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Scenarios for sustainable biofuel development

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Webinar: **Bioenergy for Sustainable Development**

Sustainable Water & Energy Solutions Network

Virtual, 8 June 2021

Outline

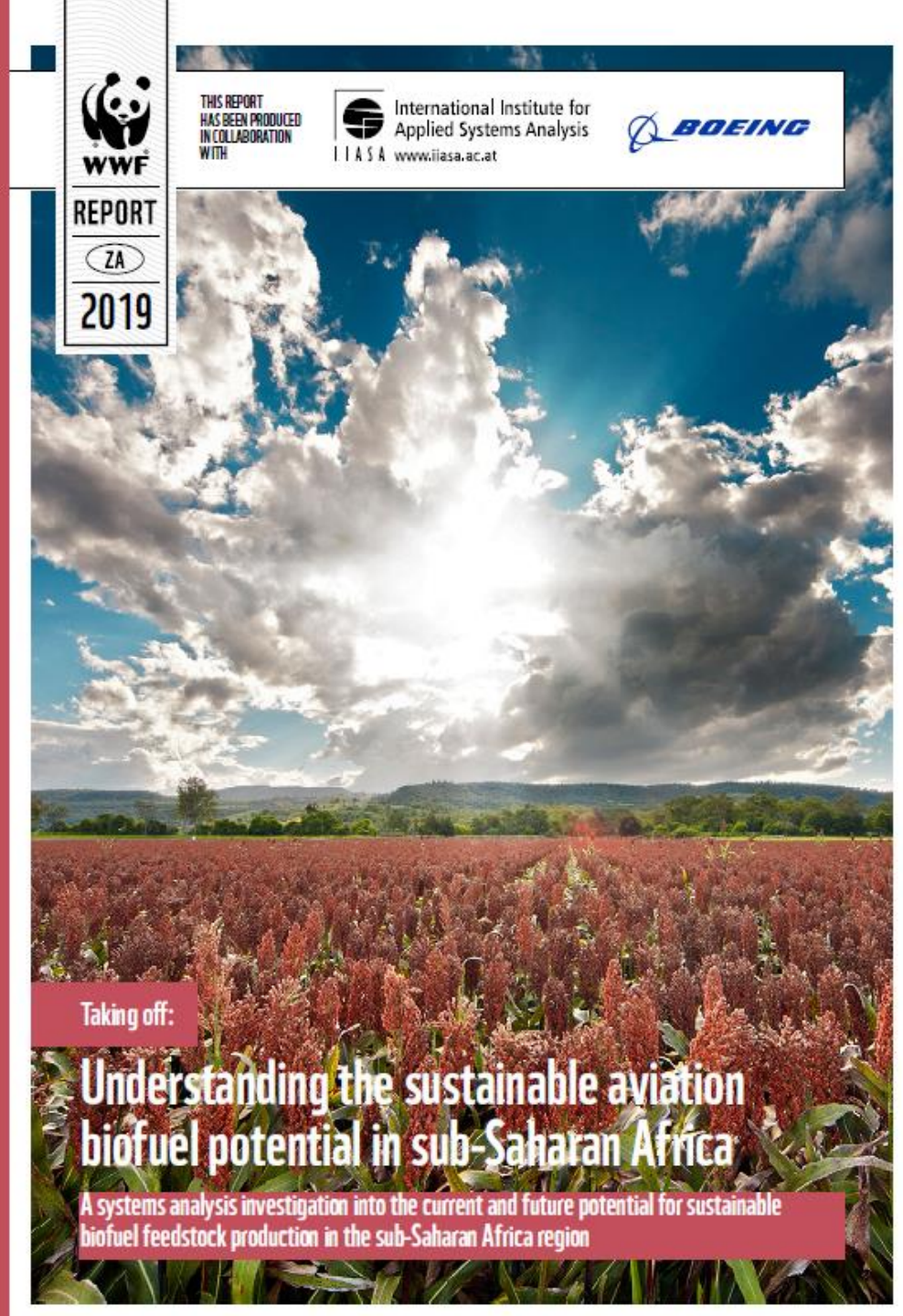
- Understanding potentials for **sustainable aviation biofuels**

- **R**oundtable on **S**ustainable **B**iomaterials (RSB)

- Land use balance → *How much land ?*
- Biofuel feedstock potentials → *Quality of land ?*
- Scenarios → *What future (2050s) potential ?*

Sustainable aviation biofuel potentials

- → Apply criteria of the **R**oundtable on **S**ustainable **B**iomaterials (RSB) to identify the regional biofuel feedstock production potential
- → Biofuel feedstock assessment
- → Scenarios to estimate potential up to 2050



http://pure.iiasa.ac.at/id/eprint/15708/

http://pure.iiasa.ac.at/id/eprint/15626/

https://rsb.org

THE 12 RSB PRINCIPLES

- Legal
- Social
- Environment
- Management

Principle 4: Human and Labour Rights

Operations do not violate human rights or labour rights, and promote decent work and the well-being of workers.

Principle 5: Rural and Social Development

In regions of poverty, operations contribute to the social and economic development of local, rural and indigenous people and communities.

Principle 6: Local Food Security

Operations ensure the human right to adequate food and improve food security in food insecure regions.

Principle 7: Conservation

Operations avoid negative impacts on biodiversity, ecosystems, and conservation values.

Principle 8: Soil

Operations implement practices that seek to reverse soil degradation and/or maintain soil health.

Principle 9: Water

Operations maintain or enhance the quality and quantity of surface and groundwater resources, and respect prior formal or customary water rights.

Principle 1: Legality

Operations follow all applicable laws and regulations.

Principle 2: Planning, Monitoring & Continuous Improvement:

Sustainable operations are planned,implemented, and continuously improved through an open, transparent, and consultative impact assessment and management process and an economic viability analysis.

