Biofuels - Global Potentials and Certification

Florian Kraxner

Petr Havlik, Uwe Schneider, Sylvain Leduc, Hannes Böttcher, Michael Obersteiner et al.

Task 29 – Socio-Economic Drivers in Implementing Bioenergy Projects
Task 38 - Greenhouse Gas Balances of Biomass and Bioenergy Systems
Task 40 - Sustainable International Bioenergy Trade: Securing Supply and Demand

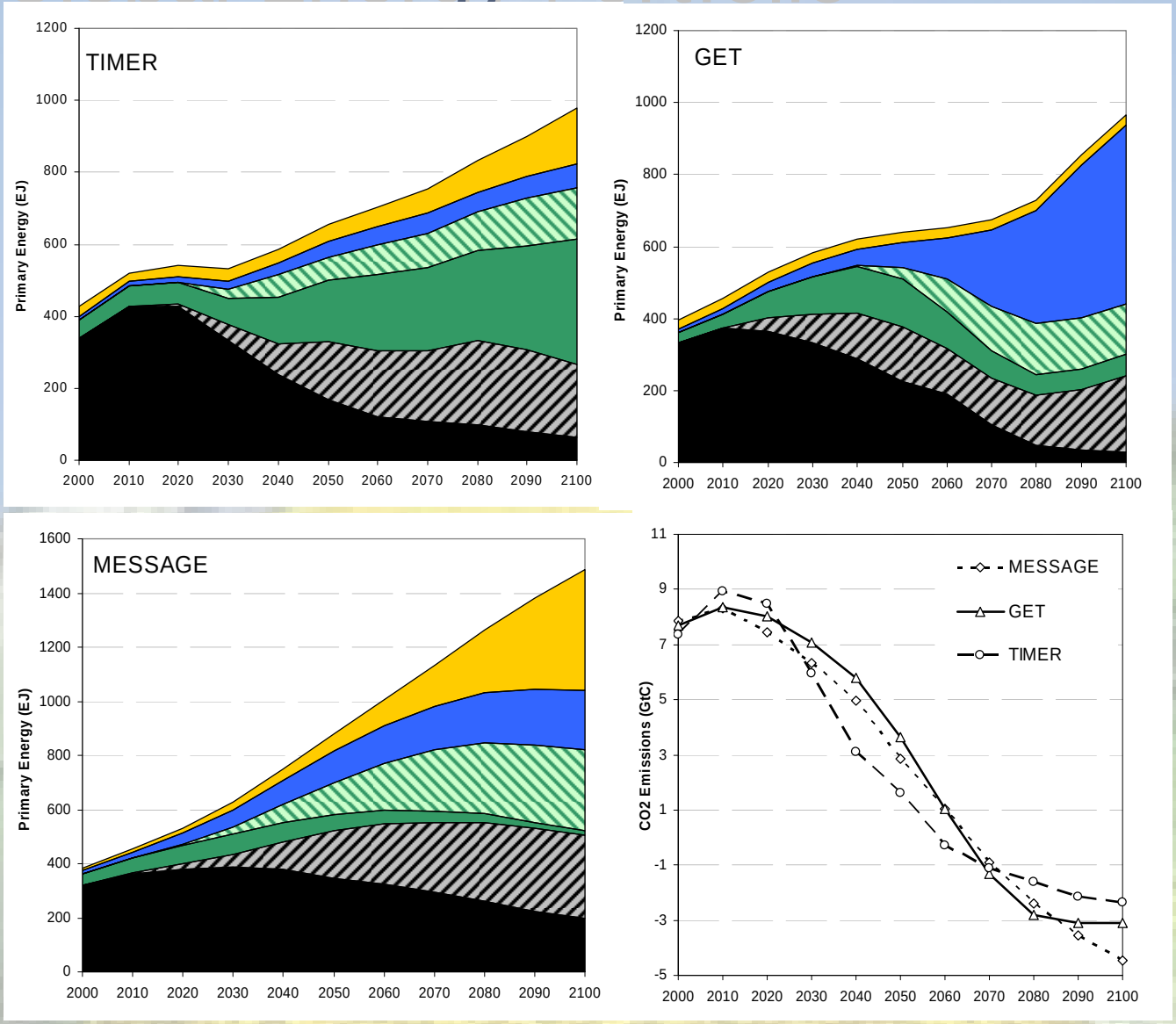
Expert Consultation on Sustainable Biomass, 25 - 27 October 2007, Dubrovnik, Croatia

Overview

- Background and Global BE Potentials
- Competition
- Biofuel Effects
- Sustainability Constraints

