ICAO ENVIRONMENT

ICAO STOCKTAKING SEMINAR
TOWARD THE 2050 VISION FOR
SUSTAINABLE AVIATION FUELS

Assessing sustainable biofuel potential in Sub-Saharan Africa

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Based on research conducted by
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and funded by
the Boeing Foundation

IIASA

BOEING

WWF

WWF-SA AND RSB WORKING TOGETHER TOWARDS SUSTAINABLE SOLUTIONS IN AVIATION BIOFUELS

RSB
Roundtable on Sustainable Biomaterials
www.rsb.org

Overview

01 INTRODUCTION

- Study context
- Aims & objectives

02 METHODOLOGY

- Land resources and agro-ecological zones methodology
- Development and climate scenarios
- Integrating sustainability principles
- Biofuel feedstocks

03 RESULTS

- Current potential
- Future potential

04 MAIN MESSAGES

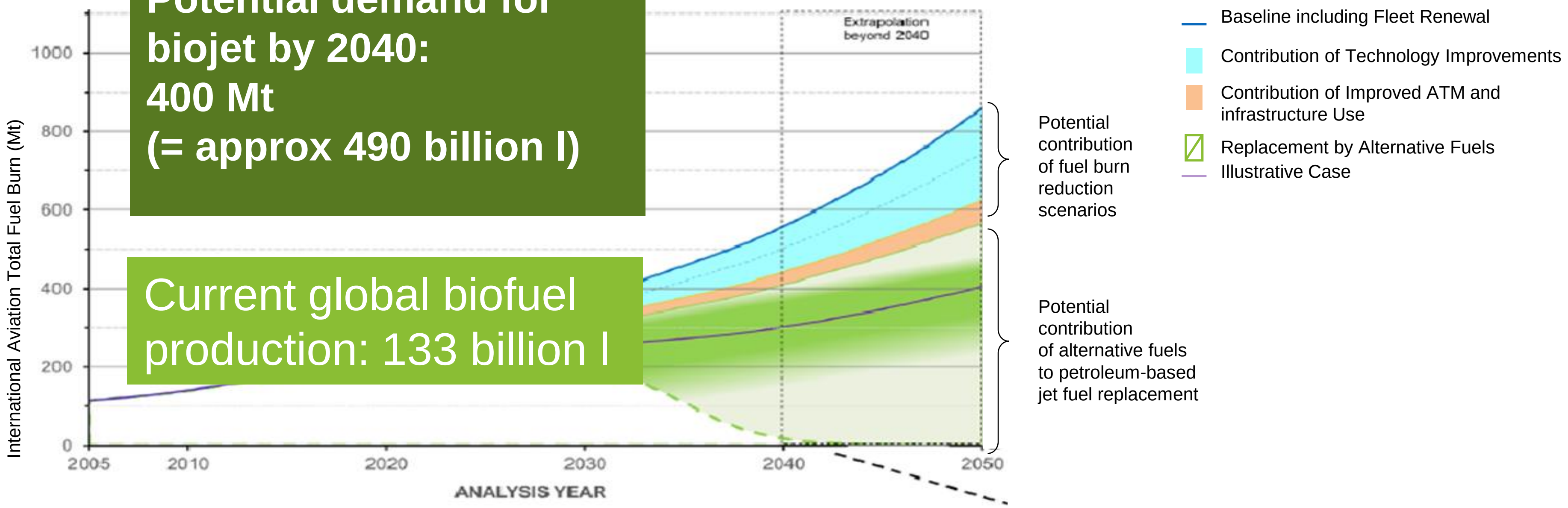
INTRODUCTION

Context

Aircraft fuel burn from international aviation, including potential replacement of jet fuel with alternative fuels (ICAO, 2016)

Potential demand for biojet by 2040:
400 Mt
(= approx 490 billion l)

Current global biofuel production: 133 billion l



Context

- Africa, and particularly sub-Saharan Africa, is seen as one of the **major expansion areas** for the production of biofuel feedstock.
- The sustainability of large scale biofuel supply **depends on available resources** for the production of biomass feedstock in the context of future demand for food, water resources and the need to safeguard natural environments.
- The importance of taking a **system view of biomass for energy development**.

