## Bio-fuels, potential and drawbacks

Which crops for what feedstock and where do we grow them

Energy Day 7 - TU Eindhoven

21 February 2013

Dr R.E.E. (Raymond) Jongschaap





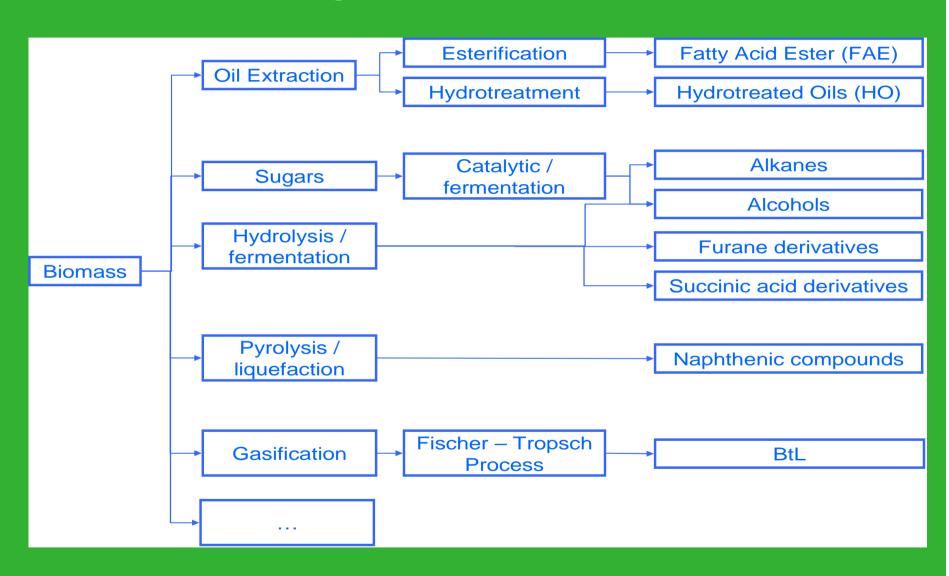
Please cite this presentation as:

Jongschaap, R.E.E., 2013. Bio-fuels, potential and drawbacks. Which crops for what feedstock and where do we grow them. Presentation TU/e Energy Day 7, 21-february-2013, Eindhoven, The Netherlands.

### Outline

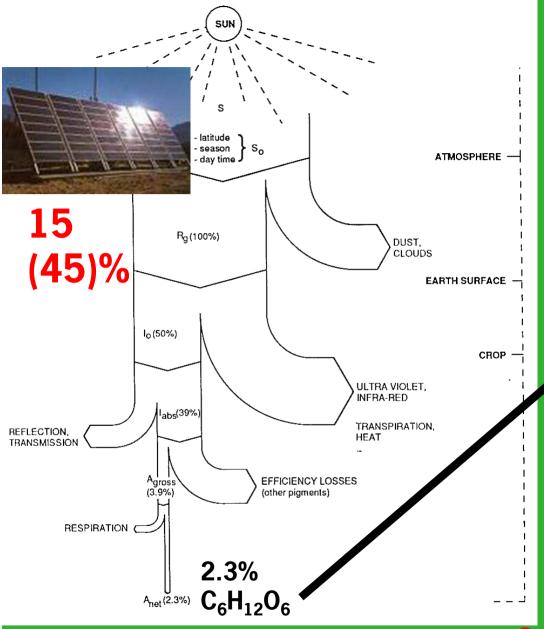
- Biomass to energy: not only biofuels
- Photosynthesis: solar energy conversion into biomass
- Production-ecology: yield gaps and crop management
- Competing claims (12 F's)
- Realistic potentials?
- Conclusions

## Thermal, biological and chemical routes

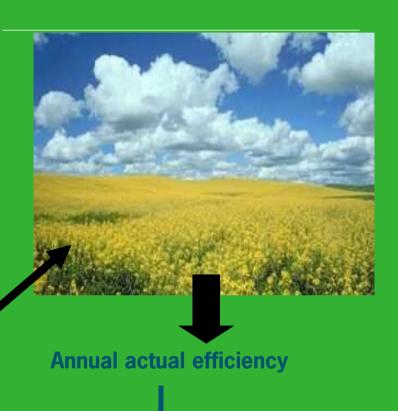


## Photosynthetic mechanisms

- Theoretical energy conversion
  - 4.5 5% for C3 crops (temperate regions)
  - 5.5 6% for C4 crops (tropical regions)
- Max rate of CO<sub>2</sub> fixation at 2000 µmol/m2/s (30° C)
  - 85 µmol/m2/s for C3 (4%)
  - 110 µmol/m2/s for C4 (5.5%)
- Not reached:
  - Respiratory costs
  - Canopies not closed



## Energy efficiency



0.5% temperate regions 2.5% year round tropical

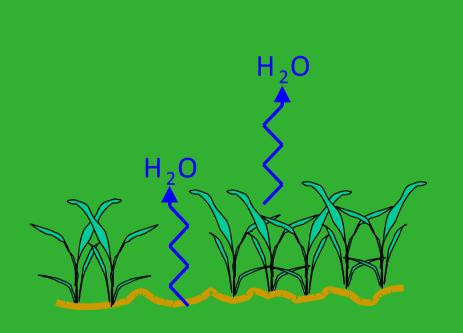
Gross !!

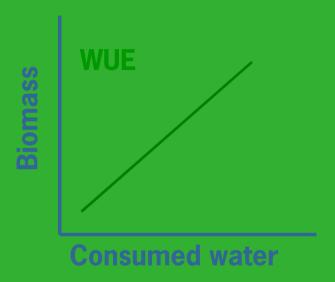




## Water Use Efficiency

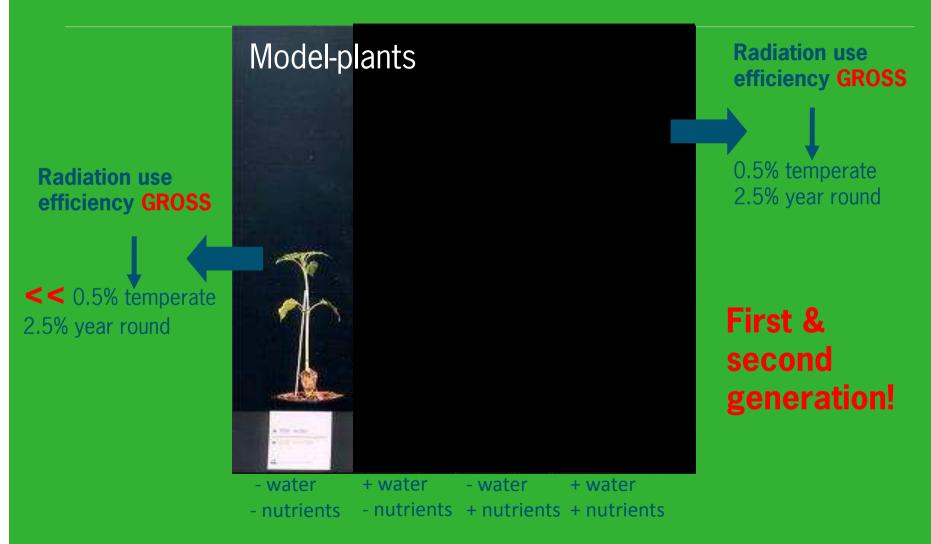
Water consumption





250 kg water / kg dry matter

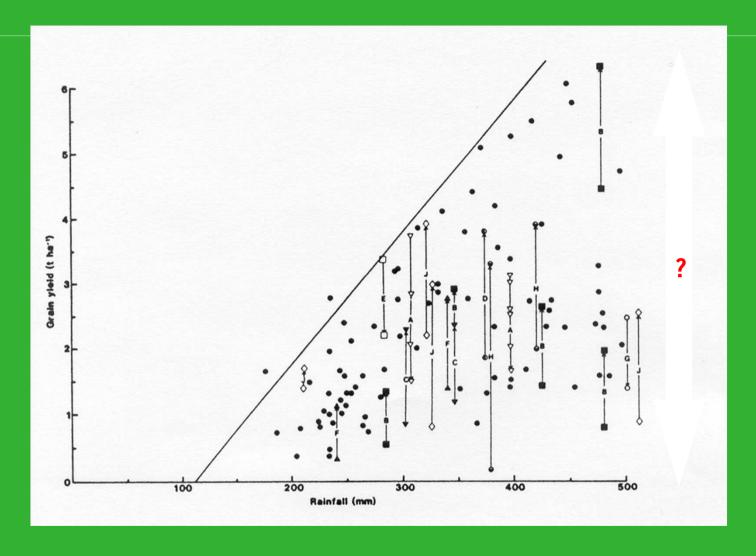
## Basic production ecological principles





Experiments
Plant Research International - Prem Bindraban

## Potential in current agriculture to increase WUE





## Location specific soil management

BUT NOT WITHOUT RISK!

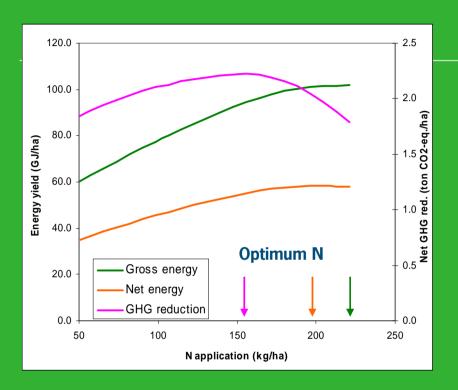
Rainfed + fertilizers

Rainfed - fertilizers





## Optimize rape seed production (NL)



2.5 non-irrig
2 irrig

1.5

0.5

1980 1985 1990 1995 2000

Year

Figure 1. Effects of oilseed rape N application rates on net energy and GHG balance.

Figure 2. Yield increase with 30 days longer growth period of oilseed rape on sandy soils relative to current crop varieties

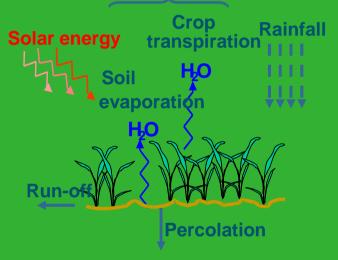


## Realistic perspective on productivity

#### **Production ecological principles drive plant production**

- Crop characteristics (LGS, RUE, DM allocation)
- Radiation
- Temperature
- Precipitation
- Soil characteristics (texture, organic matter, slope)

#### Water consumption



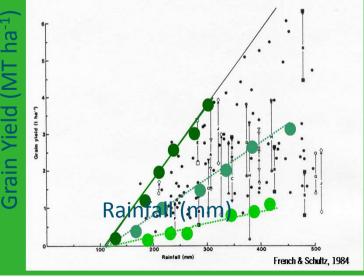
#### Socio-economic settings may limit plant production

Crop management (soil, fertilization, etc.)

#### Abiotic and biotic stresses may reduce plant production

Pests and diseases

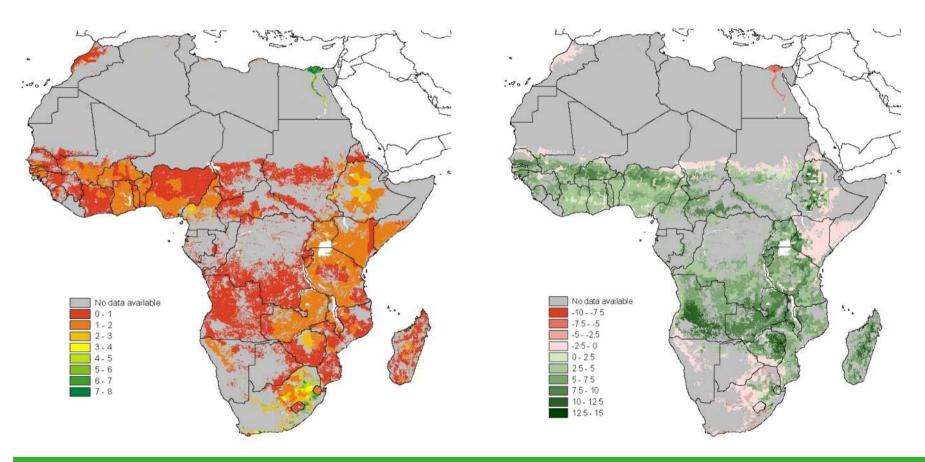




## Rain-fed yield gaps at African continent



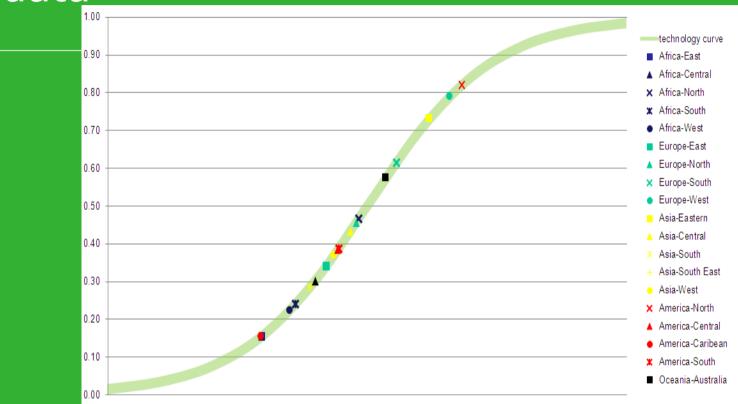
### Yield gap (t ha<sup>-1</sup>)





Source: Conijn et al. (2011)

# Upscale from spatial databases to regional data



Development Index (yield gap), expressed as ratio between actual productivity and biophysical maximum productivity levels for cereal and oilseed crops in the 22 UN sub-regions.