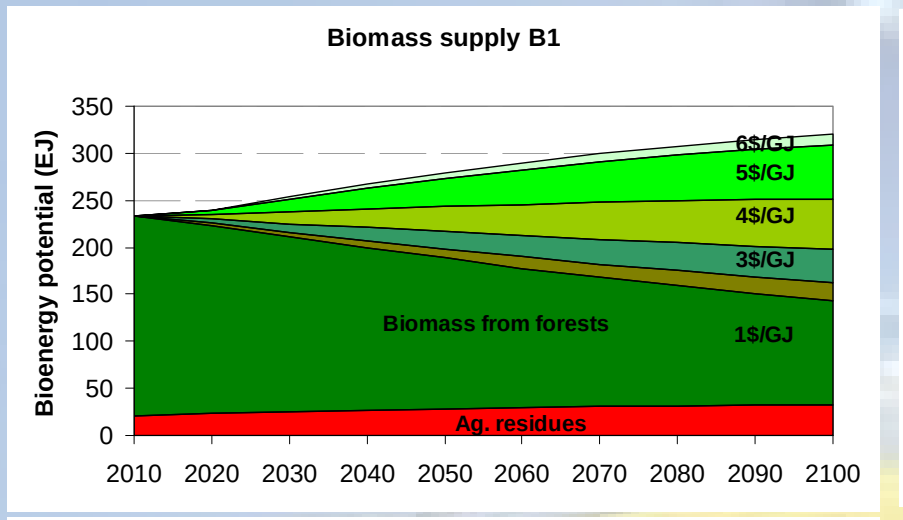
Background

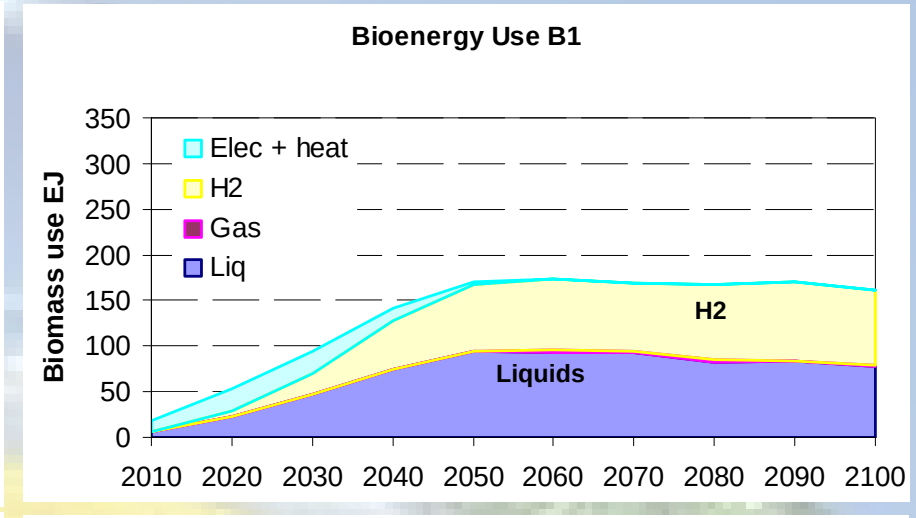
Global Energy Portfolio

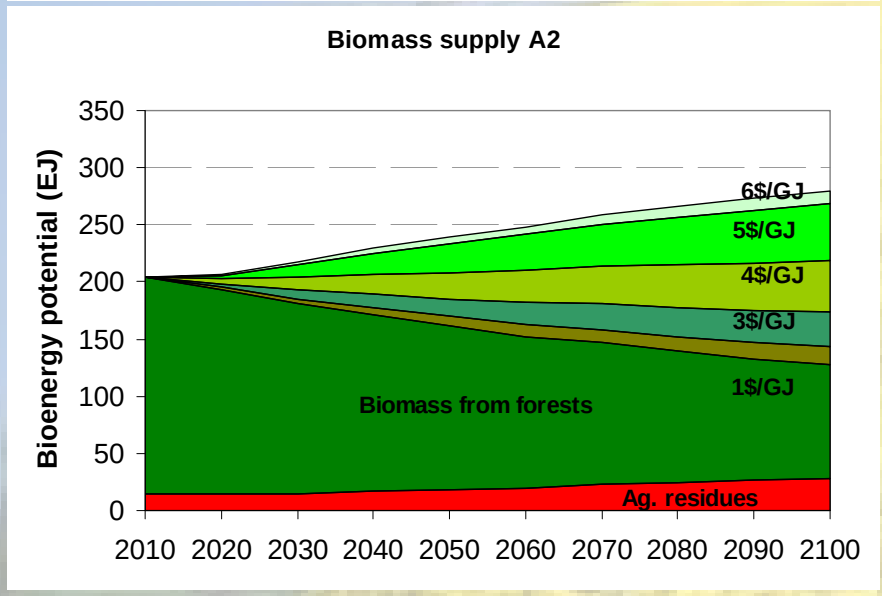


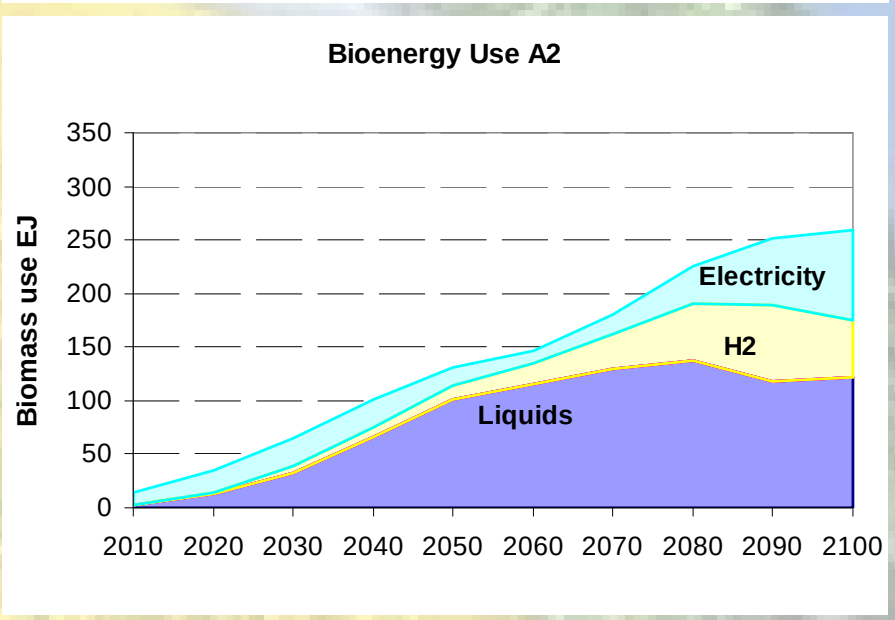
Source: Obersteiner et al. forthcoming

Bio-energy Supply Potentials and Use



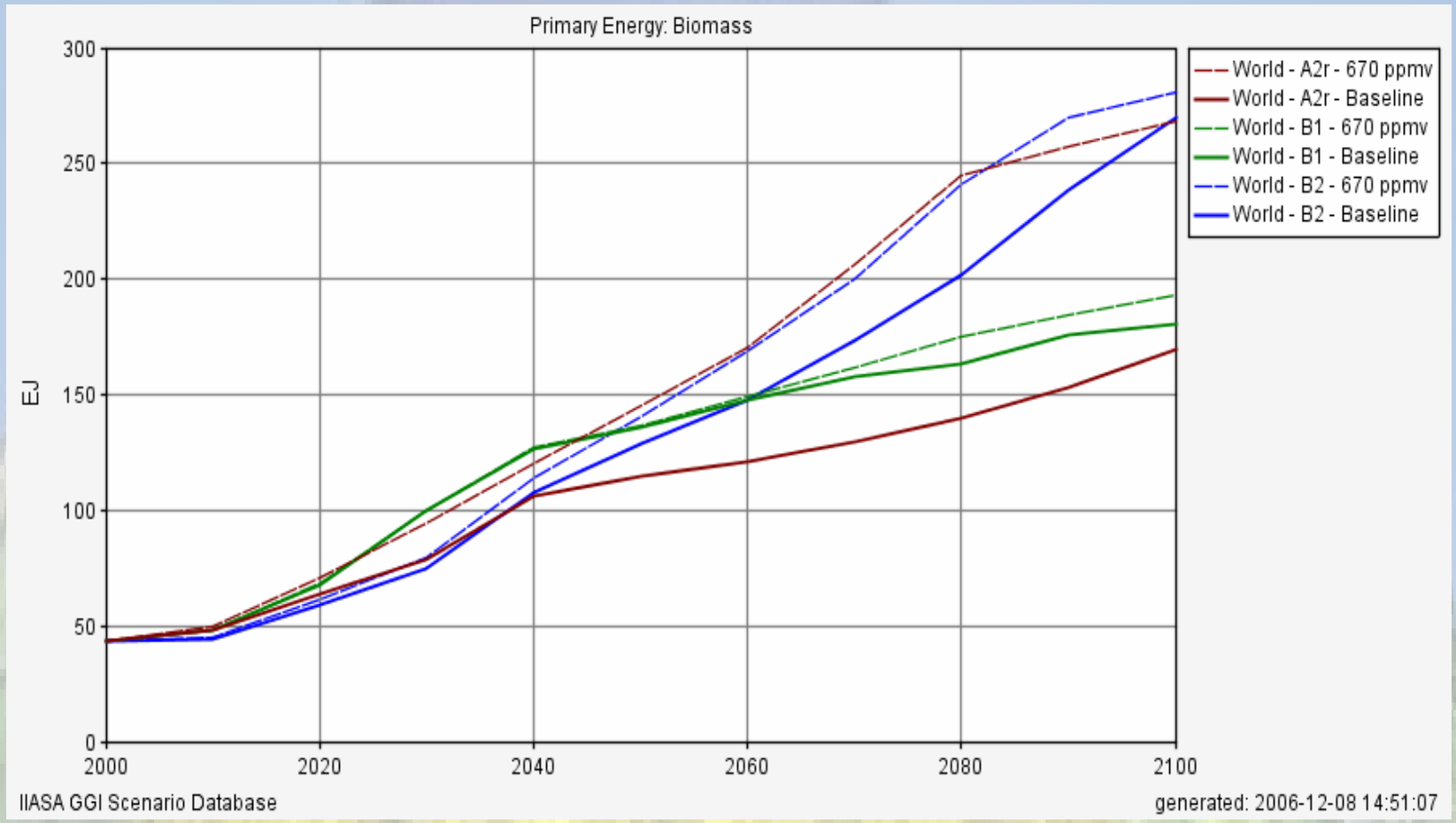




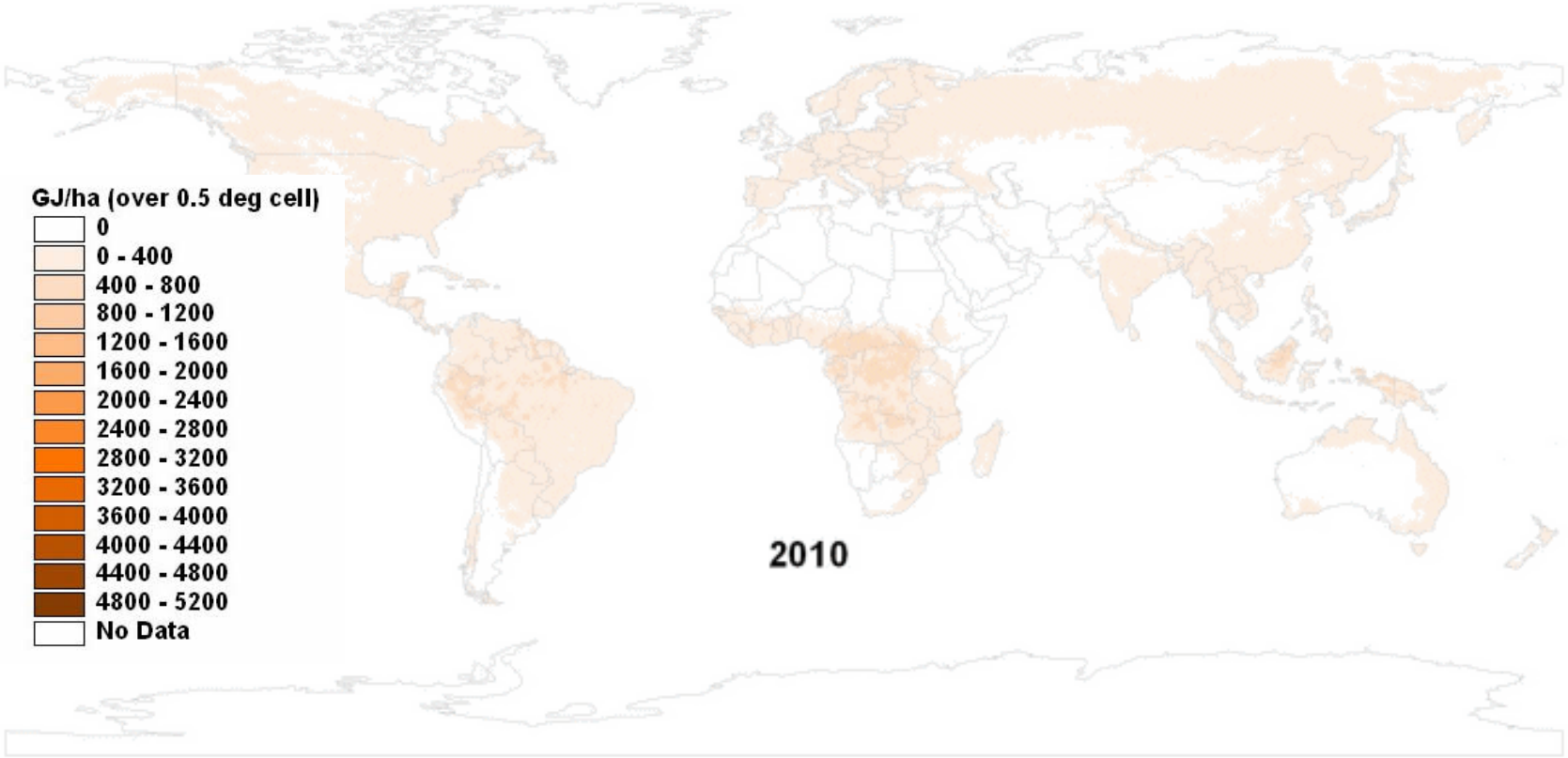


Source: Riahi et al. 2006

Biomass supply



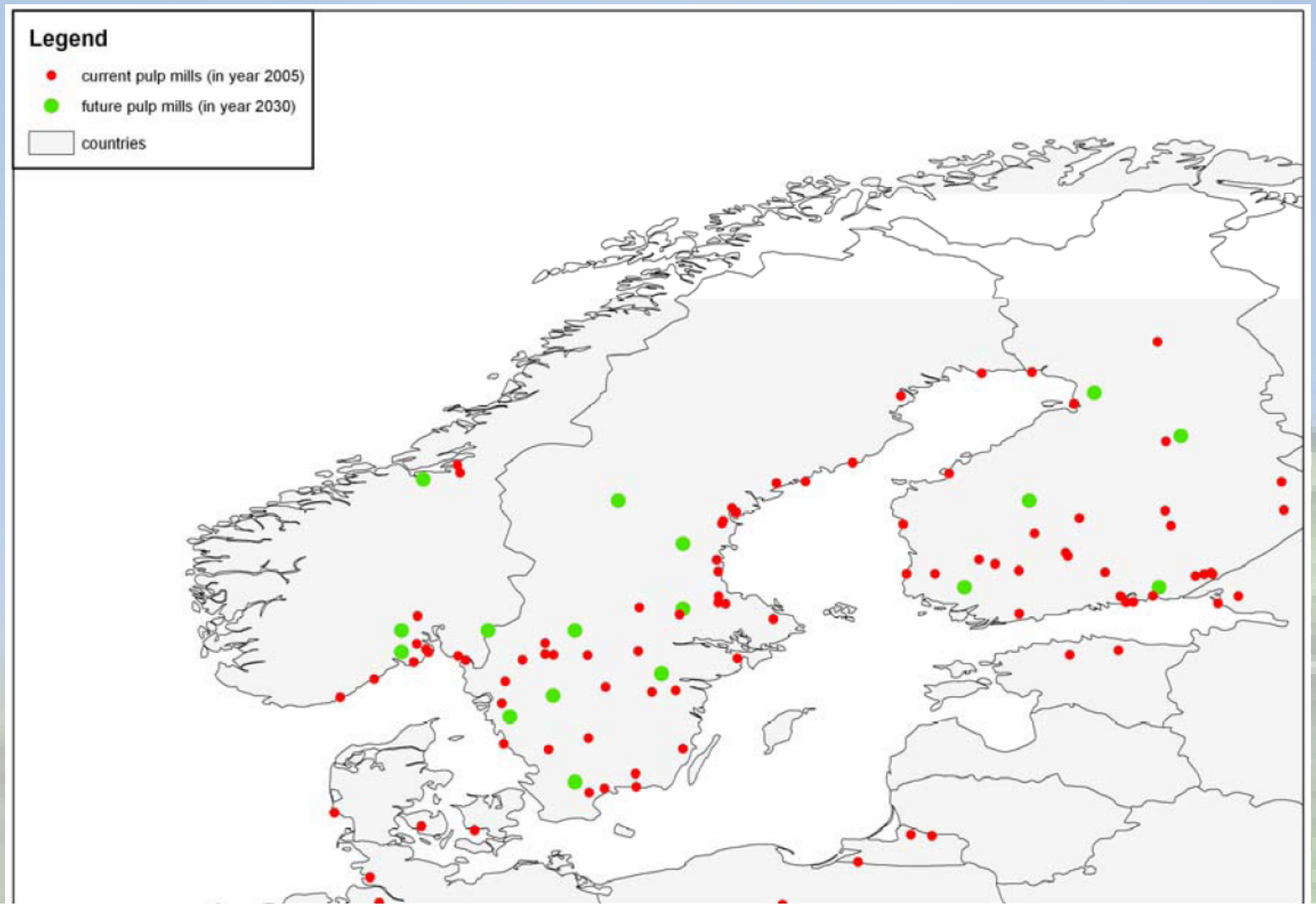
Bioenergy Supply for 2000-2100
B1 (Price < 6$/GJ)



Source: Rokitianskii et al. 2006

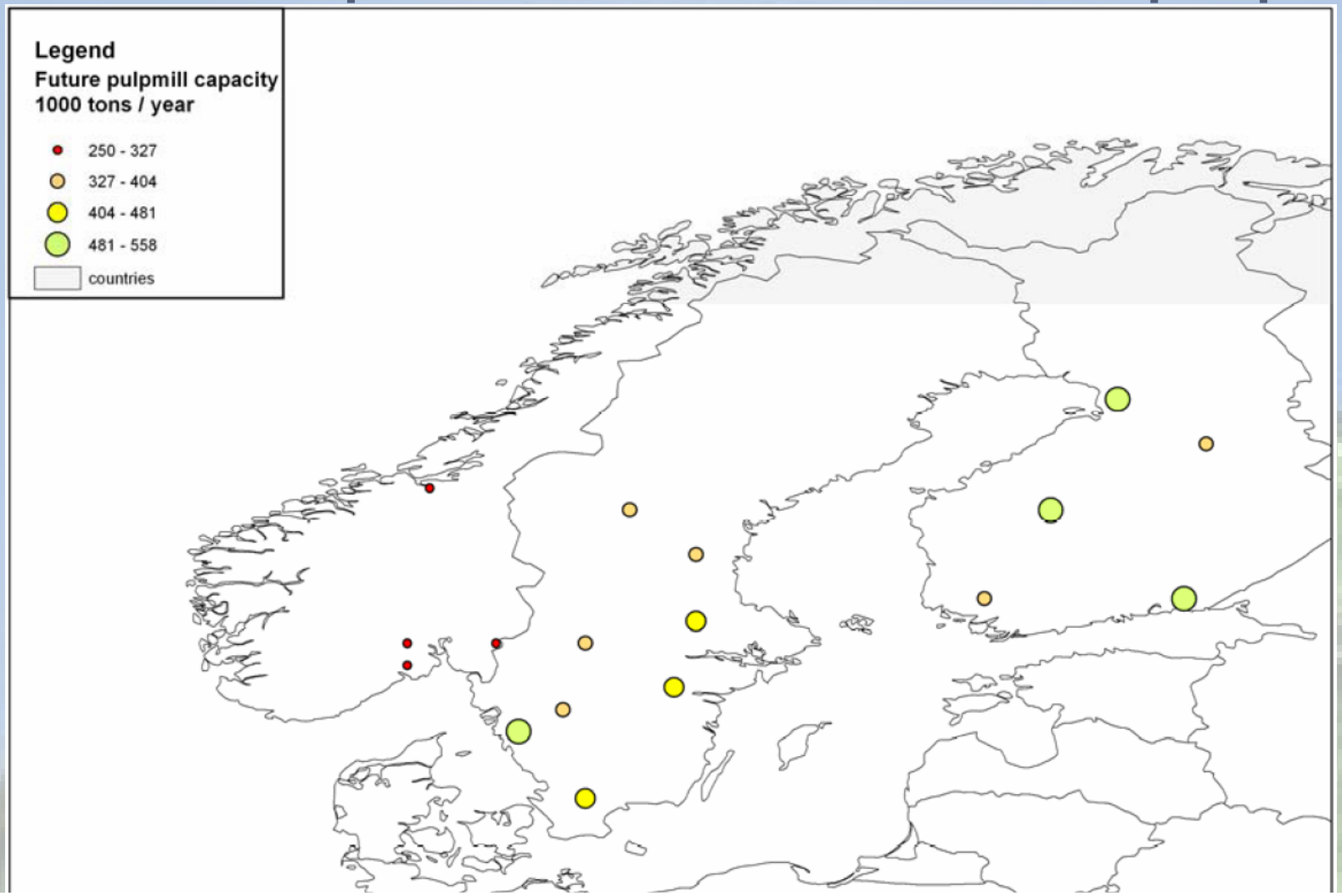
Competition

Results of spatial model: pulp mills



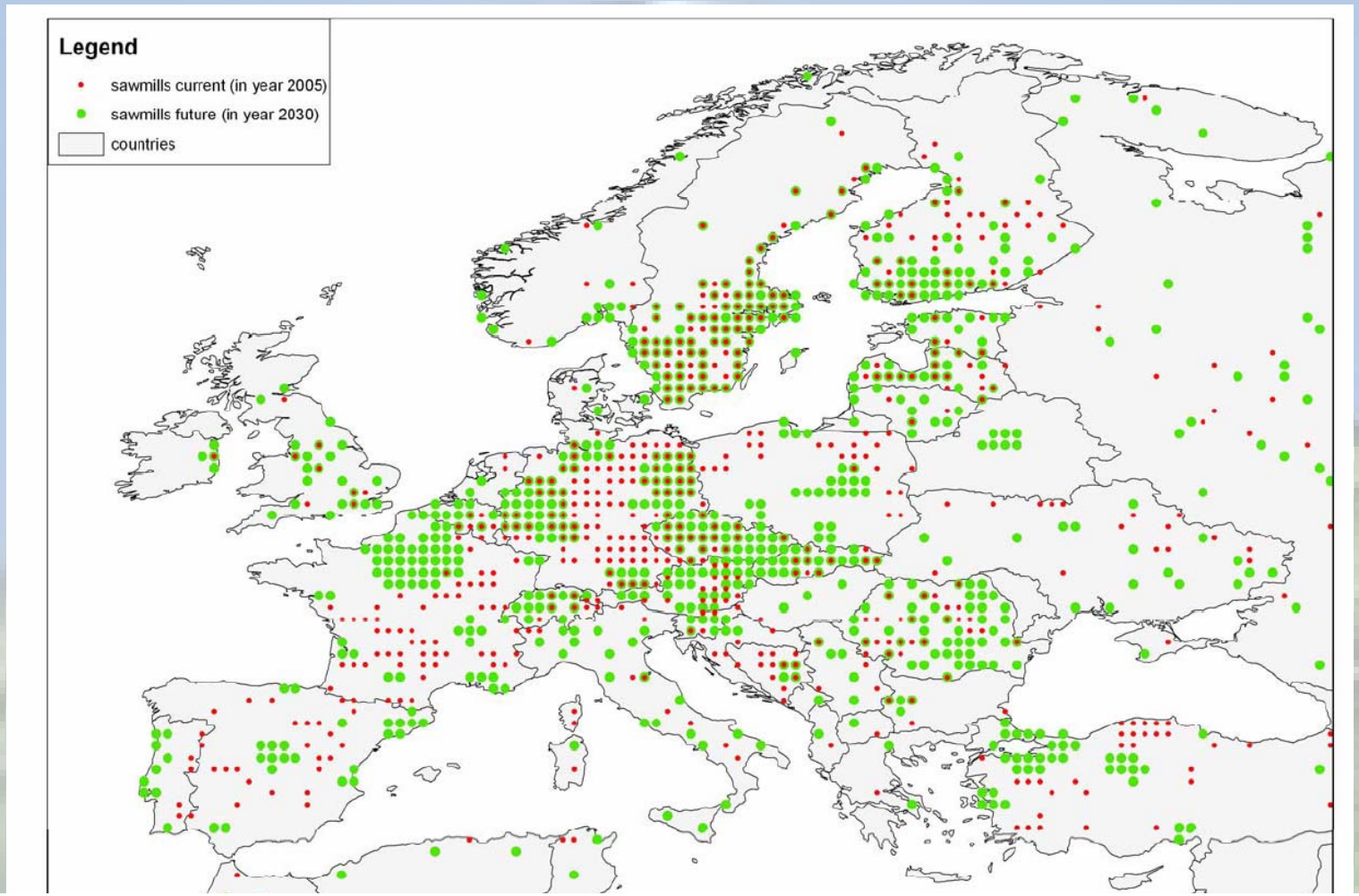
Geographically explicit distribution of current and potential future major pulp mills in the Nordic Baltic Region (2005, 2030), Leduc et al., 2007.

