

Biofuels

- Global Potentials and Certification

Florian Kraxner

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





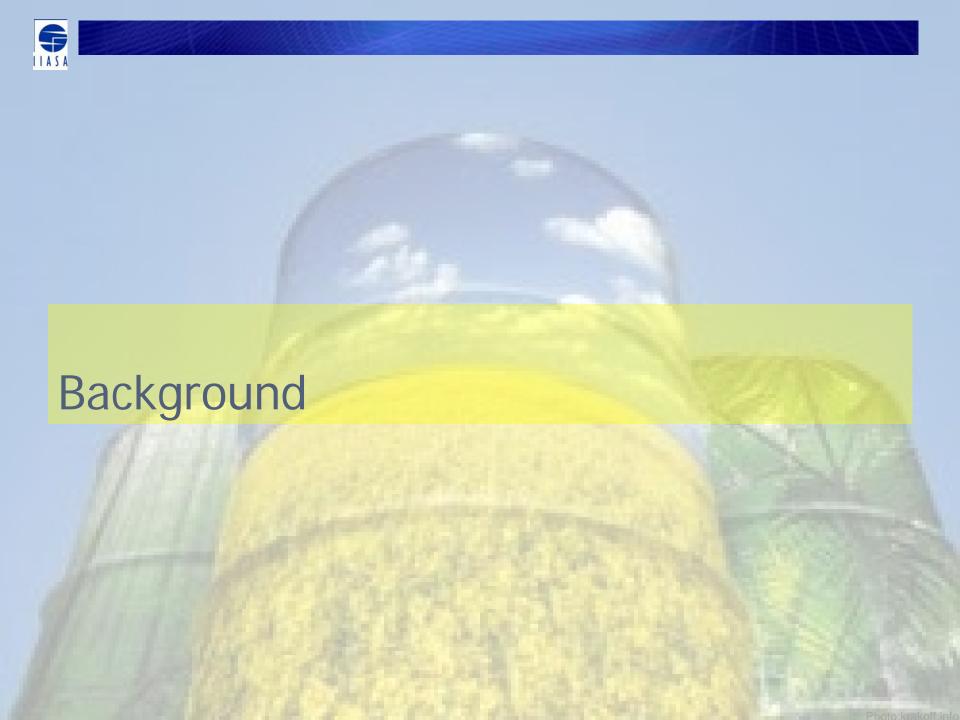


Task 29 – Socio-Economic Drivers in Implementing Bioenergy Projects
Task 38 - Greenhouse Gas Balances of Biomass and Bioenergy Systems
Task 40 - Sustainable International Bioenergy Trade: Securing Supply and Demand