Study aim

To estimate **current** and **future** technical potentials for biofuels in sub-Saharan Africa in accordance with the principles of the Roundtable on Sustainable Biomaterials (RSB) for the following categories of biofuel feedstock:

1. Land-based energy crops
2. Crop residues

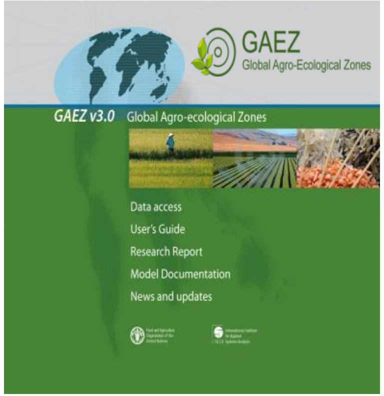
1. TO ESTIMATE THE POTENTIAL FROM LAND-BASED ENERGY CROPS, WE MUST:	2. TO ESTIMATE THE POTENTIAL FROM CROP RESIDUES, WE MUST:
1. Estimate the amount of land that is available for feedstock production 2. Pick the crop that would deliver the highest energy yield while complying with RSB criteria	1. Determine the amount of residues 2. Determine the proportion of residue that can be sustainably extracted from the field

METHODOLOGY

Land resources & agro-ecological zoning

- **FAO and IIASA** have developed a **spatial analysis system** that enables **rational land-use planning** on the basis of an inventory of land resources and evaluation of biophysical limitations and production potentials of land.

- The **AEZ methodology** follows an environmental approach; it provides a **standardized framework** for analyzing synergies and trade-offs of **alternative uses of agro-resources** (land, water, technology) for producing food and energy, while **preserving environmental quality.**



- GAEZ spatial databases provide:

✓ Spatial distribution of current land use/cover in Sub-Saharan Africa consistent with FAO cropland statistics and remotely sensed data.
✓ Inventory of protected areas & areas of high value for the environment and biodiversity
✓ Climate of 5 arcminute resolution of current (1981-2010) and projections for future (2011-2090) conditions
✓ Soil attributes and terrain/slope conditions
✓ Land productivity assessment for food crops and biofuel feedstocks

The RSB Principles

1. Legality
2. Planning, monitoring & Continuous Improvement
3. Greenhouse Gas Emissions
4. Human & Labour Rights
5. Rural and Social Development
6. Local Food Security
7. Conservation
8. Soil
9. Water
10. Air Quality
11. Use of Technology, Inputs & Management of Waste
12. Land Rights