Principle 3: Greenhouse Gas Emissions

Biofuels contribute to climate change mitigation by significantly reducing life-cycle GHG emissions as compared to fossil fuels.

Principle 10: Air Quality

Air pollution shall be minimised along the whole supply chain.

Principle 11: Use of Technology, Inputs, and Management of Waste

The use of technologies shall seek to maximise production efficiency and social and environmental performance, and minimise the risk of damages to the environment and people.

Principle 12: Land Rights

Operations shall respect land rights and land use rights.

Local Food Security

Operations ensure the human right to adequate food and improve food security in food insecure regions.

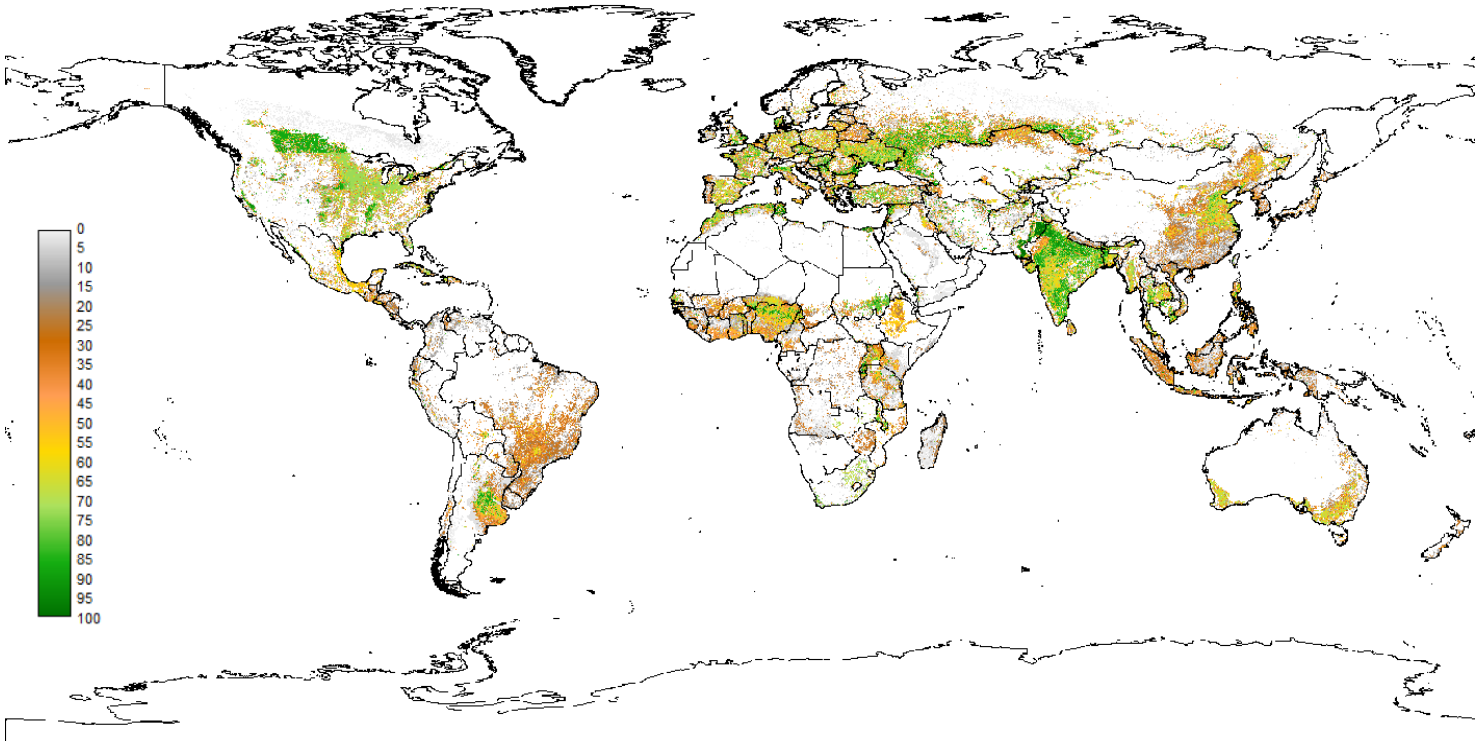
Principle 6: Local Food Security

→ Exclude cropland for food production

→ Set aside land for livestock feed

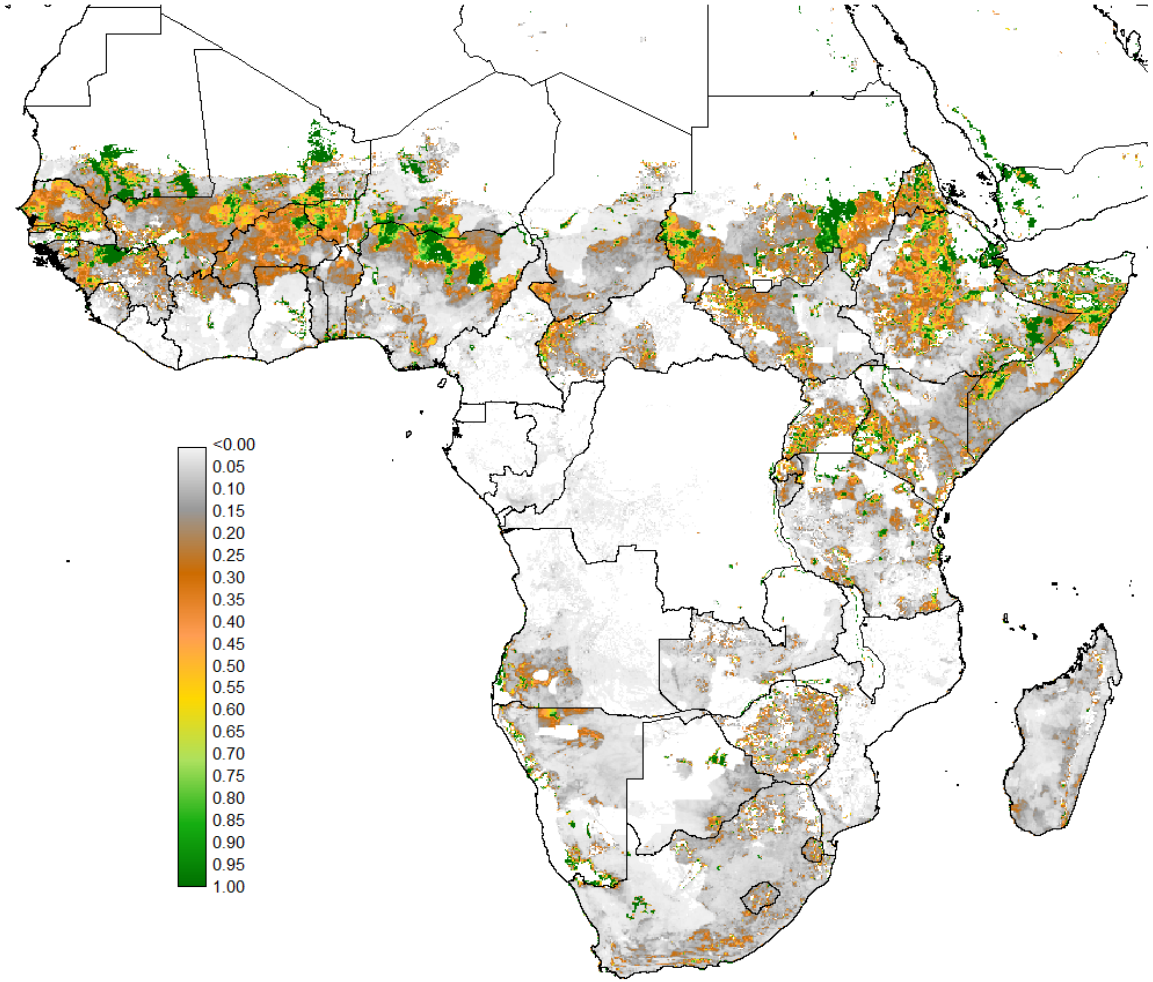
Land cover data, cropland

Distribution and intensity of cropland in GLC-Share
(% of 30 arc-second grid cell)



Source: FAO/IIASA GAEZ v4, based on Latham et al., 2014

Land requirements for ruminant livestock



Estimated share of grassland/shrubland set aside for livestock grazing, 2010

Source: Fischer et al., 2019

Conservation

Operations avoid negative impacts on biodiversity, ecosystems, and conservation values.