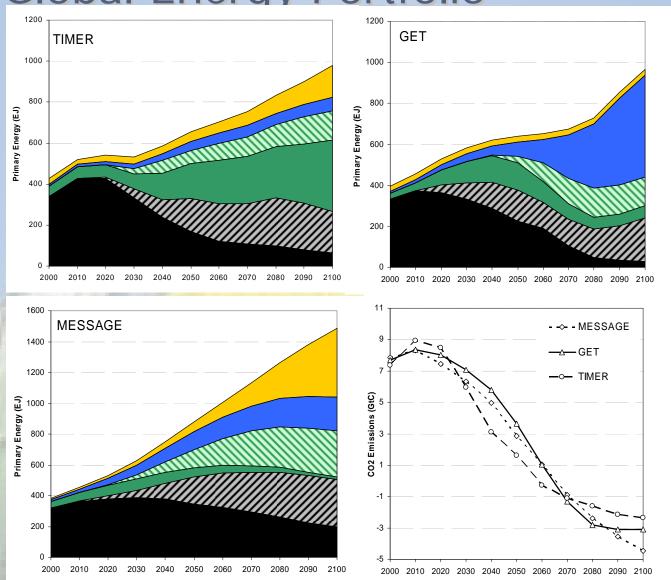
Overview

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





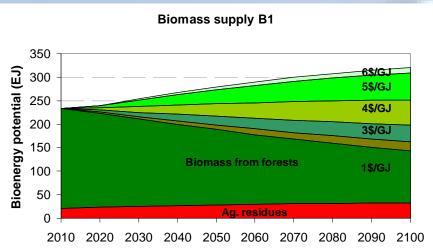
Global Energy Portfolio

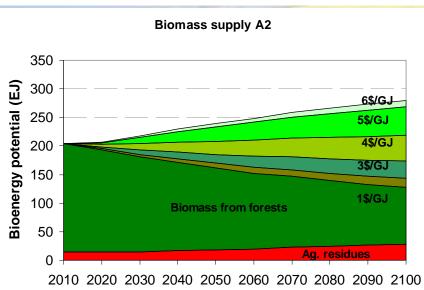


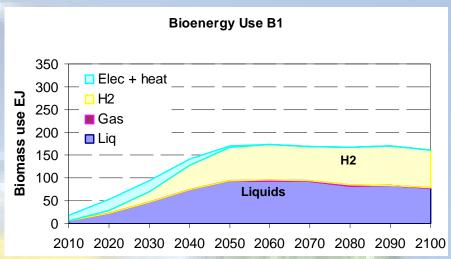
Source: Obersteiner et al. forthcoming

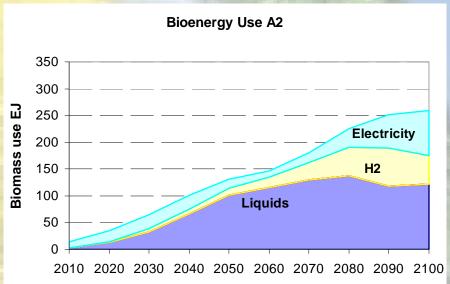


Bio-energy Supply Potentials and Use





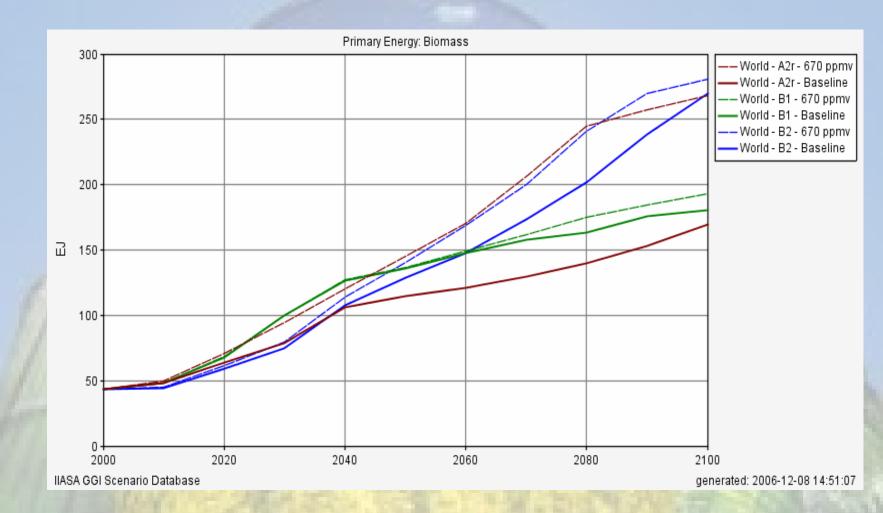




Source: Riahi et al. 2006

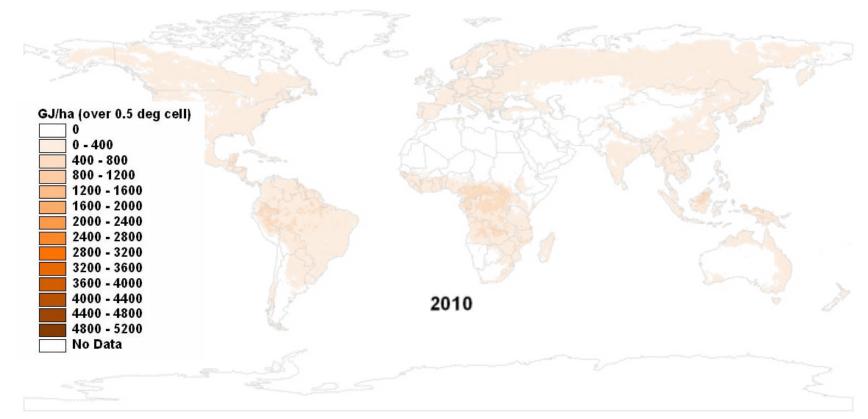


Biomass supply





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

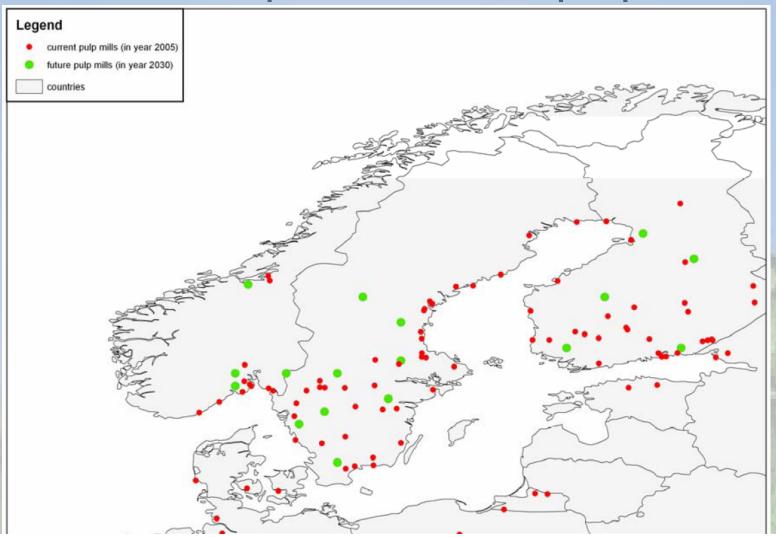


Source: Rokitianskii et al. 2006





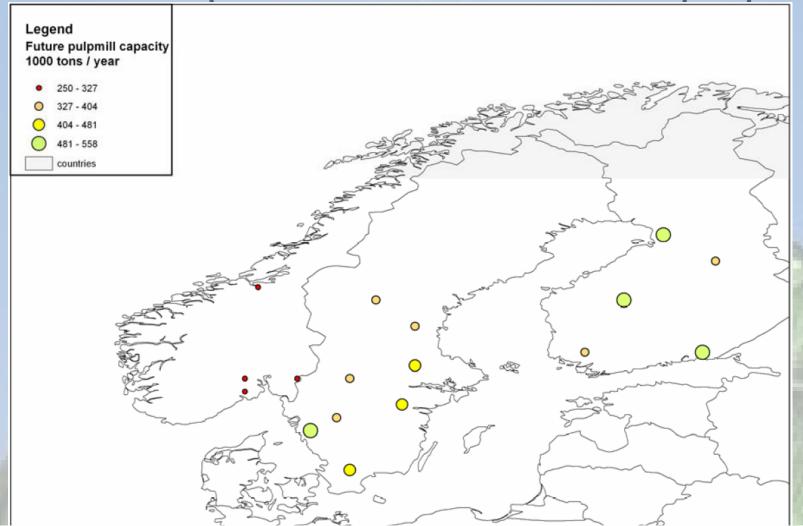
Results of spatial model: pulp mills



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



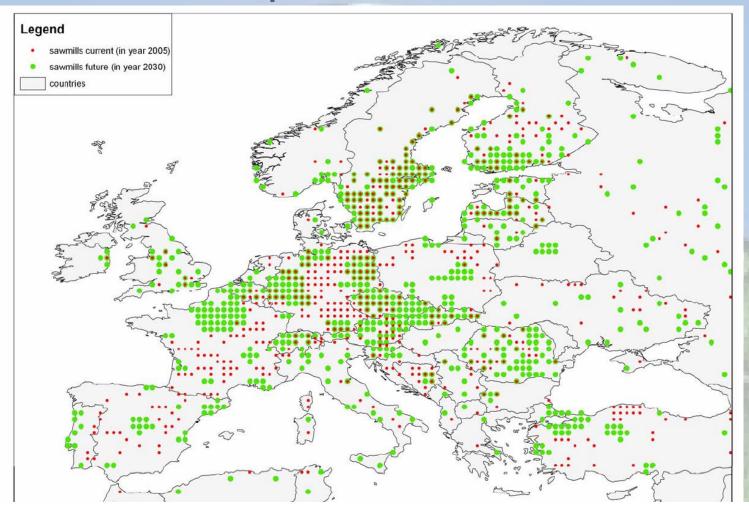
Results of spatial model: Scale of pulp mills



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.



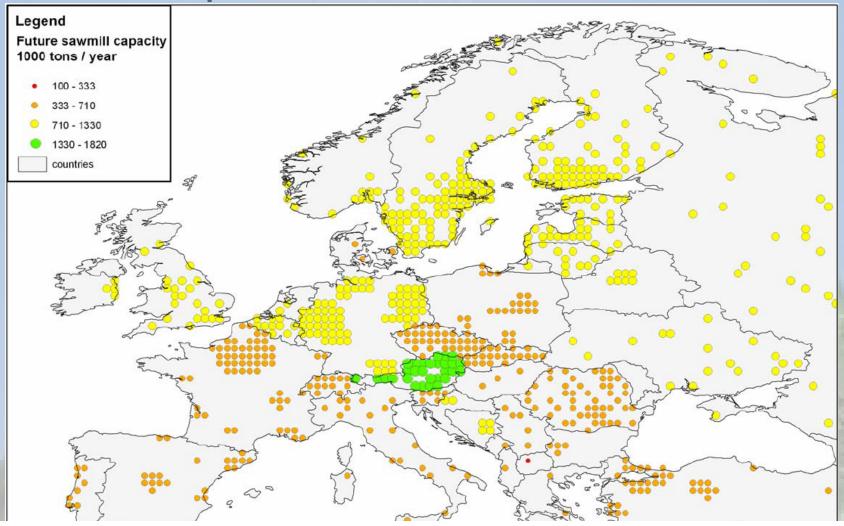
Results of spatial model: sawmills



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.



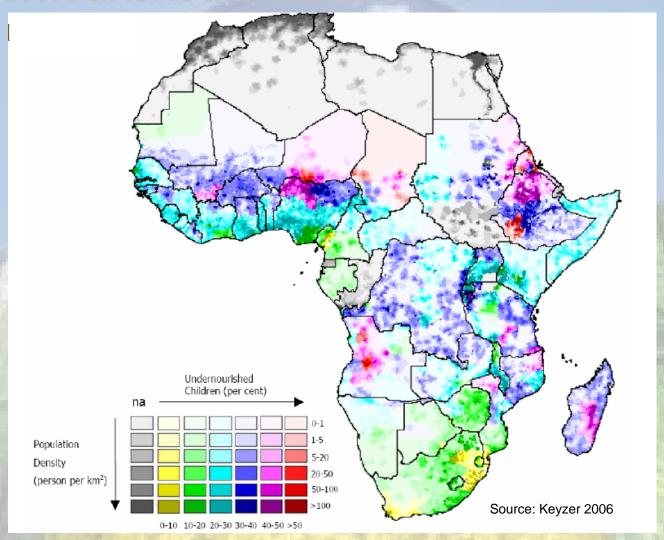
Results of spatial model: Scale of sawmills



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.



