000*	*2010*	*Million*	*% of 2000*
Africa	110	115	203	230	−27	−13%
Asia	112	116	603[1]	540[1]	64[1]	11%[1]
Latin America	122	126	46	37	9	19%
Developed	133	134	60[2]	56[2]	4[2]	7%[2]
Total	117	120	913	863	50	5%

[1]Including Oceania.

[2]Estimation.

Sources: Calculated from FAO (2013); Hunger Notes (2013).

Source: Langeveld et al. (2013) *Land use, crop management and impacts of biofuel production*

Biofuel impacts

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Table 15.7 Food availability and undernutrition in biofuel-producing countries

	Average Dietary Energy Supply (% of required)		*Number Undernourished (million)*		*Decline Number Undernourished*	
	2000	*2010*	*2000*	*2010*	*Million*	*% of 2000*
Brazil	121	132	21	14	7	32%
Indonesia	108	121	38	23	15	40%
Malaysia	126	124	–[1]	–[1]	No data	No data
Mozambique	94	100	8	9	–0.5	–6%
South Africa	121	126	–[1]	–[1]	No data	No data
China	117	123	182	153	29	16%
Total	–	–	250	200	51	20%

[1]Less than 5% of the population.
Source: Calculated from FAO (2013).

Source: Langeveld et al. (2013) *Land use, crop management and impacts of biofuel production*

Biofuel impacts

Study coverage

¬ Biofuel production
- Ethanol 97%
- Biodiesel 77%
- Not: Argentina, India, Canada

¬ Land area
- Agricultural land 35%
- Arable area 38%
- Forest 34%
- Area harvested 39%
- Population 30%

Biofuel impacts

Observations

¬ Need a better understaning of land use change

¬ Yield gap not acknowledged

¬ Time and spatial scale issues

¬ Data on farming practices: farm typology

¬ Soil related issues

Yield gaps

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Factors determining yield gap

- Management
- Incorrect nutrient applications
- Pests and diseases
- Knowledge, training
- Post harvest losses

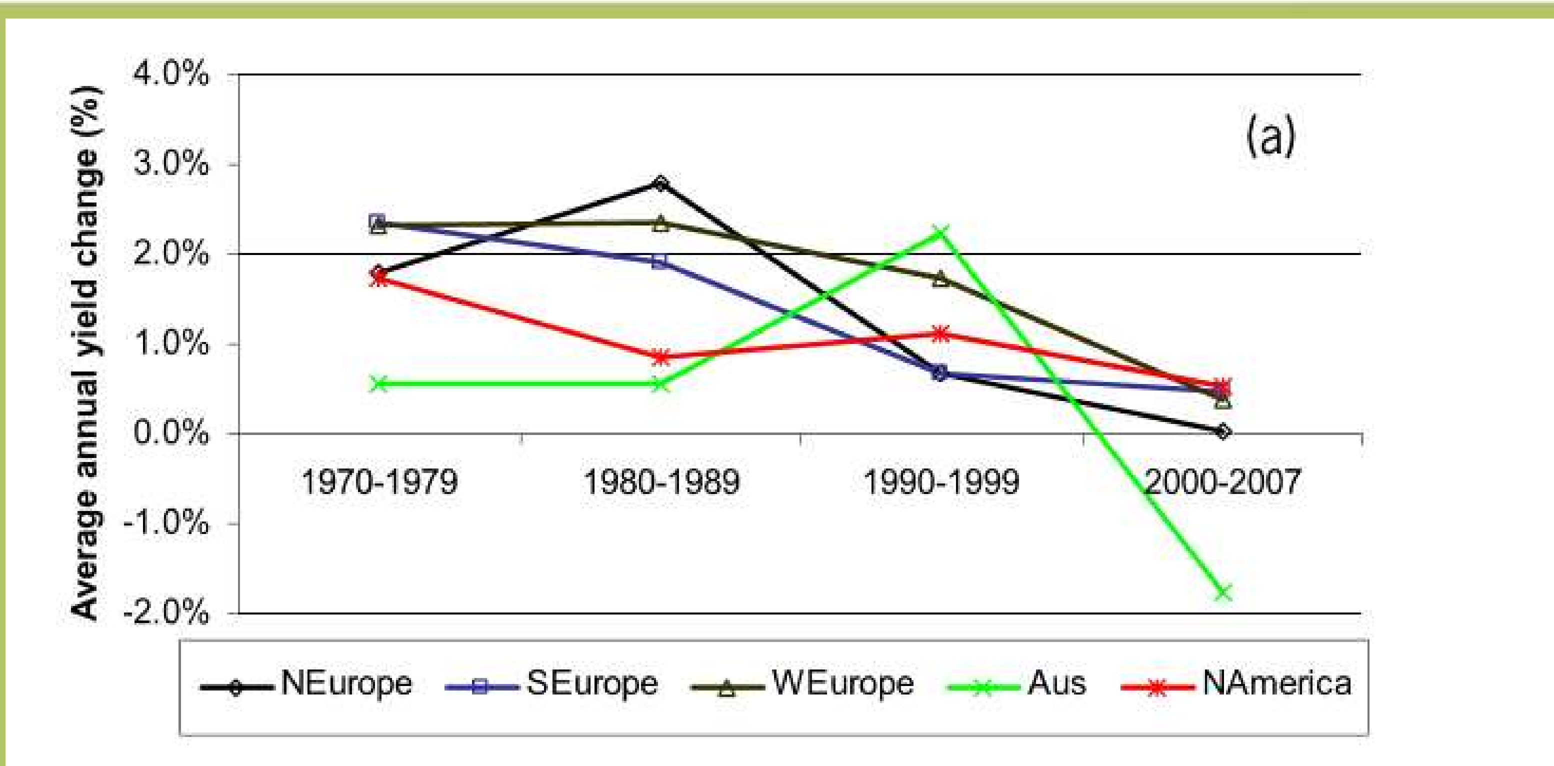
Source: Hengsdijk and Langeveld (2009) *Yield gaps and major yield trend analysis of major crops in the world. Wageningen: WOT*