## Primary causes of food crisis

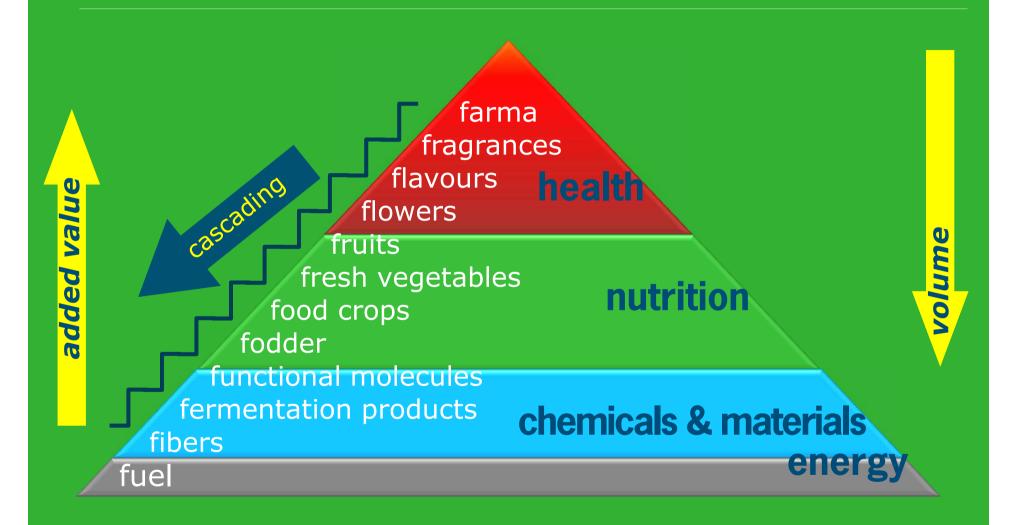
- The combination of extreme weather and subsequent decline in yields and cereal stocks; risks!
- A rapidly increasing share of non-food crops, primarily bio-fuels;
- High oil prices, affecting fertilizer use, food production, distribution and transport, and subsequently food prices;
- Speculation in the food markets.

## Global challenge for the coming decades

How can current and future generations be sustainably provided with sufficient food, energy, fibres and other ecosystem services, given the limited area of available land and natural resources, and increasing world population?

Competing claims!

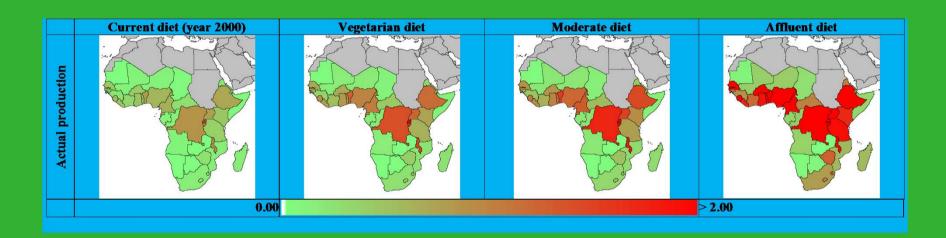
## From Food to Fashion (12 F's of Rudy Rabbinge)





# Requirement/availability of agricultural land

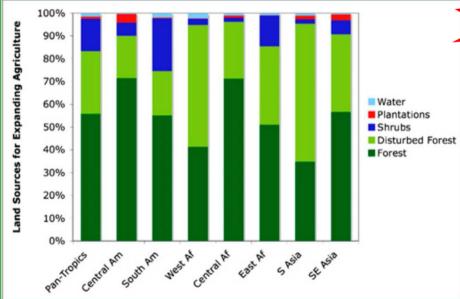
The ratio land requirements/availability for agricultural land per country in SSA for the actual production scenario and different diet compositions (current, vegetarian, moderate and affluent).



#### Ultimate expansion into forests and savanna

1980s and 1990s





iels will exacerbate expansion

expansion of agricultural land appears to come from expansion into intact forest (55%), disturbed forest (28%) and savannah (8%)



H. K. Gibbs, et al., 2010. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. PNAS, 107 (38) 16732–16737.

## Realistic potentials

- Find candidate crops
- Assess realistic production



- Consider different crop types/products
  - Lignocellulose, sugar, starch and oil crops
  - Annual and perennial crops
  - Temperate and tropical crops
  - C3 or C4 photosynthetic process











Biomass	Anr	nual	Perer	nnial
component	C3	C4	C3	C4
Lignocellulose	Italian rye grass (Lolium multiflorum)	Sweet sorghum (Sorghum saccharatum)	Reed canary grass (Phalaris arundinacea) Common reed (Phragmites australis) Perennial rye grass (Lolium perenne)	Miscanthus (Miscanthus spp.) Switch grass (Panicum virgatum)
Lignocellulose SCR			Eucalyptus (Eucalyptus spp.) Poplar (Populus spp.) Willow (Salix spp.)	
Sugar	Sugar beet (Beta vulgaris)	Maize	Cassava	Sugar cane (Saccharum officinarum)
Starch	Wheat (Triticum aestivum)	(Zea mays)	(Manihot esculenta)	
Oil	Camelina (Camelina sativa) Oilseed rape (Brassica napus) Soy (Glycine max) Sunflower (Helianthus annuus)		Jatropha (Jatropha curcas) Oil palm (Elaeis guineensis)	



## Sustainable Production Scenario settings

#### Food security

- 1st Preserve cropland and grassland for food security
- Population growth until 2050 (per UN sub region)
- Regional diet changes in time
- Extrapolate regional productivity increase (1980-2009) for lignocellulose and oil crops until regional physiological maximum!

## Sustainable Production Scenario settings

#### Resource Use

- Land use as in 2000, no deforestation
- Use cropland and grazing land only
- Multiple growing seasons per year

## Sustainable Production Scenario settings

- Crop rotation
- Rotation requirements set by crop type (oil/lignocellulose 2:1 and 1:2)
- Rotate with food crops only if possible (higher production)
- Only annuals on cropland, only perennials on grazing land
- Crop mixes (to produce cellulose, oil, starch or sugar crops in an area)
- Optimization set by (local) feed stock preference

## Production volumes per region

- Calculation steps on a regional base:
- Start with acreage cropland and grazing land in year 2000
- Reduce acreage by regional land requirements for diet production (use local population growth, diet requirements and expected diet change, productivity and productivity increase)
- Set aside (do not affect) sugar cane area
- In case of shortage of cropland, use grazing land (with 25% lower productivity)
- In case of continued shortage of cropland and grazing land: import the required acreages from other regions based on the caloric productivity

## Production volumes per region

#### Final steps:

- Use remaining cropland and grazing land for biofuel production
- Use scenarios to explore potentials

# Scenarios: how to use excess cropland and grazing land

#### General

- Only annuals species on cropland, only perennial species on grazing land
- Oil palm and jatropha only on designated areas
- Maximally use 70% of available grazing land (preserve biodiversity)
- Productivity on grazing land is 75% relative to productivity on cropland

# Scenarios: how to use excess cropland and grazing land

#### **Specific**

Maximize oil or lignocellulose production

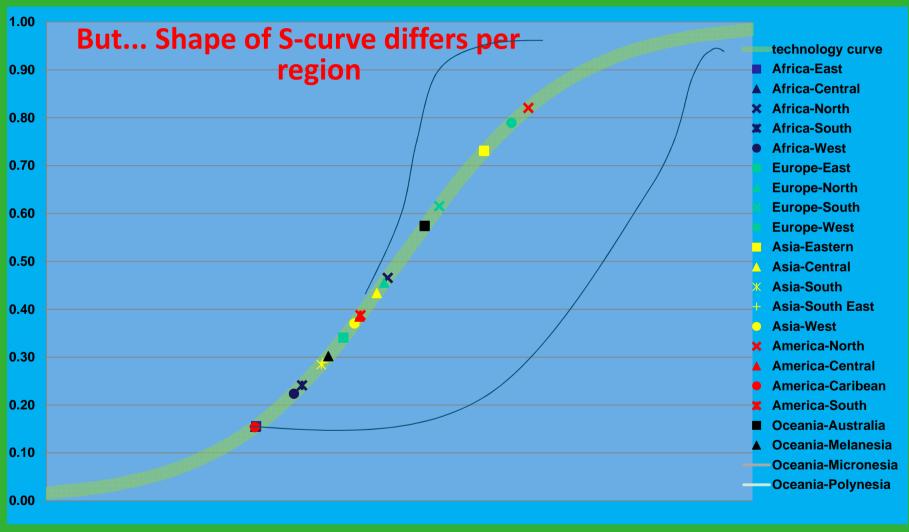
- Rotation Oil Lignocellulose 2:1 and 1:2
- In Max oil scenario: If no perennial oil species is available, use lignocellulose crop
- Include/Exclude grazing lands for biofuel production

#### Technology scenario

Solve the 'yield gap' in 2050 to the level of Europe / North America (82%)