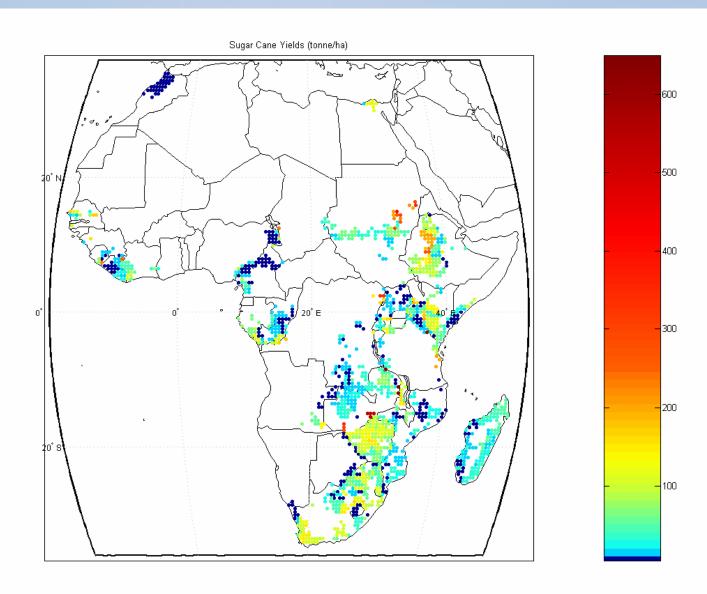
Combine with Geography of Social Sphere: Undernourished children





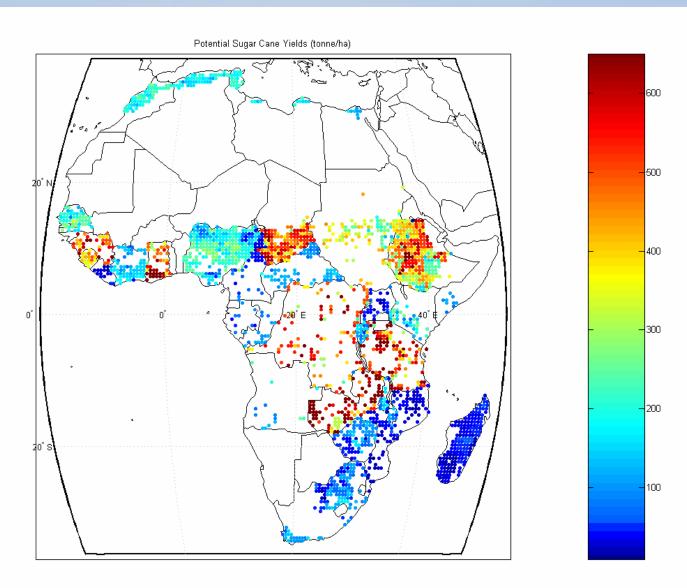


Actual Sugar Cane Yields



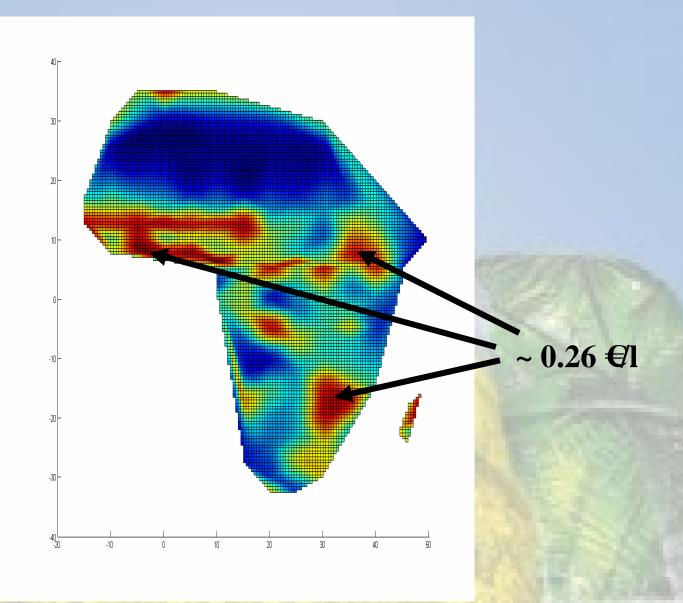


Sugar Cane Potential





Ethanol Production



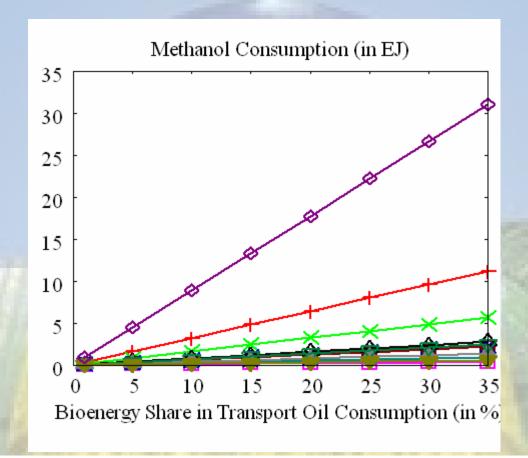


Africa Self Sufficient!

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

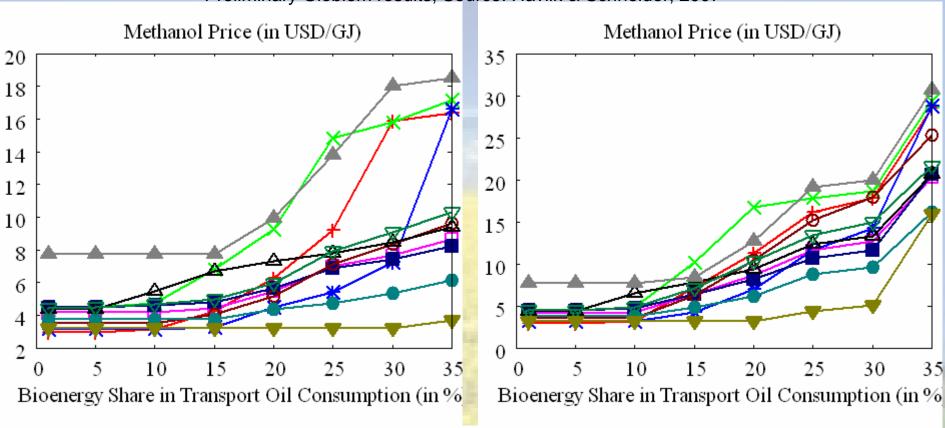


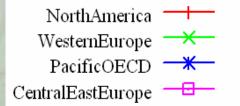






Preliminary Globiom results, Source: Havlik & Schneider, 2007





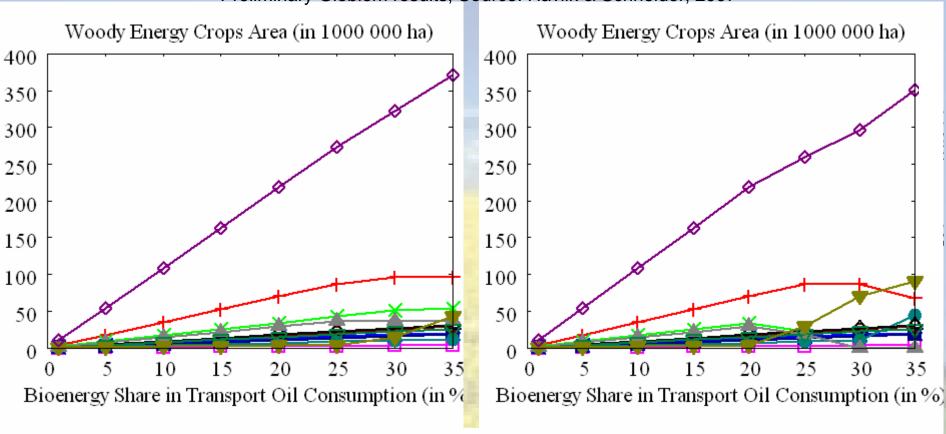




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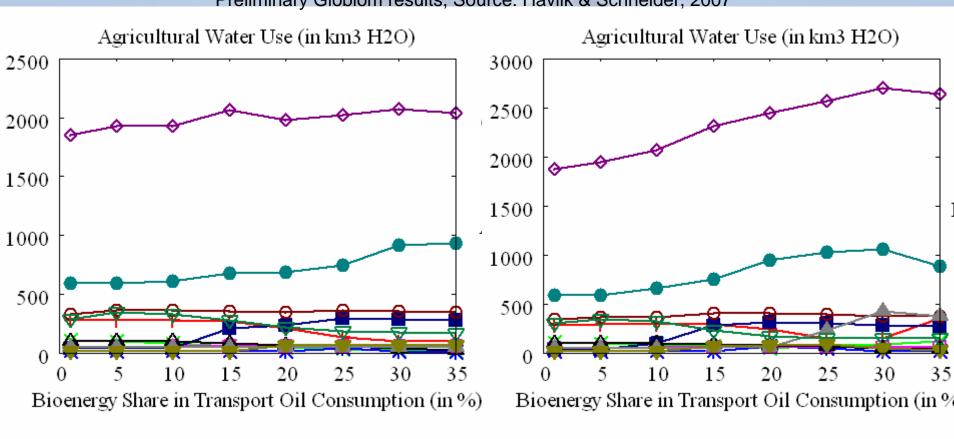