Table 3.1 Average annual change in cultivated crop areas (%) in the periods 1970-1979; 1980-1989; 1990-1999; and 2000-2007 compared to the average cultivated area in the previous decade.

Crop	1970-1979	1980-1989	1990-1999	2000-2007
Wheat	0.4	0.3	-0.4	-0.4
Rice	1.0	0.4	0.3	0.3
Maize	1.0	0.6	0.7	0.7
Soybean	3.1	2.8	1.6	3.4
Barley	2.0	0.2	-1.5	-2.6
Tropical cereals	-0.1	-0.2	-0.7	-0.2
Cotton	0.4	-0.5	0.2	-0.1
Rape seed	2.9	3.4	3.6	1.7
Dry beans	0.0	0.9	-0.3	0.3
Groundnut	0.4	-0.2	1.2	0.7
Sunflower	2.5	3.0	2.8	1.2
Sugar cane	2.1	2.1	1.6	1.3
Potato	6.3	-0.8	0.0	0.5
Cassava	1.5	1.0	1.1	1.0
Oil palm	0.3	2.7	3.8	4.4
Sugar beet	1.0	0.4	-1.3	-4.6

Source: Hengsdijk and Langeveld (2009) *Yield gaps and major yield trend analysis of major crops in the world. Wageningen: WOT*

Yield gaps



Source: Hengsdijk and Langeveld (2009) *Yield gaps and major yield trend analysis of major crops in the world. Wageningen: WOT*

Yield gaps

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Factors determining yield gap

¬ Management

¬ Incorrect nutrient applications

¬ Pests and diseases

¬ Knowledge, training

¬ Post harvest losses

Source: Hengsdijk and Langeveld (2009) *Yield gaps and major yield trend analysis of major crops in the world. Wageningen: WOT*