## Regional technological development





## Regional cropland availability

	Year	Africa		163,0562			Asia					E				Latin Ame	-1	_	Northern .	Oceania			-	At a all al
А	Year	Eastern Africa	Middle Af					Central A	Southorn	Southoad	Mostorn	Europe Eastern E	Northorn	Southorn	Wostorn		erica Central A	South Am			Molanocia	Micronesi		World
Constant or a fee dist	2000	50.6		35.9			298.1			104.7	38.5	62.3		29.7		7.7			65.3	4.7			0.1	1237.4
Cropland req for diet (Mha)	2010	64.8		36.7			316.4		309.9	104.7	38.6	55.5	20.0	28.0	37.9	8.3	29.0	70.4	69.7	4.7			0.1	1237.4
(IVIIIa)	2020	79.1	28.3	50.7			320.9		304.2	102.6	37.8	49.0	20.5	25.7	37.4	8.4	29.6	67.9	73.1	5.4			0.1	1318.7
2048	2030	93.0		56.4			315.6	6.7	294.0	97.7	36.9	43.1	20.8	29.5	36.5	8.4	29.6	64.6	75.3	5.7	1.7		0.1	1320.1
2001	2040	105.8		61.3			302.7	5.8	280.3	146.4	35.7	37.8	21.0	28.5	35.3	8.2		83.2	76.4	5.8		0.1	0.2	1375.7
(m2 p-1 y-1)	2050	116.8	37.3	65.0	6.7	70.8	284.7	5.2	264.4	147.4	34.2	33.4	21.0	27.3	33.8	7.9	27.6	81.3	76.7	5.9	1.8	0.1	0.2	1349.4
В	Year	Africa					Asia					Europe				Latin Ame	erica		Northern .	Oceania			٧	World
		Eastern Africa						Central A					Northern				Central A		Northern .			Micronesi		
Cropland	2000	56.6		45.1			151.1	32.1	231.6	93.2	48.4	204.6	15.4	42.1	31.5	7.3	35.4		206.0	22.8	1.3	0.1	0.2	1461.6
available	2010 2020	56.6 56.6		45.1 45.1			151.1 151.1	32.1 32.1	231.6 231.6	93.2 93.2	48.4 48.4	204.6 204.6	15.4 15.4	42.1 42.1	31.5	7.3	35.4	115.6	206.0 206.0	22.8 22.8	1.3		0.2	1461.6
(Mha)	2020	56.6		45.1 45.1			151.1	32.1	231.6	93.2	48.4 48.4	204.6	15.4	42.1	31.5 31.5	7.3 7.3	35.4 35.4	115.6 115.6	206.0	22.8	1.3 1.3		0.2 0.2	1461.6 1461.6
	2040	56.6		45.1			151.1	32.1	231.6	93.2	48.4	204.6	15.4	42.1	31.5	7.3	35.4	115.6	206.0	22.8			0.2	1461.6
	2050	56.6		45.1			151.1		231.6	93.2	48.4	204.6	15.4	42.1	31.5	7.3	35.4	115.6	206.0	22.8			0.2	1461.6
С	Year	Africa					Asia					Europe				Latin Ame	erica		Northern .	Oceania		i	V	World
		Eastern Africa	Middle Af	Northern	Southern	Western A	Eastern A	Central A	Southern	Southeas	Western A	Eastern E	Northern	Southern	Western	Caribbea	Central A	South Am	Northern .	Australia	Melanesia	Micronesi	Polynesia	
Oil Palm acreage	2000	0.0	0.0			3.8		0.0	5.4							0.0	0.1	0.3			0.1			10.1
Sugar cane acreage	2000	0.4	0.2	0.2	0.4	0.1		1.3	2.2	5.5	0.0			0.0		1.3	1.1	6.2	0.4	0.4	0.1		0.0	19.8
D: B-A-C	Year	Africa					Asia					Europe				Latin Ame				Oceania				World
		Eastern Africa	Middle Af	Northern	Southern	Western A	Eastern A	Central A	Southern	Southeas	Western A	Eastern E	Northern	Southern	Western	Caribbea	Central A	South Am			Melanesia	Micronesi	Polynesia	
Cropland	2000	5.6	4.0	9.0	6.5	28.5	-147.0	19.6	-72.1	-17.0	9.9	142.3	-3.9	12.3	-6.0	-1.7	7.1	39.6	140.3	17.6	-0.3	0.0	0.0	194.3 135.0
Excess / Deficit	2010	-8.6	-0.7	8.2	6.8		-165.3	21.8	-85.9	-19.3	9.8	149.1	-4.6	14.0	-6.4	-2.3	5.2	38.7	135.9	17.7	-0.5	0.0	0.0	.00.0
(Mha)	2020 2030	-23.0	-4.7	-5.6	7.9	16.2 11.9	-169.8	23.2 24.2	-80.2	-14.9	10.6 11.5	155.5	-5.1	16.3 12.5	-5.9	-2.4	4.6 4.5	41.2 44.5	132.5	16.9 16.7	-0.6	-0.1	0.0	113.0 111.6
	2030	-36.8 -49.7	-8.3	-11.5	8.7 9.4	110	-164.4 -151.6	24.2	-70.0	-10.0	11.5	161.4 166.7	-5.4	12.5	-5.0	-2.4	4.5 5.2	26.0	130.3 129.2	16.7	-0.6	-0.1 0.1	0.0	56.0
	2050	-49.7 60.6	-11.3	-10.4	10.0	5.3	122.6	25.0	-30.2	-30.7	14.2	171.2	-5.5	14.8	-3.0	1.0	6.5	27.8	128.9	16.5	-0.7	-0.1	0.0	82.3
	2000	-00.0	-13.0	-20.1	10.0	5.5	-100.0	20.1	-40.5	-55.1	17.2	171.2	-5.0	14.0	-2.0	1	0.0	21.0	120.3	10.4	-0.7	-0.1	0.0	02.0
F	Year	Africa					Asia					Europe				Latin Ame	erica		Northern .	Oceania			V	World
_		Eastern Africa	Middle Af	Northern	Southern			Central A	Southern	Southeas	Western A		Northern	Southern	Western		Central A	South Am			Melanesia	Micronesi		
Cropland deficit that	2000	0.0		0.0			147.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0		0.0	0.0	0.0	0.0	0.0	0.0		0.0	156.6
can be 'relieved by	2010	8.6														0.0							0.0	184 4
bo .oo.ou by		0.0	0.7	0.0	0.0	0.0	165.3	0.0	0.0	0.0	0.0	0.0	4.6	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	184.4
the use of grassland	2020	23.0	0.7 4.7	5.6	0.0	0.0	165.3 169.8	0.0	0.0	0.0	0.0	0.0	4.6 5.1	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	213.1
	2020 2030	23.0 36.8	0.7 4.7 8.3	5.6 11.5			100.0						4.6 5.1 5.4		5.1									213.1 231.4
the use of grassland	2020 2030 2040	36.8 49.7	8.3 11.3	5.6 11.5 16.4	0.0 0.0 0.0	0.0 0.0 0.0	169.8 164.4 151.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	5.1 5.4 5.5	0.0 0.0 0.0	5.1 5.0 3.8	0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	213.1 231.4 238.3
the use of grassland	2020 2030	36.8	8.3	5.6 11.5	0.0	0.0 0.0 0.0	169.8 164.4	0.0	0.0	0.0	0.0	0.0	4.6 5.1 5.4 5.5 5.6	0.0	5.1 5.0 3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	213.1 231.4
the use of grassland (Mha)	2020 2030 2040 2050	36.8 49.7 47.0	8.3 11.3	5.6 11.5 16.4	0.0 0.0 0.0	0.0 0.0 0.0 0.0	169.8 164.4 151.6 133.6	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0 0.0	4.6 5.1 5.4 5.5 5.6	0.0 0.0 0.0	5.1 5.0 3.8	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2
the use of grassland	2020 2030 2040	36.8 49.7 47.0 Africa	8.3 11.3 13.6	5.6 11.5 16.4 20.1	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	169.8 164.4 151.6 133.6	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0	0.0 0.0 0.0 0.0	5.1 5.0 3.8 2.3	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Northern	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	213.1 231.4 238.3
the use of grassland (Mha) F: D+E	2020 2030 2040 2050 Year	36.8 49.7 47.0	8.3 11.3 13.6 Middle Af	5.6 11.5 16.4 20.1 Northern	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Western A	169.8 164.4 151.6 133.6 Asia Eastern A	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Europe Eastern E	Northern	0.0 0.0 0.0 0.0	5.1 5.0 3.8 2.3	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Northern	0.0 0.0 0.0 0.0 Oceania Australia	0.0 0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2
the use of grassland (Mha) F: D+E	2020 2030 2040 2050 Year	36.8 49.7 47.0 Africa Eastern Africa 5.6	8.3 11.3 13.6 Middle Af	5.6 11.5 16.4 20.1 Northern 9.0	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Western A	169.8 164.4 151.6 133.6 Asia Eastern A	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Europe Eastern E	Northern 0.0	0.0 0.0 0.0 0.0 0.0 Southern	5.1 5.0 3.8 2.3	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 South Am	0.0 0.0 0.0 0.0 Northern Northern	0.0 0.0 0.0 0.0 Oceania Australia	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit	2020 2030 2040 2050 Year 2000 2010	36.8 49.7 47.0 Africa Eastern Africa 5.6 0.0	8.3 11.3 13.6 • Middle Af I	5.6 11.5 16.4 20.1 Northern 9.0 8.2	0.0 0.0 0.0 0.0 .Southern	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4	169.8 164.4 151.6 133.6 Asia Eastern A	0.0 0.0 0.0 0.0 0.0 Central A 19.6 21.8	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southeas	0.0 0.0 0.0 0.0 0.0 Western A	0.0 0.0 0.0 0.0 Europe Eastern E 142.3	Northern   0.0   0.0	0.0 0.0 0.0 0.0 0.0 Southern 12.3	5.1 5.0 3.8 2.3	0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 erica Central A 7.1	0.0 0.0 0.0 0.0 0.0 South Am 39.6 38.7	0.0 0.0 0.0 0.0 Northern 140.3	0.0 0.0 0.0 0.0 Oceania Australia 17.6	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5
the use of grassland (Mha)  F: D+E  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland	2020 2030 2040 2050 Year 2000 2010 2020	36.8 49.7 47.0 Africa Eastern Africa 5.6 0.0	8.3 11.3 13.6 Middle Af I 4.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 8.2	0.0 0.0 0.0 0.0 0.0 Southern 6.5 6.8	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Central A 19.6 21.8 23.2	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1	Northern 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0	5.1 5.0 3.8 2.3 Western I -0.2 -1.2	0.0 0.0 0.0 0.0 0.0 Latin Ame Caribbeau -1.7 -2.3	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2	0.0 0.0 0.0 0.0 Northern 140.3 135.9	0.0 0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit	2020 2030 2040 2050 Year 2000 2010	36.8 49.7 47.0 Africa Eastern Africa 5.6 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 8.2	0.0 0.0 0.0 0.0 .Southern 6.5 6.8 7.9	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2	169.8 164.4 151.6 133.6 Asia Eastern A	0.0 0.0 0.0 0.0 0.0 Central A 19.6 21.8	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southeas	0.0 0.0 0.0 0.0 0.0 Western A	0.0 0.0 0.0 0.0 Europe Eastern E 142.3	Northern   0.0   0.0	0.0 0.0 0.0 0.0 0.0 Southern 12.3	5.1 5.0 3.8 2.3	0.0 0.0 0.0 0.0 Latin Ame Caribbear -1.7 -2.3 -2.4	0.0 0.0 0.0 0.0 erica Central A 7.1	0.0 0.0 0.0 0.0 0.0 South Am 39.6 38.7	0.0 0.0 0.0 0.0 Northern 140.3	0.0 0.0 0.0 0.0 Oceania Australia 17.6	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5
the use of grassland (Mha)  F: D+E  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland	2020 2030 2040 2050 Year 2000 2010 2020 2030	36.8 49.7 47.0 Africa Eastern Africa 5.6 0.0 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 8.2 0.0	0.0 0.0 0.0 0.0 Southern 6.5 6.8 7.9 8.7	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Central A 19.6 21.8 23.2 24.2	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5	Northern 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3	5.1 5.0 3.8 2.3 Western I -0.2 -1.2 -0.8	0.0 0.0 0.0 0.0 Latin Ame Caribbear -1.7 -2.3 -2.4 -2.4	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5	0.0 0.0 0.0 0.0 0.0 Oceania Australia 17.6 16.9	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1
the use of grassland (Mha)  F: D+E  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland	2020 2030 2040 2050 Year 2000 2010 2020 2030 2040	36.8 49.7 47.0 Africa Eastern Africa 5.6 0.0 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 8.2 0.0 0.0	0.0 0.0 0.0 0.0 Southern 6.5 6.8 7.9 8.7	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Central A 19.6 21.8 23.2 24.2	0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5	0.0 0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7	Northern   0.0   0.0   0.0   0.0   0.0   0.0	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5	5.1 5.0 3.8 2.3 Western   -0.2 -1.2 -0.8 0.0	0.0 0.0 0.0 0.0 Latin Ame Caribbear -1.7 -2.3 -2.4 -2.4	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2
the use of grassland (Mha)  F: D+E  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland  Cropland	2020 2030 2040 2050 Year 2000 2010 2020 2030 2040	36.8 49.7 47.0 Africa Eastern Africa 5.6 0.0 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 8.2 0.0 0.0	0.0 0.0 0.0 0.0 Southern 6.5 6.8 7.9 8.7	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 5.3	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Central A 19.6 21.8 23.2 24.2	0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5	0.0 0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7	Northern   0.0   0.0   0.0   0.0   0.0   0.0	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5	5.1 5.0 3.8 2.3 Western   -0.2 -1.2 -0.8 0.0	0.0 0.0 0.0 0.0 Latin Ame Caribbear -1.7 -2.3 -2.4 -2.4	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6 4.5 5.2 6.5	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)	2020 2030 2040 2050 Year 2000 2010 2020 2030 2040 2050 Year	36.8 49.7 47.0 Africa Eastern Africa 5.6 0.0 0.0 0.0 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0	5.66 11.5 16.4 20.1 Northern 9.0 8.2 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Southern 6.5 6.8 7.9 8.7 9.4	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 5.3	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Central A 19.6 21.8 23.2 24.2 25.0 25.7	0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0 -56.2 -40.3	0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5 12.7	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7 171.2	Northern 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6	5.1 5.0 3.8 2.3 Western -0.2 -1.2 -0.8 0.0 0.0	0.0 0.0 0.0 0.0 Latin Ame Caribbea -1.7 -2.3 -2.4 -2.2 -1.9	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6 4.5 5.2 6.5	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5 26.0 27.8	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9 16.7 16.4	0.0 0.0 0.0 0.0 0.0 Melanesia -0.3 -0.5 -0.6 -0.6 -0.7	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland	2020 2030 2040 2050 Year 2000 2010 2020 2030 2040 2050 Year	36.8 49.7 47.0 Africa Eastern Africa 0.0 0.0 0.0 0.0 13.7 Africa Eastern Africa 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0	5.66 11.5 16.4 20.1 Northern 9.0 8.2 0.0 0.0 0.0	0.0 0.0 0.0 0.0 Southern 6.5 6.8 7.9 8.7 9.4	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 5.3	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 Asia Eastern A 0.0	0.0 0.0 0.0 0.0 Central A. 19.6 21.8 23.2 24.2 25.0 25.7	0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0 -56.2 -40.3	0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5 12.7	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7 171.2	Northern   0.0   0	0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6	5.1 5.0 3.8 2.3 Western   -0.2 -1.2 -0.8 0.0 0.0 0.0 0.0 Western   -0.2	0.0 0.0 0.0 0.0 Latin Ame Caribbea -1.7 -2.3 -2.4 -2.2 -1.9	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6 4.5 5.2 6.5	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5 26.0 27.8	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9 16.7 16.4	0.0 0.0 0.0 0.0 Melanesia -0.3 -0.5 -0.6 -0.6 -0.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.1 -0.1	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported'	2020 2030 2040 2050 Year 2000 2010 2020 2030 2040 2050 Year 2000 2010	36.8 49.7 47.0 Africa Eastern Africa 0.0 0.1 13.7 Africa Eastern Africa Eastern Africa Co.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 8.2 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southern 6.5 6.8 7.9 8.7 9.4 10.0	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 5.3	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 21.8 21.8 23.2 24.2 25.0 25.7	0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0 -56.2 -40.3	0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5 12.7	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7 171.2	Northern 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6	5.1. 5.0 3.8 2.3 Western -0.2 -1.2 -0.8 0.0 0.0 0.0 Western 0.4 1.9	0.0 0.0 0.0 0.0 Latin Ame Caribbea -1.7 -2.3 -2.4 -2.2 -1.9	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6 4.5 5.2 6.5	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5 26.0 27.8	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9 16.7 16.4	0.0 0.0 0.0 0.0 0.0 Melanesis -0.3 -0.5 -0.6 -0.6 -0.7 -0.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.1 -0.1	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland Imported/Exported' (Mha)	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020	36.8 49.7 47.0 Africa Eastern Africa 0.0 0.0 -13.7  Africa Eastern Africa Co.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 0.0 0.0 0.0 0.0 Northern -0.1	0.0 0.0 0.0 0.0 0.0 Southern 6.5 6.8 7.9 9.4 10.0 Southern 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 5.3	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 21.8 21.8 23.2 24.2 25.0 25.7	0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0 -56.2 -40.3 Southern 72.0 85.6 85.6 85.6	0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5 12.7	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7 171.2	Northern 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6	5.1. 5.0. 3.8. 2.3.  Western 1 -0.21.20.8. 0.0. 0.0. 0.0.  Western 1 0.4. 1.9.	0.0 0.0 0.0 0.0 Latin Ame Caribbea -1.7 -2.3 -2.4 -2.2 -1.9	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6 4.5 5.2 6.5	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5 26.0 27.8	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9 16.7 16.4	0.0 0.0 0.0 0.0 0.0 Melanesia -0.5 -0.6 -0.6 -0.7 -0.