Results of spatial model: Scale of pulp mills



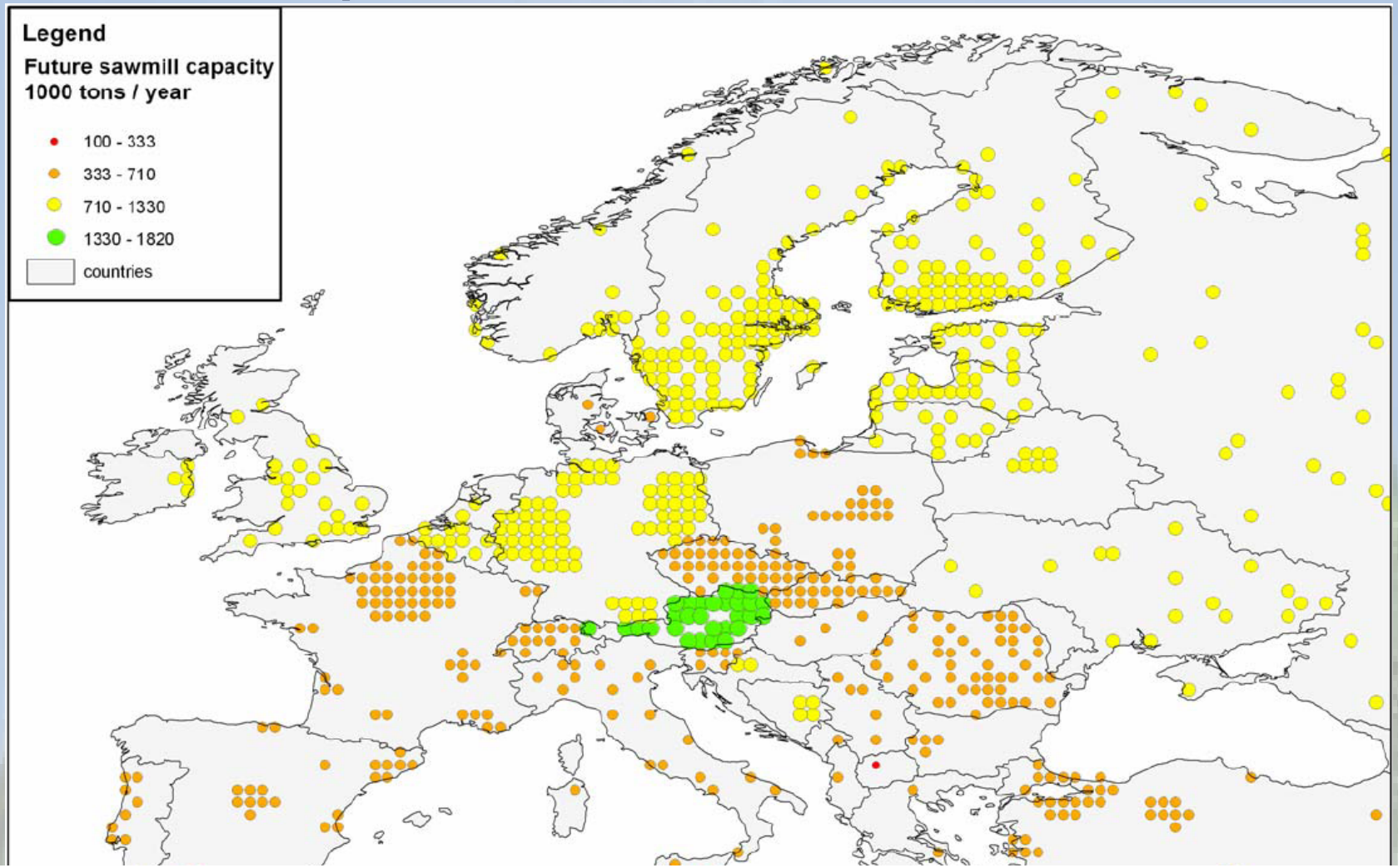
Economies of scale: Downscaled baseline scenario 2030 for production capacity of greenfield pulp mills in the Nordic–Baltic Region of Europe (2005, 2030), Leduc et al., 2007.

Results of spatial model: sawmills



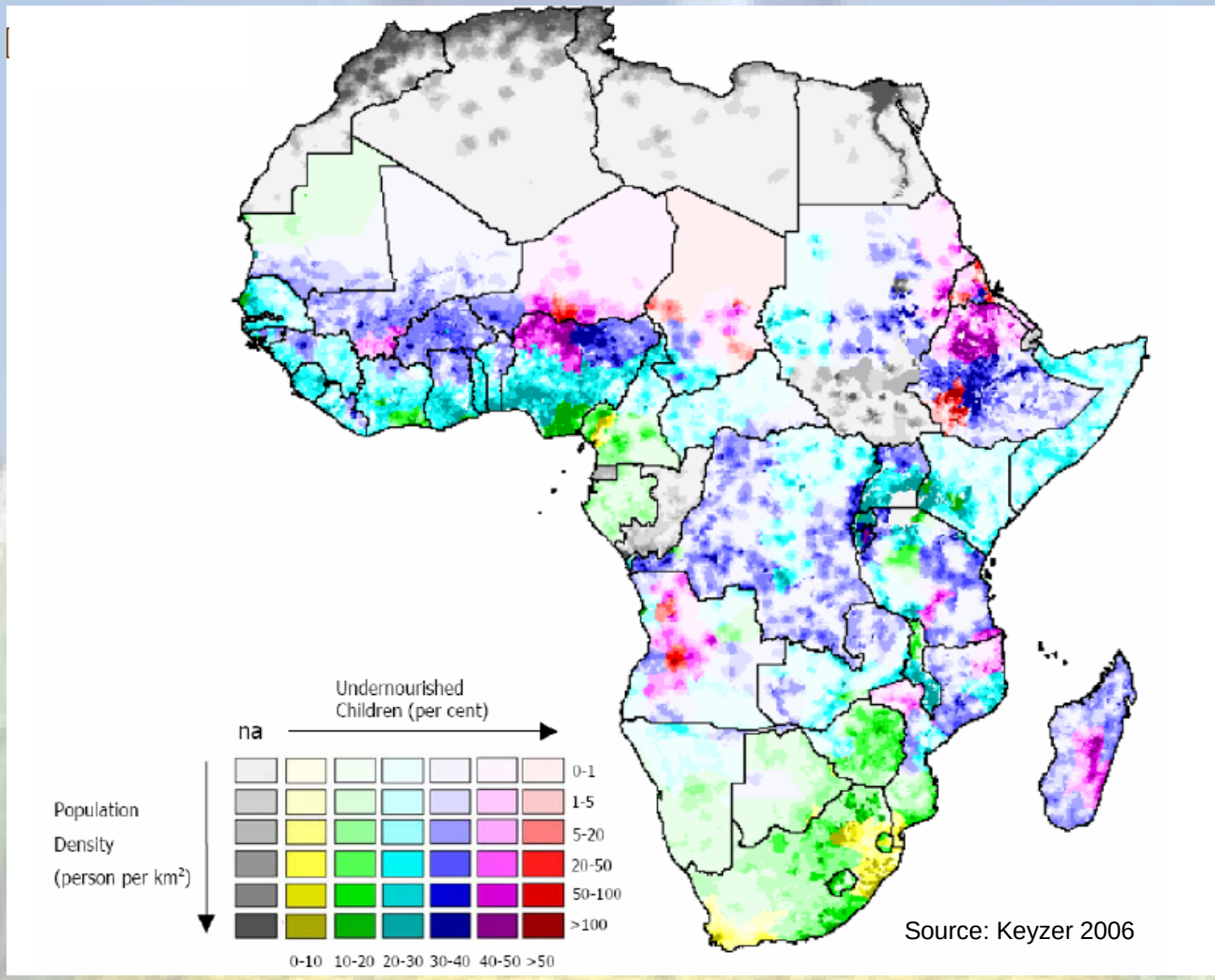
Potential supply of sawn wood by country: Geographic explicit distribution of the estimated location of current sawmills and the location of potential future major sawmills in Europe (2005, 2030), Leduc et al., 2007.

Results of spatial model: Scale of sawmills



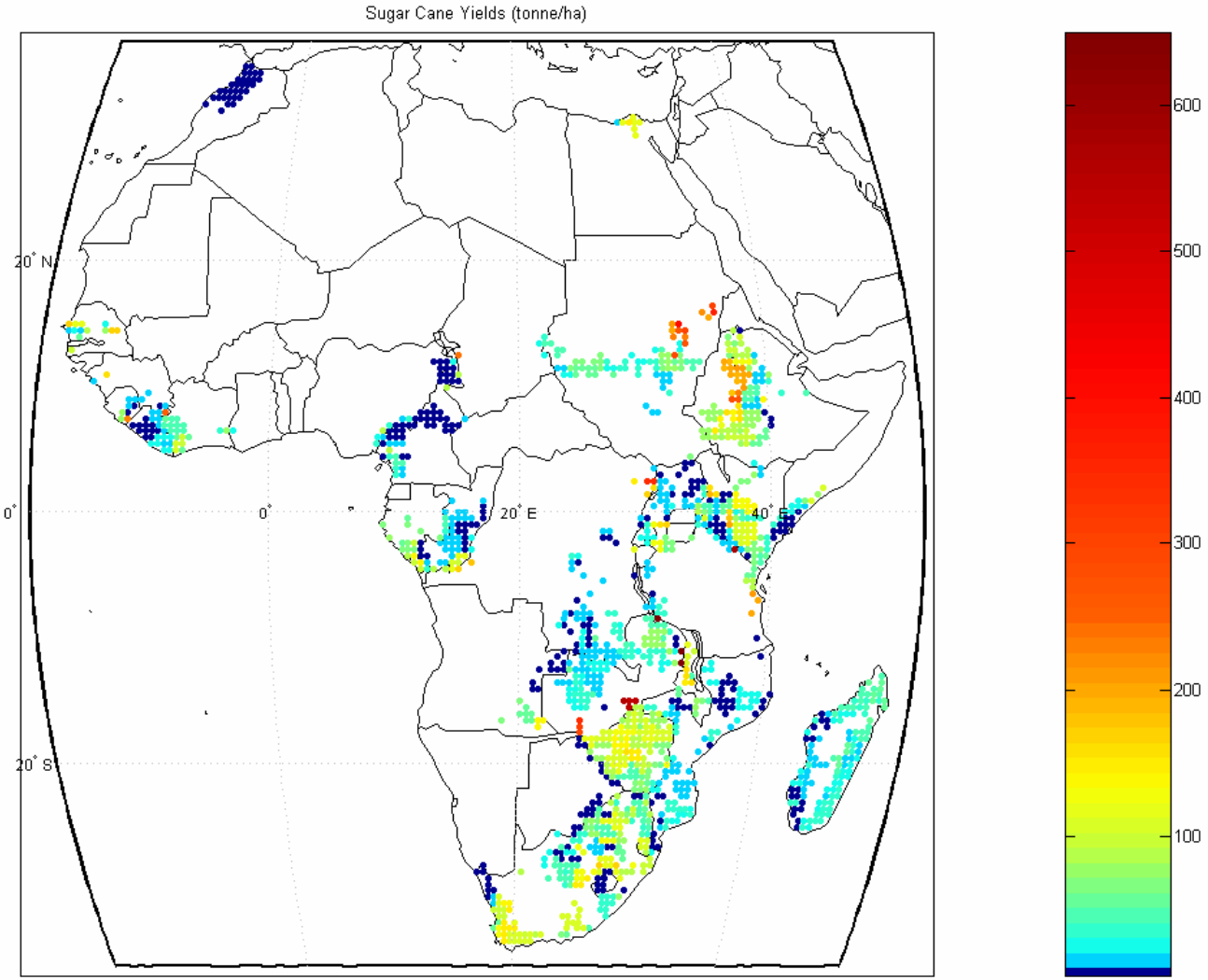
Economies of scale of new production capacity: The potential mill location and size in 2030 for production capacity of greenfield sawmills in Europe is shown under the scenario of 50% demand increase in each country. Leduc et al., 2007.