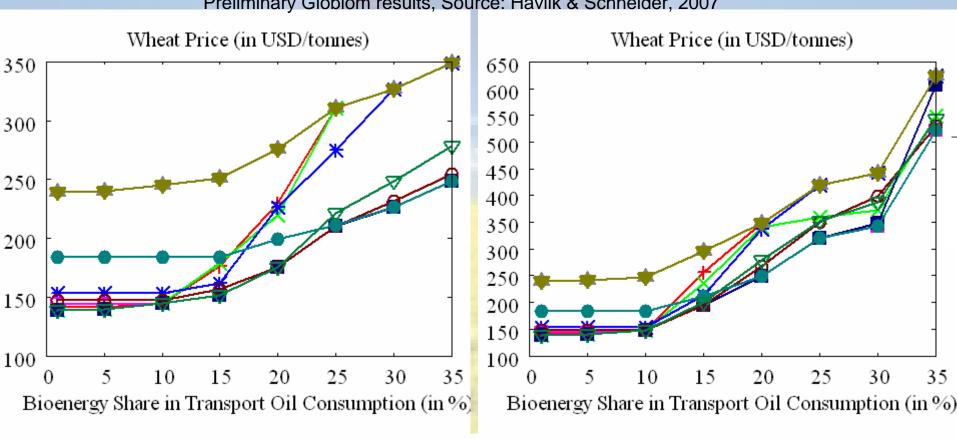


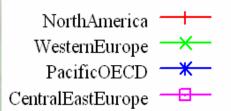








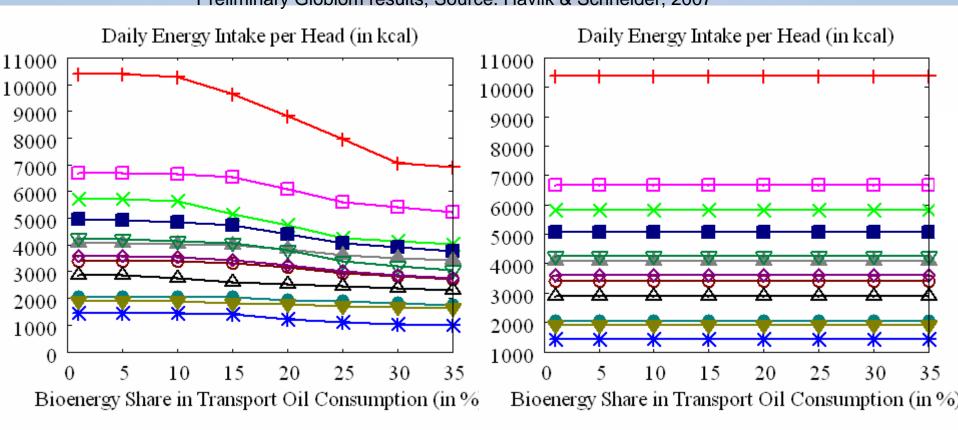














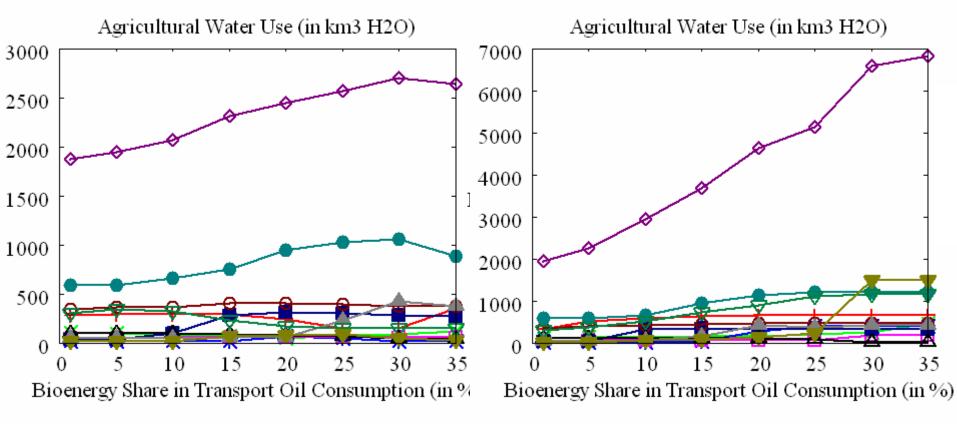


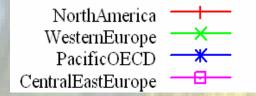




B. Methanol versus Ethanol with nutritional constraints

METHANOL ETHANOL









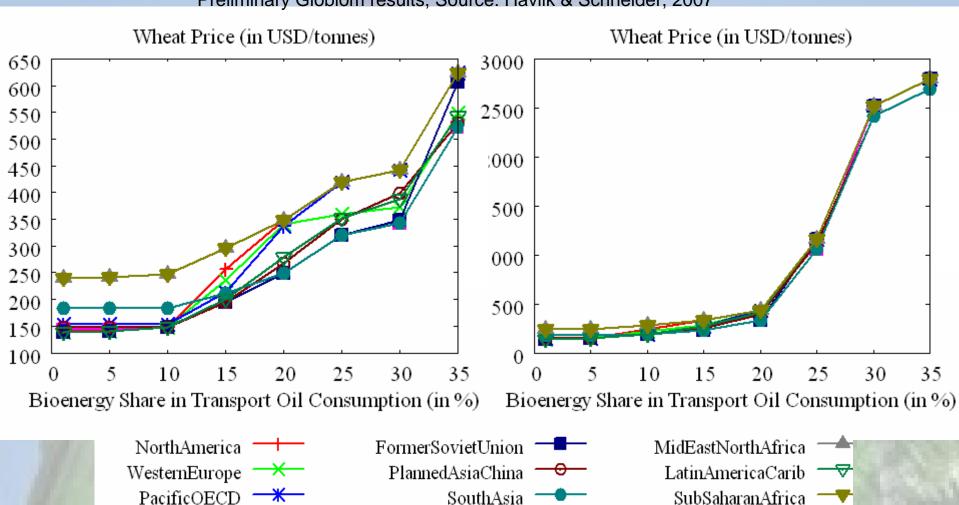


CentralEastEurope =

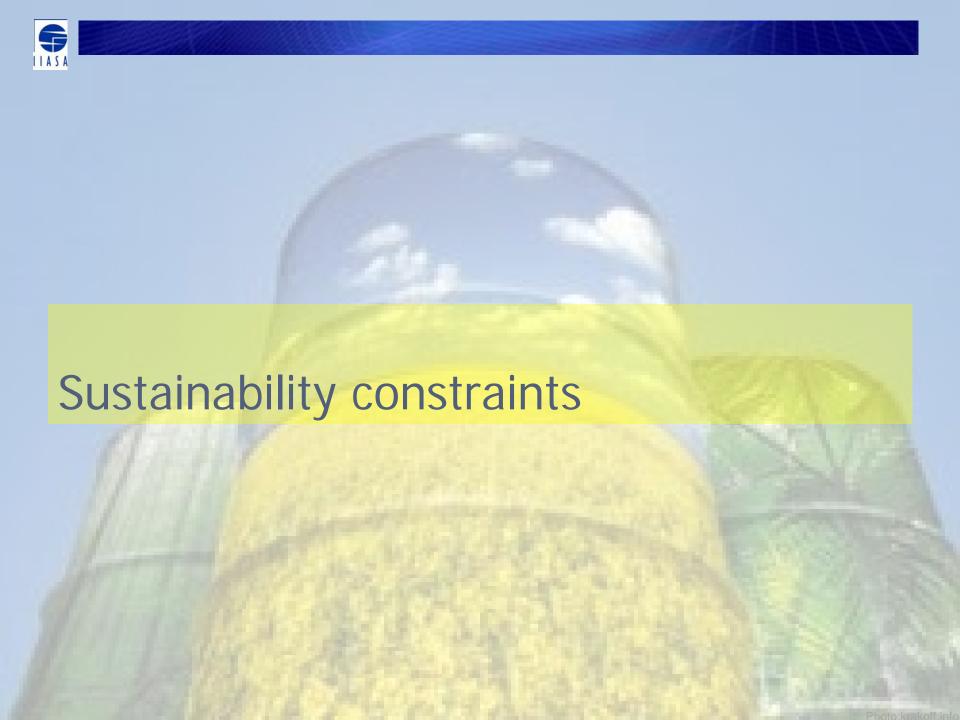
B. Methanol versus Ethanol with nutritional constraints