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.1 -0.1	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030	36.8 49.7 47.0 Africa Eastern Africi 0.0 0.0 0.1 Africa Eastern Africi 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 0.0 0.0 0.0 Northern -0.1 -0.1	0.0 0.0 0.0 0.0 0.0 Southern 6.5. 6.8 7.9 8.7 9.4 10.0 Southern 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 5.3	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 21.8 21.8 23.2 24.2 25.0 25.7	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -70.0 -56.2 -40.3 Southern 72.0 85.6 80.4 70.7	0.0 0.0 0.0 0.0 5outheas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5 12.7	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7 171.2	Northern   0.0   0	0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6	5.1 5.0 3.8 2.3 Western -0.2 -1.2 -0.8 0.0 0.0 0.0 0.0 0.0 0.4 1.9 1.1	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6 4.5 5.2 6.5	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5 26.0 27.8	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9 16.7 16.4	0.0 0.0 0.0 0.0 0.0 Melanesis -0.3 -0.5 -0.6 -0.6 -0.7 -0.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on regional difference	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050	36.8 49.7 47.0 Africa Eastern Africa 0.0 0.0 -13.7  Africa Eastern Africa Co.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 6.5 6.8 7.9 8.7 9.4.4 10.0 Southern 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 5.3	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 0.0 19.6 21.8 23.2 24.2 25.0 25.7 Central A -0.6 -0.9 -1.3	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0 -56.2 -40.3 Southern 72.0 85.6 80.4 70.7 57.1	0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5 12.7	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7 171.2	Northern 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6	\$.1 5.0 3.8 2.3 Western   -0.2 -1.2 -0.8 -0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.7 2.3 2.2 1.9 1.7 1.7 1.9 1.7	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6 4.5 5.2 6.5	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5 26.0 27.8	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9 16.7 16.4	0.0 0.0 0.0 0.0 0.0 0.0 Melane sia -0.3 -0.5 -0.6 -0.7 -0.7 Melane sia 0.4 -0.6 0.6 0.6 0.7 -0.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.1 -0.1	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030	36.8 49.7 47.0 Africa Eastern Africi 0.0 0.0 0.1 Africa Eastern Africi 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 0.0 0.0 0.0 Northern -0.1 -0.1	0.0 0.0 0.0 0.0 0.0 0.0 0.0 6.5 6.8 7.9 8.7 9.4.4 10.0 Southern 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 5.3	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 0.0 19.6 21.8 23.2 24.2 25.0 25.7 Central A -0.6 -0.9 -1.3	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -70.0 -56.2 -40.3 Southern 72.0 85.6 80.4 70.7	0.0 0.0 0.0 0.0 5outheas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5 12.7	0.0 0.0 0.0 0.0 Europe Eastern E 142.3 149.1 155.5 161.4 166.7 171.2	Northern   0.0   0	0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6	5.1 5.0 3.8 2.3 Western -0.2 -1.2 -0.8 0.0 0.0 0.0 0.0 0.0 0.4 1.9 1.1	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1.7 2.3 2.2 1.9 1.7 1.7 1.9 1.7	0.0 0.0 0.0 0.0 erica Central A 7.1 5.2 4.6 4.5 5.2 6.5	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5 26.0 27.8	0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9	0.0 0.0 0.0 0.0 Oceania Australia 17.6 17.7 16.9 16.7 16.4	0.0 0.0 0.0 0.0 0.0 Melanesis -0.3 -0.5 -0.6 -0.6 -0.7 -0.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.1 -0.1	0.0 0.0 0.0 0.0 0.0 V Polynesia 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on regional difference	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050	36.8 49.7 47.0 Africa Eastern Africa 0.0 0.0 1-13.7 Africa Eastern Africa Co.0 0.0 0.0 0.0 0.0 1.1 0.0 0.0 0.0 0.0 0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1 Northern 9.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 6.5 6.8 7.9 8.7 9.4.4 10.0 Southern 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 Western A 28.5 21.4 16.2 11.9 8.1 -0.6 -0.5 -0.2 -0.3	169.8 164.4 151.6 133.6  Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 0.0 19.6 21.8 23.2 24.2 25.0 25.7 Central A -0.6 -0.9 -1.3	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0 -56.2 -40.3 Southern 72.0 85.6 80.4 70.7 57.1	0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6	0.0 0.0 0.0 0.0 0.0 Western A 9.9 9.8 10.6 11.5 12.7	0.0 0.0 0.0 0.0 0.0 0.0 Europe Eastern E 149.1 155.5 161.4 166.7 171.2 Europe Eastern E 4-91.3 5-53.1 5-55.5 6-3.5 6-4.7	Northern 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6	\$.1 5.0 3.8 2.3 Western   -0.2 -1.2 -0.8 -0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 Latin Ame Caribbean 1.7 2.3 -2.4 -2.2 1.9 Latin Ame Caribbean 1.9 1.9 1.9 1.9 1.9 1.9 1.9 1.9 1.9 1.9	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 44.5 26.0 27.8	0.0 0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 128.9 Northern Northern Northern -54.2 -48.1 -45.1 -45.1	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 Melane sia -0.3 -0.5 -0.6 -0.7 -0.7 Melane sia 0.4 -0.6 0.6 0.6 0.7 -0.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 -0.1 -0.1	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	213.1 231.4 231.4 231.4 232.2 World 350.9 319.5 326.1 343.1 294.2 304.4 World -17.8 -0.8 -11.9 -28.8 4.3 2.6
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on regional difference	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050	36.8 49.7 47.0 Africa Eastern Africi 5.6 0.0 0.0 0.0 -13.7 Africa Eastern Africi 0.0 0.0 0.0 0.0 1.0 1.0 1.0 1.0 1.0 1.0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1  Northern 9.0 0.0 0.0 0.0  Northern -0.1 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 Southern 6.5 6.8 7.9 8.7 9.4 10.0 Southern 0.0 0.1 10.0 10.0 10.0 10.0 10.0 10.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 Western A 16.2 11.9 8.1 5.3 Western A -0.6 -0.3 -0.2	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 Asia Eastern A 0.0 0.0 0.0 Asia Asia Asia Asia Asia Asia Asia Asia	0.0 0.0 0.0 0.0 0.0 0.0 19.6 21.8 21.8 22.2 25.0 25.7  Central A. 0.6 0.9 1.3 -1.6 2.0 -2.3	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -86.9 -80.2 -70.0 -56.2 -40.3 Southern -72.0 85.6 80.4 -70.7 57.1 43.8	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6 63.6	0.0 0.0 0.0 0.0 0.0 9.9 9.8 10.6 11.5 12.7 14.2 Western A -0.2 -0.2 -0.3 -0.3	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Northern 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6 14.8 Southern -0.4 -0.5 -0.7 -0.7	5.1 5.0 3.88 2.3 Western   -0.2 -0.8 0.0 0.0 0.0 0.4 1.9 1.1 1.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 39.6 38.7 41.2 44.5 26.0 27.8 South Am -2.3 -2.3 -2.7 -3.2 -1.1	0.0 0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9 Northern -54.2 -48.1 -45.7 -45.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha) Note: based on regional difference in MJ m-2!	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year	36.8 49.7 47.0 Africa Eastern Africa 0.0 0.0 1-13.7 Africa Eastern Africa Co.0 0.0 0.0 0.0 0.0 1.1 0.0 0.0 0.0 0.0 0	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 16.4 20.1  Northern 9.0 0.0 0.0 0.0  Northern -0.1 -0.1 0.0 0.0  Northern Northern	0.0 0.0 0.0 0.0 0.0 0.0 5 6.5 6.8 7.9 9.4 10.0 Southern 0.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 Western A 16.2 11.9 8.1 5.3 Western A -1.0 -0.6 -0.3 3 -0.2 -0.1	169.8 164.4 151.6 151.6 133.6  Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -86.9 -80.2 -70.0 -56.2 -40.3 Southern -72.0 85.6 80.4 -70.7 57.1 43.8	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6 63.6	0.0 0.0 0.0 0.0 0.0 9.9 9.8 10.6 11.5 12.7 14.2 Western A -0.2 -0.2 -0.3 -0.3	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Northern  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6 14.8 Southern -0.4 -0.5 -0.7 -0.5 Southern	5.1 5.0 3.88 2.3 Western   -0.2 -0.8 0.0 0.0 0.0 0.4 1.9 1.1 1.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 26.0 27.8 South Am -2.3 -2.7 -3.2 -1.1 -1.3	0.0 0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9 Northern Northern 451.2 451.7 451.7 451.7	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 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 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	213.1 231.4 231.4 231.4 232.2 World 350.9 319.5 326.1 343.1 294.2 304.4 World -17.8 -0.8 -11.9 -28.8 4.3 2.6
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on regional difference in MJ m-2!  H  Cropland for	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2040 2050	36.8 49.7 47.0 Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 11.5 11.4 20.1  Northern 9.0 8.2 0.0 0.0 0.0 0.0 0.0 0.0  Northern -0.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 5 6.5 6.8 7.9 9.4 10.0 5 5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	169.8 164.4 151.6 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -86.9 -80.2 -70.0 -56.2 -40.3 Southern -72.0 85.6 80.4 -70.7 57.1 43.8	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6 63.6	0.0 0.0 0.0 0.0 0.0 0.0 Western A 1.5.5 12.7 14.2 Western A -0.2 -0.3 -0.3 -0.4 -0.5	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Northern 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6 14.8 Southern -0.4 -0.5 -0.7 -0.5 -0.5	5.1 5.0 5.0 5.0 5.0 6.2 6.2 6.2 6.2 6.2 6.2 6.2 6.2 6.2 6.2	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 South Am 38.7 41.2 44.5 26.0 27.8 South Am -2.3 -2.7 -3.2 -1.1 -1.3	0.0 0.0 0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 128.9 128.9 Northern Northern 140.3 140	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4 World -17.8 -0.8 -11.9 -28.8 4.3 2.6 World
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on regional difference in MJ m-2!  H  Cropland for biofutel production	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2050	36.8 49.7 47.0 Africa Eastern Africa	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 11.5 11.6 12.1 11.5 12.1 12.1 12.1 12.1 13.1 14.1 15.1 16.1 16.1 16.1 16.1 16.1 16.1 16	0.0 0.0 0.0 0.0 0.0 0.0 0.0 6.5 6.8 7.9 9.4 10.0 Southern 0.0 -0.1 -0.1 -0.2 Southern 6.4 6.5	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 19.6 21.8 23.2 24.2 25.0 25.7  Central A 0.6 -0.9 1.3 -1.6 2.0 2.3  Central A 0.20 0.20 8	0.0 0.0 0.0 0.0 0.0 Southern 72.1 -85.9 -80.2 -70.0 -56.2 -40.3 Southern 72.0 80.4 70.7 57.1 43.8	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6 63.6	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 9.9 9.8 10.6 11.5 12.7 14.2 Western A -0.2 -0.3 -0.3 -0.4 -0.5	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Northern   0.0   0	0.0 0.0 0.0 0.0 0.0 12.3 14.0 16.3 12.5 13.6 14.8 Southern -0.4 -0.5 -0.7 -0.5 -0.5 -0.5 -0.5 -0.5 -0.5 -0.5 -0.5	5.1 5.0 3.88 2.3 Western   -0.2 -0.8 0.0 0.0 0.0 0.4 1.9 1.1 1.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 39.6 38.7 41.2 44.5 26.0 27.8  South Am -2.3 -2.7 -3.2 -1.1 -1.3  South Am 37.3 36.4	0.0 0.0 0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9 Northern Northern 43.5 43.5 43.5 Northern 65.1 43.5	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 394.2 304.4 World -17.8 -0.8 4.3 2.3 2.3 2.3 2.3 2.3 2.3 2.3 2.3 2.3 2
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on regional difference in MJ m-2!  H  Cropland for	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year	36.8 49.7 47.0 Africa Eastern Afric: 0.0 0.0 0.0 13.7 Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 11.5 11.6 12.1 11.5 11.6 11.6 11.6 11.6 11.6 11.6 11	0.0 0.0 0.0 0.0 0.0 0.0 0.0 6.5 6.8 7.9 9.4 10.0 Southern 0.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1	0.0 0.0 0.0 0.0 0.0 0.0 Western A 16.2 11.9 8.1 5.3 Western A -0.6 -0.3 3.0-0.2 -0.1 0.0	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 Asia Eastern A 0.0 0.0 0.0 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -86.9 -80.2 -70.0 -56.2 -40.3 Southern -72.0 85.6 80.4 -70.7 57.1 43.8	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6 63.6	0.0 0.0 0.0 0.0 0.0 0.0 Western A 1.5.5 12.7 14.2 Western A -0.2 -0.3 -0.3 -0.4 -0.5	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Northern  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6 14.8 Southern -0.4 -0.5 -0.7 -0.4 -0.5 -0.5 Southern 11.9 13.5	5.1 5.0 5.0 5.0 5.0 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 South Am 38.7 41.2 44.5 26.0 27.8 South Am -2.3 -2.7 -3.2 -1.1 -1.3	0.0 0.0 0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 128.9 128.9 Northern Northern 140.3 140	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4 World -17.8 -0.8 -11.9 -28.8 4.3 2.6 World
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on regional difference in MJ m-2!  H  Cropland for biofutel production	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050	36.8 49.7 47.0 Africa Eastern Africa Co.0 0.0 0.0 13.7 Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 11.5 11.6 12.1 11.6 11.6 11.6 11.6 11.6 11.6	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 Western A 16.2 11.9 8.1 5.3 Western A -0.6 -0.3 3.0-0.2 -0.1 0.0	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0 -56.2 -40.3 Southern 72.0 85.6 80.4 70.7 57.1 43.8	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6 63.6	0.0 0.0 0.0 0.0 0.0 0.0 Western A 10.6 11.5.5 12.7 14.2 Western A -0.2 -0.3 -0.3 -0.3 -0.4 -0.5	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Northern 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 12.3 14.0 16.3 12.5 13.6 14.8 Southern -0.4 -0.5 -0.7 -0.7 -0.4 -0.5 Southern 11.9 13.5 13.5 13.5	## S.11   S.12   S.12   S.13   S.14   S.15	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 24.5 26.0 27.8 South Am -2.3 -2.3 -2.3 -2.7 -3.2 -1.1 -1.3 South Am 37.3 -3.6 -4.3 -4.5 -4.5 -4.5 -4.5 -4.5 -4.5 -4.5 -4.5	0.0 0.0 0.0 0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 130.3 129.2 128.9 Northern -54.2 48.1 -45.7 45.1 -43.5 Northern Northern 86.1.1 84.4 84.4	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4 World -17.8 -0.8 -11.9 -28.8 4.3 2.6 World
the use of grassland (Mha)  F: D+E  Cropland Excess / Deficit after use of grassland (Mha)  G  Cropland 'Imported/Exported' (Mha)  Note: based on regional difference in MJ m-2!  H  Cropland for biofuel production	2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year	36.8 49.7 47.0 Africa Eastern Afric: 0.0 0.0 0.0 13.7 Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa Eastern Africa 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	8.3 11.3 13.6 Middle Af 4.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	5.6 11.5 11.5 11.6 12.1 11.5 11.6 11.6 11.6 11.6 11.6 11.6 11	0.0 0.0 0.0 0.0 0.0 0.0 0.0 6.5 6.8 7.9 9.4 10.0 Southern 0.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1	0.0 0.0 0.0 0.0 0.0 0.0 Western A 16.2 11.9 8.1 5.3 Western A -0.6 -0.3 3.0-0.2 -0.1 0.0	169.8 164.4 151.6 133.6 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 Asia Eastern A 0.0 0.0 0.0 Asia Eastern A 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 Southern -72.1 -85.9 -80.2 -70.0 -56.2 -40.3 Southern -72.0 85.6 80.4 -70.7 57.1 43.8	0.0 0.0 0.0 0.0 0.0 Southeas -17.0 -19.3 -14.9 -10.0 -58.7 -59.7 Southeas 17.0 19.1 14.8 10.0 58.6 63.6	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Northern  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	0.0 0.0 0.0 0.0 0.0 Southern 12.3 14.0 16.3 12.5 13.6 14.8 Southern -0.4 -0.5 -0.7 -0.4 -0.5 -0.5 Southern 11.9 13.5	5.1 5.0 5.0 5.0 5.0 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 South Am 39.6 38.7 41.2 26.0 27.8 South Am -2.3 -2.7 -3.2 -1.1 -1.3 South Am 37.3 36.4	0.0 0.0 0.0 0.0 0.0 0.0 Northern 140.3 135.9 132.5 128.9 Northern Northern 1-54.2 -51.2 -48.1 -45.1 -43.5 Northern Northern 86.1 84.6 84.4	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	213.1 231.4 238.3 222.2 World 350.9 319.5 326.1 343.1 294.2 304.4 World -17.8 -0.8 -11.9 -28.8 4.3 2.6 World