The RSB Principles

1. **Legality**

2. **Planning, monitoring & Continuous Improvement**

3. Biofuels must deliver min 60% GHG saving after all LC + dLUC emissions are considered

4. **Human & Labour Rights**

5. **Rural and Social Development**

6. Reserve cropland for food production & sufficient grazing land for ruminant livestock

7. No deforestation for biofuel feedstock production

8. Exclude slopes, do not extract residues above a sustainable rate

9. No irrigated biofuel feedstock production, exclusion of strategic water source areas

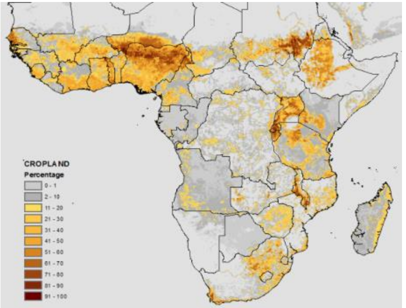
10. **Air Quality**

11. **Use of Technology, Inputs & Management of Waste**

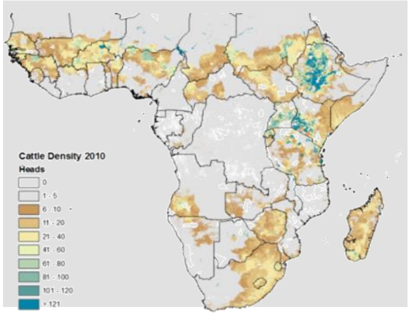
12. **Land Rights**

Exclusion layers:
cropland, grazing land, forest, environment

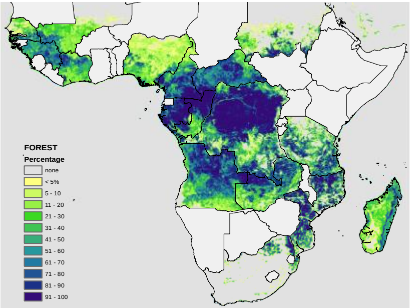
- CROPLAND



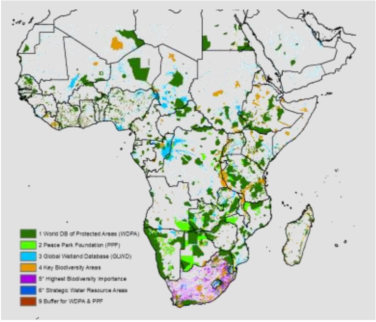
- GRAZING LAND



- FOREST



- ADDITIONAL PROTECTED AREAS



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Biofuel feedstock selection

1st generation biofuel production chains	1st generation biofuel production chains	2nd generation biofuel production chains

BIODIESEL

- Solaris
- Jatropha
- Oil palm
- Soybean
- Camelina

BIOETHANOL

- Sugarcane
- Maize (grain + stover)
- Sweet sorghum
- Cassava
- Triticale

LIGNOCELLULOSIC ETHANOL

- Miscanthus
- Crop residues

‘UMBRELLA CROP’

- Selects the best biofuel feedstock in terms of biofuel energy output and thereby defines an upper technical potential.