Combine with Geography of Social Sphere: Undernourished children



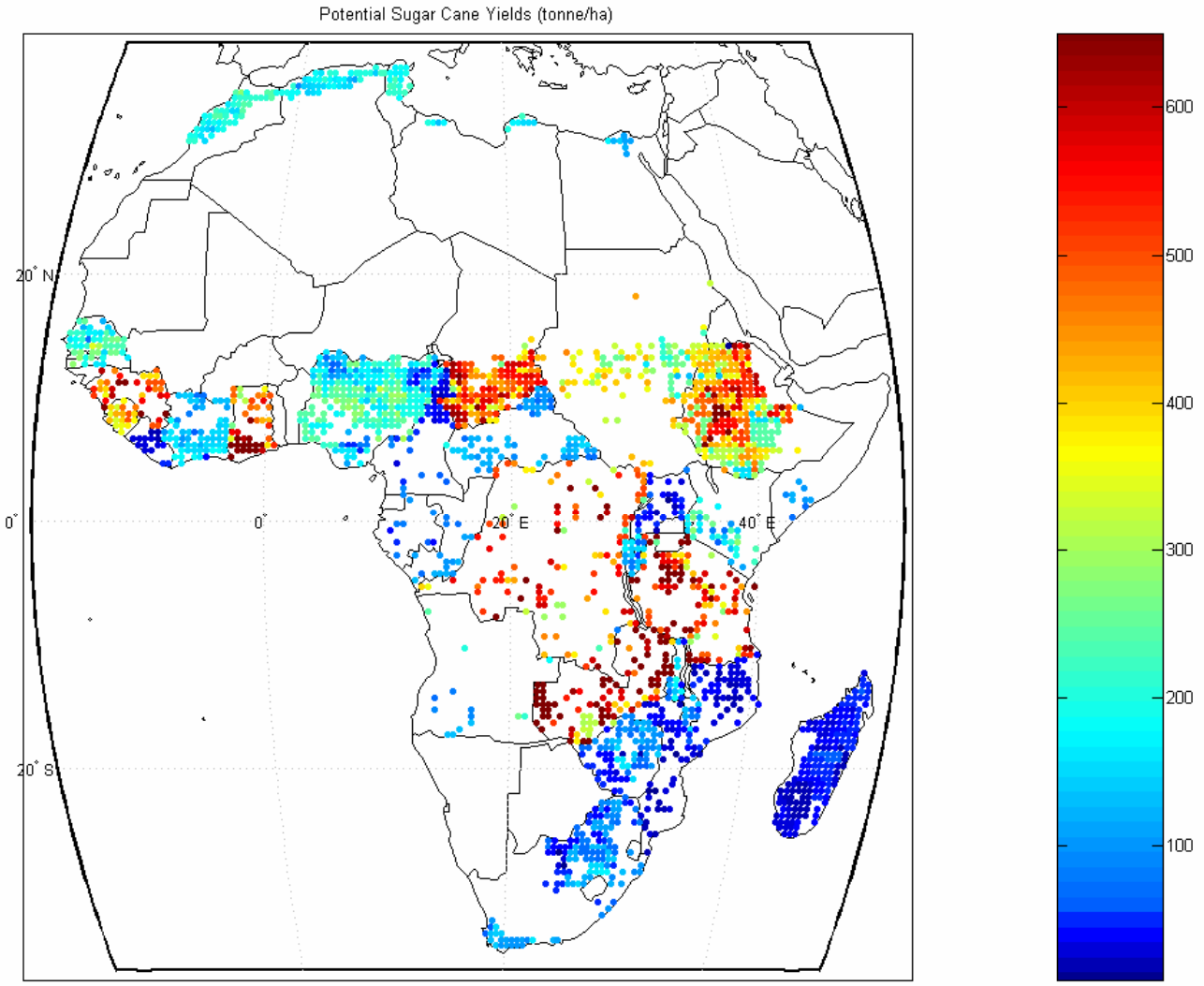
Biofuel Effects

Actual Sugar Cane Yields



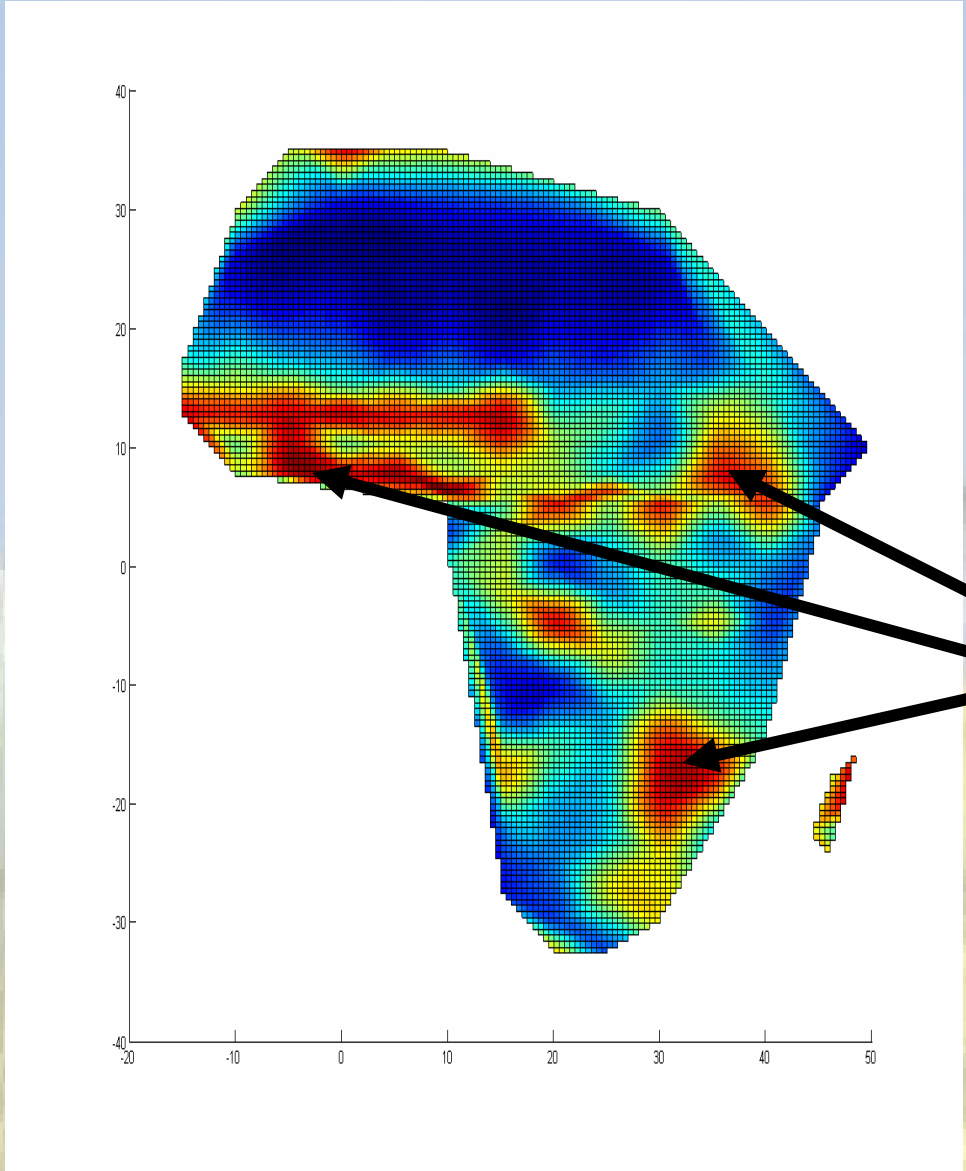
Source: Leduc et al. 2006

Sugar Cane Potential



Source: Leduc et al. 2006

Ethanol Production



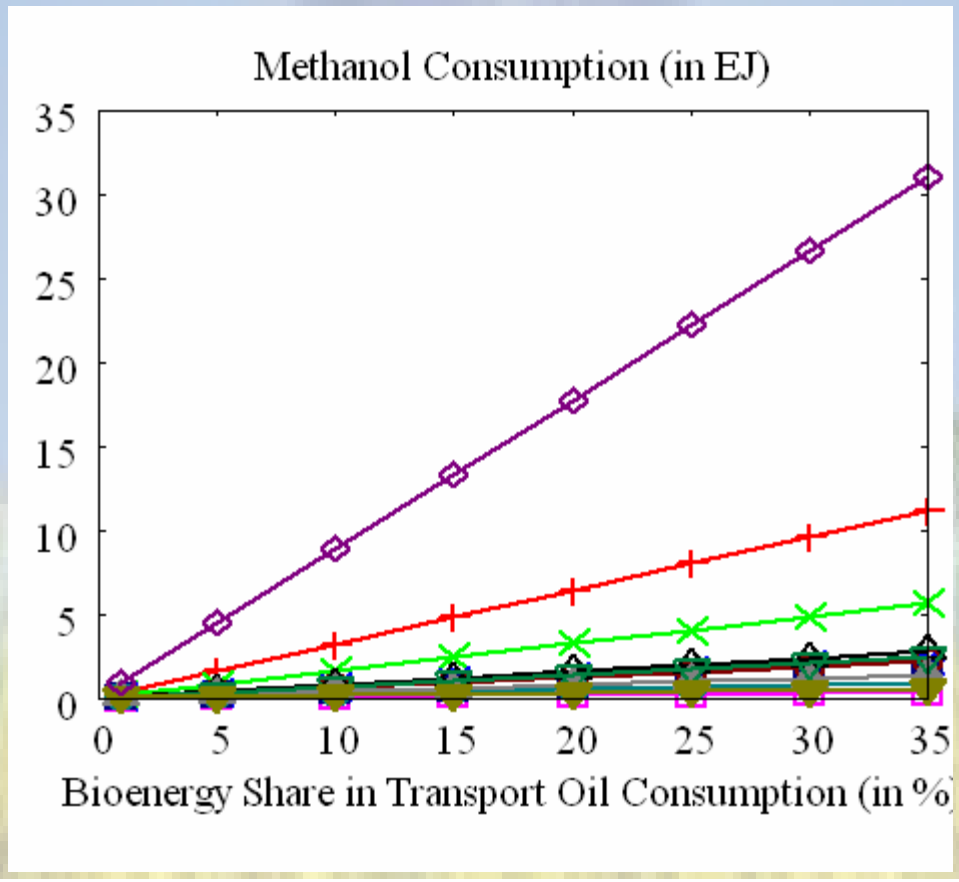
Source: Leduc et al. 2006

Africa Self Sufficient !

Productivity	200	ton / ha
Production	2.1	billion tons
Planted Area	10.5	million ha
African Arable Land Share	5.3	%
Equivalent Ethanol Productivity	15,000	L / ha
Ethanol Production	78.8	billion liters
	1.4	EJ
Africa's Fuel Consumption	1.37	EJ
Share of world ethanol Consumption	156	%
Share of world fuel Consumption	1.85	%

Source: Leduc et al. 2006

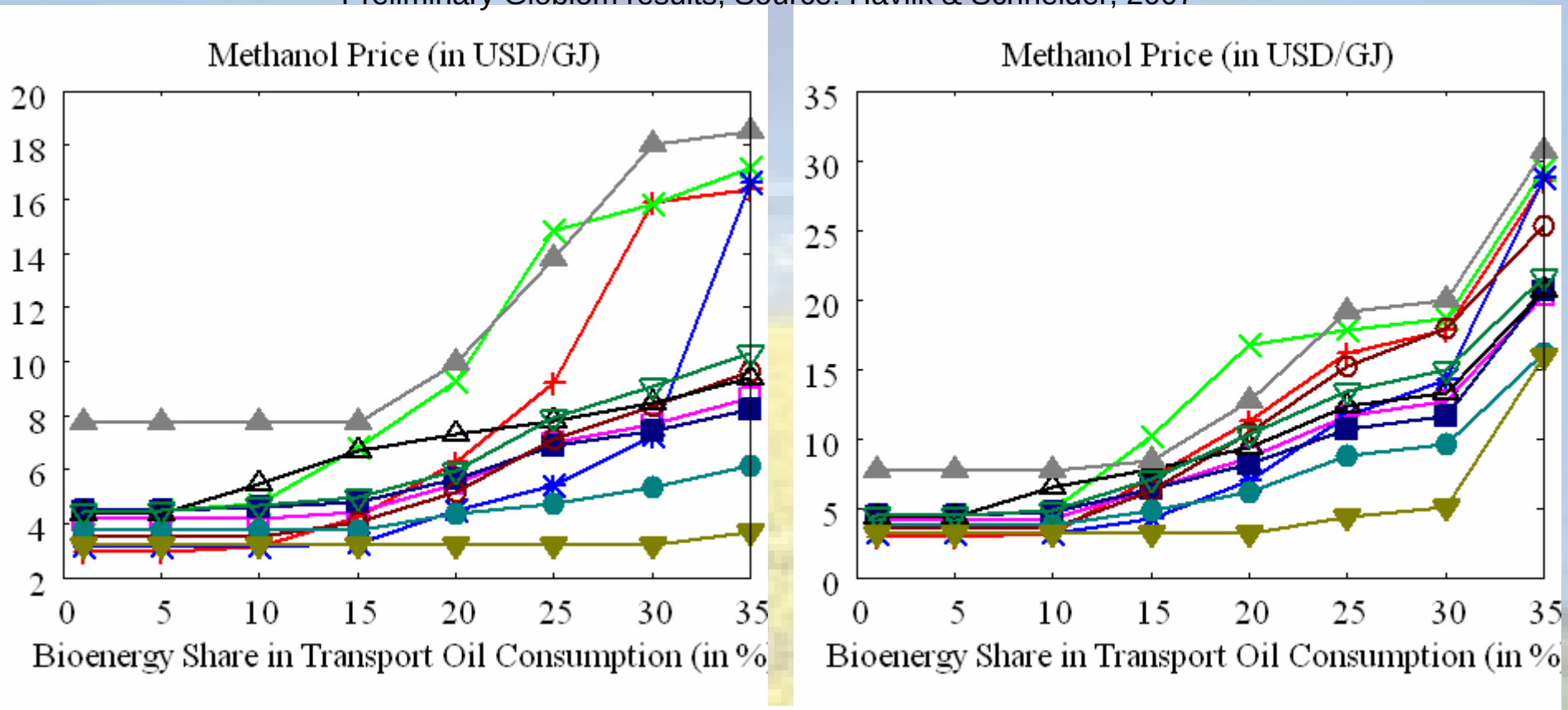
A. Methanol without and with nutritional constraints



Preliminary Globiom results, Source: Havlik & Schneider, 2007

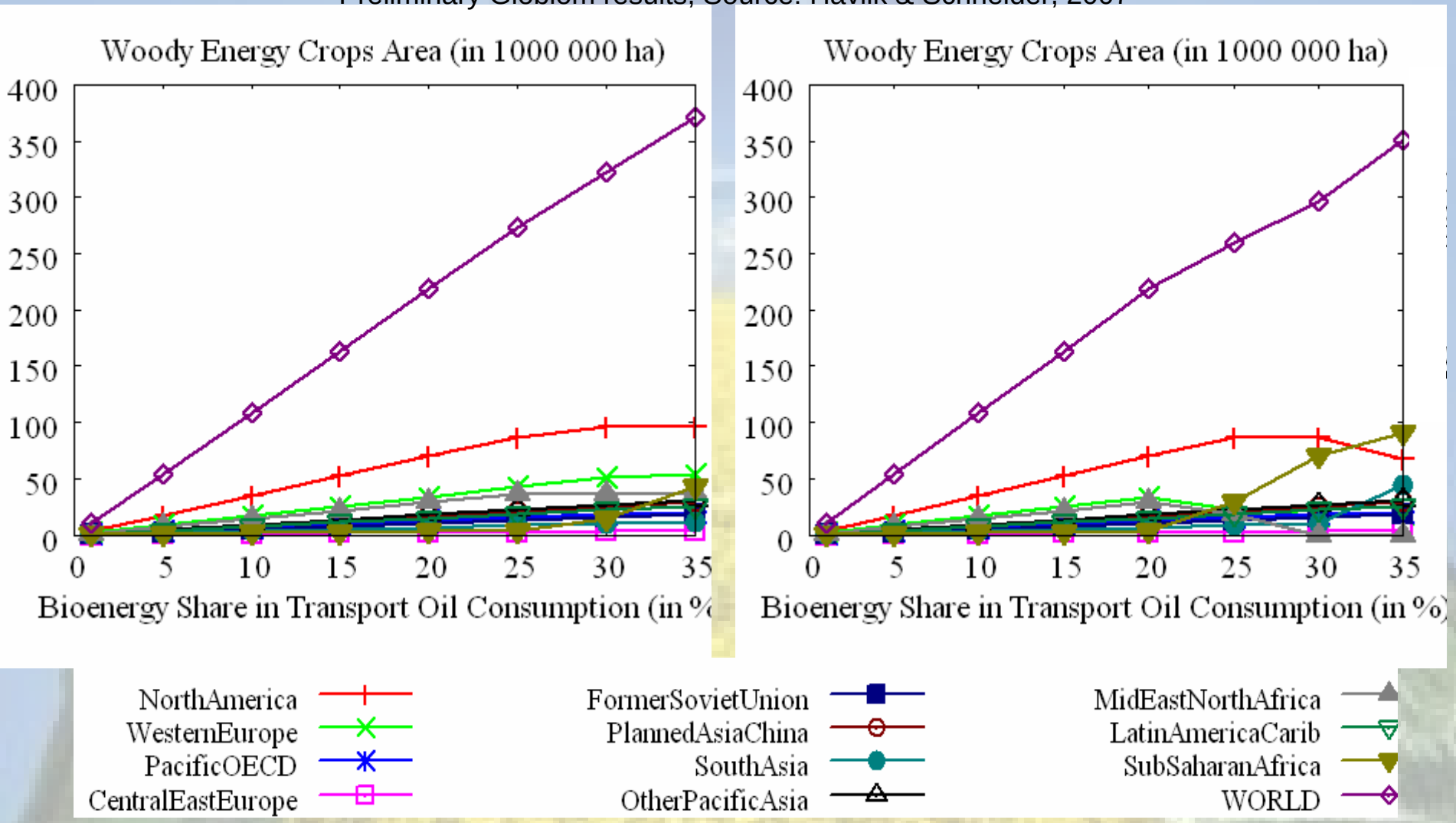
A. Methanol without and with nutritional constraints

Preliminary Globiom results, Source: Havlik & Schneider, 2007



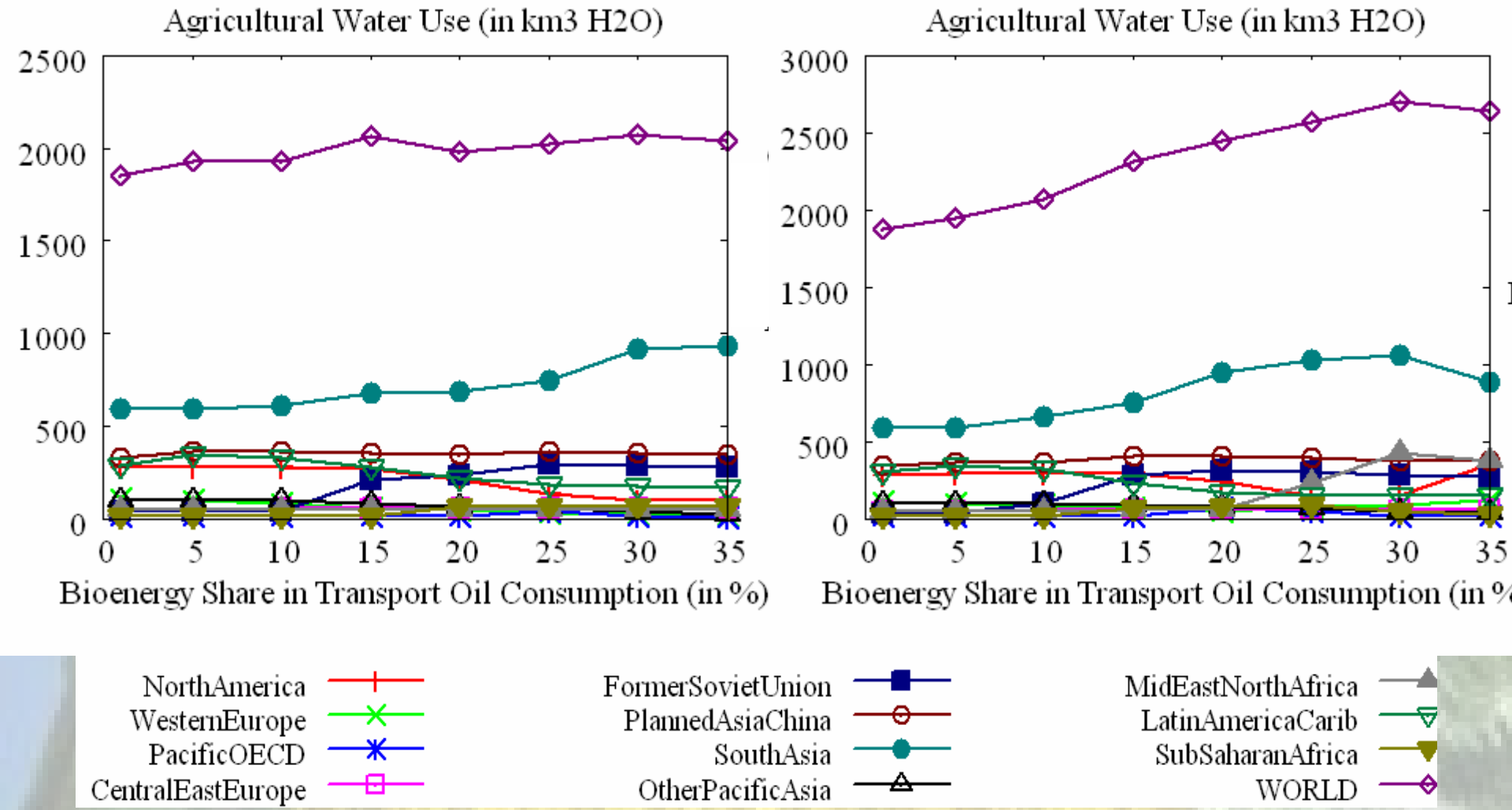
A. Methanol without and with nutritional constraints