# Regional grazing land availability

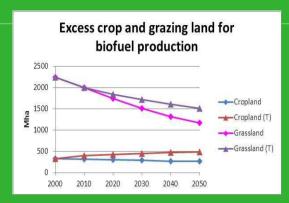
K																								
		Africa	541-1-11- A4	NI - mile - ma	0	10/	Asia	0	0	0	14/	Europe	NI	0	\A(t )	Latin Amo		O	Northern					orld
	0000	Eastern Africa 59.5		42.3			Eastern A 244.5	9.2		Southeas				Southern 14.0			Central A		Northern			Micronesi Pol		4004.0
Grassland req	2000 2010	59.5 80.4	23.1 31.7	42.3 51.4	12.1 14.2	56.0 75.2	244.5	10.8			31.6 39.6	29.4 28.8	9.1 9.6		17.7 18.4	9.1	31.8 37.3	81.8 95.8	30.8 34.3	2.2 2.5	1.7 2.1	0.1	0.1	1034.9 1233.6
(Mha)	2020	103.3	40.4	59.7	15.0	94.2	281.9	12.1		115.3	46.5	27.8	10.1	15.3	18.5	11.1	41.4	104.8	37.3	2.8	2.5	0.1	0.2	1386.1
966	2030	127.3	49.6	66.9	15.7	113.8	286.4	13.0			53.1	26.5	10.1	15.3	18.5	11.7		111.6	40.0	3.0	3.0	0.2	0.2	1516.2
2355	2040	151.7	58.6	72.9	16.2	134.2	283.5	13.6			58.7	25.1	10.7	15.2		12.0		115.9	42.0	3.2	3.4	0.2	0.2	1621.1
(m2 p-1 y-1)	2050	174.9	67.1	77.4	16.6	153.8	274.9	13.9			63.2	23.7	11.0			12.1	48.0		43.7	3.3	3.7	0.2	0.2	1699.2
( p . , , ,																								
L	Year	Africa					Asia					Europe				Latin Amo	erica		Northern	Oceania			w	orld
		Eastern Africa	Middle Af	Northern	Southern	Western	Eastern A	Central A	Southern	Southeas	Western		Northern	Southern	Western I		Central A	South Am			Melanesia	Micronesi Pol		
Grassland	2000	237.5	133.9	192.6	150.7	186.8	524.9	250.3	95.3	16.7	226.5	116.5	23.3	28.3	25.3	4.6	91.3	459.1	277.0	445.6	0.6	0.0	0.0	3487.0
available	2010	237.5	133.9	192.6	150.7	186.8	524.9	250.3	95.3		226.5	116.5	23.3	28.3	25.3	4.6	91.3	459.1	277.0	445.6	0.6	0.0	0.0	3487.0
(Mha)	2020	237.5	133.9	192.6	150.7	186.8	524.9	250.3	95.3		226.5	116.5	23.3	28.3	25.3	4.6		459.1	277.0	445.6	0.6	0.0	0.0	3487.0
	2030	237.5	133.9	192.6	150.7	186.8	524.9	250.3	95.3		226.5	116.5	23.3	28.3	25.3	4.6		459.1	277.0	445.6	0.6	0.0	0.0	3487.0
	2040	237.5	133.9	192.6	150.7	186.8	524.9	250.3	95.3		226.5	116.5	23.3	28.3	25.3	4.6		459.1	277.0	445.6	0.6	0.0	0.0	3487.0
	2050	237.5	133.9	192.6	150.7	186.8	524.9	250.3	95.3	16.7	226.5	116.5	23.3	28.3	25.3	4.6	91.3	459.1	277.0	445.6	0.6	0.0	0.0	3487.0
M: L-K	Year	Africa					Asia					Europe				Latin Amo				Oceania				orld
		Eastern Africa	Middle Af	Northern			Eastern A		Southern	Southeas					western	Caribbea	Central A		Northern		Melanesia	Micronesi Pol	ynesia	0.150
Grassland	2000	178.0	110.8	150.3	138.6	130.8	280.4	241.1	-147.6	-69.2	194.9	87.1	14.2	14.3	7.6	-4.5	59.5	377.3	246.2	443.4	-1.0	-0.1	-0.1	2452.0
Excess / Deficit	2010	157.1	102.2	141.2	136.4	111.6	256.1	239.5	-207.9	-87.3	186.9	87.7	13.7	13.4	7.0	-5.7	54.0	363.3	242.7	443.1	-1.4	-0.1	-0.1	2253.4
(Mha)	2020	134.2	93.5	132.9	135.6	92.6	243.0	238.3	-250.4	-98.6	180.0	88.7	13.3	13.0	6.8	-6.4	49.9	354.3	239.6	442.8	-1.9	-0.1	-0.1	2100.9
	2030	110.1	84.3	125.7	134.9	73.0	238.5	237.3	-285.3	-107.9	173.4	90.0	12.9	13.0	6.8	-7.0	46.5	347.5	237.0	442.6	-2.3	-0.2	-0.2	1970.8
	2040	85.8	75.3	119.7	134.4	52.6	241.4	236.7	-311.9	-114.6	167.8	91.4	12.6	13.1	7.0	-7.4	44.2	343.2	235.0	442.4	-2.7	-0.2	-0.2	1865.9
	2050	62.6	66.8	115.1	134.1	33.0	249.9	236.4	-330.5	-118.4	163.2	92.8	12.4	13.4	7.3	-7.4	43.3	341.4	233.3	442.3	-3.1	-0.2	-0.2	1787.8
	.,											_												
N: E / I	Year	Africa Eastern Africa	541-J-U- A4	NI th	0	10/	Asia	0	0	0	10/	Europe	NI - oth - or	0	\A(t )	Latin Amo		O		Oceania	Maria a a ala	Micronesi Pol		orld
Grassland used for	2000	0.0		0.0	Southern 0.0	0.0	Eastern A	0.0	0.0		0.0	0.0	Northern	Southern 0.0	western	0.0	Central A	0.0	Northern 0.0	Australia 0.0	0.0	0.0	0.0	200.0
crop production	2010	0.0	0.0	0.0	0.0	0.0	-195.9	0.0	0.0	0.0	0.0	0.0	-5.2	0.0	-7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-200.0
crop production	2010	-11.5	-0.9	7.4	0.0	0.0	-220.4	0.0	0.0		0.0	2.0	-0.1	0.0	-7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-245.9
	2020	-30.6	11.1	-15.3	0.0	0.0	-226.4 -219.2	0.0	0.0		0.0		-0.0 7.2	0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	204.2
	2040	-49.1 66.2	15.1	21.0	0.0	0.0	202.4	0.0	0.0	0.0	0.0	0.0	7.4	0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	217.7
	2050	-00.2	10.1	20.0	0.0	0.0	170.1	0.0	0.0		0.0		7.4	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	206.2
	2030				0.0	0.0	-170.1	0.0	0.0	0.0	0.0	0.0	-1.5	0.0	-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-250.2
O: M+N	Year	Africa					Asia					Europe				Latin Ame	erica		Northern	Oceania			lw	/orld
O: M+N	Year	Africa Eastern Africa	Middle Af	Northern	Southern	Western		Central A	Southern	Southeas	Western	Europe Eastern E	Northern	Southern	Western	Latin Ame		South Am	Northern Northern	Oceania Australia	Melanesia	Micronesi Pol		orld
O: M+N Grassland	Year 2000	Africa Eastern Africa 178.0	Middle Af	Northern 2	Southern	Western /		Central A	Southern	Southeas	Western 194.9		Northern 9.0	Southern 14.3	Western I		erica Central A 59.5	South Am	Northern Northern 246.2		Melanesia	Micronesi Pol		orld 2243.2
			Middle Af 110.8 101.3	Northern 150.3 141.2	Southern 138.6 136.4	Western / 130.8	Eastern A		Southern -147.6	Southeas -69.2		Eastern E	Northern 9.0	Southern 14.3 13.4				South Am 377.3 363.3	Northern	Australia	Melanesia -1.0	Micronesi Pol -0.1		
Grassland	2000	Eastern Africa 178.0	110.8	150.3	138.6	130.8	Eastern A 84.4	241.1	Southern -147.6 -207.9 -250.4	Southeas -69.2 -87.3 -98.6	194.9	Eastern E 87.1	Northern 9.0 7.6 6.5	14.3	0.0	-4.5 -5.7	Central A 59.5	377.3	Northern 246.2	Australia 443.4	Melanesia -1.0 -1.4 -1.9	Micronesi Pol -0.1 -0.1		2243.2
Grassland Excess / Deficit	2000 2010	Eastern Africa 178.0 145.5	110.8 101.3	150.3 141.2	138.6 136.4	130.8 111.6	Eastern A 84.4 35.7	241.1 239.5	Southern -147.6 -207.9 -250.4 -285.3	-69.2 -87.3	194.9 186.9	87.1 87.7	9.0 7.6	14.3 13.4	0.0	-4.5 -5.7	Central A 59.5 54.0	377.3 363.3	Northern 246.2 242.7	Australia 443.4 443.1	Melanesia -1.0 -1.4 -1.9 -2.3	Micronesi Pol -0.1 -0.1 -0.1 -0.2	ynesia -0.1 -0.1	2243.2 2007.4
Grassland Excess / Deficit after crop production	2000 2010 2020	Eastern Africa 178.0 145.5 103.6	110.8 101.3 87.3	150.3 141.2 125.5	138.6 136.4 135.6	130.8 111.6 92.6	84.4 35.7 16.6 19.3	241.1 239.5 238.3	Southern -147.6 -207.9 -250.4 -285.3 -311.9	-69.2 -87.3 -98.6	194.9 186.9 180.0	87.1 87.7 88.7	9.0 7.6	14.3 13.4	0.0	-4.5 -5.7	59.5 54.0 49.9	377.3 363.3 354.3	Northern 246.2 242.7 239.6	Australia 443.4 443.1 442.8	Melanesia -1.0 -1.4 -1.9 -2.3 -2.7	Micronesi Pol -0.1 -0.1 -0.1 -0.2 -0.2	ynesia -0.1 -0.1	2243.2 2007.4 1816.7
Grassland Excess / Deficit after crop production	2000 2010 2020 2030	178.0 145.5 103.6 61.0	110.8 101.3 87.3 73.3 60.2	150.3 141.2 125.5 110.4	138.6 136.4 135.6 134.9	130.8 111.6 92.6 73.0	84.4 35.7 16.6 19.3	241.1 239.5 238.3 237.3	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5	-69.2 -87.3 -98.6	194.9 186.9 180.0 173.4	87.1 87.7 88.7 90.0	9.0 7.6 6.5 5.7	14.3 13.4 13.0 13.0	0.0	-4.5 -5.7	59.5 54.0 49.9 46.5	377.3 363.3 354.3 347.5	Northern 246.2 242.7 239.6 237.0	Australia 443.4 443.1 442.8 442.6	Melanesia -1.0 -1.4 -1.9 -2.3 -2.7 -3.1	Micronesi Pol -0.1 -0.1 -0.1 -0.2 -0.2 -0.2	ynesia -0.1 -0.1	2243.2 2007.4 1816.7 1662.2
Grassland Excess / Deficit after crop production	2000 2010 2020 2030 2040	178.0 178.0 145.5 103.6 61.0	110.8 101.3 87.3 73.3 60.2	150.3 141.2 125.5 110.4 97.8	138.6 136.4 135.6 134.9 134.4	130.8 111.6 92.6 73.0 52.6	84.4 35.7 16.6 19.3 39.3	241.1 239.5 238.3 237.3 236.7	Southern -147.6 -207.9 -250.4 -285.3 -311.9 -330.5	-69.2 -87.3 -98.6 -107.9 -114.6	194.9 186.9 180.0 173.4 167.8	87.1 87.7 88.7 90.0 91.4	9.0 7.6 6.5 5.7 5.2	14.3 13.4 13.0 13.0 13.1	0.0 0.0 0.0 0.1 2.0	Caribbea -4.5 -5.7 -6.4 -7.0 -7.4	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2	Northern 246.2 242.7 239.6 237.0 235.0	Australia 443.4 443.1 442.8 442.6 442.4	Melanesia -1.0 -1.4 -1.9 -2.3 -2.7 -3.1	Micronesi Pol -0.1 -0.1 -0.1 -0.2 -0.2 -0.2	ynesia -0.1 -0.1	2243.2 2007.4 1816.7 1662.2 1548.2
Grassland Excess / Deficit after crop production	2000 2010 2020 2030 2040	178.0 178.0 145.5 103.6 61.0	110.8 101.3 87.3 73.3 60.2	150.3 141.2 125.5 110.4 97.8	138.6 136.4 135.6 134.9 134.4	130.8 111.6 92.6 73.0 52.6	84.4 35.7 16.6 19.3 39.3	241.1 239.5 238.3 237.3 236.7	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5	-69.2 -87.3 -98.6 -107.9 -114.6	194.9 186.9 180.0 173.4 167.8	87.1 87.7 88.7 90.0 91.4	9.0 7.6 6.5 5.7 5.2	14.3 13.4 13.0 13.0 13.1	0.0 0.0 0.0 0.1 2.0	-4.5 -5.7	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2	Northern 246.2 242.7 239.6 237.0 235.0	Australia 443.4 443.1 442.8 442.6 442.4	Melanesia -1.0 -1.4 -1.9 -2.3 -2.7 -3.1	Micronesi Pol -0.1 -0.1 -0.1 -0.2 -0.2 -0.2	yne sia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2	2243.2 2007.4 1816.7 1662.2 1548.2
Grassland Excess / Deficit after crop production	2000 2010 2020 2030 2040 2050	Eastern Africa 178.0 145.5 103.6 61.0 19.6	110.8 101.3 87.3 73.3 60.2 48.6	150.3 141.2 125.5 110.4 97.8 88.4	138.6 136.4 135.6 134.9 134.4 134.1	130.8 111.6 92.6 73.0 52.6 33.0	Eastern A 84.4 35.7 16.6 19.3 39.3 71.8	241.1 239.5 238.3 237.3 236.7 236.4	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4	194.9 186.9 180.0 173.4 167.8 163.2	87.1 87.7 88.7 90.0 91.4 92.8	9.0 7.6 6.5 5.7 5.2 4.9	14.3 13.4 13.0 13.0 13.1 13.4	0.0 0.0 0.0 0.1 2.0 4.3	-4.5 -5.7 -6.4 -7.0 -7.4 -7.4 Latin Ame	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2 341.4	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1	Micronesi Pol -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2	yne sia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5
Grassland Excess / Deficit after crop production (Mha)  P  Grassland	2000 2010 2020 2030 2040 2050 Year	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0  Africa	110.8 101.3 87.3 73.3 60.2 48.6	150.3 141.2 125.5 110.4 97.8 88.4	138.6 136.4 135.6 134.9 134.4 134.1	130.8 111.6 92.6 73.0 52.6 33.0	Eastern A 84.4 35.7 16.6 19.3 39.3 71.8	241.1 239.5 238.3 237.3 236.7 236.4	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4	194.9 186.9 180.0 173.4 167.8 163.2	87.1 87.7 88.7 90.0 91.4 92.8	9.0 7.6 6.5 5.7 5.2 4.9	14.3 13.4 13.0 13.0 13.1 13.4	0.0 0.0 0.0 0.1 2.0 4.3	-4.5 -5.7 -6.4 -7.0 -7.4 -7.4 Latin Ame	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2 341.4	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2	yne sia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5
Grassland Excess / Deficit after crop production (Mha)  P  Grassland 'Imported/Exported'	2000 2010 2020 2030 2040 2050 Year 2000 2010	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0  Africa	110.8 101.3 87.3 73.3 60.2 48.6	150.3 141.2 125.5 110.4 97.8 88.4	138.6 136.4 135.6 134.9 134.4 134.1	130.8 111.6 92.6 73.0 52.6 33.0	Eastern A 84.4 35.7 16.6 19.3 39.3 71.8	241.1 239.5 238.3 237.3 236.7 236.4	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5 Southern 147.6 207.9	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas 69.2 87.3	194.9 186.9 180.0 173.4 167.8 163.2	87.1 87.7 88.7 90.0 91.4 92.8	9.0 7.6 6.5 5.7 5.2 4.9	14.3 13.4 13.0 13.0 13.1 13.4	0.0 0.0 0.1 2.0 4.3 Western I	-4.5 -5.7 -6.4 -7.0 -7.4 -7.4 Latin Ame	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2 341.4	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2	yne sia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.1 Wyne sia 0.1 0.1	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5