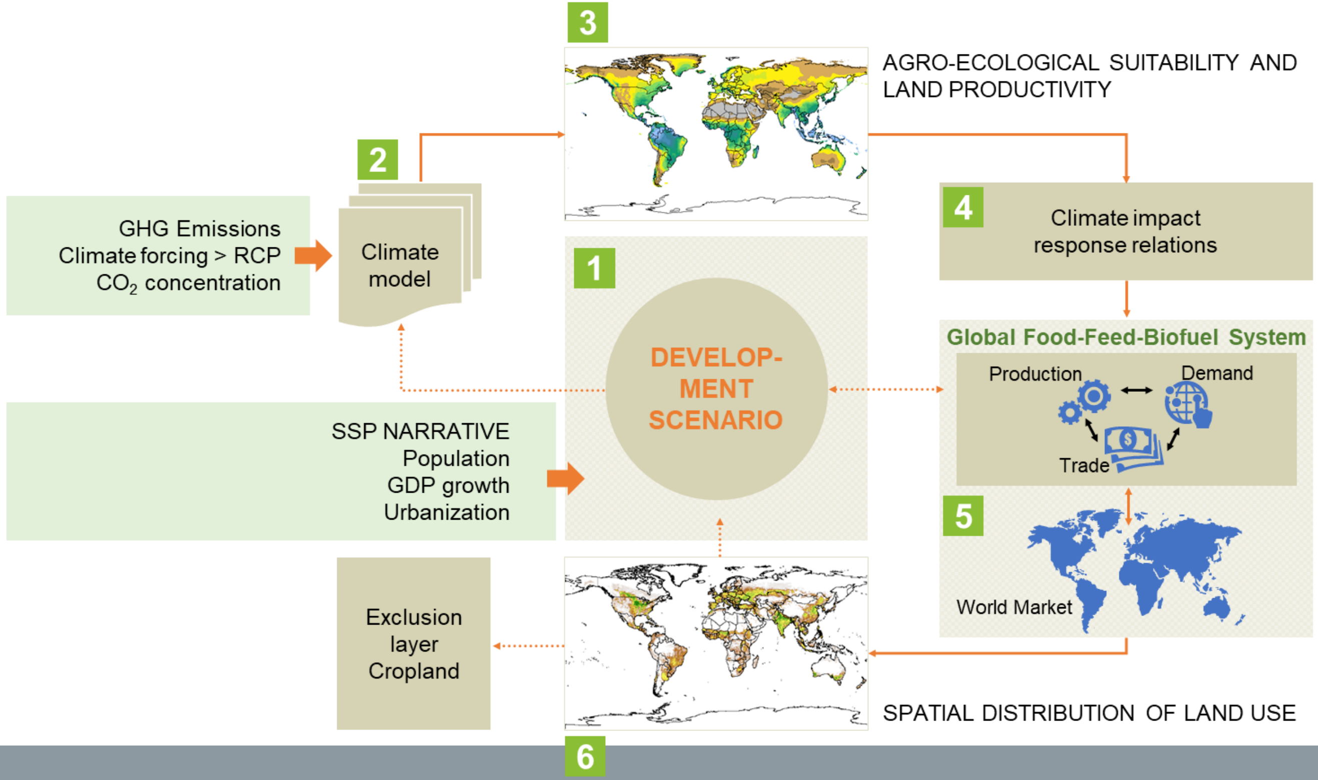
Development scenarios until 2050

CONSISTENT WITH IPCC

- Shared Socio-economic Pathways (SSP) for:
  - population and GDP projections
  - food demand, food production and trade
  - cropland use and irrigation demand for food production together with
- Representative Concentration Pathways (RCP) for climate change projections
- Both are input to the assessment framework of the IIASA World Food System (WFS) and GAEZ models

SCENARIO	SOCIO-ECONOMIC DEVELOPMENT NARATIVE	CORRESPONDING EMISSION PATHWAYS & CLIMATE CHANGE
SC1 – SUSTAINABILITY	Sustainability (SSP1)	RCP 2.6
SC2 – MIDDLE	Middle of the Road (SSP2)	RCP 6.0

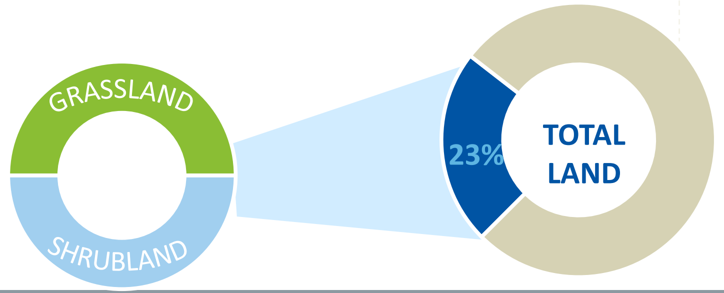
Assessment framework



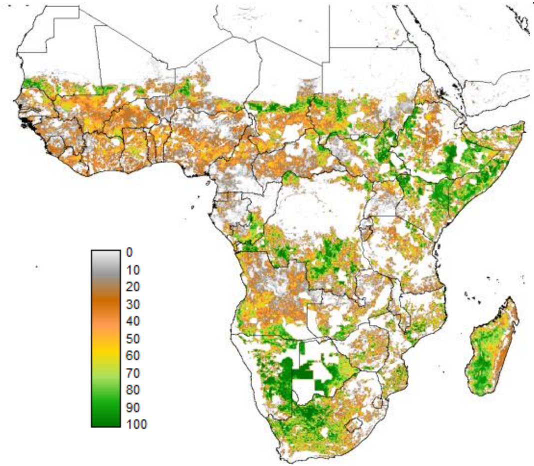
RESULTS
current technical potential

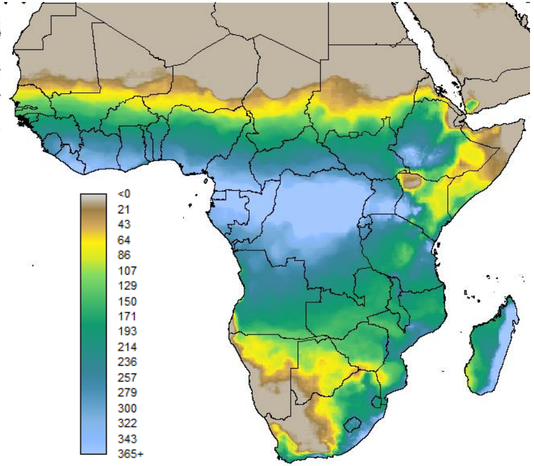
Estimation of current REMAIN land

LAND EXTENTS (MIO KM2)	2010
TOTAL LAND	24.27
NO-GO AREAS	
Exclusion layer FOOD – Cropland for food	-2.35
Exclusion layer FOREST	-6.90
Exclusion layer ENVIRONMENT + Grazing	-3.89
Exclusion SPARSELY VEGETATED and BARE LAND	-5.62
LAND CONSIDERED FOR BIOFUEL FEEDSTOCK PRODUCTION	**5.5**



Intensity and spatial distribution of REMAIN land (%), and number of annual growing period days, in 2010