METHANOL ETHANOL

Preliminary Globiom results, Source: Havlik & Schneider, 2007

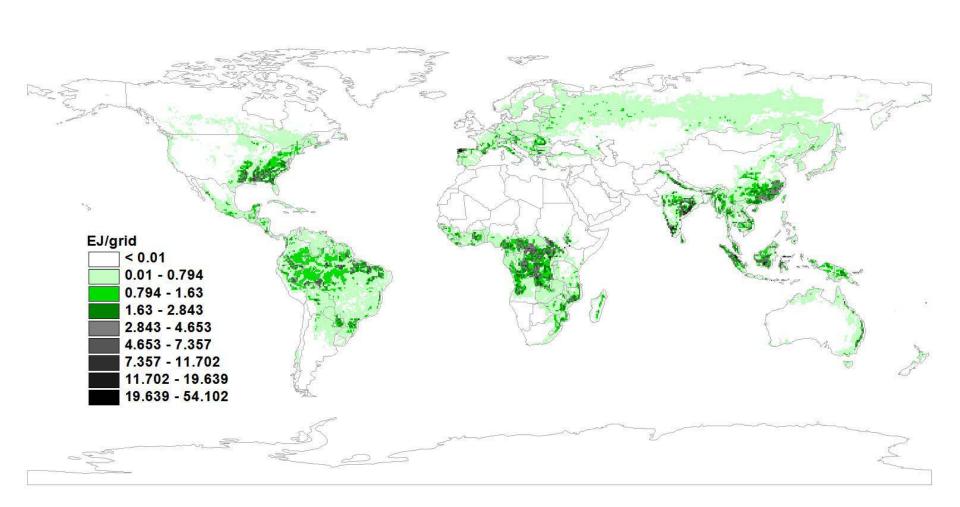


OtherPacificAsia





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

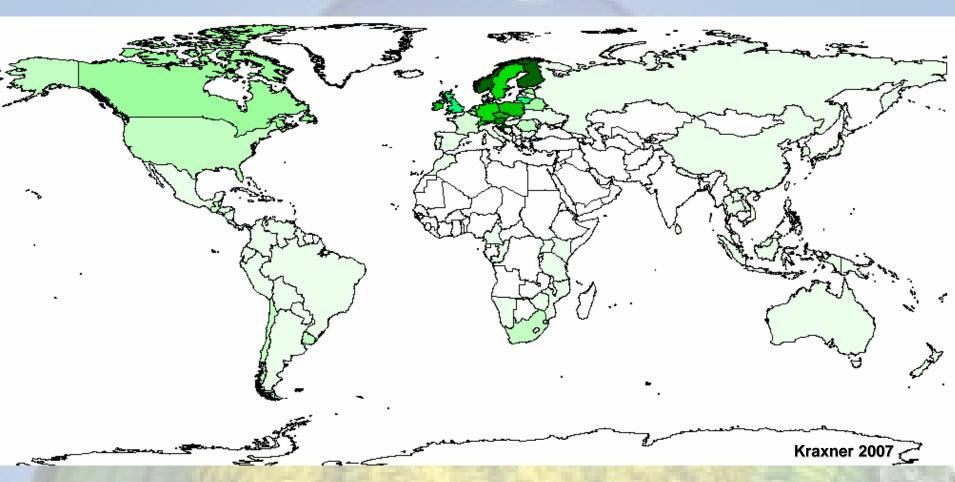


Source: Rokitianskii et al. 2006



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

									_													
Overv	ew key options												Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Theme 8		
	on may appliable							М	itigation	effect [+, 0 or	-1	Land-use, lar	Deforestation	GHG balance	Loss of biodi	Water conce	Soil degrad	at Other env	iror Socio-eco	nor F	Potential
No			Mitigation option		Type of	Timing of	Timing of		CO2			N2O		Sustainabili	ity implicatio	ns (1: criteria	might apply			le)		
			• .		impact	impact	costs									,					total	sustainable
	Type of activity	Activity	Practice	specific management (change)									Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria	7 Criteria	3	
				Afforestation of degraded land					medium	long											absolute	min-max
1	LUC	Afforestation	Afforestation	rinorobiation of dogradod land	sequestration	delayed	immediate	+	+	+	+	+	0	0	0	1	1	0	1	0		
2	LUC	Afforestation Afforestation	Afforestation Afforestation	Afforestation of wetland Afforestation of grassland	sequestration sequestration	delayed	immediate	-	0	+	-	+	1	0	0	1	0	0	1	0		
1	LIC	Afforestation	Afforestation	Afforestation of cropland	sequestration	delayed	immediate	+	+	+	+	+	1	0	0	0	0	0	1	1		+
- 5	LIIC	Reforestation	Afforestation		sequestration	delayed	immediate	0			-	-	1	0	0	1	0	0	+ +	1		
6	LUC	Deforestation	Avoid deforestation	Forest conservation of primary for		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	+	+	+		+	1	0	0	0	0	0	1	0		
13	Vegetation C management Vegetation C management	Forest management	Silviculture	Improve forest management	sequestration	delayed	immediate	0	+	+	_	+	0	0	0	0	0	0	0	0	_	1
15	Vegetation C management	Forest management Forest management	Residue management Water management	Reduced slash burning Drainage	conservation	immediate	delayed	-	0	+	-	-	0	0	1	1	0	1	1	0		+
16	Vegetation C management	Forest management	Fire management		conservation	immediate	immediate	- :	0		0	+	0	0	0	1	0	0	0	0		1
17	Vegetation C management	Forest management	Pest management	Pest management	conservation	immediate	immediate	-	0	+		+	0	0	0	i	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	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		
23	Vegetation C management	Cropland management	Nutrient management	Precision farming	reduction	immediate	immediate	0	+	+	0	0	0	0	0	0	0	0	0	0		
	Vegetation C management	Cropland management	Nutrient management	Reduced fertilizer rates	reduction	immediate	delayed	0	0	+		0	0	0	0	0	0	1	0	1 1		
	Vegetation C management Vegetation C management	Cropland management Cropland management	Nutrient management Tillage / residue management	Fertilizer free zones Reduced tillage	reduction conservation	immediate immediate	delayed	0	0		+	+	0	0	0	0	0	0	0	1		
20	7				conservation	immediate	delayed	+	+	+	+	+	0	0	0	0	0	0	0	1	_	+
28	Vegetation C management Vegetation C management	Cropland management Cropland management	Tillage / residue management Tillage / residue management	Zero tillage Reduced residue removal	sequestration	delaved	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		
	Vegetation C management	Cropland management	Upland water management	Irrigation	reduction	immediate	immediate	-	-	-	-	-	1	0	0	0	1	1	1	1		
	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		
	Vegetation C management	Agroforestry	Set-aside and land-use change		sequestration	delayed	immediate	0	+	+	+	+	0	0	0	0	0	0	0	0		
	Vegetation C management	Grazing land management	Livestock grazing intensity Fertilization	Livestock grazing intensification Fertilization	reduction	immediate	immediate	-	0	0	-	-	0	0	1	1		0	1	0		
39	Vegetation C management Vegetation C management	Grazing land management Grazing land management	Fire management	Fire management	sequestration	immediate	immediate	0	0	0	0	0	0	0	+	0	0	0	1	0	_	1
40	Vegetation C management	Grazing land management	Increased productivity	Increasing productivity	sequestration	delayed	immediate	-	-	-	-	-	0	0	1	1	1	1	1	0		1
	Vegetation C management	Organic soils	Restoration		sequestration	delayed	immediate	0	0	+	+	0	1	0	0	0	0	1	0	1	_	
	Vegetation C management	Degraded lands	Restoration		sequestration	delayed	immediate	Ö	0	+	+	0	Ö	0	Ö	0	0	Ö	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		
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	1	0 (1)	0 (1)	1	1	1	1	1		
48	Bioenergy	Sugar cane	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+		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	1		
50	Bioenergy	Com	Biofuel, first generation	Bioethanol	substitution	immediate	immediate	+	0	0		0	1	0	0 (1)	1	1	1	1	1		
51	Bioenergy Bioenergy	Com Rapeseed	Biofuel, second generation Biofuel, first generation	BM gasification/syngas Biodiesel	substitution substitution	immediate immediate	immediate immediate	+	+	+	0	0	1	0	0 (1)	1	1	1	0	0		
52	Bioenergy	Rapeseed	Biofuel, first generation	Bioethanol	substitution	immediate	immediate	+	+	0		0	1	0	0 (1)	1	-	1	+ +	1		
54	Bioenergy	Rapeseed	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+		0	1	0	0(1)	1	1	1	0	0		
55	Bioenergy	Oil palm	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	0		0		0	1	0 (1)	0 (1)	i	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	11	0 (1)	0	11	1	1	1	1		