Grassland Excess/ Deficit after crop production (Mha)  P  Grassland 'Imported/Exported' (Mha)	2000 2010 2020 2030 2040 2050 Year 2000 2010 2020	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0  Africa	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af	150.3 141.2 125.5 110.4 97.8 88.4 Northern	138.6 136.4 135.6 134.9 134.4 134.1 Southern	130.8 111.6 92.6 73.0 52.6 33.0 Western A	Eastern A 84.4 35.7 16.6 19.3 39.3 71.8	241.1 239.5 238.3 237.3 236.7 236.4 Central A	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5 Southern 147.6 207.9 250.4	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas 69.2 87.3 98.6	194.9 186.9 180.0 173.4 167.8 163.2 Western 4	87.1 87.7 88.7 90.0 91.4 92.8	9.0 7.6 6.5 5.7 5.2 4.9	14.3 13.4 13.0 13.0 13.1 13.4	0.0 0.0 0.0 0.1 2.0 4.3 Western I	-4.5 -5.7 -6.4 -7.0 -7.4 -7.4 Latin Ame	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2 341.4 South Am	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 <b>Melanesia</b> 1.0 1.4	-0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.1 -0.1 0.1	ynesia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5
Grassland Excess / Deficit after crop production (Mha)  P  Grassland 'Imported/Exported' (Mha) Note: based on	2000 2010 2020 2030 2040 2050 Year 2000 2010 2020 2030	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0  Africa	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0	150.3 141.2 125.5 110.4 97.8 88.4 Northern	138.6 136.4 135.6 134.9 134.4 134.1 Southern	130.8 111.6 92.6 73.0 52.6 33.0 Western / -11.8 -14.6 -15.2 -14.2	Eastern A 84.4 35.7 16.6 19.3 39.3 71.8	241.1 239.5 238.3 237.3 236.7 236.4 Central A	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5 Southern 147.6 207.9 250.4 285.3	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -69.2 -87.3 -98.6 -107.9	194.9 186.9 180.0 173.4 167.8 163.2 Western 4	Eastern E 87.1 87.7 88.7 90.0 91.4 92.8 Europe Eastern E -7.9 -11.5	9.0 7.6 6.5 5.7 5.2 4.9	14.3 13.4 13.0 13.0 13.1 13.4	0.0 0.0 0.1 2.0 4.3 Western I	-4.5 -5.7 -6.4 -7.0 -7.4 -7.4 Latin Ame	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2 341.4 South Am	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern Northern -22.2 -31.8 -39.4 -46.2	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania Australia -40.0 -58.0 -72.8 -86.4	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesia 1.0 1.4 1.9 2.3	-0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.1 0.1 0.1 0.1	ynesia -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5
Grassland Excess / Deficit after crop production (Mha)  P  Grassland 'Imported/Exported' (Mha) Note: based on equal productivity	2000 2010 2020 2030 2040 2050 Year 2000 2010 2020 2030 2040	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0 Africa Eastern Africa -16.1 -19.1 -17.0 -11.9	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 -13.3 -14.4 -14.3	150.3 141.2 125.5 110.4 97.8 88.4 Northern	138.6 136.4 135.6 134.9 134.4 134.1 Southern	130.8 111.6 92.6 73.0 52.6 33.0 Western A	Eastern A 84.4 35.7 16.6 19.3 39.3 71.8	241.1 239.5 238.3 237.3 236.7 236.4 Central A	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5 Southern 147.6 207.9 250.4 285.3 311.9	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas 69.2 87.3 98.6 107.9	194.9 186.9 180.0 173.4 167.8 163.2 Western 4	Eastern E 87.1 87.7 88.7 90.0 91.4 92.8 Europe Eastern E -7.9 -11.5	9.0 7.6 6.5 5.7 5.2 4.9	14.3 13.4 13.0 13.0 13.1 13.4	0.0 0.0 0.1 2.0 4.3 Western I	-4.5 -5.7 -6.4 -7.0 -7.4 -7.4 Latin Ame	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2 341.4 South Am	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 <b>Melanesia</b> 1.0 1.4 1.9 2.3 2.7	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.1 0.1 0.1 0.1 0.2 0.2	ynesia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 wynesia 0.1 0.1 0.1 0.2 0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5
Grassland Excess / Deficit after crop production (Mha)  P  Grassland 'Imported/Exported' (Mha) Note: based on	2000 2010 2020 2030 2040 2050 Year 2000 2010 2020 2030	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0  Africa	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 -13.3 -14.4 -14.3	150.3 141.2 125.5 110.4 97.8 88.4 Northern	138.6 136.4 135.6 134.9 134.4 134.1 Southern	130.8 111.6 92.6 73.0 52.6 33.0 Western / -11.8 -14.6 -15.2 -14.2	Eastern A 84.4 35.7 16.6 19.3 39.3 71.8	241.1 239.5 238.3 237.3 236.7 236.4 Central A	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5 Southern 147.6 207.9 250.4 285.3	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -69.2 -87.3 -98.6 -107.9	194.9 186.9 180.0 173.4 167.8 163.2 Western 4	Eastern E 87.1 87.7 88.7 90.0 91.4 92.8 Europe Eastern E -7.9 -11.5	9.0 7.6 6.5 5.7 5.2 4.9	14.3 13.4 13.0 13.0 13.1 13.4	0.0 0.0 0.1 2.0 4.3 Western I	-4.5 -5.7 -6.4 -7.0 -7.4 -7.4 Latin Ame	59.5 54.0 49.9 46.5 44.2 43.3	377.3 363.3 354.3 347.5 343.2 341.4 South Am	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern Northern -22.2 -31.8 -39.4 -46.2	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania Australia -40.0 -58.0 -72.8 -86.4	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesia 1.0 1.4 1.9 2.3	-0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.1 0.1 0.1 0.1	ynesia -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5
Grassland Excess / Deficit after crop production (Mha)  P  Grassland 'Imported/Exported' (Mha)  Note: based on equal productivity between regions	2000 2010 2020 2030 2040 2050 Year 2000 2010 2020 2030 2040 2050	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0  Africa Eastern Africa 1-19.1 1-17.0 11.9 4.3 0.0	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 -13.3 -14.4 -14.3	150.3 141.2 125.5 110.4 97.8 88.4 Northern	138.6 136.4 135.6 134.9 134.4 134.1 Southern	130.8 111.6 92.6 73.0 52.6 33.0 Western / -11.8 -14.6 -15.2 -14.2	Eastern A 84.4 35.7 16.6 19.3 39.3 71.8 Asia Eastern A -7.6 4.7 -2.7 -3.8 -6.6	241.1 239.5 238.3 237.3 236.7 236.4 Central A	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5 Southern 147.6 207.9 250.4 285.3 311.9	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas 69.2 87.3 98.6 107.9	194.9 186.9 180.0 173.4 167.8 163.2 Western 4	Eastern E 87.1 87.7 90.0 91.4 92.8 Europe Eastern E -7.9 -11.5 -14.6 -20.1 -21.9	9.0 7.6 6.5 5.7 5.2 4.9	14.3 13.4 13.0 13.0 13.1 13.4	0.0 0.0 0.1 2.0 4.3 Western I	Caribbeai -4.5 -5.7 -6.4 -7.0 -7.4 -7.4 -7.4 -4.5 -7.6 -7.4 -7.4 -7.4 -7.7 -7.4 -7.7 -7.4 -7.7 -7.7	Central A 59.5 54.0 49.9 46.5 44.2 43.3 erica Central A -7.1 -8.2 -9.1	377.3 363.3 354.3 347.5 343.2 341.4 South Am	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern Northern -22.2 -31.8 -39.4 -46.2 -51.7 -55.0	Australia 443.4 4443.1 442.8 442.6 442.4 442.3 Oceania Australia -49.0 -72.8 -86.4 -97.4 -104.2	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 <b>Melanesia</b> 1.0 1.4 1.9 2.3 2.7	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.1 0.1 0.1 0.1 0.2 0.2	ynesia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5 /orld 0.0 0.0 0.0 0.0
Grassland Excess / Deficit after crop production (Mha)  P  Grassland 'Imported/Exported' (Mha) Note: based on equal productivity	2000 2010 2020 2030 2040 2050 Year 2000 2010 2020 2030 2040	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0 Africa Eastern Africa -16.1 -19.1 -17.0 -11.9 -4.3 0.0	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 -13.3 -14.4 -14.3 -13.2 -11.5	150.3 141.2 125.5 110.4 97.8 88.4 Northern -13.6 -18.5 -20.6 -21.5 -20.8	138.6 136.4 134.6 134.9 134.4 134.1 Southern -12.5 -17.9 -22.3 -26.3 -29.6	130.8 111.6 92.6 73.0 52.6 33.0 Western A -11.8 -14.6 -15.2 -14.2 -11.6	Eastern A  84.4  35.7  16.6  19.3  39.3  71.8  Asia  Eastern A  -7.6  -4.7  -2.7  -3.8  -8.6  -16.9  Asia	241.1 239.5 238.3 237.3 236.7 236.4 Central A -21.8 -31.4 -39.2 -46.3 -52.1 -55.7	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -69.2 -87.3 -98.6 -107.9 -114.6 -118.4	194.9 186.9 180.0 173.4 167.8 163.2 Western 4-17.6 -24.5 -29.6 -33.8 -36.9	Eastern E 87.1 87.7 88.7 90.0 91.4 92.8 Europe Eastern E -7.9 -11.5 -14.6 -20.1 -21.9 Europe	9.0 7.6 6.5 5.7 5.2 4.9 Northern -0.8 -1.0 -1.1 -1.1 -1.2	14.3 13.4 13.0 13.0 13.1 13.4 Southern -1.3 -1.7 -2.1 -2.5 -2.9 -3.1	0.0 0.0 0.1 2.0 4.3 Western I 0.0 0.0 0.0 0.0 0.0	Caribbeai	Central A	377.3 363.3 354.3 347.5 343.2 341.4 South Am -34.0 -47.6 -58.3 -67.8 -75.5 -80.5	Northern 246.2 242.7 239.6 237.0 235.0 233.3 Northern Northern -22.2 -31.8 -39.4 -46.2 -51.7 -55.0 Northern	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania Oceania	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesia 1.0 1.4 1.9 2.3 -2.7 3.1	-0.1   -0.1   -0.1   -0.2   -0.2   -0.2     -0.2     -0.2     -0.2     -0.1   -0.1   -0.1   -0.1   -0.1   -0.2   -	ynesia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5
Grassland Excess / Deficit after crop production (Mha)  P  Grassland 'Imported/Exported' (Mha) Note: based on equal productivity between regions	2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0  Africa Eastern Africa 1-19.1 1-17.0 11.9 4.3 0.0	110.8 101.3 87.3 77.3 60.2 48.6 Middle Af -10.0 -13.3 -14.4 -14.3 -13.2 -11.5	150.3 141.2 125.5 110.4 97.8 88.4 Northern -13.6 -18.5 -20.6 -21.5 -20.8 Northern	138.6 136.4 135.6 134.9 134.4 134.1 Southern -12.5 -17.9 -22.3 -29.6 -31.6	130.8 111.6 92.6 73.0 52.6 33.0 Western / -11.8 -14.6 -15.2 -14.2 -1.7.8	Eastern A  84.4  35.7  36.6  19.3  39.3  71.8  Asia  Eastern A  -7.6  -16.9  Asia  Eastern A	241.1 239.5 238.3 237.3 236.7 236.4 Central A -21.8 -31.4 -46.3 -52.1 -55.7	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5  Southern 147.6 207.9 250.4 285.3 311.9 330.5	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -69.2 -87.3 -98.6 -107.9 -114.6 -118.4	194.9 186.9 180.0 173.4 167.8 163.2 Western / -17.6 -24.5 -29.6 -33.8 -36.9 -38.5	Eastern E 87.1 88.7 90.0 91.4 92.8 Europe 1-1514.6 -20.1 -21.9 Europe Eastern E 5-29.0 1-1517.6 -20.1 -21.9	9.0 7.6 6.5 5.7 5.2 4.9 Northern -0.8 -1.0 -1.1 -1.1 -1.2	14.3 13.4 13.0 13.0 13.1 13.4 Southern -1.3 -1.7 -2.1 -2.5 -2.9 -3.1	0.0 0.0 0.0 0.1 2.0 4.3 Western I 0.0 0.0 0.0 0.0 Western I 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	Caribbea  4.5  6.4  -7.0  -7.4  Latin Ame Caribbea  4.5  5.7  6.4  7.0  7.4  Latin Ame Caribbea	Central A 59.5 54.0 49.9 46.5 44.2 43.3 cerica Central A -7.1 -8.2 -9.1 -9.7 -10.2 erica Central A	377.3 363.3 354.3 347.5 343.2 341.4  South Am -34.0 -47.6 -67.8 -75.5 -80.5	Northern 246.2 249.7 239.6 237.0 235.0 233.3 Northern Northern 1-22.2 -31.8 -39.4 -46.2 -51.7 -55.0 Northern Northern Northern	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania Australia -40.0 -58.0 -72.8 -97.4 -104.2 Oceania Australia	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesia 1.0 1.4 -1.9 2.3 2.7 3.1	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 Micronesi Pol	ynesia -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5 /orld 0.0 0.0 0.0 0.0