Principle 7:
Conservation

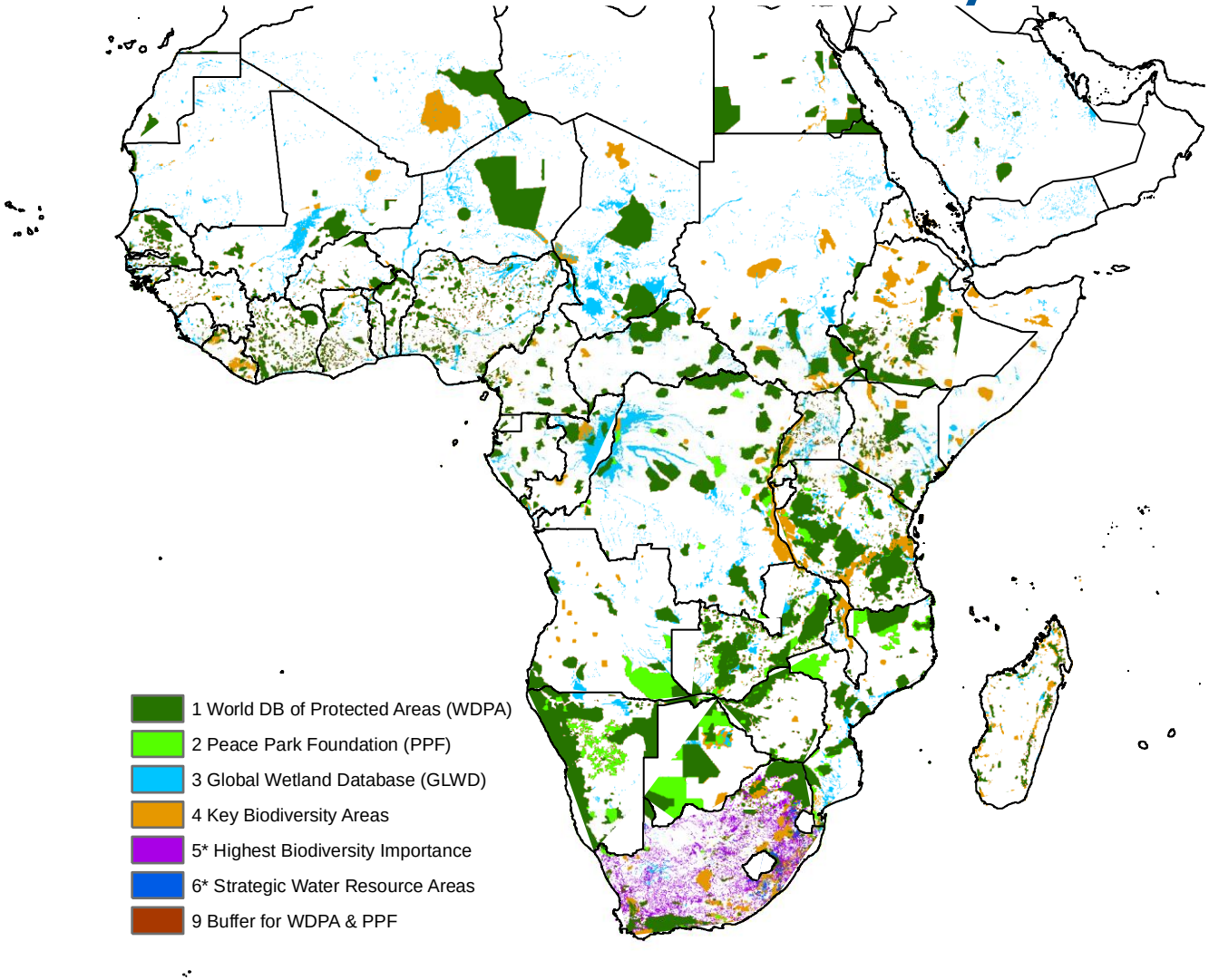
EXCLUDE

→ All forest land

→ Areas of importance for the environment and biodiversity (WDPA, GLWD, KBA,….)

→ Buffer around protected areas

Land set-aside for environment and biodiversity



Source: Fischer et al., 2019

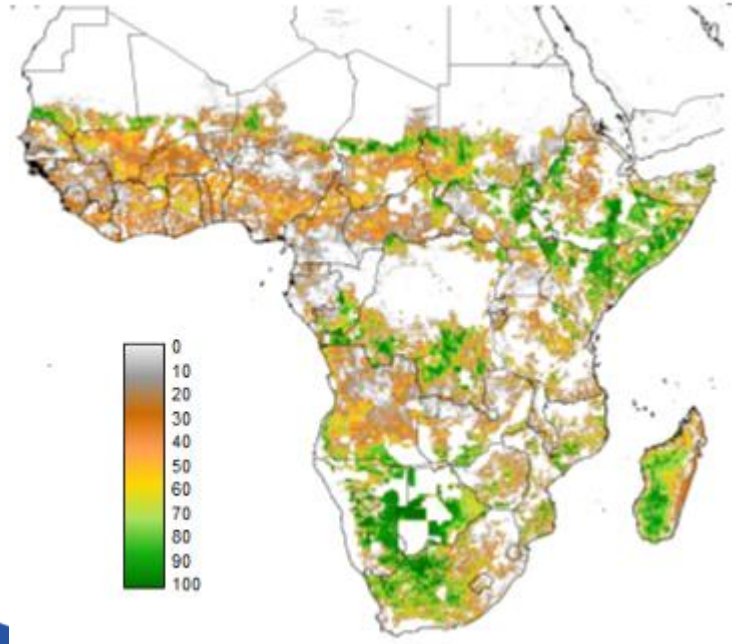
Land related RSB criteria

- Respect food security
- No deforestation
- Safeguard environment & biodiversity

Exclusion layers
FOOD, FOR, ENV

REMAIN land

Intensity and spatial distribution of REMAIN land



Region	Total land	REMAIN land In 2010	
	1000 km²	1000 km²	%
Eastern Africa	3,562	1,042	29
Central Africa	5,329	1,152	22
Southern Africa	4,737	1,431	30
Sudano-Sahelian Africa	8,541	1,493	17
Gulf of Guinea	2,097	386	18
Total Sub-Saharan Africa	24,266	**5,504**	23

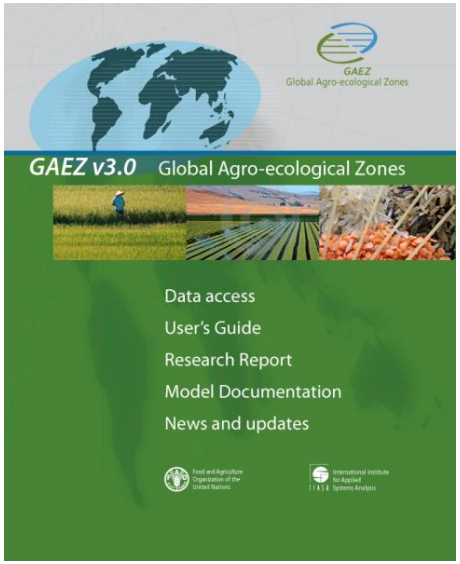
Source: Fischer et al., 2019

Land related RSB criteria

Land balance and exclusions for Sub-Saharan Africa, 2010

	1000 km^2	Land use category	% of total	Excluded	Reason for exclusion	REMAIN land[1]
1	Cropland	2,353	10 %	2,353	Food security	0
2	Forest	6,901	28 %	6,901	Environment[2]	0
3	Built-up land	270	1 %	270	Not for farming	0
4	Water	281	1 %	281	Not for farming	0
5	Shrub land	4,538	19 %	1,270	Environment (Env)	
				454	Livestock (Lvst)[3]	
				1,724	Env & Lvst	2,813
6	Grassland	4,856	20 %	1,608	Environment (Env)	
				558	Livestock (Lvst)[3]	
				2,166	Env & Lvst	2,691
7	Sparsely veg. & bare	5,068	21%	5,068	Not considered for commercial farming	0
	TOTAL	24,266	100%	18,759		5,504