Preliminary Globiom results, Source: Havlik & Schneider, 2007



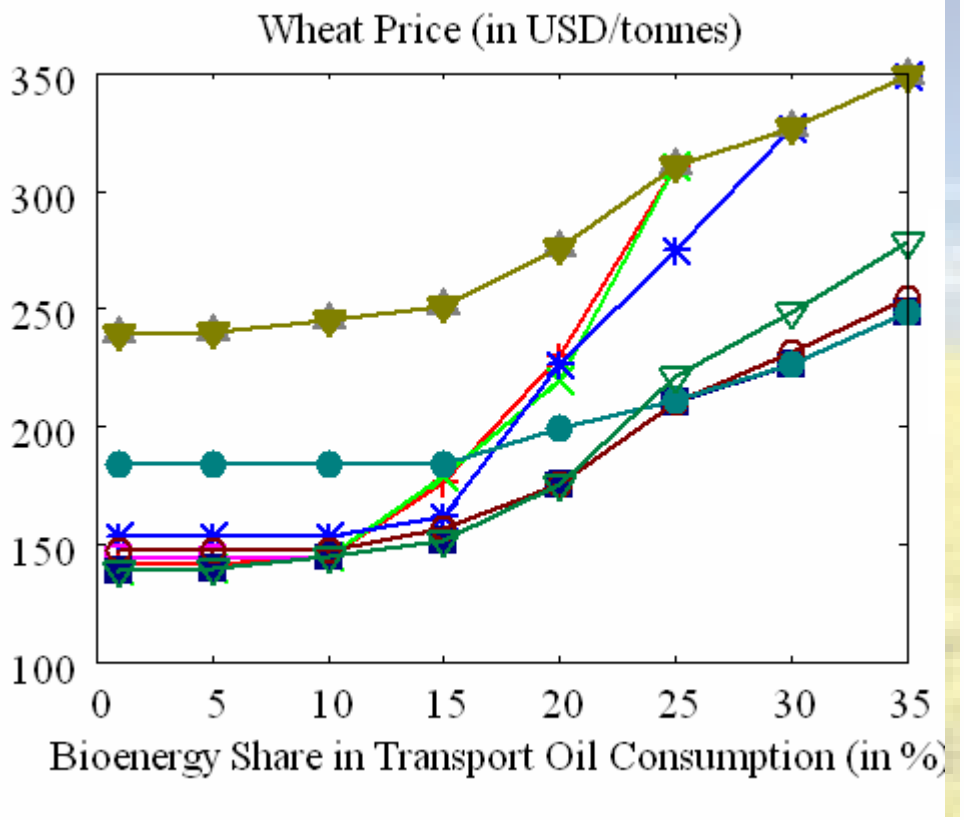
A. Methanol without and with nutritional constraints

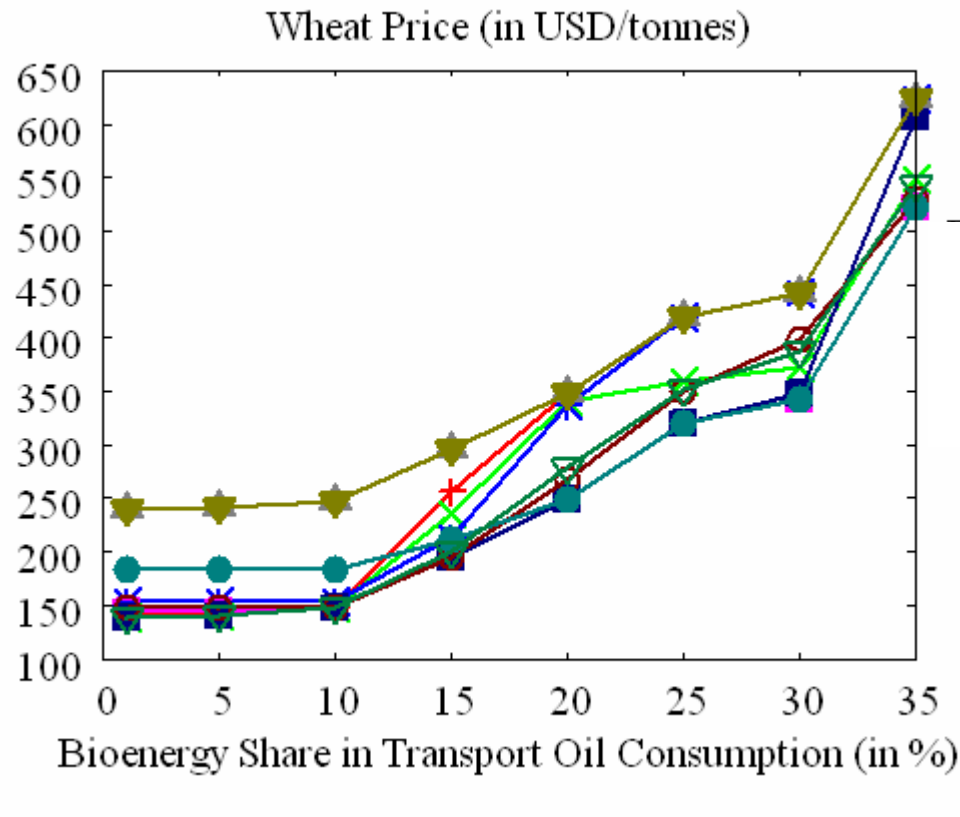
Preliminary Globiom results, Source: Havlik & Schneider, 2007



A. Methanol without and with nutritional constraints

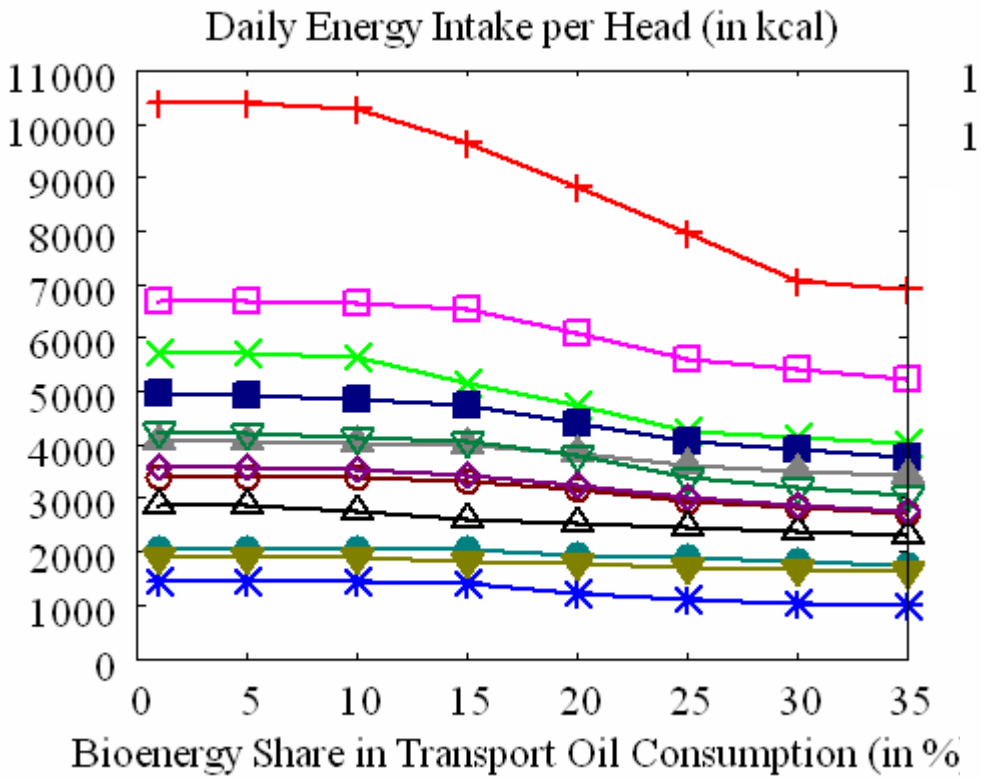
Preliminary Globiom results, Source: Havlik & Schneider, 2007

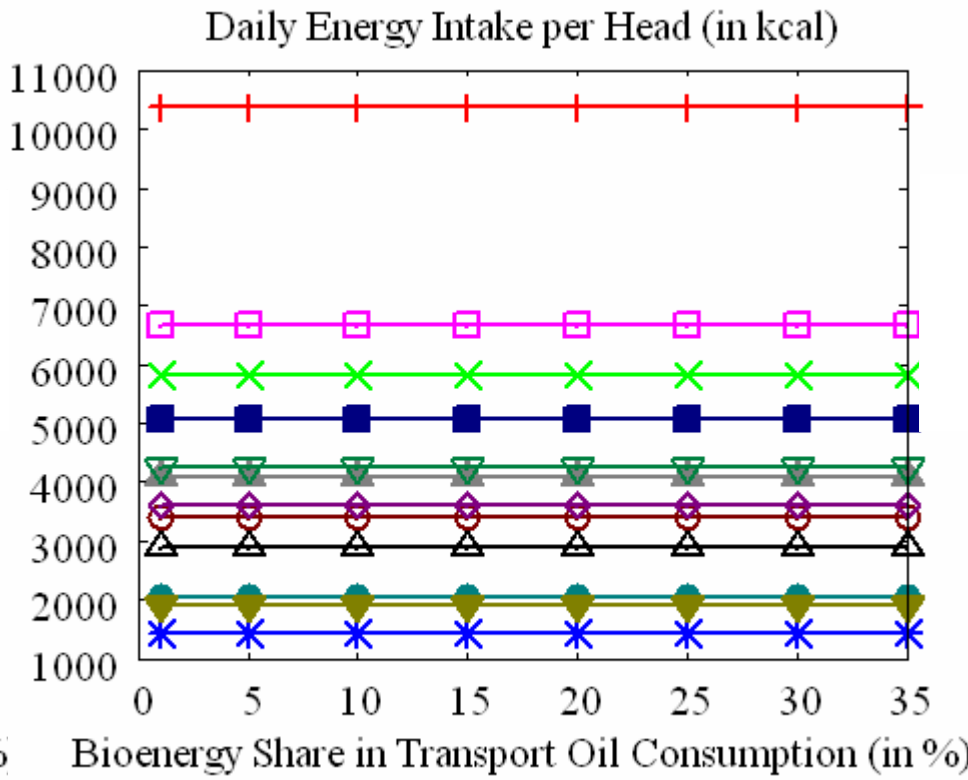




A. Methanol without and with nutritional constraints

Preliminary Globiom results, Source: Havlik & Schneider, 2007



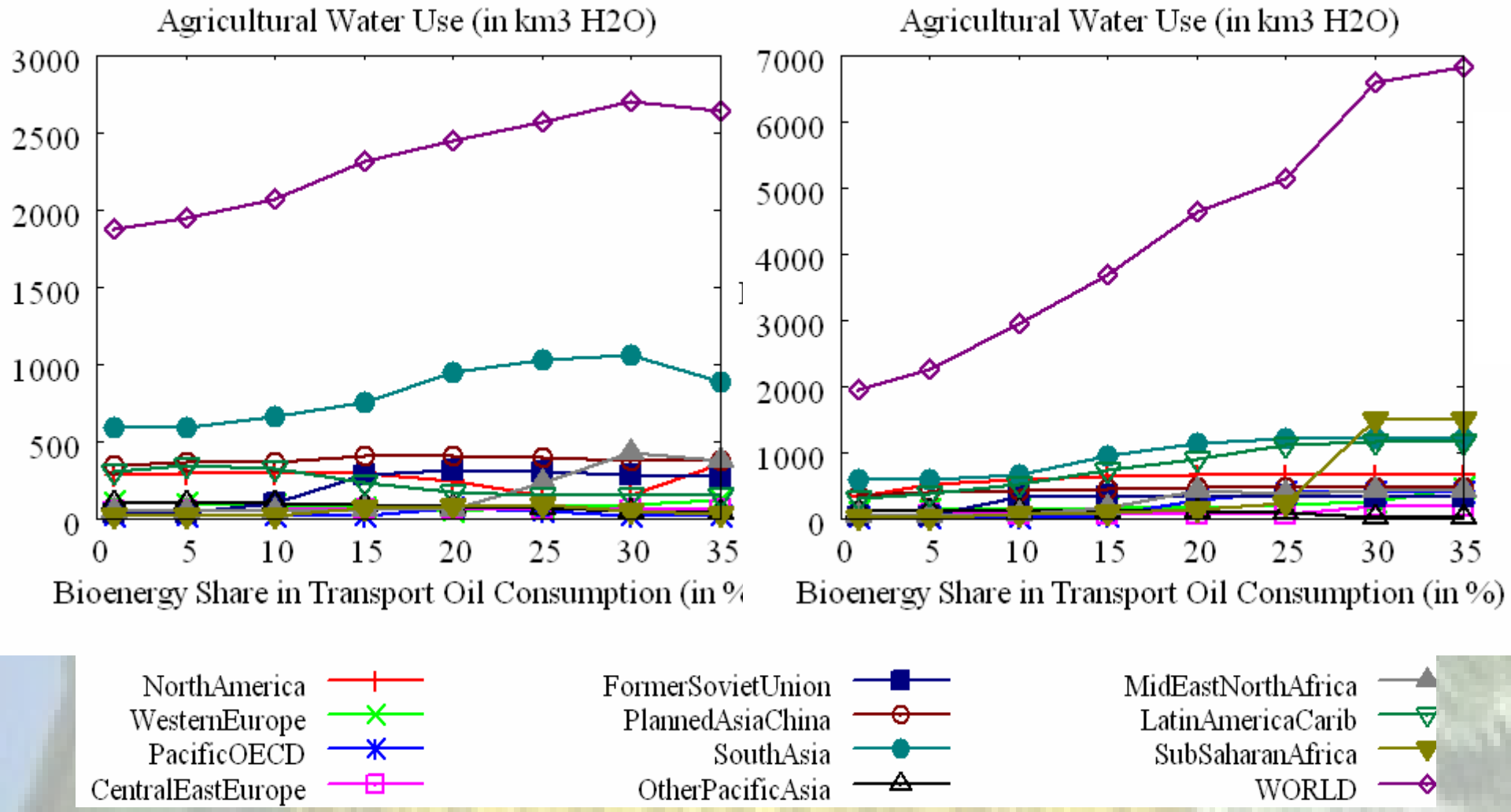


NorthAmerica
WesternEurope
PacificOECD
CentralEastEurope
FormerSovietUnion
PlannedAsiaChina
SouthAsia
OtherPacificAsia
MidEastNorthAfrica
LatinAmericaCarib
SubSaharanAfrica
WORLD