Grassland Excess / Deficit after crop production (Mha)  P Grassland 'Imported/Exported' (Mha) Note: based on equal productivity between regions  Q: O+P Grassland	2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0 Africa Eastern Africa 1-19.1 1-17.0 11.9 4.3 0.0 Africa Eastern Africa 1-16.1	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 -13.3 -14.4 -14.3 -13.2 -11.5	150.3 141.2 125.5 110.4 97.8 88.4 Northern13.6 -20.6 -21.5 -20.8 Northern	138.6 136.4 136.4 134.9 134.4 134.1 Southern -12.5 -17.9 -22.3 -26.3 -31.6 Southern	130.8 111.6 92.6 73.0 52.6 33.0 Western 4 -11.8 -15.2 -14.2 -7.8	Eastern A  84.4  35.7  16.6  19.3  71.8  Asia  Eastern A  -7.6  -4.7  -2.7  -3.8  -8.6  -16.9  Asia  Eastern A	241.1 239.5 237.3 236.7 236.4 Central A -21.8 -31.4 -39.2 -46.3 -55.7 Central A 219.4	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5  Southern 147.6 -207.9 -250.4 -285.3 -311.9 -330.5  Southern 0.0	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas	194.9 186.9 180.0 173.4 167.8 163.2 Western - -17.6 -24.5 -29.6 -33.8 -38.5	Eastern E 87.1 87.7 88.7 90.0 91.4 92.8 Europe Eastern E -7.9 -11.5 -14.6 -17.6 -20.1 -21.9 Europe Eastern E -7.9 9.7 9.7 9.7 9.7 9.7 9.7 9.7 9.7 9.7	9.0 7.6 6.5 5.7 5.2 4.9 Northern -0.8 -1.0 -1.1 -1.1 -1.2 -1.2	14.3 13.4 13.0 13.0 13.1 13.4 Southern -1.3 -1.7 -2.1 -2.5 -2.9 -3.1	0.0 0.0 0.0 0.1 0.0 0.0 0.0 0.0 0.0 0.0	Caribbeal	Central A  59.5 54.0 49.9 46.5 44.2 43.3 erica Central A  -7.1 -9.7 -10.2 erica Central A  -6.5 -7.1 -9.7 -10.2	377.3 363.3 347.5 343.2 341.4 South Am -34.0 -58.3 -67.8 -75.5 -80.5	Northern 246.2 242.7 239.6 237.0 235.0 235.0 235.3 Northern Northern 46.2 -51.7 Northern Northern Northern 224.0	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania Australia -40.0 -58.0 -72.8 -86.4 -97.4 -104.2 Oceania Australia 40.0	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesia 1.0 1.0 1.4 1.9 2.3 2.7 3.1	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 0.1 0.1 0.2 0.2 0.2 0.2 0.3 0.4 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1	ynesia -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2  ynesia 0.1 0.1 0.2 0.2 0.2 0.2 0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5 /orld 0.0 0.0 0.0 0.0
Grassland Excess / Deficit after crop production (Mha)  P Grassland 'Imported/Exported' (Mha) Note: based on equal productivity between regions  Q: O+P Grassland for bioenergy prod	2000 2010 2020 2030 2040 2050 Year  2000 2010 2020 2030 2040 2050 Year	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0 Africa Eastern Africa -19.1 -17.0 -11.9 -4.3 0.0 Africa Eastern Africa Eastern Africa Eastern Africa	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 -13.3 -14.4 -14.3 -13.2 -11.5	150.3 141.2 125.5 110.4 97.8 88.4 Northern -13.6 -21.5 -20.8 Northern -21.5 -20.8	138.6 136.4 135.6 134.9 134.4 134.1 Southern -12.5 -17.9 -22.3 -26.3 -29.6 -31.6	130.8 111.6 92.6.5 73.0 52.6 33.0 Western -11.8 -14.6 -7.8 Western Western 97.0	Eastern A 84.4 35.7 16.6 19.3 71.8 Asia Eastern A -7.6 -4.7 -2.7 -3.8 -8.6 -16.9 Asia Eastern A 38.3 Asia Eastern A 7.3 Asia Asia Asia Asia Asia Asia Asia Asia	241.1 239.5 238.3 237.3 236.7 236.4 Central A -31.4 -39.2 -55.1 Central A 219.4 208.1	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5  Southern 147.6 207.9 250.4 285.3 311.9 330.5  Southern 0.0	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -0.0 -0.0	194.9 186.9 180.0 173.4 167.8 163.2 Western 177.6 -24.5 -29.6 -33.8 -36.9 -38.5	Eastern E 87.1 87.7 88.7 99.0 91.4 92.8 Europe Eastern E -7.9 -11.5 -14.6 -17.6 -20.1 Europe Eastern E 79.3 76.2 9.7 76.2	9.0 7.6 6.5; 5.7 5.2 4.9 Northern -0.8 -1.0 -1.1 -1.1 -1.2 -1.2 Northern	14.3 13.4 13.0 13.0 13.1 13.1 13.4  Southern -1.3 -1.7 -2.5 -2.9 -3.1  Southern 13.0 11.6	0.0 0.0 0.0 0.0 0.0 0.1 2.0 4.3  Western I 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 Western I 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	Caribbeal	Central A  59.5 54.0 49.9 46.5 44.2 43.3 erica Central A  -7.1 -8.2 -9.1 -9.7 -10.2 erica Central A  Central A  Gentral A	377.3 363.3 354.3 347.5 343.2 341.4 South Am -47.6 -58.3 -67.5 -80.5	Northern	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania -40.0 -58.0 -72.8 -86.4 -97.4 -104.2 Oceania Australia 40.0 4	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesia 1.0 1.4 1.9 2.3 3.2,7 3.1	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 Micronesi Pol 0.1 0.2 0.2 0.2 0.2 0.2	ynesia -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1 -0.1	2243,2 2007,4 1816,7 1662,2 1548,2 1491,5 /orld 0.0 0.0 0.0 0.0 0.0 (orld 2243,2 2007,4
Grassland Excess / Deficit after crop production (Mha)  P Grassland 'Imported/Exported' (Mha) Note: based on equal productivity between regions  Q: O+P Grassland	2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0 19.6 Africa Eastern Africa -16.1 -19.1 -17.0 -11.9 4.3 0.0 Africa Eastern Africa 16.9 11.9 4.3 6.0	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 13.3 -14.4 -14.3 -11.5 Middle Af 100.8 8.0 0 72.9	150.3 141.2 125.5 110.4 97.8 88.4 Northern -13.6 -21.5 -20.6 -21.5 -20.8 Northern 136.7 122.7	138.6 136.4 135.6 134.9 134.4 134.1 134.1 134.1 134.1 Southern -12.5 -17.9 -22.3 -26.3 -29.6 -31.6	130.8 111.6 92.6 73.0 52.6 33.0 Western / -11.8 -14.6 -7.8 Western / 119.0 97.0 77.4	Eastern A 84.4 35.7 16.6 19.3 71.8 Asia Eastern A 7.6 4.7 -2.7 3.8 8.6 -16.9 Asia Eastern A 7.8 3.9 3.3 3.3 3.3 3.3 3.3 3.3 3.3 3.3 3.3	241.1 239.5 238.3 237.3 236.7 236.4  Central A -21.8 -31.4 -39.2 -46.3 -52.1 -55.7  Central A 219.4 219.4 199.1	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5	69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas 69.2 -98.6 -107.9 -114.6 -118.4 Southeas -0.0 0.0	194.9 186.9 180.0 173.4 167.8 163.2 Western -17.6 -24.5 -29.6 -36.9 -38.5 Western 177.3 162.4	Eastern E 87.1 87.7 88.7 90.0 91.4 92.8 Europe Eastern E -11.5 -14.6 -20.1 -21.9 Europe Eastern E -20.7 79.3 76.2	9.0 7.6 6.5.5 5.7 5.2 4.9 Northern -0.8 -1.0 -1.1 -1.1 -1.2 -1.2 Northern 8.2 6.6 6.5.5	14.3 13.4 13.0 13.0 13.1 13.1 13.4  Southern -1.3 -1.7 -2.1 -2.5 -2.9 -3.1  Southern 13.0 11.6 10.9	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Caribbeai	Central A	377.3 363.3 354.3 347.5 343.2 341.4  South Am -34.0 -47.6 -58.3 -77.5 -80.5  South Am 343.3 315.7 296.0	Northern 246.2 242.7 239.6 237.0 235.0 235.0 235.3 Northern Northern -22.2 -31.8 -39.4 -46.2 -51.7 -55.0 Northern Northern 224.0 24.0 200.2	Australia 443.4 443.1 442.8 442.6 442.4 442.3  Oceania Australia -40.0 -72.8 -86.4 -97.4 -104.2  Oceania Australia 40.0 30.3 30.3	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesia -1.0 1.4 -1.9 -2.3 -2.7 3.1	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 0.1 0.1 0.2 0.2 0.2 0.2 0.0 0.0 0.0	ynesia -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.0 -0.0 -0.0 -0.0	2243.2 2007.4 1816.7 1662.2 1491.5 /orld 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.
Grassland Excess / Deficit after crop production (Mha)  P Grassland 'Imported/Exported' (Mha) Note: based on equal productivity between regions  Q: O+P Grassland for bioenergy prod	2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2020 2030	Eastern Africa 178.0 145.5 103.6 103.6 10.0 19.6 0.0 Africa Eastern Africa 1-19.1 1-17.0 11.9 4.3 0.0 Africa Eastern Africa 16.1 19.1 1-17.0 11.0 11.0 11.0 11.0 11.0 11.0 11.0	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 113.3 -14.4 14.3 -13.2 -11.5 Middle Af 100.8 88.0 72.9 55.0	150.3 141.2 125.5 110.4 97.8 88.4  Northern -13.6 -20.6 -21.5 -20.8  Northern 136.7 122.7 124.8 88.8	138.6 136.4 135.6 134.9 134.4 134.1 Southern -12.5 -17.9 -22.3 -26.3 -29.6 -31.6 Southern 126.1 118.6 118.6 118.3 108.6	130.8 111.6 92.6 73.0 52.6 33.0 Western / -11.8 -14.6 -7.8 Western / 119.0 97.0 77.4	Eastern A 84.4 95.7 16.6 19.3 37.1 16.6 19.3 39.3 71.8 Asia Eastern A -7.6 -7.6 -6 -16.9 Asia Eastern A 76.8 31.0 13.9	241.1 239.5 238.3 237.3 236.7 236.4 Central A -31.4 -52.1 -55.7 Central A 219.4 208.1 199.1	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5  Southern 147.6 -207.9 -250.4 -285.3 -311.9 -330.5  Southern 0.0 0.0 0.0	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -69.2 87.3 98.6 107.9 -114.6 -118.4 Southeas -0.0 0.0	194.9 186.9 180.0 173.4 167.8 163.2 Western -17.6 -24.5 -29.6 -33.8 -38.5 Western 177.3 162.4 139.6	Eastern E 87.1 87.7 88.7 90.0 91.4 92.8 Europe Eastern E -7.9 -11.5 -14.6 -20.1 -21.9 Europe Eastern E 79.3 76.2 74.1	9.0 7.6 6.5 5.7 5.2 4.9 Northern -0.8 -1.0 -1.1 -1.2 -1.2 Northern 8.2 6.6 6.6	14.3 13.4 13.0 13.0 13.1 13.4  Southern -1.3 -1.7 -2.1 -2.5 -2.9 -3.1  Southern 13.0 11.6 11.6 11.6 11.6 10.9 10.5	0.0 0.0 0.0 0.0 0.0 0.1 2.0 4.3  Western I 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 Western I 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	Caribbeai -4.5 -5.7 -6.4 -7.0 -7.4 -7.4 -7.4 -7.4 -7.4 -7.4 -7.4 -7.4	Central A 59.5 54.0 49.9 46.5 44.2 43.3 erica Central A 5.4, -7.1 8.2 9.1 9.7 -10.2 erica Central A 6.9 44.7 37.4	377.3 363.3 354.3 347.5 343.2 341.4  South Am -34.0 -47.6 -58.3 -67.8 -75.5 -80.5  South Am 343.3 315.7 279.7	Northern 246.2 242.7 239.6 237.0 235.0 235.0 235.3 Northern Northern -55.0 Northern Northern 224.0 210.9 210.9 210.9 210.9	Australia 443.4 443.1 442.8 442.6 442.4 442.3 Oceania Australia -40.0 -58.0 -72.8 -97.4 -104.2 Oceania Australia 403.4 385.1 385.1 385.1 370.0 356.3	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesi: 1.0 1.4 1.9 2.3 -2.7 3.1 Melanesi: 0.0 0.0	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 0.1 0.1 0.2 0.2 0.2 0.2 0.0 0.0 0.0 0.0	ynesia -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2	2243.2 2007.4 1816.7 1662.2 1548.2 1491.5 /orld 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.
Grassland Excess / Deficit after crop production (Mha)  P Grassland 'Imported/Exported' (Mha) Note: based on equal productivity between regions  Q: O+P Grassland for bioenergy prod	2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050  Year  2000 2010 2020 2030 2040 2050	Eastern Africa 178.0 145.5 103.6 61.0 19.6 0.0 19.6 Africa Eastern Africa -16.1 -19.1 -17.0 -11.9 4.3 0.0 Africa Eastern Africa 16.9 11.9 4.3 6.0	110.8 101.3 87.3 73.3 60.2 48.6 Middle Af -10.0 143.3 -14.4 -14.3 -13.2 -11.5 Middle Af 100.8 88.0 72.9 59.0	150.3 141.2 125.5 110.4 97.8 88.4 Northern -13.6 -21.5 -20.6 -21.5 -20.8 Northern 136.7 122.7	138.6 136.4 135.6 134.9 134.4 134.1 134.1 134.1 134.1 Southern -12.5 -17.9 -22.3 -26.3 -29.6 -31.6	130.8 111.6 92.6 73.0 52.6 33.0 Western / -11.8 -14.6 -7.8 Western / 119.0 97.0 77.4	Eastern A 84.4 35.7 16.6 19.3 71.8 Asia Eastern A 7.6 4.7 -2.7 3.8 8.6 -16.9 Asia Eastern A 7.8 3.9 3.3 3.3 3.3 3.3 3.3 3.3 3.3 3.3 3.3	241.1 239.5 238.3 237.3 236.7 236.4  Central A -21.8 -31.4 -39.2 -46.3 -52.1 -55.7  Central A 219.4 219.4 199.1	-147.6 -207.9 -250.4 -285.3 -311.9 -330.5	-69.2 -87.3 -98.6 -107.9 -114.6 -118.4 Southeas -69.2 87.3 98.6 107.9 -114.6 -118.4 Southeas -0.0 0.0	194.9 186.9 180.0 173.4 167.8 163.2 Western -17.6 -24.5 -29.6 -36.9 -38.5 Western 177.3 162.4	Eastern E 87.1 87.7 88.7 90.0 91.4 92.8 Europe Eastern E -11.5 -14.6 -20.1 -21.9 Europe Eastern E -20.7 79.3 76.2	9.0 7.6 6.5.5 5.7 5.2 4.9 Northern -0.8 -1.0 -1.1 -1.1 -1.2 -1.2 Northern 8.2 6.6 6.5.5	14.3 13.4 13.0 13.0 13.1 13.1 13.4  Southern -1.3 -1.7 -2.1 -2.5 -2.9 -3.1  Southern 13.0 11.6 10.9	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	Caribbeai	Central A	377.3 363.3 354.3 347.5 343.2 341.4  South Am -34.0 -47.6 -58.3 -77.5 -80.5  South Am 343.3 315.7 296.0	Northern 246.2 242.7 239.6 237.0 235.0 235.0 235.3 Northern Northern -22.2 -31.8 -39.4 -46.2 -51.7 -55.0 Northern Northern 224.0 24.0 200.2	Australia 443.4 443.1 442.8 442.6 442.4 442.3  Oceania Australia -40.0 -72.8 -86.4 -97.4 -104.2  Oceania Australia 40.0 30.3 30.3	-1.0 -1.4 -1.9 -2.3 -2.7 -3.1 Melanesia -1.0 1.4 -1.9 -2.3 -2.7 3.1	-0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 0.1 0.1 0.2 0.2 0.2 0.2 0.0 0.0 0.0	ynesia -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.2 -0.2 -0.2 -0.1 -0.1 -0.1 -0.1 -0.2 -0.2 -0.2 -0.0 -0.0 -0.0 -0.0	2243.2 2007.4 1816.7 1662.2 1491.5 /orld 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.