Only a relatively small fraction of REMAIN land can support economically viable energy crops production because of differences in prevailing agro-climatic, soil and terrain conditions

-> Very suitable (VS) (prime) or suitable (S) (good) for specific energy crop production (60–100% of potential yield)

-> Moderately suitable (MS) land (40–60% of potential yields); often not economically viable for commercial production, but may become so with high agricultural commodity prices

Adding the GHG restrictions

- Biofuels must deliver min 60% GHG saving after all LC + dLUC emissions are considered
- dLUC: soil carbon & above and below ground biomass
- Indirect land-use change
- Allocation of GHG burden to multi-product crops

Land area in South Africa that would support production of energy crops for RSB-compliant biofuel

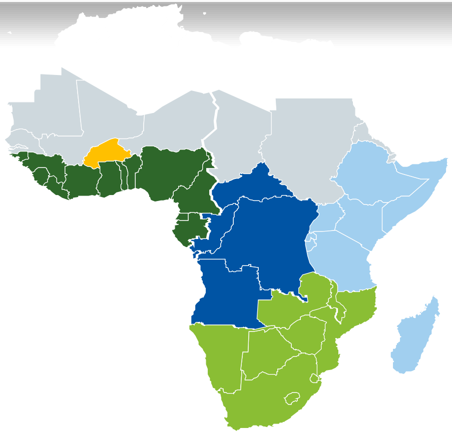
SA total land area
1 222 587 km^2

Total REMAIN land
493 264 km^2 (40% of total)

Prime and good REMAIN land for production of energy crops
37 349 km^2 (3% of total)

GHG criteria compliant prime and good REMAIN land
6 153 mio km^2 (0.5%)

Moderately suitable GHG compliant REMAIN land – 11 261 km^2 (0.9%)

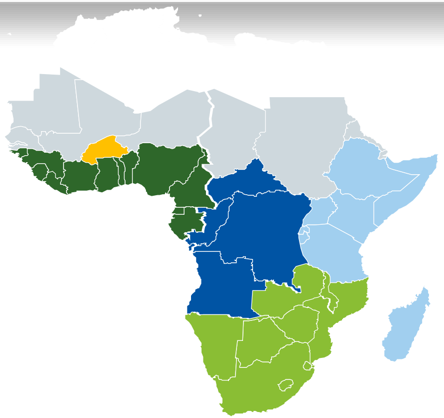


Current technical potential for "umbrella crops" with max energy yield and min 60% GHG saving (in PJ)

Very Suitable And Suitable Land

	Sugarcane	Oilpalm	Miscanthus	Jatropha	Solaris	Sweet Sorghum	Total
EASTERN AFRICA	253	38	1 188	84			1 564
CENTRAL AFRICA	513	898	959	882			3 342
SOUTHERN AFRICA	0.20		584	33	1		617
SUDANO-SAHELIAN A.	26		291	36			353
GULF OF GUINEA	115	297	594	183			1 188
GRAND TOTAL	**907**	**1 294**	**3 645**	**1 217**	**1**		**7 064**

Source: WDPA, PPF, GLWD, IBAT, Mining-Guidelines and own analysis



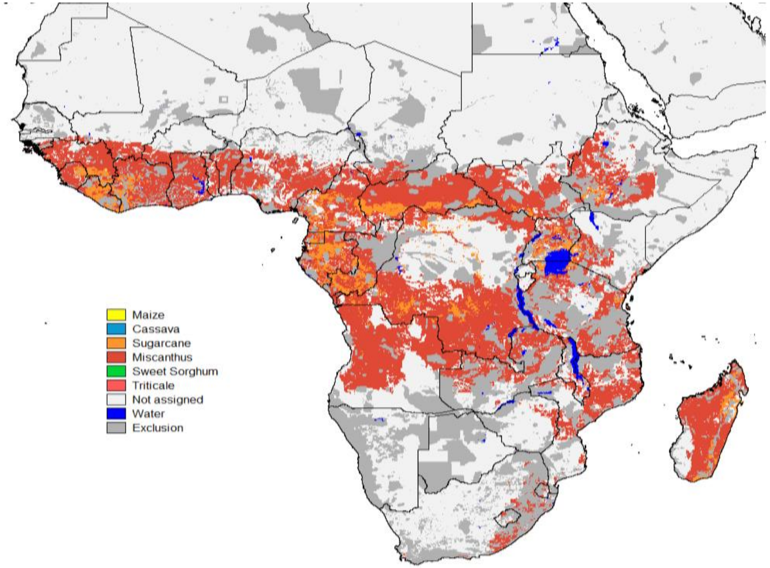
Current technical potential for “umbrella crops” with max energy yield and min 60% GHG saving (in PJ)