Biofuel feedstock assessment



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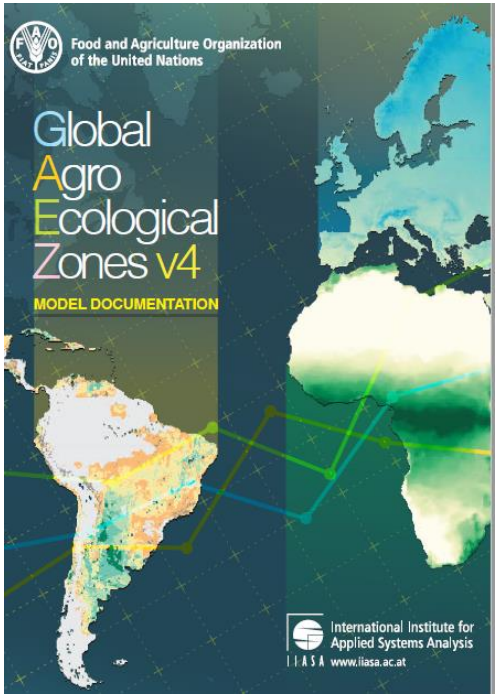

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Biofuel Feedstocks	Bio-material
Solaris tobacco	Vegetable oil
Jatropha	Vegetable oil
Oil palm	Vegetable oil
Soybean	Vegetable oil
Camelina	Vegetable oil
Macauba	Vegetable oil
Ethiopian rape	Vegetable oil
Sugar cane	Sugar
Sweet Sorghum	Sugar/Starch
Maize	Starch
Cassava	Starch
Triticale	Starch
Miscanthus	Lignocellulosic
Energy cane	Lignocellulosic
Hardy artichoke	Lignocellulosic
Agric. crop residues	Lignocellulosic

Soil

Operations implement practices that seek to reverse soil degradation and/or maintain soil health.

Principle 8:
Soil

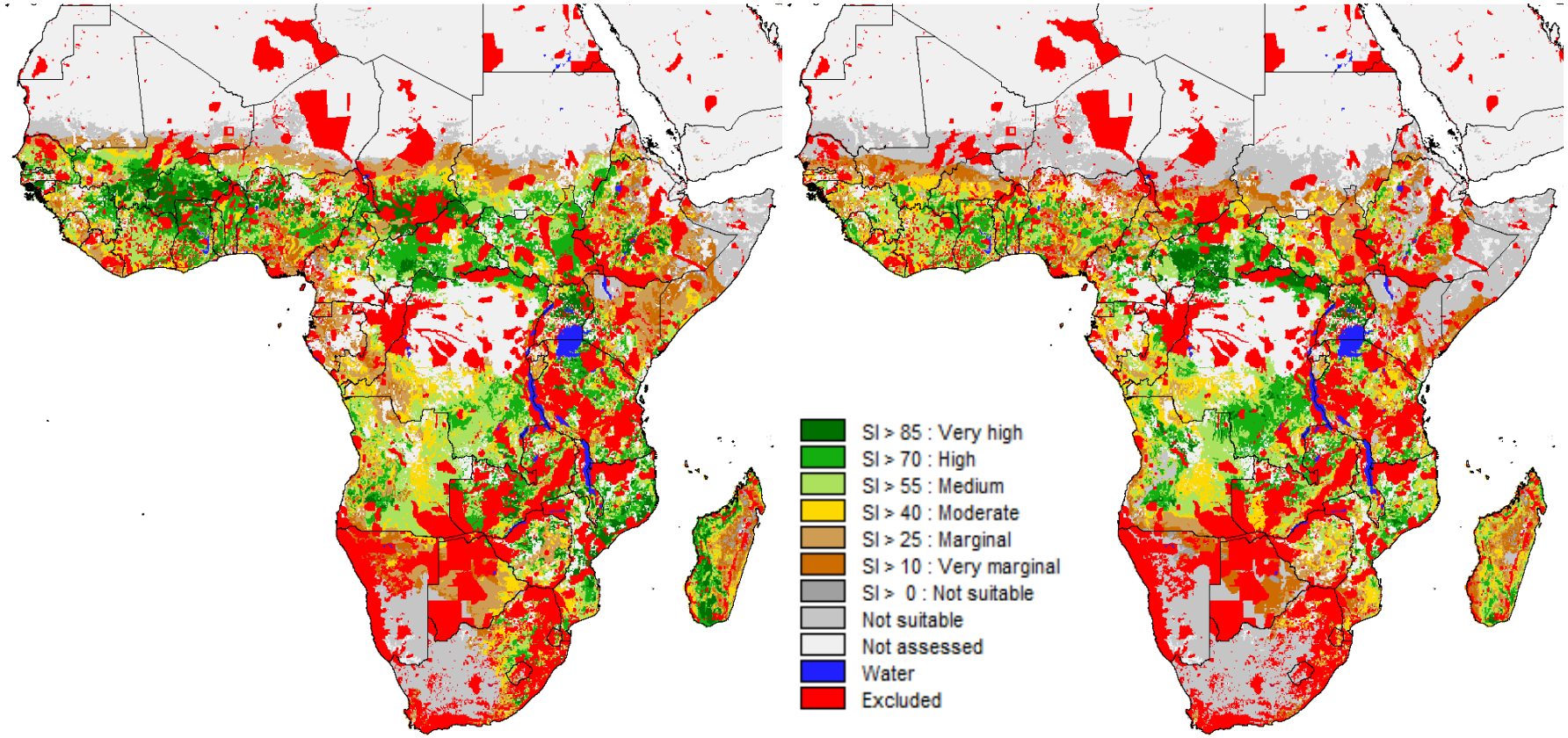
→ Exclude areas of high soil organic matter content

→ to maintain soil fertility, assume only 50% of crop residues used for biofuel feedstock

Agro-ecological suitability of rain-fed biofuel feedstock production on REMAIN land

Sweet sorghum

Cassava



Source: Fischer et al., 2019

Land suitability and farm economics

Acronym	Suitability description	Farm economics
VS	Very suitable land (80-100 % of maximum achievable yield in Sub-Saharan Africa)	Prime land offering best conditions for economic feedstock production
S	Suitable land (60—80%)	Good land for economic feedstock production
MS	Moderately suitable land (40-60%)	Moderate land with substantial climate and/or soil/terrain constraints requiring high product prices for profitability
mS	Marginally suitable land (20-40%)	Commercial production not viable. Land could be used for subsistence production when no other land is available
VmS	Very marginally suitable (< 20%)	Economic production not feasible
NS	Not suitable	Production not possible

GHG emissions

Biofuels contribute to climate change mitigation by significantly reducing life-cycle GHG emissions as compared to fossil fuels.