58	Bioenergy	Agriculture (generic)	Combustion	Heat	substitution	immediate	immediate	0	0	+		0	1	0	0	1	11	1	1	0		
59	Bioenergy	Agriculture (generic)	Combustion	Electricity	substitution	immediate	immediate	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	1	0	0	1	1	1	0	0		
61	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, first generation	Methanol	substitution	immediate	immediate	+	+	0		0	1 1	0 (1)	0	1	1 1	1	0	0		
	Bioenergy	Poplar, pine, willow energy plantation	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	0	_	0	1	0 (1)	0	1		1	0	0		
63	Bioenergy Bioenergy	Poplar, pine, willow energy plantation	Combustion	Heat Electricity	substitution substitution	immediate immediate	immediate immediate	+	0	+	0	0	1	0 (1)	0	1	1	1	0	0		
	Bioenergy	Poplar, pine, willow energy plantation Forestry (generic)	Combustion Combustion	Heat	substitution	immediate	immediate	+	+	+		0	0	0 (1)	0	0	0	0	0	0		
	Bioenergy	Forestry (generic)	Combustion	Electricity	substitution	immediate	immediate		0	+		0	0	0	0	0	0	0	0	0		
	Bioenergy	Forestry (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	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	Ĩ.	1	1		
69	Bioenergy	Residues from agriculture	Combustion	Electricity	substitution	immediate	immediate	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	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	1		
74	Biomaterials Biomaterials	Fibre products	Wood products	Increase forest product recycling	substitution	immediate	immediate	0	+	+		0	0	0	0	0	0	0	1 1	1		
75	Biomaterials Biomaterials	Fibre products	Wood products Chemicals	Increase forest product use Increase product chain efficiency	substitution	immediate immediate	immediate immediate	0	+	+	0	0	1	0	0	0	0	0	1 0	0		
76	Biomaterials Biomaterials	Chemical products Chemical products	Chemicals	Increase product chain efficiency Increase biomaterial use	substitution	immediate	immediate	0	0	+	0	0	1	0 (1)	0	0	0	0	1	1		
	Diomatildis	Onemical products	CHOHICAIS	increase Dicinatenal use	SUDSULUUION	inneuiale	mineulate	U	U	- 7	U	U		0 (1)	U	U	U	U				

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



7/6	rvie	w key options												Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Theme 8		
_									M	litigation	effect [+, 0 or	-1	Land-use, la	Deforestation	GHG balanc	Loss of biodi	Water conce	Soil degrada	Other enviro	Socio-econor	P	Potential
No	,			Mitigation option		Type of	Timing of	Timing of		CO2		CH4	N20		Sustainabil	ity implicatio	ns (1: criteria	a might apply	, 0: critria noi	n applicable)			
						impact	impact	costs														total	sustainable
	П	Type of activity	Activity	Practice	specific management (ch	ge)								Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8		
									short	medium	long											absolute	min-max
	1 0	UC	Afforestation	Afforestation	Afforestation of degrad land	sequestration	n delayed	immediate	+	+	+	+	+	0	0	0	1	1	0	1	0		
		IC	Afforestation	Afforestation	Afforestation of wear and	sequestration	n delayed	immediate	-	0	+	-	+	1	0	0	1	0	1	1	0		
	3 L		Afforestation	Afforestation	Afforestation	sequestration	n delayed	immediate	-	+	+	0	+	1	0	0	1	0	0	1	1		
	4 LI		Afforestation	Afforestation	Afforest of cropland	sequestration	n delayed	immediate	+	+	+	+	+	1	0	0	0	0	0	1	1		
	5 LI		Reforestation	Afforestation	orestation of former forest	and sequestration	n delayed	immediate	0	+	+	+	+	1	0	0	1	0	0	1	1		
	6 LI		totion	Avoid deforest	Forest conservation of primary			immediate	0	+	+	+	0	1	0	0	0	0	0	0	0		
_	711	IC .	Deferestation	respectation	QEM. Drimany to cocondary fo	root conconvatio	n immodiate	immodiato		Λ	Λ	0	0	1	0	1	- 1	Λ.	- 1	0	1		

Overview key option	S		
		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

51 Bloenergy	Com	Bioruei, second generation	BM gasification/syngas	substitution	immediate	immediate	+	+	+	0	U	1	U	0	1	1 1	1	0	U	4		4
52 Bioenergy	Rapeseed	Biofuel, first generation	Biodiesel	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1			
	Rapeseed		Bioethanol	substitution	immediate	immediate	+	+	0	0	0	1	0	0 (1)	1	1	1	1	1			
54 Bioenergy	Rapeseed		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	1	0	0	1	1	1	1				
60 Bioenergy	Agriculture (generic)		BM gasification/syngas	substitution	immediate	immediate	0		+	0	0	1	0	0	1	1	1	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				
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				
63 Bioenergy	Poplar, pine, willow energy plantation	Combustion	Heat	substitution	immediate	immediate	+	+	+	0	0	1	0 (1)	0	1	1	1	0				
64 Bioenergy	Poplar, pine, willow energy plantation	Combustion	Electricity	substitution	immediate	immediate	0		0	0	0	1	0 (1)	0	1	1	1	0				
65 Bioenergy	Forestry (generic)	Combustion	Heat	substitution	immediate	immediate	+	+	+	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				
67 Bioenergy	Forestry (generic)	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	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	1	1	1			1
69 Bioenergy	Residues from agriculture	Combustion	Electricity	substitution	immediate	immediate	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	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	1	1	1			
73 Bioenergy	Residues from forestry	Biofuel, second generation	BM gasification/syngas	substitution	immediate	immediate	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	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			
																				Pho	to Krak	aff