Very Suitable + Suitable + Moderately Suitable

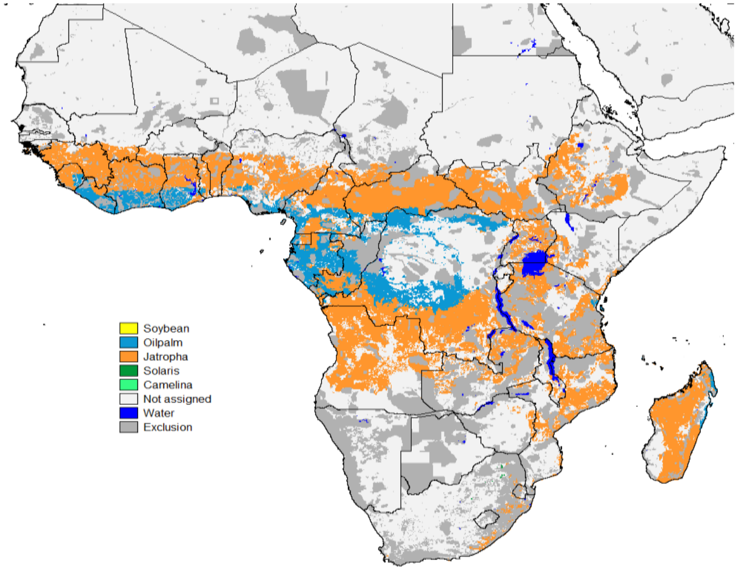
	Sugarcane	Oilpalm	Miscanthus	Jatropha	Solaris	Sweet Sorghum	Total
EASTERN AFRICA	301	47	2 644	11			3 003
CENTRAL AFRICA	898	1 293	4 923	126			7 499
SOUTHERN AFRICA	0.20		1 293	3	1		1 297
SUDANO-SAHELIAN A.	27.00		1 058	30			792
GULF OF GUINEA	167	437	1 990	2			2 596
GRAND TOTAL	1 394	2	11 908	184	1		15 510

Source: WDPA, PPF, GLWD, IBAT, Mining-Guidelines and own analysis

Best RSB-compliant bioethanol feedstocks on REMAIN land (current)