Yield gaps

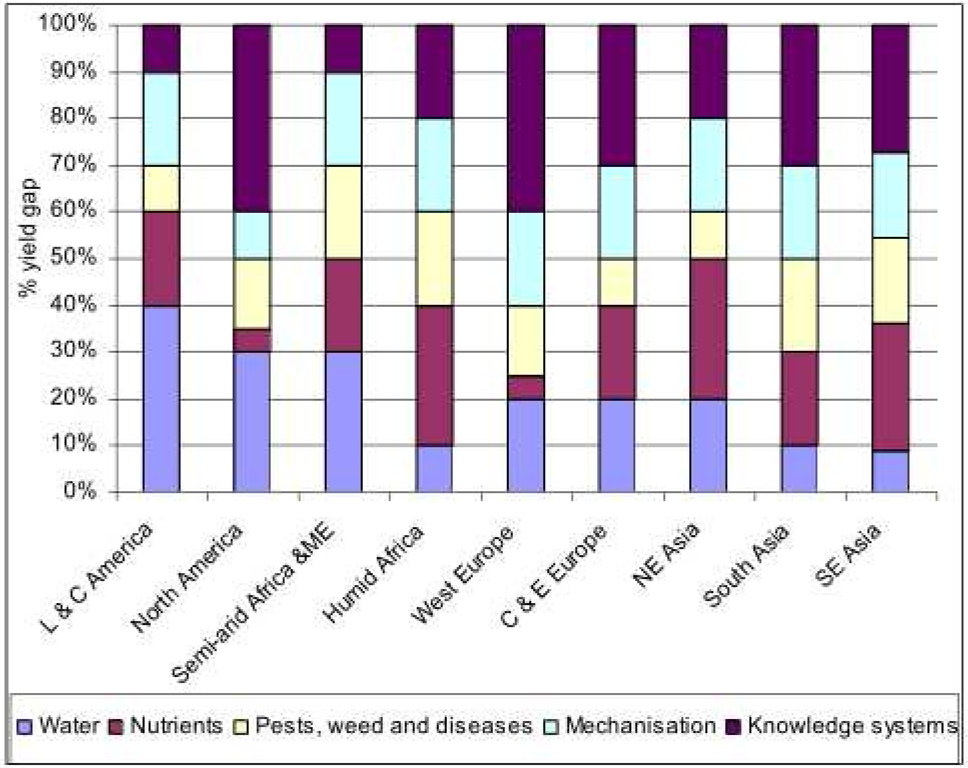


Figure 3.5 ***Maize****: Relative contribution of five production constraints, i.e. sub-optimal availability of water, nutrients, crop protection, labour/mechanisation and/or knowledge, to the gap between current and potential yields in different parts of the world.*

Source: Hengsdijk and Langeveld (2009) *Yield gaps and major yield trend analysis of major crops in the world. Wageningen: WOT*