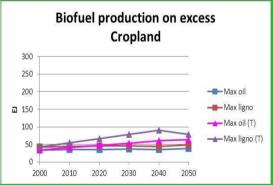


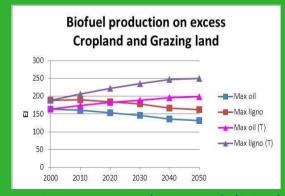
Source: Jongschaap et al. (2011)

### Scenario results

- Technology development (closing the 'yield gap') avails 186 Mha cropland and 236 Mha grazing land for other purposes (Total 422 Mha)
- Increasing productivity of grazing land is difficult
- Huge and remote areas, less productive
- Effects through livestock products (feed conversion ratios) lag behind







Source: Jongschaap et al. (2011)

### Conclusions

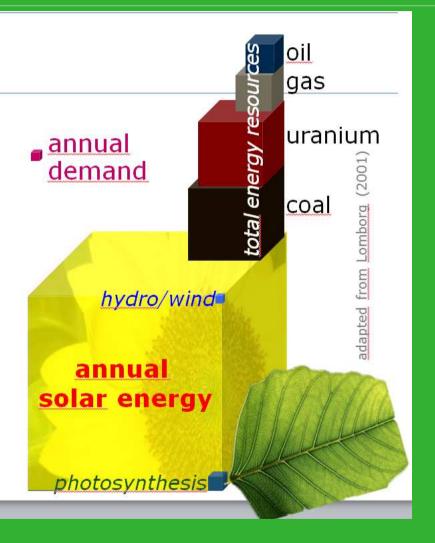
## Solar energy

#### Enormous potential, but ...

- Biology inefficient to fix solar energy
- 10% of all tranport fuels needs 26% or all crop production!
- Totality of world's crops would produce
   13% of world's primary energy (9% when efficiencies in appropriation included)

(V0 <u>version HPLE</u> report <u>Biofuels and</u> Food Security: www.fao.org/cfs/cfs-hple)







## Conclusions

We have a food problem!





#### References

Bindraban, P.S. 2013. Agro-ecological principles and biofuels. 2013 Stakeholders Conference
– Bioeconomy Days "Bioeconomy in the EU: achievements and directions for the future".

Dublin, 14-15 February 2013.

Bindraban, P.S., J.G. Conijn, R.E.E. Jongschaap, Q. Jing, M.A. Hanjra, J. Kijne, P. Steduto, H. Udo, 2011. Enhancing use of rainwater for meat production on grasslands – an ecological opportunity towards food security. Proceedings 686, p1-23. 18th annual Conference of the International Fertiliser Society. 8-10 December, 2010, Cambridge, UK.

Conijn, J.G., E.P. Querner, M.L. Rau, H. Hengsdijk, J.W. Kuhlman, G.W. Meijerink, B. Rutgers, P.S. Bindraban, 2011. Agricultural resource scarcity and distribution: a case study of crop production in Africa

Wageningen: Plant Research International, (Report / Plant Research International 380).

#### References

French R.J., J.E. Schultz, 1984. Water use efficiency of wheat in a Mediterranean-type environment: 1. The relationship between yield, water use and climate. Australian Journal of Agricultural Research 35:743-764.

Jongschaap, R.E.E., J.G. Conijn, B. Rutgers, Ph. Novelli, 2011 Sustainable Way for Alternative Fuels and Energy for Aviation: Sustainable biomass production scenarios and availability. Plant Research International, Wageningen, The Netherlands. ONERA, Paris, France. SWAFEA Technical report D 6.2.4.

Monfreda, C., N. Ramankutty, J.A. Foley,, 2008. Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. Global Biogeochem. Cycles, 22, GB1022, 19 pp.