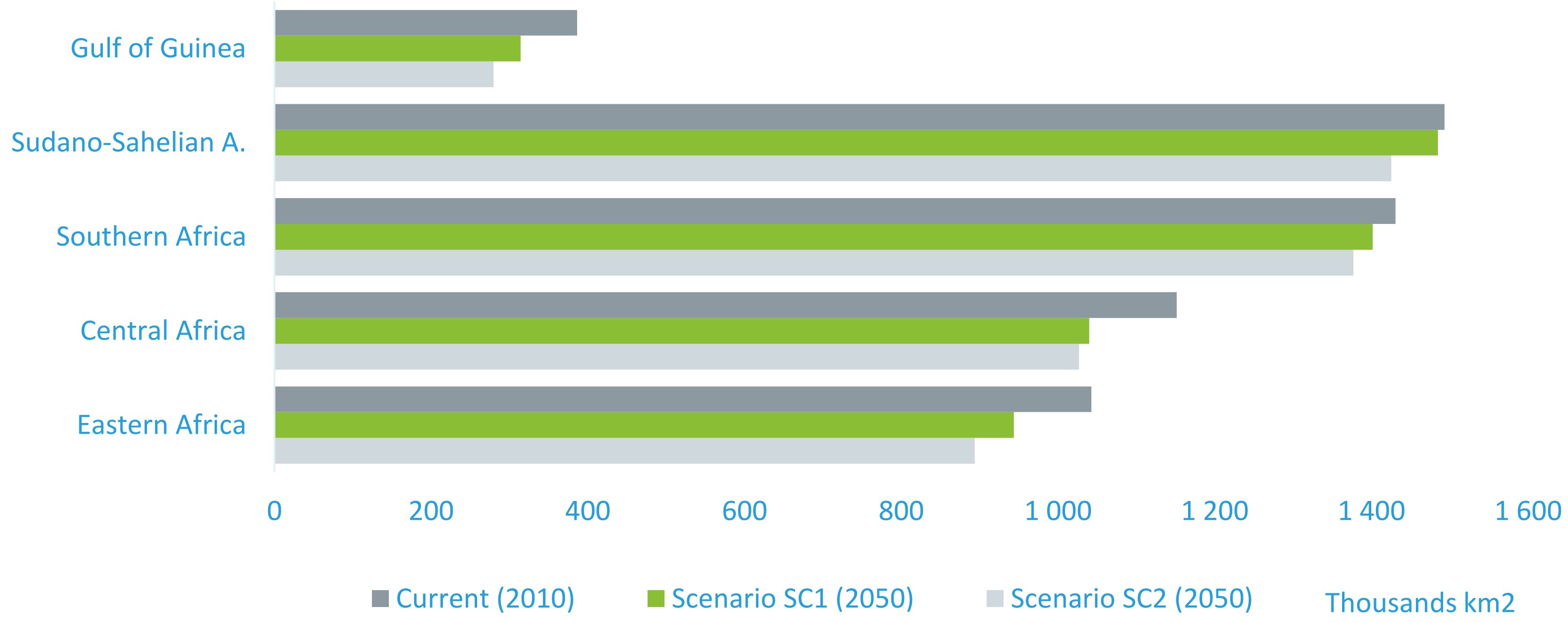


Best RSB-compliant biodiesel feedstocks on REMAIN land (current)

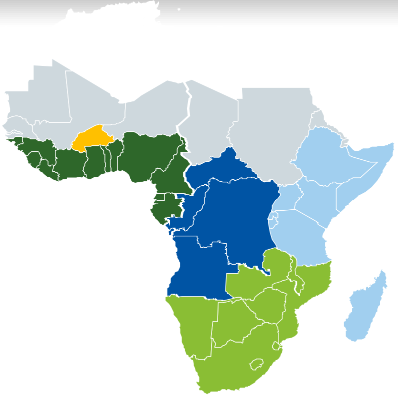


RESULTS
future technical potential

Changes in future availability of REMAIN land



Source: WDPA, PPF, GLWD, IBAT, Mining-Guidelines and own analysis

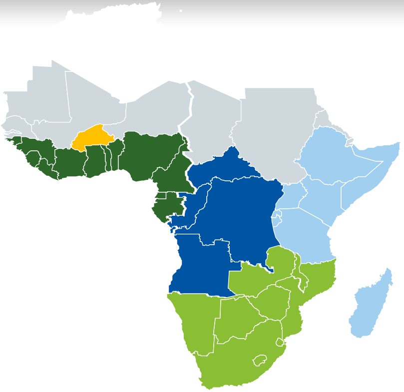


Future (2050) technical potential for “umbrella crops” with max energy yield and min 60% GHG saving (SC1)

Very Suitable + Suitable

	Sugarcane	Oilpalm	Miscanthus	Jatropha	Solaris	Sweet Sorghum	Total
EASTERN AFRICA	113	80	639	39			872
CENTRAL AFRICA	98	646	514	838	3		2 099
SOUTHERN AFRICA	0.60		273	21	27	8	329
SUDANO-SAHELIAN A.	1		227	24		10	262
GULF OF GUINEA	9	76	236	80			400
GRAND TOTAL	222	801	1 890	1 001	30	18	3 962

Source: WDPA, PPF, GLWD, IBAT, Mining-Guidelines and own analysis



Future (2050) technical potential for "umbrella crops" with max energy yield and min 60% GHG saving (SC1)

Future Potential *Relative* to Current Potential (VS+S)

	Sugarcane	Oilpalm	Miscanthus	Jatropha	Solaris	Sweet Sorghum	Total
EASTERN AFRICA	-55%	111%	-46%	-54%			-44%
CENTRAL AFRICA	-81%	-28%	-46%	-5%	300%		-37%
SOUTHERN AFRICA	200%		-53%		2 600%	800%	-47%
SUDANO-SAHELIAN A.	-96%		-22%	-33%		1000%	-26%
GULF OF GUINEA	-92%	-74%	-60%	-56%			-66%
GRAND TOTAL	-76%	-38%	-48%	-18%	2 900%	1800%	-44%