Yield gaps

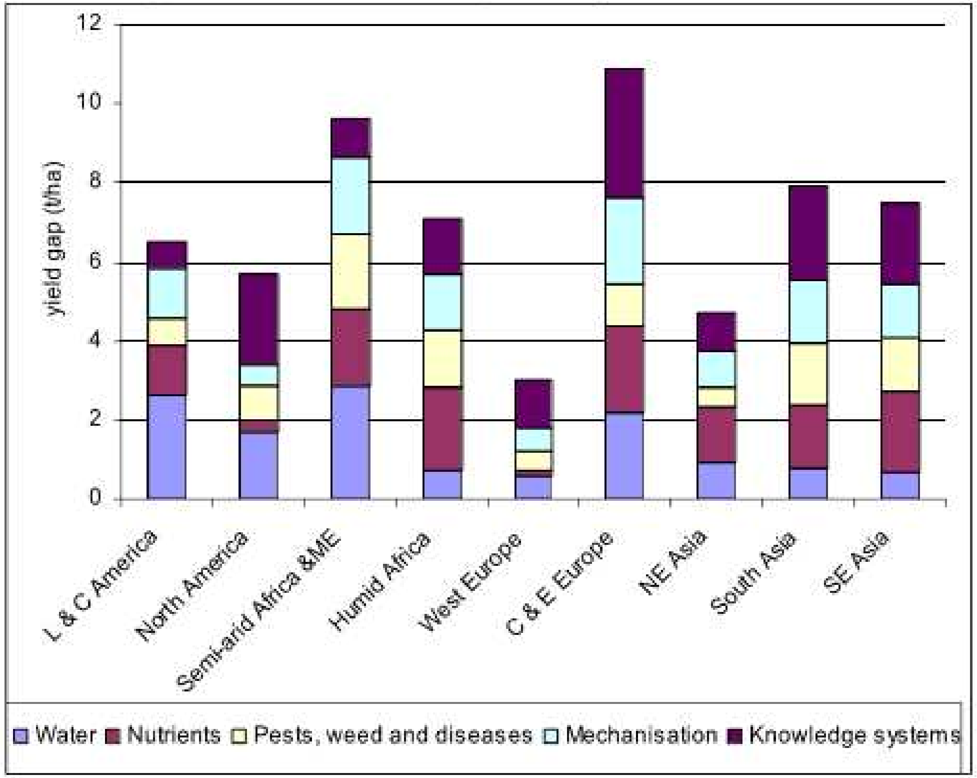
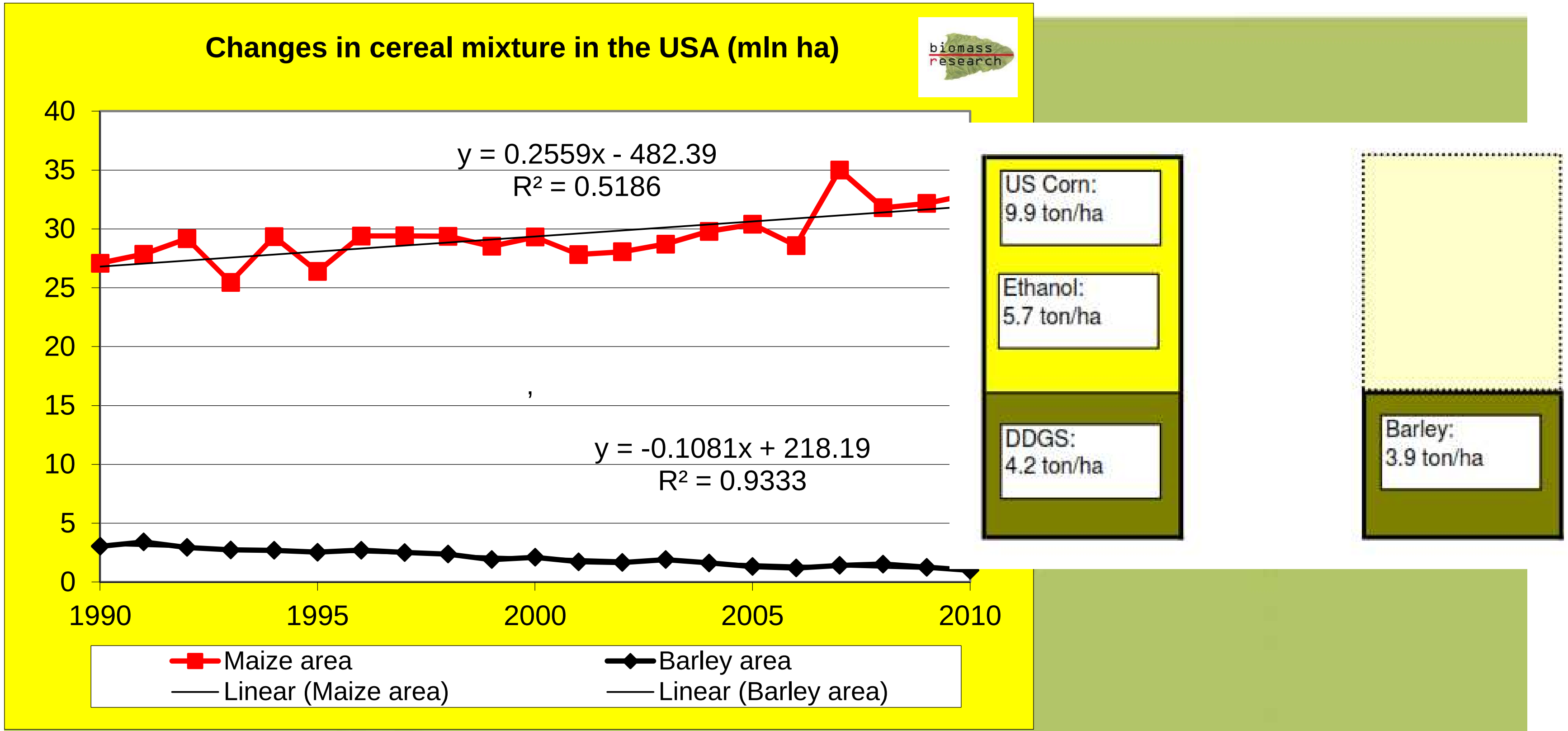