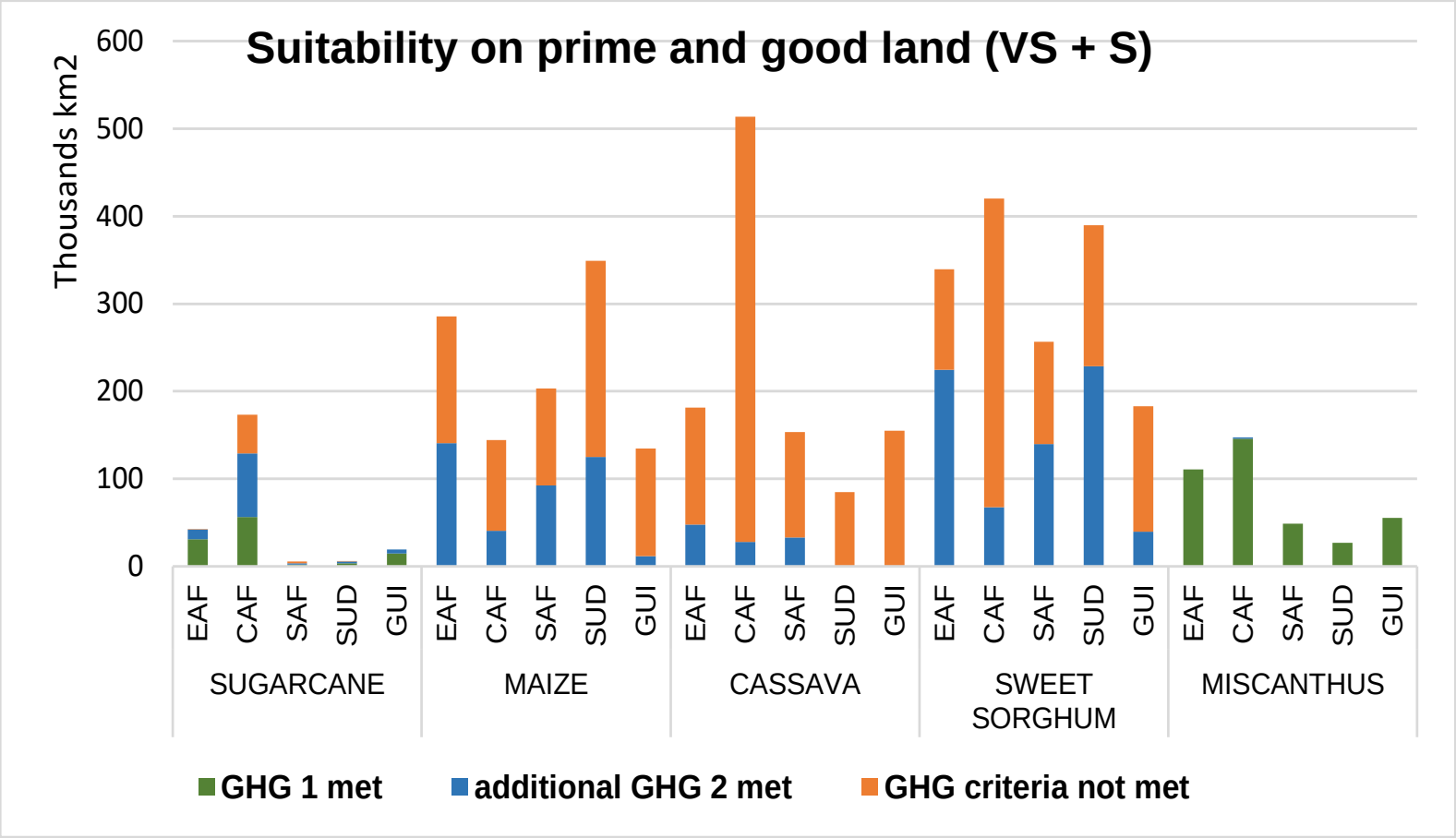
Principle 3: Greenhouse Gas Emissions

→ 60 % minimum saving vis-à-vis fossil fuels

→ Fossil fuel comparator of 94 g CO_{2equ}/MJ

- **Life cycle** emissions of biofuel pathway
  assumed g CO2 eq / MJ for each biofuel feedstock
- Annualized emissions from **direct land use change**
  [Soil carbon stock changes, Biomass carbon stocks, Management options, Co-product allocation]

Suitability of REMAIN land for sugar/starch/lignocellulose based biofuel feedstocks