Source: WDPA, PPF, GLWD, IBAT, Mining-Guidelines and own analysis

Technical potential from energy crops relative to global bio jet fuel demand

POSSIBLE DEMAND BY GLOBAL INTERNATIONAL AVIATION IN 2050 AS PROPOSED IN THE ICAO VISION FOR ALTERNATIVE FUELS	**285 MT/A**
SSA technical potential by 2050 from VS + S land	93 Mt/a
% global demand that could be met by biofuel from feedstock grown on VS + S land	~30 %
SSA technical potential by 2050 from VS + S + MS land	260 Mt/a
% global demand that could be met by biofuel from feedstock grown on VS + S + MS land	~90 %

Technical potential relative to aviation fuel demand: South Africa

DEMAND	SA TOTAL CURRENT	SA TOTAL 2050
Fuel demand - mio l	2 600	6 896
Fuel demand – PJ	97	258
% that could be satisfied by all energy crops in SA ***	80 - 180%	60 - 115%

**biofuel*
***assumed 3% annual growth for jet fuel demand*
****from VS+S+MS land in SC1 (lower bound) and SC2 (upper bound) scenarios*

MAIN MESSAGES

Key insights from the modelling work

- Even the strictest environmental sustainability criteria allow for a meaningful technical potential for biofuels in SSA.
- The potential for all crops increases substantially if we include **“moderately” suitable areas** (where 40% - 60% of the maximum potential yield is achieved), but the economic attractiveness of farming in such areas demands higher commodity prices or higher subsidies.
- Opportunities for **annual feedstock crops are not on virgin land;** if dLUC is involved, they mostly cannot meet the GHG criteria. Rather focus on abandoned agricultural land, inter/rotation cropping or marginal land.
- **Perennial crops**, with soil carbon stock change factors > 1 and considerable carbon stocks in vegetation, **can very often meet the strict GHG criteria,** so have a wider range of options in terms of planting areas.

Key insights from the modelling work

- **Caveats:**
  - **Significant investment in climate change adaptation are urgently needed, to avoid a sharp reduction in crop yields** that is otherwise expected for most crops and across all regions. (Exceptions: potential for solaris and sweet sorghum expected to increase over time
  - Miscanthus is showing by far the largest **theoretical** potential in SSA, however, no experience with mischantus in the region-> agricultural trials and full risk assessment (invasiveness!) are needed before this potential can be exploited.
  - **Technical** potential vs **economic** potential.
- Case for local value chains towards domestic fuel mix (how do we support this?).

OTHER INTIATIVES IN THE REGION

Further Boeing funding (2019-2021) secured to:

In South Africa

- Assess the potential for alternative production routes in South Africa & their socio-economic benefits
- Create a specific guidance for new feedstocks (i.e. alien invasive plants)

In Ethiopia

- Develop a roadmap for the SAF sector in Ethiopia
- Supply chains support – working with individual sectors (agricultural, waste management, manufacturing) to build capacity, developing tools and protocols, regional indicators

In Brazil

- Replicate resource assessment
- Assess the additional positive social and environmental benefits of key feedstocks (macauba, carinata, etc.) as well as the potential of integrated production systems (crops-livestock-forestry) to provide feedstock for SAF production

switchafrica GREEN

Funded by
the European Union

wastetowing

First of its kind in Africa.

Aims to prove the feasibility of waste-based sustainable bio jet fuel production and consumption in South Africa with the view to replicating elements of the project in other African countries.

It will enable 25 MSMEs to be meaningfully involved in the development of a new value chain in South Africa – the production of SAF.

It will adhere to global sustainability standards that have been chosen by the aviation industry for the development of a biofuel sector that promotes food security, biodiversity, and water, land and labour rights.

Ultimately, the project will address the need for a reduction in GHG emitted by aviation, while better capacitating micro, small and medium enterprises to promote and adopt sustainable consumption practices and seize green economy opportunities.

a project brought to you by:

FETOLA WWF SkyNRG

ICAO

THANK YOU

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