B. Methanol versus Ethanol with nutritional constraints

METHANOL **ETHANOL**

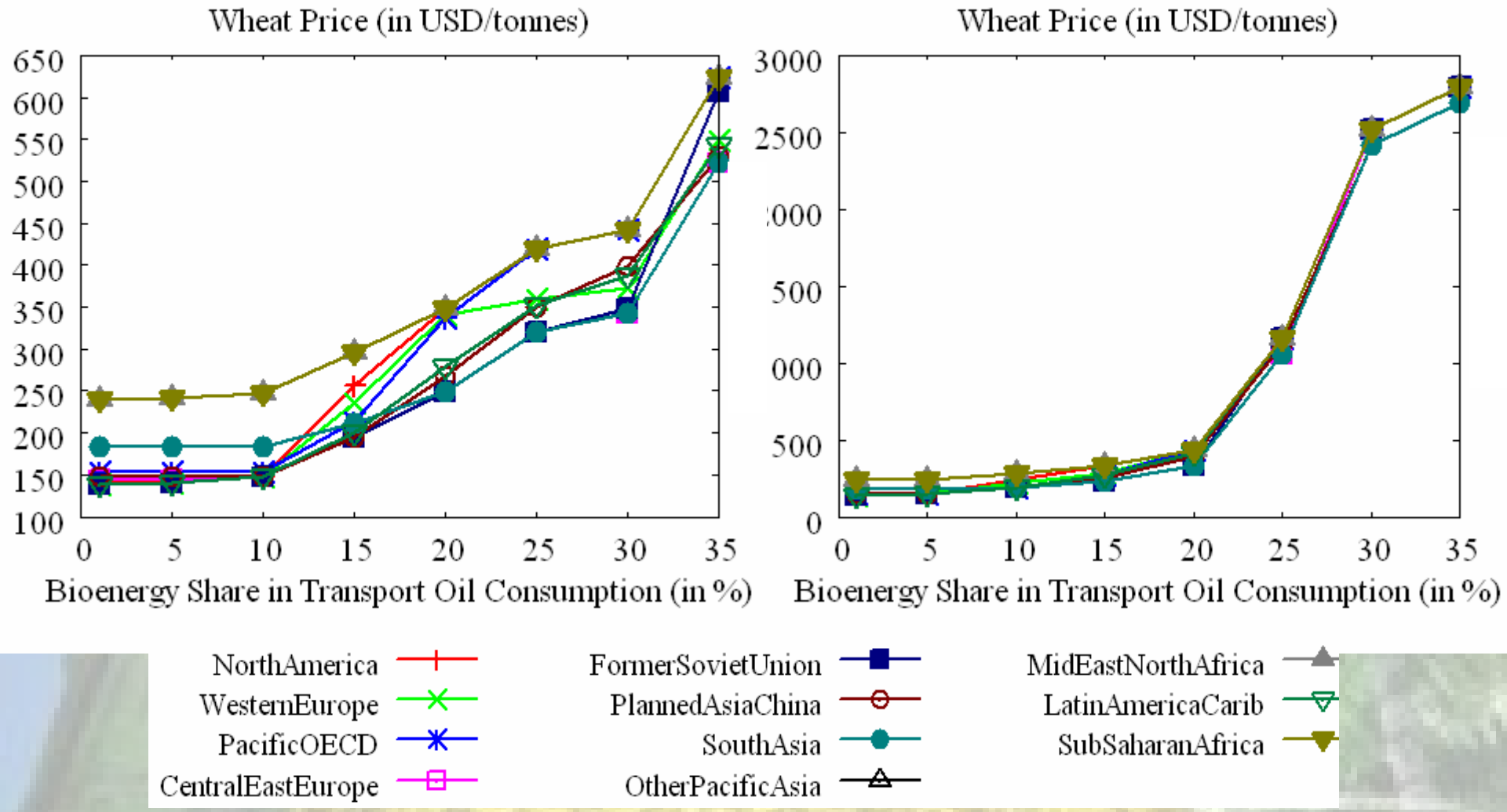
Preliminary Globiom results, Source: Havlik & Schneider, 2007



B. Methanol versus Ethanol with nutritional constraints

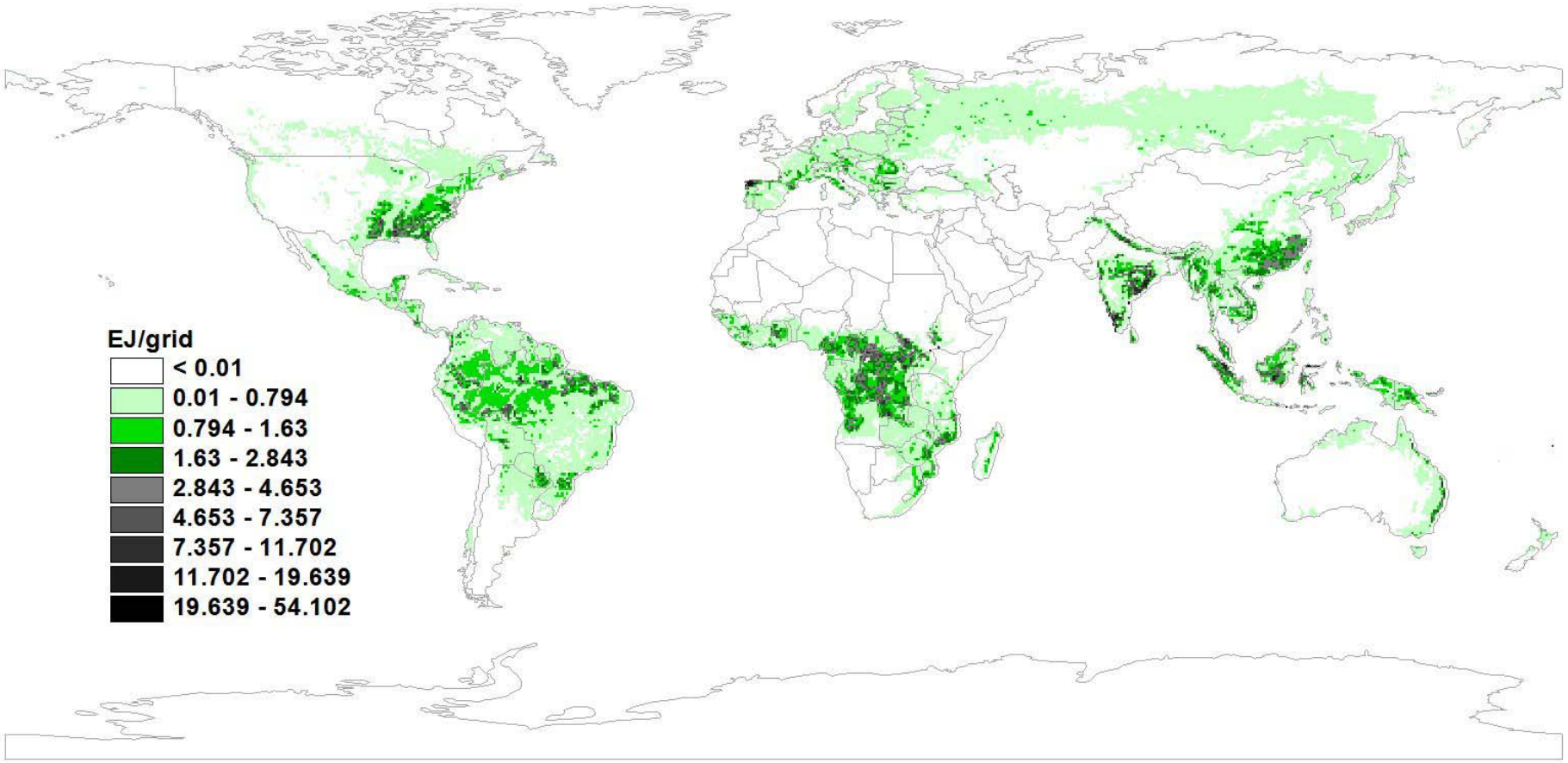
METHANOL **ETHANOL**

Preliminary Globiom results, Source: Havlik & Schneider, 2007



Sustainability constraints

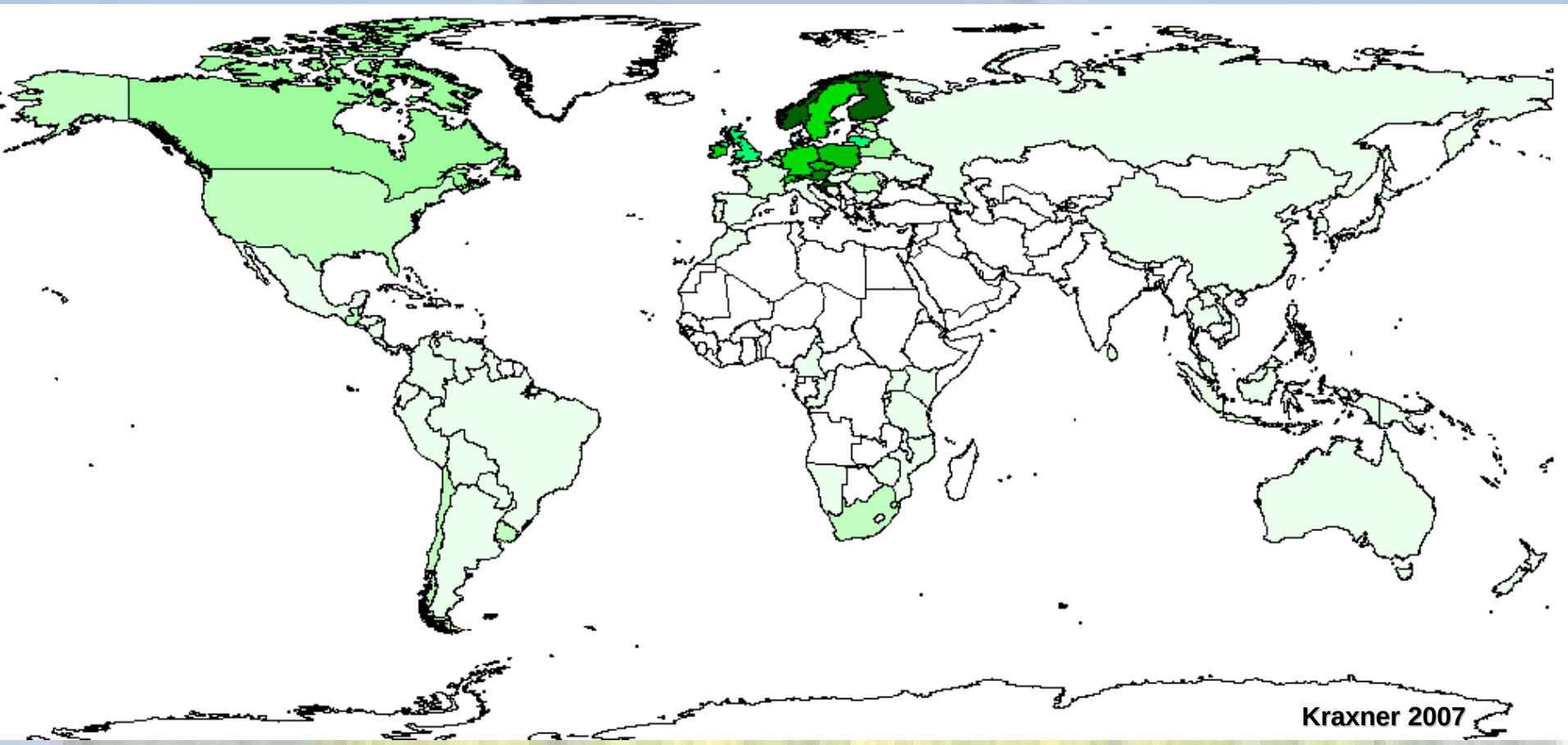
Cumulative biomass production (EJ/grid) for bioenergy 2000 - 2100



Source: Rokitianskii et al. 2006

Forest Certification Potential

Certified area relative to forest area by countries

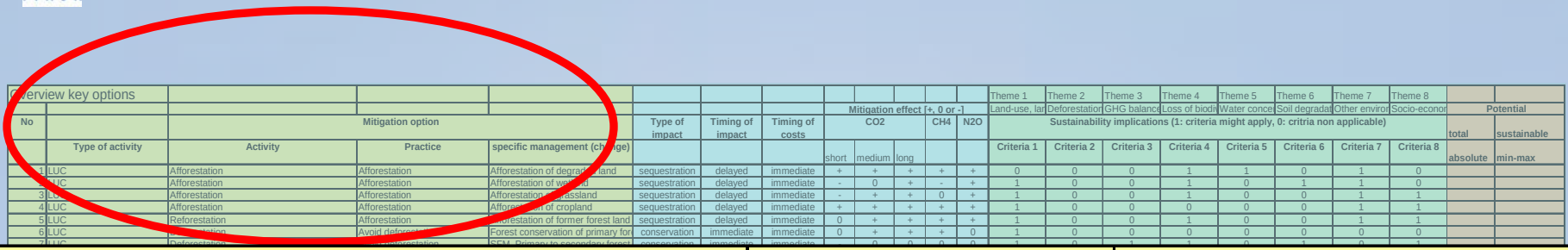


Source: compiled from FAO 2005, 2001; ATFS 2007; FSC 2007; PEFC 2007.