Figure 3.6 ***Maize****: Contribution of five production constraints, i.e. sub-optimal availability of water, nutrients, crop protection, labour/mechanisation and/or knowledge, to the yield gap in different parts of the World.*

Source: Hengsdijk and Langeveld (2009) *Yield gaps and major yield trend analysis of major crops in the world. Wageningen: WOT*

Land use change: crops



Source: Langeveld et al. (2014) *Biofuel cropping systems. Carbon, land and food. London: Earthscan*

Landscapes

biomass
research

Scale: landscape approach

- ¬ Not: one single crop analysis
- ¬ Not: food vs fuel
- ¬ Activity oriented
- ¬ Soil based ?
- ¬ Multi-actor ?

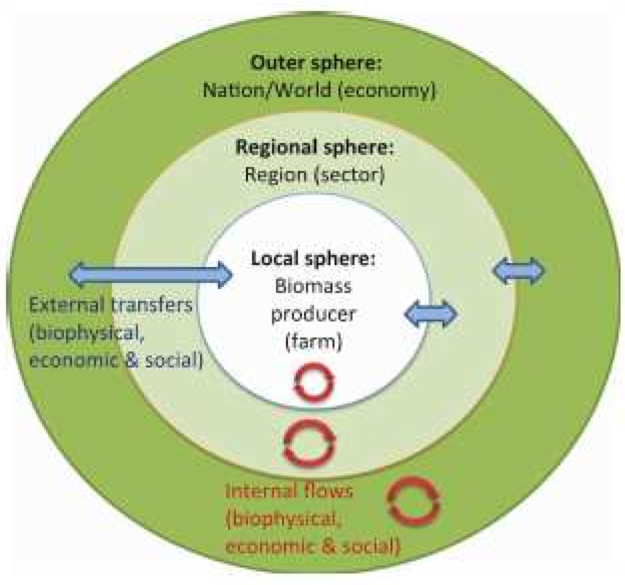


Fig. 1 Biomass producers and their spheres of interaction

Source: Gan et al. (2014) *Agent based modelling approach determining corn stover removal rate and transboundary effects.* ***Environmental Management*** *(2014) 53:333–342*

Landscapes

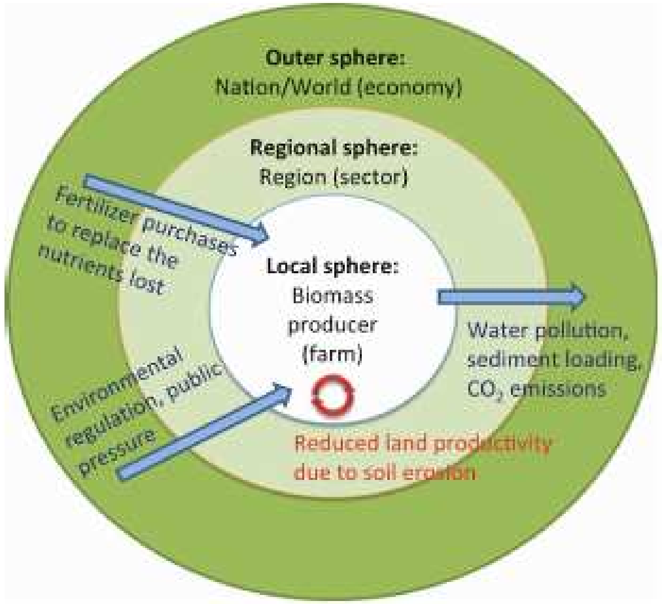


Fig. 2 Potential transfers and interaction among spheres due to soil erosion caused by stover removal