/erv	riew key options							heme 1 Theme 2 The	me 3 Theme 4 Them	ne 5 Theme 6 Them	ne 7 Theme 8	
							Mitigation effect [+, (or -1 Land-use, lar Deforestation GH	G balance Loss of biodir Water	r conce Soil degradat Other	enviror Socio-econor	Potentia
0			Mitigation option		Type of impact	Timing of Timing of impact costs	f CO2 CI	H4 N2O Sustainability in	nplications (1: criteria migh	t apply, 0: critria non appl	icable)	sustai
	Type of activity	Activity	Practice	specific manageme	nt (change)	Impact Costs		Criteria 1 Criteria 2 Cr	iteria 3 Criteria 4 Cri	eria 5 Criteria 6 Crit	eria 7 Criteria 8	Journal
1	IUC A	Afforestation	Afforestation	Afforestation of degra	ded land segue ation	delayed immediate	short medium long	+ 0 0	0 1	1 0	absolut	ite min-m
2	LUC	Afforestation	Afforestation	Afforestation of wetlan	nd sequestration	delayed immediate	- 0	+ 1 0	0 1	0 1	1 0	
3	LUC A	Afforestation	Afforestation	Afforestation of grass	land sequestration	Ues., immediate		0 + 1 0	0 1	0 0	1 1	
5	LUC R	Reforestation	Afforestation	Afforestation of cropia	r forest land sequestration	delayed immediate	0 + + -	+ + 1 0	0 1	0 0	1 1	
6	LUC D	Deforestation	Avoid deforestation	Forest conservation of	f primary for conservation	immediate immediate	0 + +	+ 0 1 0	0 0	0 0	0 0	
7	LUC D	Deforestation Deforestation	Avoid deforestation Avoid deforestation	SFM, Primary to seco	ndary forest conservation of secondary conservation	immediate immediate	9 - 0 0 0	0 0 1 0	1 1	0 1	0 1	
9	LUC D	Degradation	Avoid degradation	Sustainable Forest M	anagement conservation	immediate immediate	0 0 + (0 0 1 0	0 0	0 0	0 0	
10	Vegetation C management F	orest management	Silviculture	Longer rotations Species change	sequestration	delayed delayed	+ + + (0 + 1 0	0 0	0 0	1 0	
12	Vegetation C management F	orest management	Silviculture	Continuous Cover Fo	restry sequestration	delayed immediate	+ + + (0 + 1 0	0 0	0 0	1 0	
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	Bioenergy S	agui cuito										
48		Som	Biofuel, second generation	BM gasification/synga	substitution	immediate immediate	9 + + + 0	0 0 1 0(1)	0 1	1 1 1	0 0	
48 49 50	Bioenergy C	ougar cane Corn Corn	Biofuel, second generation Biofuel, first generation Biofuel, first generation	BM gasification/synga Biodiesel Bioethanol	substitution substitution substitution	immediate immediate immediate immediate immediate	2 + + + (2 0 0 0 0 (2 + 0 0 0	0 0 1 0 (1) 0 0 1 0 0 0 1 0	0 1 0 (1) 1 0 (1) 1	1 1 1 1 1 1 1	0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
48 49 50 51	Bioenergy C Bioenergy C Bioenergy C	ougar cane Corn Corn Canacad	Biofuel, second generation Biofuel, first generation Biofuel, first generation Biofuel, second generation Biofuel, first generation	BM gasification/synga Biodiesel Bioethanol BM gasification/synga	substitution substitution substitution substitution substitution	immediate immediate immediate immediate immediate immediate immediate immediate	3 + + + (3 0 0 0 0 (3 + 0 0 0 (4 + 0 0 0 (0 0 1 0 (1) 0 0 1 0 0 0 0 1 0 0 0 0 1 0	0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 0 1 1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1 1	
48 49 50 51 52 53	Bioenergy C Bioenergy C Bioenergy C Bioenergy R Bioenergy R	ugar cane Com Com Com Capeseed Capeseed	Biofuel, second generation Biofuel, first generation Biofuel, first generation Biofuel, second generation Biofuel, first generation Biofuel, first generation	BM gasification/synga Biodiesel Bioethanol BM gasification/synga Biodiesel Bioethanol	s substitution substitution substitution substitution substitution substitution substitution substitution	immediate	2 + + + + (2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 1 0 (1) 0 0 1 0 0 0 0 1 0	0 1 0 0 1 0 0 1 0 0 1 1 0 1 0 1 0 1 0 1 0 1 0 1 1 0 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
48 49 50 51 52 53 54	Bioenergy C Bioenergy C Bioenergy C Bioenergy R Bioenergy R Bioenergy R	ugar cane com com com com dapeseed tapeseed tapeseed	Biofuel, second generation Biofuel, first generation Biofuel, first generation Biofuel, first generation Biofuel, first generation Biofuel, first generation Biofuel, second generation	BM gasification/synga Biodiesel Bioethanol BM gasification/synga Biodiesel Bioethanol BM gasification/synga	substitution	immediate	3 + + + + 1 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 1 0 (1) 0 0 1 0 0 0 1 0	0 1 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0	
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48 49 50 51 52 53 54 55 56 57 58 59	Bloenergy C Bloenergy C Bloenergy C Bloenergy R Bloenergy R Bloenergy R Bloenergy R Bloenergy C Bloenergy A Bloenergy A	ugar cane orm orm com tapeseed tapeseed tapeseed tapeseed tapeseed tapeseed tapeseed tapean t	Biofuel, second generation Biotuel, first generation Biotuel, first generation Biotuel, second generation Biotuel, second generation Biotuel, second generation Biotuel, second generation Biotuel, first generation Biotuel, first generation Biotuel, second generation Combustion Combustion Combustion Biotuel, second generation Combustion Biotuel, second generation Combustion Combustion Biotuel, second generation Combustion Co	BM gasification/synga Bioethanol BM gasification/synga Biodiesel Bioethanol BM gasification/synga Bioethanol BM gasification/synga Heat Bioethanol BM gasification/synga Heat	is substitution	mmedate mmedate mmedate mmediate immediate immediate immediate immediate immediate immediate immediate mmediate	0 + + + + 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 1 0 (1) 0 0 0 1 0 0 (1) 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1	0 1 0 1 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 1 0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
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Ove	rview key options												T' me 1	Theme 2	Theme 3		Theme 5			Theme 8		
								- N	litigation	n effect	[+, 0 or	-1	and-use, la	ar Deforestati	or GHG balance	ce Loss of biodi	i Water conce	e Soil degrada	t Other enviro	Socio-econo	P	otential
No			Mitigation option		Type of impact	Timing of impact	Timing of costs		CO2		CH4	N20				ons (1: criteria			,		tal	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		absolute	min-max
		Afforestation	Afforestation	Afforestation of degraded land	sequestration	delayed	immediate	+	+	+	+	+		0	0	1	1	0	1			
		Afforestation	Afforestation	Afforestation of wetland	sequestration	delayed	immediate	-	0	+	-	+	1	0	0	1	0	1	1	0		
		Afforestation	Afforestation	Afforestation of grassland	sequestration	delayed	immediate	-	+	+	0	+	1		0	1	0	0		1		
		Afforestation	Afforestation	Afforestation of cropland	sequestration		immediate	+	+	+	+	+	1	0		0	0		1	1		
		Reforestation	Afforestation	Afforestation of former forest land		delayed	immediate	0	+	+	+	+	1	0	0		0	0	1	1		
		Deforestation	Avoid deforestation	Forest conservation of primary for		immediate	immediate	0	+	+	+	0	1	0	0	0	0	0	0	0		
		Deforestation	Avoid deforestation	SFM, Primary to secondary forest			immediate	-	0	0	0	0	1	0	1	1	0	1	0	1		
		Deforestation	Avoid deforestation	Forest conservation of secondary	conservation	immediate	immediate	0	+	+	0	0	1	0	0	0	0	0	0	0		
		Degradation	Avoid degradation	Sustainable Forest Management	conservation	immediate	immediate	0	0	+	0	0	1	0	0	0	0	0	0	0		
		Forest management	Silviculture	Longer rotations	sequestration	delayed	delayed	+	+	+	0	+	1	0	0	0	0	0	1	0		
		Forest management	Silviculture	Species change	sequestration	delayed	immediate	-	0	0	0	0	1	0	1	1	1	1	1	0		
		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	1	0		
	15 Vegetation C management	Forest management	Water management	Drainage	sequestration	delayed	immediate	-	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		Agronomy	Increased productivity	sequestration	delayed	immediate	-	-	-	-	-	0	0	1	1	1	1	1	0		
	19 Vegetation C management		Agronomy	Crop rotations	sequestration		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	1_0	0	0	0	0		
en	ne 1	Themo	e 2 Thei	ne 3 The	me 4		lт	her	ne s	5			Then	ne 6		The	me 7			The	me 8	3

Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Theme 8
Land-use, land availability						Other environmental	Socio-economic
and land-use conflicts	Deforestation	GHG balance	Loss of biodiversity	Water concerns	Soil degradation	concerns	standards
	Sust	ainability impli	cations (1: criteria r	night apply, 0: cr	itria non applical	ole)	

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

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 Restoration Sequestration delayed immediate 0 0 + + 0 0 0 0 0 0	
44 Vegetation C management Livestock management Liv	
45 Vegetation C management Manure / biosolid management / biosolid management / biosolid management / b	
46 Bioenergy Sugar cane Biofuel, first generation Biodiesel substitution immediate immediate + 0 0 0 0 1 0 (1) 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 1	
48 (Bioenergy Sugar cane Biofuel, second generation BM gasification/syngas substitution immediate immediate + + + + 0 0 1 1 0 (1) 0 1 1 1 0 0 0	
49 Bioenergy Com Biofuel, first generation Biodiesel substitution immediate immediate 0 0 0 0 0 1 0 0(1) 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 1	
51 Bioenergy Corn Biofuel, second generation BM gasification/syngas substitution immediate immediate + + + + 0 0 0 1 1 0 0 1 1 1 0 0	
52 Bioenergy Rapeseed Biofuel, first generation Biodiesel substitution immediate immediate + + + 0 0 0 0 1 0 0(1) 1 1 1 1 1 1	
53 Bioenergy Rapeseed Biofuel, first generation Bioethanol substitution immediate immediate + + + 0 0 0 0 1 0 0(1) 1 1 1 1 1 1	
54 Bioenergy Rapeseed Biofuel, second generation BM gasification/syngas substitution immediate immediate + + + + 0 0 0 1 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) 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 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 1	
58 Bioenergy Agriculture (generic) Combustion Heat substitution immediate immediate 0 0 1 + 0 0 1 0 0 1 1 1 1 1 0	
59 Bioenergy Agriculture (generic) Combustion Electricity substitution immediate immediate 0 0 1 + 0 0 1 0 0 1 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 0 0	
61 Bioenergy Poplar, pine, willow energy plantation Siofuel, first generation Methanol substitution immediate immediate + + 0 0 0 0 1 0 0 1 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 0 1 0 0 1 1 0 1 1 1 0 0	
63 Bioenergy Poplar, pine, willow energy plantation Combustion Heat substitution immediate immediate + + + + 0 0 1 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 0 1 1 0 1 1 1 1 0 0 0	
65 Bioenergy Forestry (generic) Combustion Heat substitution immediate immediate + + + + 0 0 0 0 0 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 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 0	
68 Bioenergy Residues from agriculture Combustion Heat substitution immediate immediate 0 0 0 + 0 0 0 0 0 0 1 1 1 1	
69 Bioenergy Residues from agriculture Combustion Electricity substitution immediate immediate 0 0 + 0 0 0 0 0 0 1 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 1	
71 Bioenergy Residues from forestry Combustion Heat Substitution immediate immediate 0 0 + 0 0 0 0 0 0 0	
72 Bioenergy Residues from forestry Combustion Electricity substitution immediate immediate 0 0 0 + 0 0 0 0 0 0 1 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 1	
74 Biomaterials Fibre products Wood products Increase forest product recycling substitution immediate immediate 0 + + + 0 0 0 0 0 0 0 0 0 1 1 1	
75 Biomaterials Fibre products Wood products Increase forest product use substitution immediate immediate 0 0 0 + 0 0 1 1 0 0 0 0 0 0 1 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 0 0	
77 Biomaterials Chemical products Chemicals Increase biomaterial use substitution immediate immediate 0 0 0 + 0 0 1 0(1) 0 0 0 0 1 1	
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Overview key option	ons												$\overline{}$	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Ther 6		
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No				Mitigation optio	on		Type of impact	Timing of impact	Timing o	of	CO2		CH4 N	20	Sustainabil	ity implication	ns (1: criteria	a might apply	, 0: critria n	on applicab	le)	total	sustaina
Type of ac	ctivity	Activity	·	Practio	ce	specific management (ch		mpact	00000				_	Criteria	1 Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria	7 riteria	8	
41110				Λ <i>66</i> 6-6:		A44		and all and and	in a second	short	medium	long	_		-		4	4		4	+	absolute	e min-max
2 LUC	A	Afforestation		Afforestation Afforestation		Afforestation of degraded la Afforestation of wetland	and sequestrati	on delayed			+	+	+ -	+ 0	0	0	1	0	1	1			+
3 LUC	Д	Afforestation	i	Afforestation		Afforestation of grassland	sequestrat	on delayed	immedia	te -	+	+	0	+ 1	0	0	1	0	0	1	1		
4 LUC	А	Afforestation		Afforestation		Afforestation of cropland	sequestrat	on delayed	immedia	e +	+	+	+	+ 1	0	0	0	0	0	1	1		
5 LUC	l l	Reforestation		Afforestation Avoid deforestation	nn.	Aftorestation of former fore	st land sequestrat	on delayed	immedia	e 0	+	+	+	+ 1	0	0	1 0	0	0	1 0	1 0		_
7 LUC		Deforestation		Avoid deforestation	on	SFM, Primary to secondary	forest conservati	n immediate	immedia	ie -	0	0	0	0 1	0	1	1	0	1	0	1		
8 LUC		Deforestation		Avoid deforestation	on	Forest conservation of second	ondary conservati	n immediate	immedia	te 0	+	+	0	0 1	0	0	0	0	0	0	0		
9 LUC	nnagoment E	Degradation Forest management		Avoid degradation Silviculture	1	Sustainable Forest Manage Longer rotations	ement conservati	n immediate on delayed	immedia	e 0	0	+	0	0 1	0	0	0	0	0	0	0		_
11 Vegetation C ma	anagement F	orest management		Silviculture		Species change	sequestrati	on delayed	immedia	ie -	0	0	0	0 1	0	1	1	1	1	1	0		
12 Vegetation C ma	anagement F	orest management		Silviculture		Continuous Cover Forestry	sequestrati	on delayed	immedia	e +	+	+	0	+ 1	0	0	0	0	0	1	0		
13 Vegetation C ma	anagement F	orest management		Silviculture		Improve forest managemen	nt sequestrati	on delayed	immedia	te 0	+	+	+ -	+ 1	0	0	1	0	0	0	0		
15 Vegetation C ma	anagement F	orest management		Residue manager Water manageme	ent	Reduced slash burning Drainage	sequestrati	on delayed	immedia	e -	0	+	-	- 0	0	1	1	1	1	1	0		
16 Vegetation C ma	anagement F	orest management		Fire management	1	Fire management	conservati	n immediate	immedia	te -	0	+	0	+ 0	0	0	1	0	0	0	0		
17 Vegetation C ma	anagement F	orest management		Pest managemen	ıt	Pest management	conservati	n immediate	immedia	e -	0	+	0	+ 0	0	0	1	1	1	1	0		
18 Vegetation C mai	anagement C	Cropland management		Agronomy Agronomy		Increased productivity Crop rotations	sequestrati	on delayed	immedia	te O	+	+	0	0 0	0								
20 Venetation C ma	anagement (ronland management		Agronomy		Catch crops	conservati	n immediate	immedia	e 0	-	+	0	+ 0	0				Dat	ont	ial		
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!Comments!



?Questions?

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