Mitigation – Key Options Matrix

Overview key options													Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Theme 8		
								Mitigation effect (+, 0 or -)					Land-use, lan	Deforestation	GHG balance	Loss of biodiv	Water conce	Soil degradat	Other environ	Socio-econor	Potential	
No	Mitigation option				Type of impact	Timing of impact	Timing of costs	CO2			CH4	N2O	Sustainability implications (1: criteria might apply, 0: critria non applicable)								total	sustainable
	Type of activity	Activity	Practice	specific management (change)				short	medium	long			Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	absolute	min-max
1	LUC	Afforestation	Afforestation	Afforestation of degraded land	sequestration	delayed	immediate	+	+	+	+	+	0	0	0	1	1	0	1	0		
2	LUC	Afforestation	Afforestation	Afforestation of wetland	sequestration	delayed	immediate	-	0	+	-	+	1	0	0	1	0	1	1	0		
3	LUC	Afforestation	Afforestation	Afforestation of grassland	sequestration	delayed	immediate	-	+	+	0	+	1	0	0	1	0	0	1	1		
4	LUC	Afforestation	Afforestation	Afforestation of cropland	sequestration	delayed	immediate	+	+	+	+	+	1	0	0	0	0	0	1	1		
5	LUC	Reforestation	Afforestation	Afforestation of former forest land	sequestration	delayed	immediate	0	+	+	+	+	1	0	0	1	0	0	1	1		
6	LUC	Deforestation	Avoid deforestation	Forest conservation of primary for	conservation	immediate	immediate	0	+	+	+	0	1	0	0	0	0	0	0	0		
7	LUC	Deforestation	Avoid deforestation	SFM, Primary to secondary forest	conservation	immediate	immediate	-	0	0	0	0	1	0	1	1	0	1	0	1		
8	LUC	Deforestation	Avoid deforestation	Forest conservation of secondary	conservation	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0		
9	LUC	Degradation	Avoid degradation	Sustainable Forest Management	conservation	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	0	0		
10	Vegetation C management	Forest management	Silviculture	Longer rotations	sequestration	delayed	delayed	+	+	+	0	+	1	0	0	0	0	0	1	0		
11	Vegetation C management	Forest management	Silviculture	Species change	sequestration	delayed	immediate	-	0	0	0	0	1	0	1	1	1	1	1	0		
12	Vegetation C management	Forest management	Silviculture	Continuous Cover Forestry	sequestration	delayed	immediate	+	+	+	0	+	1	0	0	0	0	0	1	0		
13	Vegetation C management	Forest management	Silviculture	Improve forest management	sequestration	delayed	immediate	0	+	+	+	+	1	0	0	1	0	0	0	0		
14	Vegetation C management	Forest management	Residue management	Reduced slash burning	conservation	immediate	delayed	+	+	+	+	+	0	0	0	0	0	0	1	0		
15	Vegetation C management	Forest management	Water management	Drainage	sequestration	delayed	immediate	-	0	+	-	-	0	0	1	1	1	1	1	0		
16	Vegetation C management	Forest management	Fire management	Fire management	conservation	immediate	immediate	-	0	+	0	+	0	0	0	1	0	0	0	0		
17	Vegetation C management	Forest management	Pest management	Pest management	conservation	immediate	immediate	-	0	+	0	+	0	0	0	1	1	1	1	0		
18	Vegetation C management	Cropland management	Agronomy	Increased productivity	sequestration	delayed	immediate	-	-	-	-	-	0	0	1	1	1	1	1	0		
19	Vegetation C management	Cropland management	Agronomy	Crop rotations	sequestration	delayed	immediate	0	+	+	0	0	0	0	0	0	0	0	0	0		
20	Vegetation C management	Cropland management	Agronomy	Catch crops	conservation	immediate	immediate	0	+	+	0	+	0	0	0	0	0	0	0	0		
21	Vegetation C management	Cropland management	Agronomy	More legumes	sequestration	delayed	immediate	0	+	+	0	+	0	0	0	1	0	0	0	0		
22	Vegetation C management	Cropland management	Agronomy	Deintensification	conservation	immediate	delayed	0	+	+	0	0	0	0	0	0	0	0	0	0		
23	Vegetation C management	Cropland management	Nutrient management	Precision farming	reduction	immediate	immediate	0	+	+	0	0	0	0	0	0	0	0	0	0		
24	Vegetation C management	Cropland management	Nutrient management	Reduced fertilizer rates	reduction	immediate	delayed	0	0	+	+	0	0	0	0	0	0	1	0	1		
25	Vegetation C management	Cropland management	Nutrient management	Fertilizer free zones	reduction	immediate	delayed	0	0	+	+	+	0	0	0	0	0	1	0	1		
26	Vegetation C management	Cropland management	Tillage / residue management	Reduced tillage	conservation	immediate	delayed	+	+	+	+	+	0	0	0	0	0	0	0	1		
27	Vegetation C management	Cropland management	Tillage / residue management	Zero tillage	conservation	immediate	delayed	+	+	+	+	+	0	0	0	0	0	0	0	1		
28	Vegetation C management	Cropland management	Tillage / residue management	Reduced residue removal	sequestration	delayed	delayed	0	+	+	0	0	0	0	0	0	0	0	0	0		
29	Vegetation C management	Cropland management	Tillage / residue management	Reduced residue burning	conservation	immediate	delayed	+	+	+	0	0	0	0	0	0	0	0	0	0		
30	Vegetation C management	Cropland management	Upland water management	Irrigation	reduction	immediate	immediate	-	-	-	-	-	1	0	0	0	1	1	1	1		
31	Vegetation C management	Cropland management	Upland water management	Drainage	reduction	immediate	immediate	-	-	-	-	-	0	0	1	1	0	0	1	0		
32	Vegetation C management	Cropland management	Rice management	Improved water management	reduction	immediate	immediate	0	+	+	+	+	0	0	0	0	0	0	0	0		
33	Vegetation C management	Cropland management	Rice management	Improved fertilization	reduction	immediate	immediate	0	0	+	0	0	0	0	1	0	1	0	1	0		
34	Vegetation C management	Cropland management	Rice management	Improved cultivars	reduction	immediate	immediate	0	0	+	0	0	0	0	0	1	1	0	1	0		
35	Vegetation C management	Cropland management	Set-aside and land-use change	Set-aside	sequestration	delayed	immediate	0	+	+	+	+	1	0	0	0	0	0	0	1		
36	Vegetation C management	Cropland management	Set-aside and land-use change	Wetland restoration	sequestration	delayed	immediate	+	+	+	+	+	0	0	0	0	0	0	0	1		
37	Vegetation C management	Agroforestry	Set-aside and land-use change	Tree crops, shelter belts etc.	sequestration	delayed	immediate	0	+	+	+	+	0	0	0	0	0	0	0	0		
38	Vegetation C management	Grazing land management	Livestock grazing intensity	Livestock grazing intensification	reduction	immediate	immediate	-	-	-	-	-	0	0	1	1	1	1	1	0		
39	Vegetation C management	Grazing land management	Fertilization	Fertilization	sequestration	immediate	immediate	-	0	0	-	-	0	0	1	1	0	0	1	0		
40	Vegetation C management	Grazing land management	Fire management	Fire management	conservation	immediate	immediate	0	0	+	0	0	0	0	1	0	0	0	1	0		
41	Vegetation C management	Grazing land management	Increased productivity	Increasing productivity	sequestration	delayed	immediate	-	-	-	-	-	0	0	1	1	1	1	1	0		
42	Vegetation C management	Organic soils	Restoration	Rewetting / abandonment	sequestration	delayed	immediate	0	0	+	+	0	1	0	0	0	0	1	0	1		
43	Vegetation C management	Degraded lands	Restoration	Restoration	sequestration	delayed	immediate	0	0	+	+	0	0	0	0	0	0	0	0	0		
44	Vegetation C management	Livestock management	Livestock management	Improved feeding practices	reduction	immediate	immediate	0	0	0	0	0	0	0	1	1	1	1	1	0		
45	Vegetation C management	Manure / biosolid management	Manure / biosolid management	More efficient use of manure	reduction	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
46	Bioenergy	Sugar cane	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
47	Bioenergy	Sugar cane	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
48	Bioenergy	Sugar cane	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0		
49	Bioenergy	Corn	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0	0 (1)	1	1	1	1	1		
50	Bioenergy	Corn	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	0	0	0	0	1	0	0 (1)	1	1	1	1	1		
51	Bioenergy	Corn	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0		
52	Bioenergy	Rapeseed	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1		
53	Bioenergy	Rapeseed	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1		
54	Bioenergy	Rapeseed	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0		
55	Bioenergy	Oil palm	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
56	Bioenergy	Oil palm	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
57	Bioenergy	Oil palm	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	1	1		
58	Bioenergy	Agriculture (generic)	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0		
59	Bioenergy	Agriculture (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0		
60	Bioenergy	Agriculture (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	0	0		
61	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, first generation	Methanol	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0		
62	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0		
63	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0		
64	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Electricity	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	0	0		
65	Bioenergy	Forestry (generic)	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	0	0	0	0	0	0	0	0		
66	Bioenergy	Forestry (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
67	Bioenergy	Forestry (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
68	Bioenergy	Residues from agriculture	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
69	Bioenergy	Residues from agriculture	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
70	Bioenergy	Residues from agriculture	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
71	Bioenergy	Residues from forestry	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
72	Bioenergy	Residues from forestry	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
73	Bioenergy	Residues from forestry	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
74	Biomaterials	Fibre products	Wood products	Increase forest product recycling	substitution	immediate	immediate	0	+	+	0	0	0	0	0	0	0	0	1	1		
75	Biomaterials	Fibre products	Wood products	Increase forest product use	substitution	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	1	1		
76	Biomaterials	Chemical products	Chemicals	Increase product chain efficiency	substitution	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0		
77	Biomaterials	Chemical products	Chemicals	Increase biomaterial use	substitution	immediate	immediate	0	0	+	0	0	1	0 (1)	0	0	0	0	1	1		

Source: The Global Potential of Sustainable Forestry for Bioenergy Supply and Climate Change Mitigation, (IIASA for WWF, unpublished, 2007)



Overview key options

No	Mitigation option				Type of impact	Timing of impact	Timing of costs	Mitigation effect [+, 0 or -]				
								CO2			CH4	N2O
	Type of activity	Activity	Practice	specific management (change)				short	medium	long		
1	LUC	Afforestation	Afforestation	Afforestation of degraded land	sequestration	delayed	immediate	+	+	+	+	+
2	LUC	Afforestation	Afforestation	Afforestation of wetland	sequestration	delayed	immediate	-	0	+	-	+
3	LUC	Afforestation	Afforestation	Afforestation of grassland	sequestration	delayed	immediate	-	+	+	0	+
4	LUC	Afforestation	Afforestation	Afforestation of cropland	sequestration	delayed	immediate	+	+	+	+	+
5	LUC	Reforestation	Afforestation	Reforestation of former forest land	sequestration	delayed	immediate	0	+	+	+	+
6	LUC	Avoid deforestation		Forest conservation of primary for	conservation	immediate	immediate	0	+	+	+	0
7	LUC	Deforestation		SFM, Primary to secondary forest	conservation	immediate	immediate	-	0	0	0	0

No	Sustainability implications (1: criteria might apply, 0: critria non applicable)								Potential	
	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Theme 8		
	Land-use, lan	Deforestation	GHG balance	Loss of biodiv	Water conce	Soil degradat	Other environ	Socio-econor	total	sustainable
	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	absolute	min-max
1	0	0	0	1	1	0	1	0		
2	1	0	0	1	0	1	1	0		
3	1	0	0	1	0	0	1	1		
4	1	0	0	0	0	0	1	1		
5	1	0	0	1	0	0	1	1		
6	1	0	0	0	0	0	0	0		
7	1	0	1	1	0	1	0	1		

Overview key options

	Mitigation option		
Type of activity	**Activity**	**Practice**	**specific management (change)**
LUC	Deforestation	Avoid deforestation	Forest conservation of primary forest
Vegetation C management	Cropland management	Nutrient management	Precision farming
Bioenergy	Sugar cane	Biofuel, first generation	Biodiesel
Bioenergy	Corn	Biofuel, first generation	Bioethanol…
Bioenergy	Rapeseed	Biofuel, second generation	BM gasification/syngas
Bioenergy	Agriculture (generic)	Combustion	Heat
Bioenergy	Agriculture (generic)	Combustion	Electricity
Bioenergy	Poplar, pine, willow energy plantation	Biofuel, second generation	BM gasification/syngas
Biomaterials	Fibre products	Wood products	Increase forest product recycling
Biomaterials	Fibre products	Wood products	Increase forest product use
Biomaterials	Chemical products	Chemicals	Increase product chain efficiency
Biomaterials	Chemical products	Chemicals	Increase biomaterial use
……	……	……	……

No	Type of activity	Activity	Practice	specific management (change)	Type of impact	Timing of impact	Timing of costs	CO2 short	CO2 medium	CO2 long	CH4	N2O	Land-use, lan	Deforestation	GHG balance	Loss of biodiv	Water conce	Soil degradat	Other environ	Socio-econor	total	sustainable
													Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	absolute	min-max
51	Bioenergy	Corn	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	1	0		
52	Bioenergy	Rapeseed	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1		
53	Bioenergy	Rapeseed	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1		
54	Bioenergy	Rapeseed	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0		
55	Bioenergy	Oil palm	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
56	Bioenergy	Oil palm	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
57	Bioenergy	Oil palm	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	1	1		
58	Bioenergy	Agriculture (generic)	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0		
59	Bioenergy	Agriculture (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0		
60	Bioenergy	Agriculture (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	0	0		
61	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, first generation	Methanol	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0		
62	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0		
63	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0		
64	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Electricity	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	0	0		
65	Bioenergy	Forestry (generic)	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	0	0	0	0	0	0	0	0		
66	Bioenergy	Forestry (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
67	Bioenergy	Forestry (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
68	Bioenergy	Residues from agriculture	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
69	Bioenergy	Residues from agriculture	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
70	Bioenergy	Residues from agriculture	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
71	Bioenergy	Residues from forestry	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
72	Bioenergy	Residues from forestry	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
73	Bioenergy	Residues from forestry	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
74	Biomaterials	Fibre products	Wood products	Increase forest product recycling	substitution	immediate	immediate	0	+	+	0	0	0	0	0	0	0	0	1	1		
75	Biomaterials	Fibre products	Wood products	Increase forest product use	substitution	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	1	1		
76	Biomaterials	Chemical products	Chemicals	Increase product chain efficiency	substitution	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0		
77	Biomaterials	Chemical products	Chemicals	Increase biomaterial use	substitution	immediate	immediate	0	0	+	0	0	1	0 (1)	0	0	0	0	1	1		

Overview key options

No	Mitigation option			Type of impact	Timing of impact	Timing of costs	Mitigation effect [+, 0 or -]					Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Theme 8	Potential	
							CO2			CH4	N2O	Sustainability implications (1: criteria might apply, 0: critria non applicable)								total	sustainable
	Type of activity	Activity	Practice	specific management (change)			short	medium	long			Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	absolute	min-max
1	LUC	Afforestation	Afforestation	Afforestation of degraded land	sequestration	delayed	immediate	+	+	+	+	+	0	0	0	1	1	0	1	0	
2	LUC	Afforestation	Afforestation	Afforestation of wetland	sequestration	delayed	immediate	-	0	+	+	+	1	0	0	1	0	1	1	0	
3	LUC	Afforestation	Afforestation	Afforestation of grassland	sequestration	delayed	immediate	+	+	+	0	+	1	0	0	1	0	0	1	1	
4	LUC	Afforestation	Afforestation	Afforestation of cropland	sequestration	delayed	immediate	+	+	+	+	+	1	0	0	0	0	0	1	1	
5	LUC	Reforestation	Afforestation	Afforestation of former forest land	sequestration	delayed	immediate	0	+	+	+	+	1	0	0	1	0	0	1	1	
6	LUC	Deforestation	Avoid deforestation	Forest conservation of primary for	conservation	immediate	immediate	0	+	+	+	0	1	0	0	0	0	0	0	0	
7	LUC	Deforestation	Avoid deforestation	SFM, Primary to secondary forest	conservation	immediate	immediate	-	0	0	0	0	1	0	1	1	0	1	0	1	
8	LUC	Deforestation	Avoid deforestation	Forest conservation of secondary	conservation	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0	
9	LUC	Degradation	Avoid degradation	Sustainable Forest Management	conservation	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	0	0	
10	Vegetation C management	Forest management	Silviculture	Longer rotations	sequestration	delayed	delayed	+	+	+	0	+	1	0	0	0	0	0	1	0	
11	Vegetation C management	Forest management	Silviculture	Species change	sequestration	delayed	immediate	-	0	0	0	0	1	0	1	1	1	1	1	0	
12	Vegetation C management	Forest management	Silviculture	Continuous Cover Forestry	sequestration	delayed	immediate	+	+	+	0	+	1	0	0	0	0	0	1	0	
47	Bioenergy	Sugar cane	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1	
48	Bioenergy	Sugar cane	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0	
49	Bioenergy	Corn	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0	0 (1)	1	1	1	1	1	
50	Bioenergy	Corn	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	0	0	0	0	1	0	0 (1)	1	1	1	1	1	
51	Bioenergy	Corn	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0	
52	Bioenergy	Rapeseed	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1	
53	Bioenergy	Rapeseed	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1	
54	Bioenergy	Rapeseed	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0	
55	Bioenergy	Oil palm	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1	
56	Bioenergy	Oil palm	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1	
57	Bioenergy	Oil palm	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	1	1	
58	Bioenergy	Agriculture (generic)	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0	
59	Bioenergy	Agriculture (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0	
60	Bioenergy	Agriculture (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	0	0	
61	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, first generation	Methanol	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0	
62	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0	
63	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0	
64	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Electricity	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	0	0	
65	Bioenergy	Forestry (generic)	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	0	0	0	0	0	0	0	0	
66	Bioenergy	Forestry (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0	
67	Bioenergy	Forestry (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0	
68	Bioenergy	Residues from agriculture	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1	
69	Bioenergy	Residues from agriculture	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1	
70	Bioenergy	Residues from agriculture	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1	
71	Bioenergy	Residues from forestry	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1	
72	Bioenergy	Residues from forestry	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1	
73	Bioenergy	Residues from forestry	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1	
74	Biomaterials	Fibre products	Wood products	Increase forest product recycling	substitution	immediate	immediate	0	+	+	0	0	0	0	0	0	0	0	1	1	
75	Biomaterials	Fibre products	Wood products	Increase forest product use	substitution	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	1	1	
76	Biomaterials	Chemical products	Chemicals	Increase product chain efficiency	substitution	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0	
77	Biomaterials	Chemical products	Chemicals	Increase biomaterial use	substitution	immediate	immediate	0	0	+	0	0	1	0 (1)	0	0	0	0	1	1	