Source: Gan et al. (2014) *Agent based modelling approach determining corn stover removal rate and transboundary effects.* ***Environmental Management*** *(2014) 53:333–342*

Landscapes

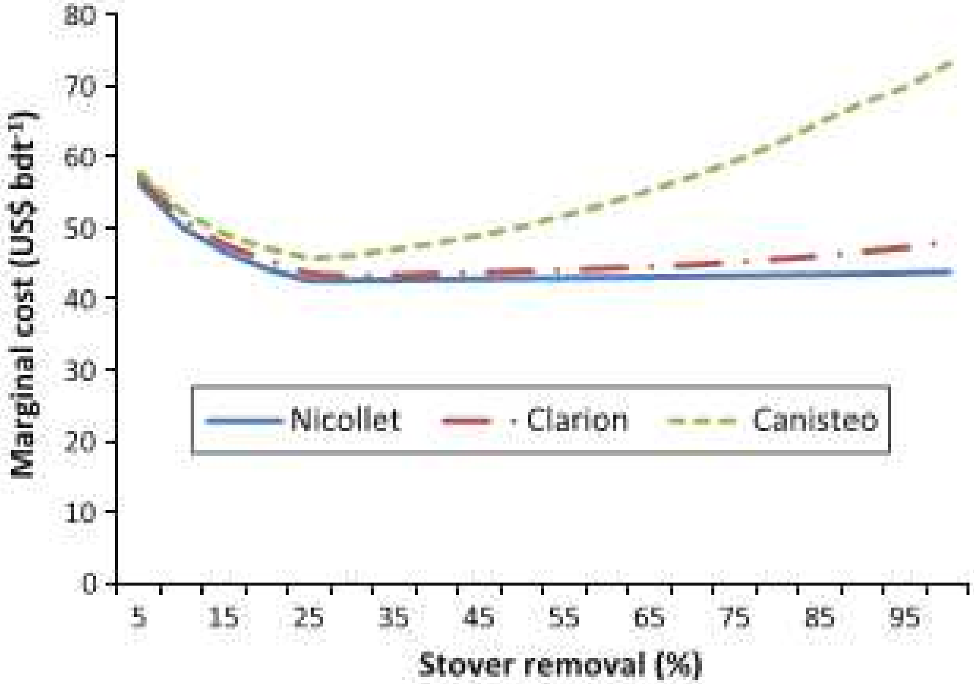


Fig. 3 Total marginal cost of corn stover removal by soil type in Palo Alto County, Iowa (including the costs of soil erosion, nutrient loss, and stover harvesting)

Source: Gan et al. (2014) *Agent based modelling approach determining corn stover removal rate and transboundary effects.* ***Environmental Management*** *(2014) 53:333–342*

Landscapes

Table 3 Multipliers of producing corn stover ethanol in Palo Alto County, Iowa, USA

Sphere	Value (US\$ L^{-1})	Multiplier I	Multiplier II
Local sphere (farm)	0.19		
Regional sphere (sector)	0.42	3.23	
Outer sphere (economy)			
Energy security premium	0.13		
GHG offset value at the following CO_2 prices (US\$ t^{-1})			
5	0.01		3.97
10	0.02		4.02
15	0.02		4.06
20	0.03		4.10
25	0.04		4.14

Source: Gan et al. (2014) *Agent based modelling approach determining corn stover removal rate and transboundary effects.* ***Environmental Management*** *(2014) 53:333–342*

Conclusion

Issues

- ¬ Land use dynamics are simplified and underestimated
- ¬ No ground for assumptions land use change
- ¬ GHG emissions will be different than assumed
- ¬ No food vs fuel, no impact on undernutrition
- ¬ Local level impacts may still be negative
- ¬ Influence of soil quality

Further action

biomass research

Research and other activities

¬ Enhance data scrutiny (land use, land cover, co-products, emissions)

¬ Integrate knowledge and data (soils, crop cultivation, conversion, chain organisation)

¬ Research on chain organisation, development

¬ Improve communication!