Source: Fischer et al., 2019

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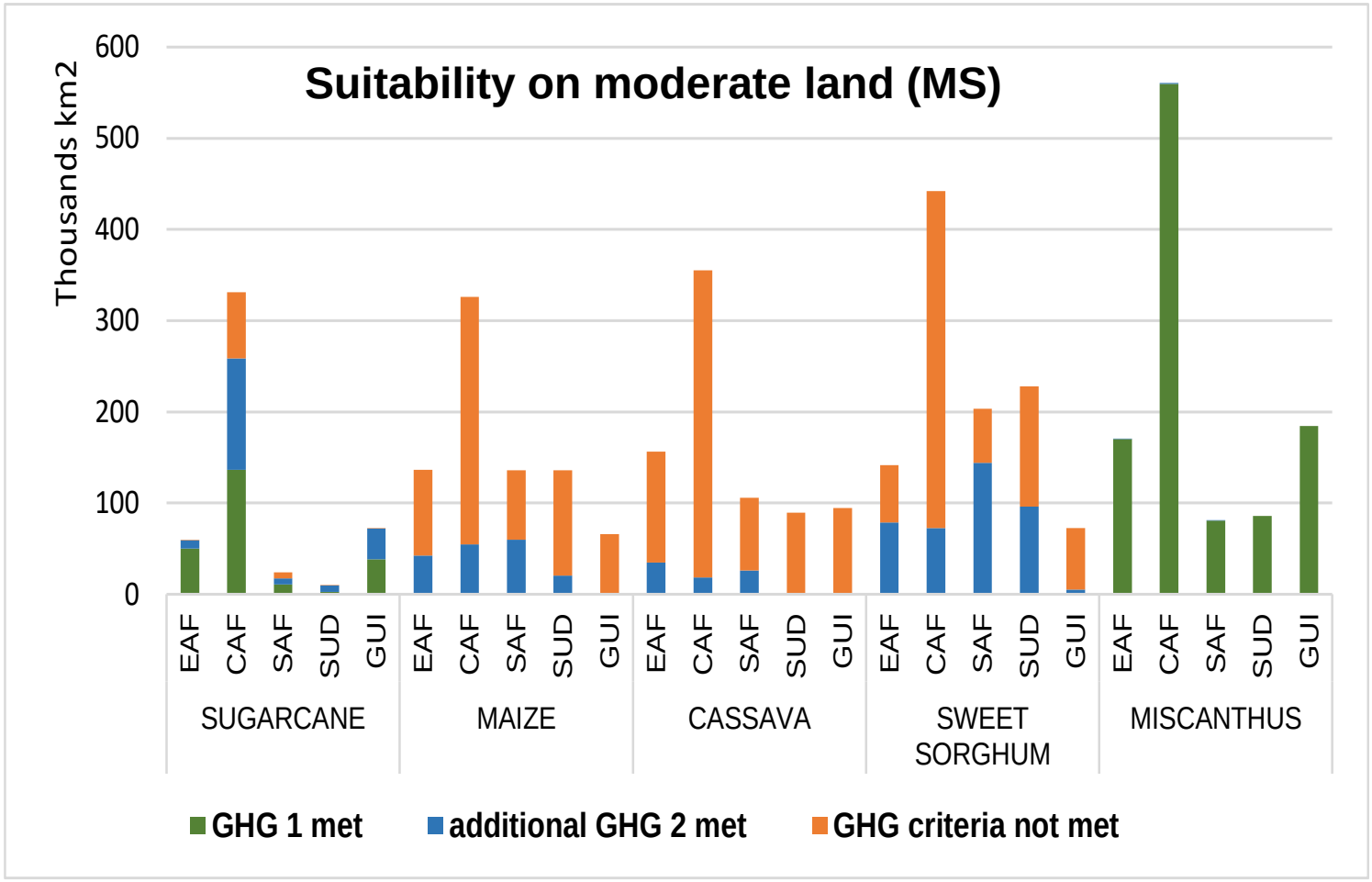


Source: Fischer et al., 2019

Water

Operations maintain or enhance the quality and quantity of surface and groundwater resources, and respect prior formal or customary water rights.

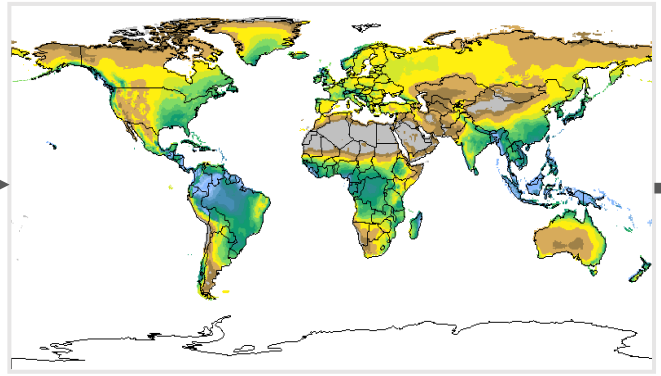
Principle 9:
Water

→ Consider irrigated biofuel feedstock production only in areas where water scarcity does not prevail today or in the future.

SCENARIOS

- GHG Emissions
- Climate forcing
  -> RCP
- CO_2 concentration

Agro-ecological suitability and land productivity



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Climate impact response relations

4

2 Climate model

1 Development scenario

SSP narrative
- Population
- GDP growth
- Urbanization

Production

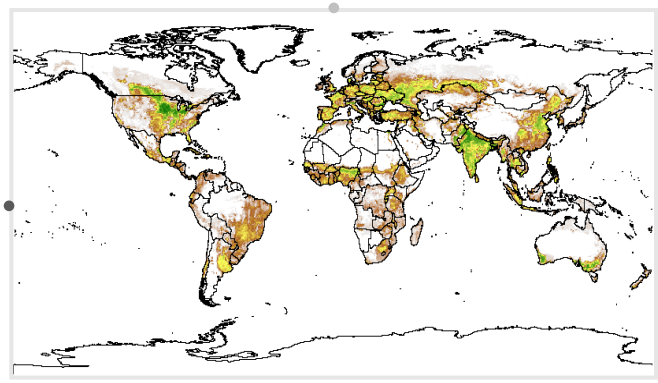
Demand

Trade

Global Food-Feed-Biofuel System

World Market

5



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Spatial distribution of land use