			Mitigation effect [+, 0 or -]				
Type of impact	Timing of impact	Timing of costs	CO2			CH4	N2O
			short	medium	long		
sequestration	delayed	immediate	-	0	+	-	+
conservation	immediate	immediate	0	+	+	+	0
reduction	immediate	immediate	0	+	+	0	0

Overview key options

No	Type of activity	Activity	Practice	specific management (change)	Type of impact	Timing of impact	Timing of costs	Mitigation effect [+, 0 or -] CO2 short	CO2 medium	CO2 long	CH4	N2O	Theme 1 Land-use, land availability and land-use conflicts	Theme 2 Deforestation	Theme 3 GHG balance	Theme 4 Loss of biodiversity	Theme 5 Water concerns	Theme 6 Soil degradation	Theme 7 Other environmental concerns	Theme 8 Socio-economic standards	Potential absolute	Potential sustainable min-max
													Sustainability implications (1: criteria might apply, 0: critria non applicable)									
													Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8		
1	LUC	Afforestation	Afforestation	Afforestation of degraded land	sequestration	delayed	immediate	+	+	+	+	+		0	0	1	1	0	1			
2	LUC	Afforestation	Afforestation	Afforestation of wetland	sequestration	delayed	immediate	-	0	+	-	+	1	0	0	1	0	1	1	0		
3	LUC	Afforestation	Afforestation	Afforestation of grassland	sequestration	delayed	immediate	-	+	+	0	+	1		0	1	0	0	1	1		
4	LUC	Afforestation	Afforestation	Afforestation of cropland	sequestration	delayed	immediate	+	+	+	+	+	1	0		0	0	0	1	1		
5	LUC	Reforestation	Afforestation	Afforestation of former forest land	sequestration	delayed	immediate	0	+	+	+	+	1	0	0	1	0	0	1	1		
6	LUC	Deforestation	Avoid deforestation	Forest conservation of primary for	conservation	immediate	immediate	0	+	+	+	0	1	0	0	0	0	0	0	0		
7	LUC	Deforestation	Avoid deforestation	SFM, Primary to secondary forest	conservation	immediate	immediate	-	0	0	0	0	1	0	1	1	0	1	0	1		
8	LUC	Deforestation	Avoid deforestation	Forest conservation of secondary	conservation	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0		
9	LUC	Degradation	Avoid degradation	Sustainable Forest Management	conservation	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	0	0		
10	Vegetation C management	Forest management	Silviculture	Longer rotations	sequestration	delayed	delayed	+	+	+	0	+	1	0	0	0	0	0	1	0		
11	Vegetation C management	Forest management	Silviculture	Species change	sequestration	delayed	immediate	-	0	0	0	0	1	0	1	1	1	1	1	0		
12	Vegetation C management	Forest management	Silviculture	Continuous Cover Forestry	sequestration	delayed	immediate	+	+	+	0	+	1	0	0	0	0	0	1	0		
13	Vegetation C management	Forest management	Silviculture	Improve forest management	sequestration	delayed	immediate	0	+	+	+	+	1	0	0	1	0	0	0	0		
14	Vegetation C management	Forest management	Residue management	Reduced slash burning	conservation	immediate	delayed	+	+	+	+	+	0	0	0	0	0	0	1	0		
15	Vegetation C management	Forest management	Water management	Drainage	sequestration	delayed	immediate	-	0	+	-	-	0	0	1	1	1	1	1	0		
16	Vegetation C management	Forest management	Fire management	Fire management	conservation	immediate	immediate	-	0	+	0	+	0	0	0	1	0	0	0	0		
17	Vegetation C management	Forest management	Pest management	Pest management	conservation	immediate	immediate	-	0	+	0	+	0	0	0	1	1	1	1	0		
18	Vegetation C management	Cropland management	Agronomy	Increased productivity	sequestration	delayed	immediate	-	-	-	-	-	0	0	1	1	1	1	1	0		
19	Vegetation C management	Cropland management	Agronomy	Crop rotations	sequestration	delayed	immediate	0	+	+	0	0	0	0	0	0	0	0	0	0		
20	Vegetation C management	Cropland management	Agronomy	Catch crops	conservation	immediate	immediate	0	+	+	0	+	0	0	0	0	0	0	0	0		
40	Vegetation C management	Grazing land management	Fire management	Fire management	conservation	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	0	0		
41	Vegetation C management	Grazing land management	Increased productivity	Increasing productivity	sequestration	delayed	immediate	-	-	-	-	-	0	0	1	1	1	1	1	0		
42	Vegetation C management	Organic soils	Restoration	Rewetting / abandonment	sequestration	delayed	immediate	0	0	+	+	0	1	0	0	0	0	1	0	1		
43	Vegetation C management	Degraded lands	Restoration	Restoration	sequestration	delayed	immediate	0	0	+	+	0	0	0	0	0	0	0	0	0		
44	Vegetation C management	Livestock management	Livestock management	Improved feeding practices	reduction	immediate	immediate	0	0	0	0	0	0	0	1	1	1	1	1	0		
45	Vegetation C management	Manure / biosolid management	Manure / biosolid management	More efficient use of manure	reduction	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
46	Bioenergy	Sugar cane	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
47	Bioenergy	Sugar cane	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
48	Bioenergy	Sugar cane	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0		
49	Bioenergy	Corn	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0	0 (1)	1	1	1	1	1		
50	Bioenergy	Corn	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	0	0	0	0	1	0	0 (1)	1	1	1	1	1		
51	Bioenergy	Corn	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0		
52	Bioenergy	Rapeseed	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1		
53	Bioenergy	Rapeseed	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1		
54	Bioenergy	Rapeseed	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0		
55	Bioenergy	Oil palm	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
56	Bioenergy	Oil palm	Biofuel, first generation	Bioethanol…	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
57	Bioenergy	Oil palm	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	1	1		
58	Bioenergy	Agriculture (generic)	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0		
59	Bioenergy	Agriculture (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0		
60	Bioenergy	Agriculture (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	0	0		
61	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, first generation	Methanol	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0		
62	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0		
63	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0		
64	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Electricity	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	0	0		
65	Bioenergy	Forestry (generic)	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	0	0	0	0	0	0	0	0		
66	Bioenergy	Forestry (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
67	Bioenergy	Forestry (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
68	Bioenergy	Residues from agriculture	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
69	Bioenergy	Residues from agriculture	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
70	Bioenergy	Residues from agriculture	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
71	Bioenergy	Residues from forestry	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
72	Bioenergy	Residues from forestry	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
73	Bioenergy	Residues from forestry	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
74	Biomaterials	Fibre products	Wood products	Increase forest product recycling	substitution	immediate	immediate	0	+	+	0	0	0	0	0	0	0	0	1	1		
75	Biomaterials	Fibre products	Wood products	Increase forest product use	substitution	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	1	1		
76	Biomaterials	Chemical products	Chemicals	Increase product chain efficiency	substitution	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0		
77	Biomaterials	Chemical products	Chemicals	Increase biomaterial use	substitution	immediate	immediate	0	0	+	0	0	1	0 (1)	0	0	0	0	1	1		

Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Theme 8
Land-use, land availability and land-use conflicts	Deforestation	GHG balance	Loss of biodiversity	Water concerns	Soil degradation	Other environmental concerns	Socio-economic standards
Sustainability implications (1: criteria might apply, 0: critria non applicable)							
Criteria 1	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**	**Criteria 6**	**Criteria 7**	**Criteria 8**
0	0	0	1	1	0	1	0
1	0	0	1	0	1	1	0
1	0	0	1	0	0	1	1

Overview key options

No	Type of activity	Activity	Practice	Mitigation option: specific management (change)	Type of impact	Timing of impact	Timing of costs	Mitigation effect [+, 0 or -]: CO2 short	CO2 medium	CO2 long	CH4	N2O	Theme 1 Land-use, lar	Theme 2 Deforestation	Theme 3 GHG balance	Theme 4 Loss of biodiv	Theme 5 Water concer	Theme 6 Soil degradat	Theme 7 Other environ	Theme 8 Socio-econo	Potential: total absolute	Potential: sustainable min-max
													Sustainability implications (1: criteria might apply, 0: critria non applicable)									
													Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8		
1	LUC	Afforestation	Afforestation	Afforestation of degraded land	sequestration	delayed	immediate	+	+	+	+	+	0	0	0	1	1	0	1			
2	LUC	Afforestation	Afforestation	Afforestation of wetland	sequestration	delayed	immediate	-	0	+	-	+	1	0	0	1	0	1	1	0		
3	LUC	Afforestation	Afforestation	Afforestation of grassland	sequestration	delayed	immediate	-	+	+	0	+	1	0	0	1	0	0	1	1		
4	LUC	Afforestation	Afforestation	Afforestation of cropland	sequestration	delayed	immediate	+	+	+	+	+	1	0	0	0	0	0	1	1		
5	LUC	Reforestation	Afforestation	Afforestation of former forest land	sequestration	delayed	immediate	0	+	+	+	+	1	0	0	1	0	0	1	1		
6	LUC	Deforestation	Avoid deforestation	Forest conservation of primary for	conservation	immediate	immediate	0	+	+	+	0	1	0	0	0	0	0	0	0		
7	LUC	Deforestation	Avoid deforestation	SFM, Primary to secondary forest	conservation	immediate	immediate	-	0	0	0	0	1	0	1	1	0	1	0	1		
8	LUC	Deforestation	Avoid deforestation	Forest conservation of secondary	conservation	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0		
9	LUC	Degradation	Avoid degradation	Sustainable Forest Management	conservation	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	0	0		
10	Vegetation C management	Forest management	Silviculture	Longer rotations	sequestration	delayed	delayed	+	+	+	0	+	1	0	0	0	0	0	1	0		
11	Vegetation C management	Forest management	Silviculture	Species change	sequestration	delayed	immediate	-	0	0	0	0	1	0	1	1	1	1	1	0		
12	Vegetation C management	Forest management	Silviculture	Continuous Cover Forestry	sequestration	delayed	immediate	+	+	+	0	+	1	0	0	0	0	0	1	0		
13	Vegetation C management	Forest management	Silviculture	Improve forest management	sequestration	delayed	immediate	0	+	+	+	+	1	0	0	1	0	0	0	0		
14	Vegetation C management	Forest management	Residue management	Reduced slash burning	conservation	immediate	delayed	+	+	+	+	+	0	0	0	0	0	0	1	0		
15	Vegetation C management	Forest management	Water management	Drainage	sequestration	delayed	immediate	-	0	+	-	-	0	0	1	1	1	1	1	0		
16	Vegetation C management	Forest management	Fire management	Fire management	conservation	immediate	immediate	-	0	+	0	+	0	0	0	1	0	0	0	0		
17	Vegetation C management	Forest management	Pest management	Pest management	conservation	immediate	immediate	-	0	+	0	+	0	0	0	1	1	1	1	0		
18	Vegetation C management	Cropland management	Agronomy	Increased productivity	sequestration	delayed	immediate	-	-	-	-	-	0	0								
19	Vegetation C management	Cropland management	Agronomy	Crop rotations	sequestration	delayed	immediate	0	+	+	0	0	0	0								
20	Vegetation C management	Cropland management	Agronomy	Catch crops	conservation	immediate	immediate	0	+	+	0	+	0	0								
41	Vegetation C management	Grazing land management	Increased productivity	Increasing productivity	sequestration	delayed	immediate	-	-	-	-	-	0	0								
42	Vegetation C management	Organic soils	Restoration	Rewetting / abandonment	sequestration	delayed	immediate	0	0	+	+	0	1	0								
43	Vegetation C management	Degraded lands	Restoration	Restoration	sequestration	delayed	immediate	0	0	+	+	0	0	0								
44	Vegetation C management	Livestock management	Livestock management	Improved feeding practices	reduction	immediate	immediate	0	0	0	0	0	0	0	1	1	1	1	1	0		
45	Vegetation C management	Manure / biosolid management	Manure / biosolid management	More efficient use of manure	reduction	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
46	Bioenergy	Sugar cane	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
47	Bioenergy	Sugar cane	Biofuel, first generation	Bioethanol...	substitution	immediate	immediate	+	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
48	Bioenergy	Sugar cane	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0		
49	Bioenergy	Corn	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0	0 (1)	1	1	1	1	1		
50	Bioenergy	Corn	Biofuel, first generation	Bioethanol...	substitution	immediate	immediate	+	0	0	0	0	1	0	0 (1)	1	1	1	1	1		
51	Bioenergy	Corn	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0		
52	Bioenergy	Rapeseed	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1		
53	Bioenergy	Rapeseed	Biofuel, first generation	Bioethanol...	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1		
54	Bioenergy	Rapeseed	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	0	1	0	0	1	1	1	0	0		
55	Bioenergy	Oil palm	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
56	Bioenergy	Oil palm	Biofuel, first generation	Bioethanol...	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0 (1)	1	1	1	1	1		
57	Bioenergy	Oil palm	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	1	1		
58	Bioenergy	Agriculture (generic)	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0		
59	Bioenergy	Agriculture (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	1	0		
60	Bioenergy	Agriculture (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	1	0	0	1	1	1	0	0		
61	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, first generation	Methanol	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0		
62	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	0	0	0	1	0 (1)	0	1	1	1	0	0		
63	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0	0		
64	Bioenergy	Poplar, pine, willow energy plantation	Combustion	Electricity	substitution	immediate	immediate	0	0	0	0	0	1	0 (1)	0	1	1	1	0	0		
65	Bioenergy	Forestry (generic)	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	0	0	0	0	0	0	0	0		
66	Bioenergy	Forestry (generic)	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
67	Bioenergy	Forestry (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	0	0	0		
68	Bioenergy	Residues from agriculture	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
69	Bioenergy	Residues from agriculture	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
70	Bioenergy	Residues from agriculture	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
71	Bioenergy	Residues from forestry	Combustion	Heat	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
72	Bioenergy	Residues from forestry	Combustion	Electricity	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
73	Bioenergy	Residues from forestry	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	0	0	+	0	0	0	0	0	0	0	1	1	1		
74	Biomaterials	Fibre products	Wood products	Increase forest product recycling	substitution	immediate	immediate	0	+	+	0	0	0	0	0	0	0	0	1	1		
75	Biomaterials	Fibre products	Wood products	Increase forest product use	substitution	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	1	1		
76	Biomaterials	Chemical products	Chemicals	Increase product chain efficiency	substitution	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0		
77	Biomaterials	Chemical products	Chemicals	Increase biomaterial use	substitution	immediate	immediate	0	0	+	0	0	1	0 (1)	0	0	0	0	1	1		

Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6
Land-use, land availability and land-use conflicts	Deforestation	GHG balance	Loss of biodiversity	Water concerns	Soil degradat
Sustainability implications (1: criteria might apply, 0: critria non app					
Criteria 1	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**	**Criteria 6**
0	0	0	1	1	0
1	0	0	1	0	1
1	0	0	1	0	0

Potential	
total	**sustainable**
absolute	**min/max range**

!Comments!

?Questions?

Florian Kraxner, kraxner@iiasa.ac.at
Petr Havlik, havlikp@iiasa.ac.at
Uwe A. Schneider, uwe.schneider@zmaw.de
Sylvain Leduc, leduc@iiasa.ac.at
Hannes Böttcher, boettcher@iiasa.ac.at
Michael Obersteiner, oberstei@iiasa.ac.at

et al…

www.iiasa.ac.at www.geo-bene.eu