Source: Fischer et al., 2009

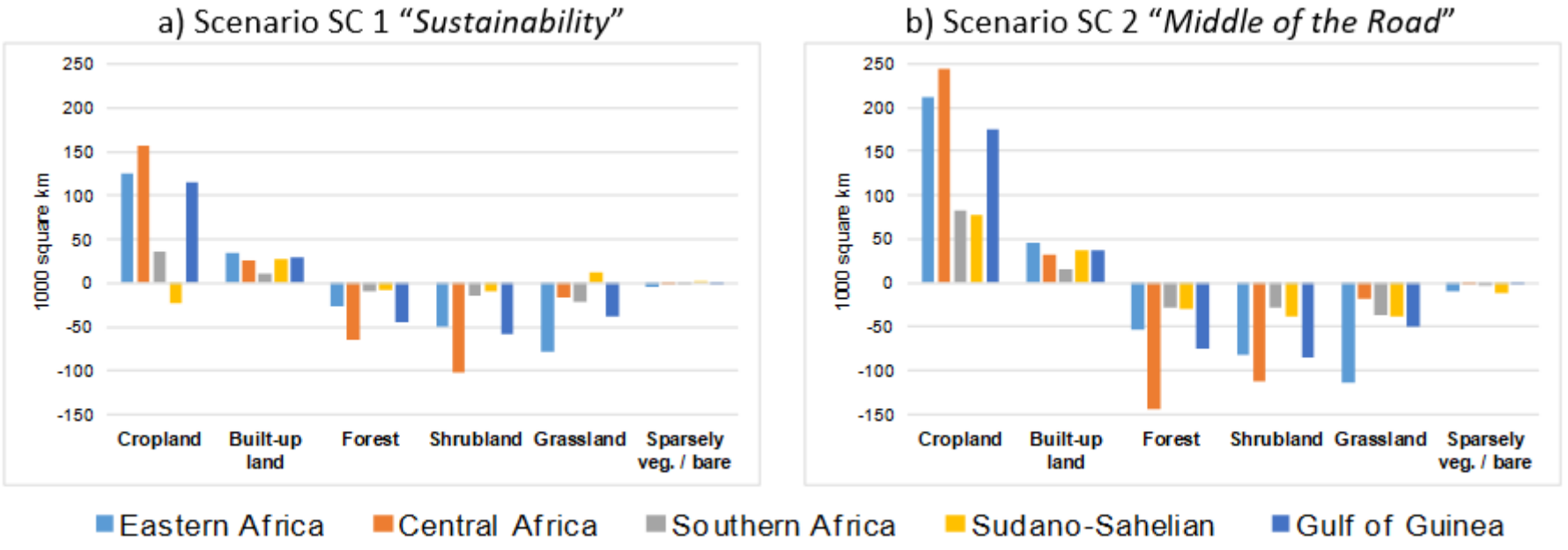
Development scenarios
consistent with IPCC

	SC1 Sustainability	SC2 Medium
Shared Socio-economic Pathways (SSPs)	SSP1 Sustainability - Taking the Green Road	SSP2 Middle of the Road
Climate Forcing Ensemble Mean	RCP 2.6	RCP 6.0
2050 CO_2 concentrations*	443 ppm	493 ppm

***** CO_2 concentration in Reference Period 1982-2010 is 360 ppm

Scenario Land use changes

Land use changes in the development scenarios, 2010 to 2050



Source: Fischer et al., 2019

Biofuel potential of REMAIN land ins SSA compliant with GHG criteria, contribution by crop

Climate	Reference (1981-2010)			Ensemble RCP2.6 (2041-2070)		Ensemble RCP6.0 (2041-2070)	
CO2 conc.	360ppm			443ppm		493ppm	
Land use	2010	SC1-2050	SC2-2050	SC1-2050	SC1-2050	SC2-2050	SC2-2050
CO2 fertilization	reference			with	without	with	without
Prime and good land VS+S (*Petajoules*)							
Maize	0	0	0	0	0	0	0
Sorghum	0	0	0	18	14	38	25
Triticale	0	0	0	0	0	0	0
Cassava	0	0	0	0	0	0	0
Sugarcane	907	692	647	222	208	150	133
Miscanthus	3,645	2,773	2,444	1,890	1,515	1,963	1,392
Oil palm	1,294	1,081	1,030	801	649	920	659
Jatropha	17	961	909	1,001	852	906	785
Soybean	0	0	0	0	0	0	0
Camelina	0	0	0	0	0	0	0
Solaris	1	1	1	30	14	28	11
TOTAL VS+S	**7,064**	5,508	5,030	**3,962**	3,252	**4,003**	3,004
TOTAL VS+S+MS	**15,510**	12,860	11,962	**11,171**	10,528	**11,159**	10,154

Source: Fischer et al., 2019

Biofuel potential of REMAIN land compliant with GHG criteria of the RSB

- For sub-Saharan Africa, we estimate a current biofuel potential of 7 PJ down to 3-4 PJ by the 2050s produced on prime and good land.
- If demand is strong and crop prices are high, farmer may also cultivate on moderately suitable land, which more than doubles the potential to 15 PJ (current) and 10-11 PJ (2050s)
- Main RSB compliant crops include miscanthus, sugar cane, oil palm and jatropha.
- By the 2050s land use changes required for food (and expanding urban areas) are the main reason for reduction of potentials.
- Further reductions are due to climate change, partly compensated by CO_2 fertilization effect. In smaller areas, some crops (solaris, sorghum) may benefit from climate change.

Take home messages

Sustainability of land-based biofuels depends on

- Land availability, e.g. estimation on REMAIN land
- GHG reduction potential vis-à-vis fossil fuels
  determines viable crops
- Economics of production, i.e. strong demand and
  higher achievable prices make moderately suitable areas
  interesting for biofuel feedstock production

Thank you!

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